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Don't Talk To Me Until I've Had My Coffee: An Analysis of Colombia's Changing Coffee and Agricultural Sector in the Face of Climate Change

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Don't Talk To Me Until I've Had My Coffee:
An Analysis of Colombia's Changing Coffee and Agricultural Sector in the Face of Climate
Change

Senior Project Submitted to
The Division of Social Studies
of Bard College

by
Nita Vemuri

Annandale-on-Hudson, New York
May 2023

Acknowledgments

At the time of writing this it is 11:51 pm the day before this project is due, so I will keep it short so as to not sacrifice even more sleep in the writing of this paper.

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Abstract

“With each year that passes, Atlantic and Pacific cyclone generating areas have experienced higher sea surface temperatures and increases in the intensity and duration of tropical storms.” (Sherbinin et al., 2007) While climate change remains a myth to some, it has become a reality for many, especially those whose livelihoods depend on climate-vulnerable fields and occupations. Latin American countries are especially subjected to climate change consequences because of their vast agricultural sectors and their reliance on ENSO (El Niño Southern Oscillation) patterns, **“There is a clear relationship between the dynamics of weather and climate transformation in welfare and economic prosperity.”** (Acevedo et al., 2020) Additionally, many South American countries are going through (or recently underwent) periods of intense political turmoil and economic crisis, leaving their economies in vulnerable states, thus diminishing their ability to recover from climate disasters and adequately adjust to potential climate change problems.

Standing 10th in the world for “climate risk linked to natural hazards, Colombia faces various climate-driven socioeconomic stressors.” (Climate Centre, 2020). A large part of Colombia’s rural economy and culture is sustained by its coffee sector and abundant natural resources suitable for many other tropical farming and tourism types. These enterprises do not perform well under the stresses of extreme weather variations caused by global warming. Besides being subjected to the increasing effects of climate change, Colombia’s agricultural sector faces several other challenges, such as internal violence (and its aftermath), land distribution inequality, a diminishing labor pool due to urbanization, increasing input costs, and a rise in international competition due to open trade market agreements. As a result of these issues, agricultural practices have been altered or abandoned altogether, and the rural economy has also undergone significant restructuring in the past three decades. Although many changes in rural Colombia have been consequences of an urbanizing economy and other socio-political problems, the move away from agricultural reliance and reorganization of the rural economy has largely been exacerbated by climate change, ultimately destabilizing the rural portion of the economy. Without proper government support and understanding of how complex rural political issues interact with the environment, the lowest income populations are affected most by these changes, hindering Colombia’s ability to progress towards development fully. As Colombia embarks on a new political chapter with the inauguration of its new left-leaning President, Gustavo Petro, now more than ever is the time to research and enact change.

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Introduction

Colombia has a very diverse topography, with the Andes mountains traversing through the northern region of the country, the Amazon forest stretching over the south, the Choco jungle bordering Panama, and the tropical grasslands of Los Llanos tropical grasslands tracing along the Venezuelan border, just of a few of Colombia's notable geographical features. The country also has coastlines facing the Atlantic, Pacific Oceans, and Caribbean Sea. Colombia has sustained a bountiful agricultural sector with abundant resources from the Andes Mountains and Amazon Rainforest, creating the tropical weather perfect for cultivating various rare fruits and vegetables. Cooler temperatures in the Andean foothills facilitate the farming of delicate crops like coffee and flowers. Historically, a large part of Colombia's population has sustained their livelihoods through agriculture, and the profits from this sector have spearheaded industrialization and rural growth.

As the country develops and urbanizes, it has slowly shifted away from agriculture and commodity export towards the service and information sectors; in the last forty years, Colombia's GDP share of agriculture, forestry, and fisheries has substantially declined from 19.2% in 1981 to only 7.4% in 2021 (World Bank.) Colombia is now classified as an upper-middle-income country (USNEWS, 2021.) However, a significant portion of its population (27%) remains in extreme poverty, ranking as South America's second most unequal nation (World Bank, 2018). Thus, agriculture is still crucial in providing wages and better living conditions in the most impoverished rural areas where many would otherwise be unemployed. Employment in agriculture comprised 16.45% of total employment in 2020, and 3.7 million people in Colombia rely on the agricultural industry for their occupations and livelihoods

(Ramires-Villegas et al., 2012). Agricultural fields also cover approximately 40% of Colombia's land. (World Bank; Romero & Molina, 2015.)

Farming allows rural populations to amass wealth and move up the ladder. This sector also plays an important social and cultural role, as most agriculture is organized in small-scale family-owned farming, with plots smaller than 10 hectares (Romero & Molina, 2015.) Small-scale integrated farming is more sustainable than large-scale farming. However, it is also more vulnerable to climate change as these farms lack the large-scale resources to adapt to or recover from climate disasters. Colombia's mountainous topography and geographical organization also make it particularly vulnerable to climate hazards compared to other countries, "In 2010, it was the third most affected country from weather-related losses according to the Global Climate Risk Index 2012." (Harmeling, 2011) The weakness of this sector was especially evident following the 2010-2011 La Niña disaster, a year-long period of unpredictable flooding and volatile weather which induced massive agricultural damage, with profit losses totaling 6 billion US dollars in damages (USAID, 2017) and 800,000 hectares (74% of agricultural land) affected (Romero & Molina, 2015).

The impacts of climate change, coupled with Colombia's unique political challenges, have created complex issues in adaptation, reconstruction, and development of the rural economy. The country's once-thriving coffee sector is now declining due to these impacts. Although short-term changes in adapting to climate change, like replacing crops, may have seemed individually beneficial, they have had adverse long-term consequences for the collective, resulting in new environmental and socio-economic problems such as sustainability concerns, rising input costs, decreased productivity and profits, the expanding role of foreign corporations, and land ownership inequality - bringing to question whether the current agro-business model

can withstand future environmental shocks. Only by understanding how these challenges interact with each other can we look forward to potential solutions that are sustainable in the long term.

Chapter 1: Colombian Agriculture in the face of Climate Change

General Overview of Topography

Colombia can be split into 5 distinct regions: “the Andean region in the center, the Caribbean region in the north, the Pacific coastal region in the west, the Orinoquia region near the border of Venezuela and the Amazon region in the southeast.” (Romero and Molina, 2015)

Figure 1:

The 5 Natural Regions of Colombia



Source: Romero & Molina, 2015

As a result of these distinctly different regions, Colombia has a variety of climate zones as well: the Lower Lying Tropical Zone experiences "alternating dry and wet seasons," and covers most of the country. Following that is the Temperate zone (between 900-1980m), where most of the population lives. Then is the Cold Zone which experiences two wet seasons and finally is the Paramous zone at the highest elevation, with no vegetation since it is covered by snow. (Romero

& Molina, 2015) Colombia's topography is "megadiverse, filled with a diverse range of ecosystems, paramos, mangroves, wetlands, coral reefs, glaciers, oceans, and tropical forests as well as significant biodiversity and water resources." (World Bank, 2021). The country's rain patterns are dictated by El Niño Southern Oscillation (ENSO), characterized by changes in sea level water pressure, temperature, and wind speed/direction. Each region has its distinct and consistent climate and weather patterns, "The Andean regions experience a bimodal pattern of rains during April–June and October–December, while the northern Caribbean region, due to its proximity to the equator, experiences a single rainy season between May–October." (World Bank, 2021) These previously consistent climate conditions dictated Colombian migration, settlement, and agriculture - crops were planted in the specific weather conditions where they were most likely to flourish.

Climate Change Vulnerability

Colombia's agricultural sector relies on consistent weather patterns for successful harvests which climate change has begun to alter. According to the Federación Colombiana de Ganaderos (2018), the livestock sector, which employs 19 percent of agricultural workers, has lost approximately 1.8 billion US dollars in the last ten years due to El Niño-Southern Oscillation. 90% of the agricultural workers interviewed in a 2021 study conducted by Jessica Eise noted significant deviations from previously consistent temperature patterns They also stated that this has caused changes in the maturity timeline of plants, crop taste, and soil degradation. 74% of the farmers from that study also reported increased agricultural diseases, plagues, and natural disasters such as landslides. Volatile precipitation patterns have led to difficulties securing clean water supplies for agriculture and basic living. As farmers are less able

to predict when their crops will mature, harvests have become more sparse and inconsistent, causing disruptions in rural workers' livelihoods and communities:

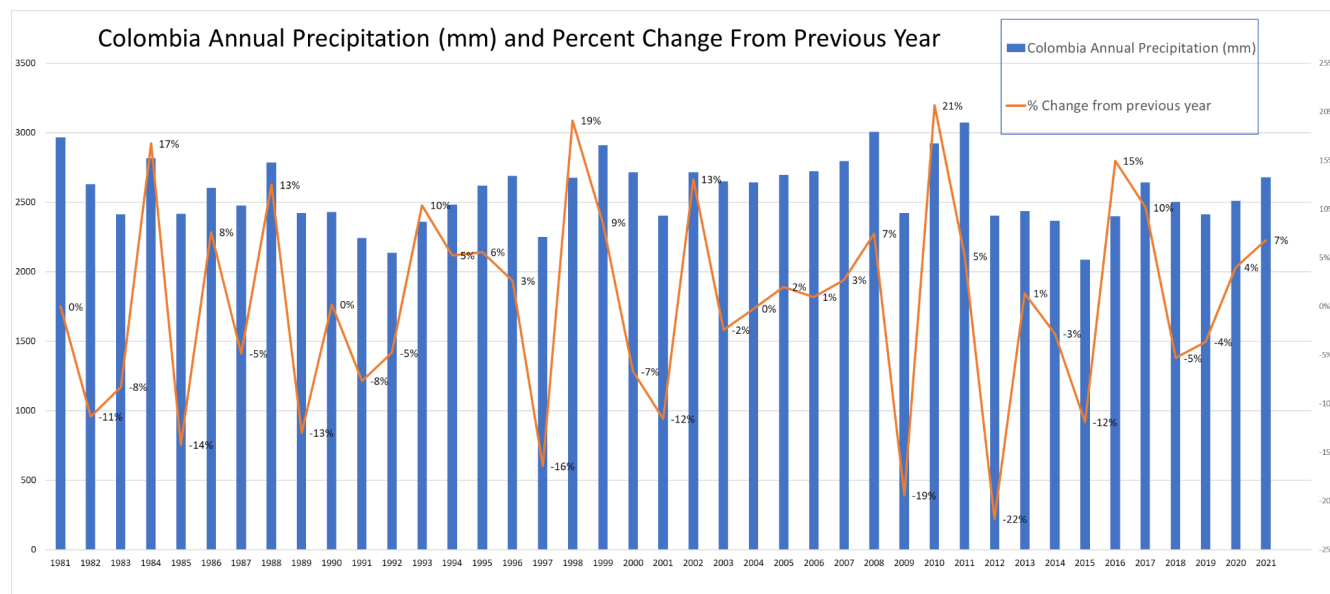
“Debido a mi afición por el cultivo del café, tras casarme, mi marido y yo asumimos la inversión de comprar una pequeña plantación de café, a la que dedicamos también gran parte de nuestras vidas. Pero debido al cambio climático, las cosas se han puesto muy difíciles, y tras varios años de pérdida de beneficios.... Because of my love for growing coffee, after I first got married, my husband and I took on the investment of purchasing a small coffee plantation, to which we dedicated a large part of our lives too. But because of climate change, it has made things very difficult, and after several years of lost profits, despite my insistence on continuing to try to make it work, we realized that this was affecting our incomes and livelihoods.... I eventually made the choice to eradicate coffee plants from my farm. The farm does not have the appropriate climate anymore, the soil does not have the correct humidity or nutrients that the plants need, and there have been problems with obtaining clean water because of the droughts... Coffee has sustained my family for generations... So this decision to halt coffee production was only because of climate change causing soil degradation, lack of clean water, and poor harvests. The cost of maintaining harvests grew too much because of the plagues and the diseases, we had to hire more workers and buy more pesticides, which were detrimental to our health, the health of our employees and ultimately bad for the consumer as well.”

(Source: Translated interviews from Eise 2021,)

The two most noticeable symptoms of climate change in Colombia are increased variability in temperature and rainfall.

Figure 2:

Colombia Annual Precipitation and Percent Change From Previous Year

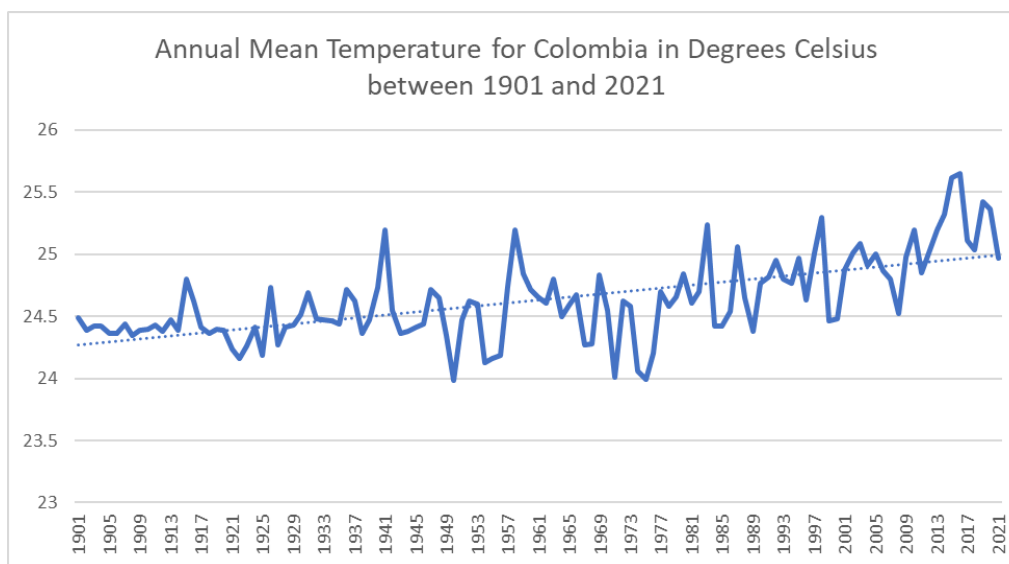


Data Source: Word Bank Climate Knowledge Portal

The data for Figure 1 is from the World Bank Climate Knowledge Portal. Annual precipitation is measured in mm. The most year to year change in the amount of precipitation (measured in percent change from the previous year) occurred between 2008-2009, 2009-2010, and 2011-2012. Significant changes in yearly rainfall were also recorded between 1996-1997 and 1997-1998. The periods between 2008 and 2012 and then again from 1996 - 1998 were both years in which significant changes in ENSO patterns were recorded. The annual rainfall mean between 1991 and 2021 was 2573.127 mm, and the standard deviation was 230.55 mm. The median of this variable is 2601.01 mm, close to the mean. The variance of this variable is 53154.12, which is relatively large. The outlier years were 2011 and 2015, surrounding the most significant ENSO disasters with an all-time high of 3072.91 mm of rain and subsequent drought of 2085.79 mm of rainfall for the respective years. The average absolute deviation from the mean was 190.89 mm, and the median absolute deviation was 124.33.

Figure 3:

Colombia Temperature Trendline between 1901 and 2021



Data Source: World Bank Climate Knowledge Portal

The Colombian Annual Mean Temperature data was sourced from the World Bank Climate Knowledge Portal. The annual mean temperature is measured in degrees Celsius. One important note on this measurement is that the temperature in Colombia varies significantly from the tropical areas to the Andean regions. So the mean temperature of the entire country does not represent the realities of temperature from region to region. The trend line for this data set is positive, indicating consistently rising temperatures throughout the last century. Within the last 20 years, the average temperature has increased by 1 degree (as described in Magrin et al., 2007). “The frequency of hot days and hot nights have increased significantly every season since 1960 (+20 percent in 1960-2006)” (República de Colombia 2010). The annual mean temperature for Colombia between 1901 and 2021 was 24.63 degrees Celsius, with a standard deviation of .336 degrees Celsius. The variance of this variable was .11, which is small. However, even minor deviations in the temperature can have exponential effects. In 1950, Colombia experienced its lowest annual mean temperature (within the time frame of the data set) at 23.98 degrees Celsius, and in 2016, Colombia experienced its highest annual mean temperature within the time frame of 25.62 degrees Celsius. The median absolute deviation was .19.

Due to rising temperatures, glacial melting and floods leading to landslides have become much more frequent. Glacier coverage has decreased by 3-5 percent annually (World Bank, 2011). Over the period from 1851 to 2005, “the frequency and size of severe rainfall events have tripled, while the frequency of tropical cyclones has doubled.” (USAID, 2017) Flooding has caused land degradation and, ironically, has led to water shortages as unsafe flood waters contaminate the clean water supply when there are insufficient dam capacity and water diversion measures. According to a 2010 report by the Republic of Colombia, 50 percent of the municipal headwaters were already displaying symptoms of water shortages. The report also indicated

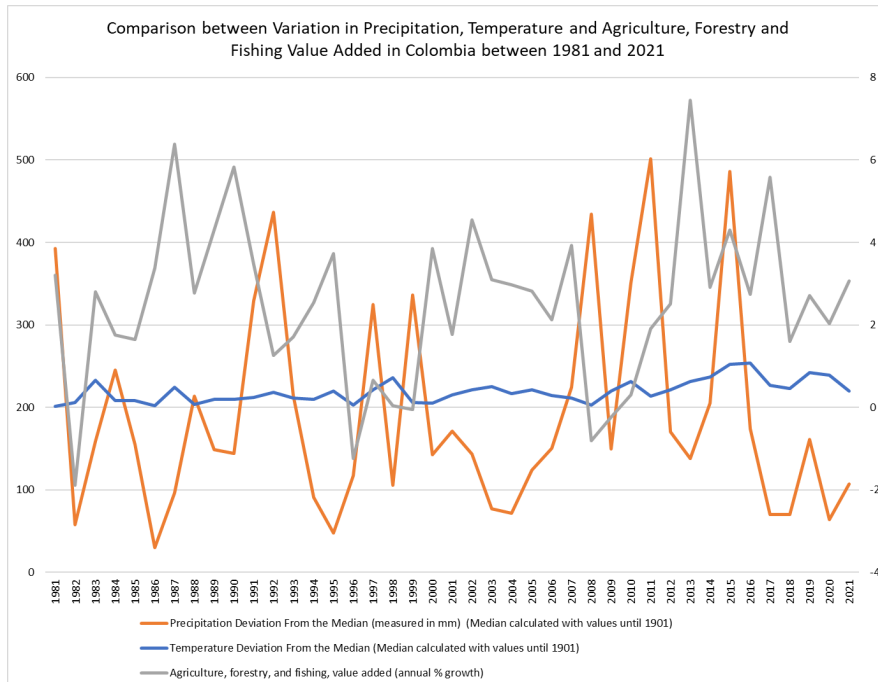
climate change forecasts predicted more severe water shortages in the Andes regions (home to 80% of the population). Increased flooding and rising sea levels have also led to soil salinization, reducing agricultural land and destroying the ecosystem. Between 1980 and 2010, climate disasters (mainly landslides and flooding) led to 2.2 billion dollars in losses or around 2.6 percent of GDP. (Posada & Villa, 2010) While some areas experience extreme rainfall, others experience prolonged droughts, as some regions have experienced their worst dry spells in 30 years (Romero & Molina, 2015); significant rivers like the Cauca and Magdalena undergo their driest periods on record in 2015, leading to disastrous water shortages and fires in the north and west. The severity of this dry spell prompted the government to spend 4.2 billion pesos to mitigate its effects.

The combination of these climate change effects has ultimately led to a decrease in land productivity: the USDA reported that in 2022, despite an increase in planting density, productivity fell by 3% in agriculture due to adverse weather conditions. The following figure compares trends in precipitation variation, temperature variation, and agriculture, forestry, and fishing value added (annual %growth):

(Figure on next page)

Figure 4:

Variation in Precipitation, Temperature, and Agriculture between 1981 and 2021



Data Source: World Bank Climate Knowledge Portal

The figure shows that a reduced or negative growth rate follows the periods with significant variations in Precipitation and Temperature in agriculture, forestry, and fishing value added. This is the case during the period between 1995-1996, a recorded ENSO climate disaster year, as well as during the period between 2010 and 2012. Colombia previously sustained a commodity export economy and a thriving agricultural sector, however now it is becoming increasingly vulnerable to the effects of climate change.

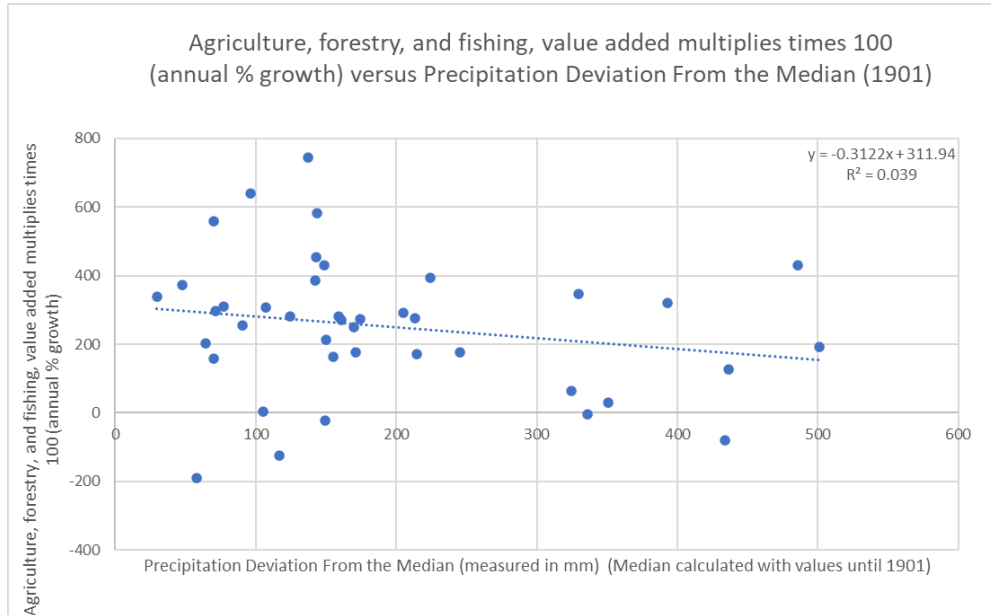
Line of Best Fit

The following figures demonstrate the scatterplots when attempting to find a line of best fit demonstrating the correlation between fluctuations in precipitation and

agricultural output as well as the correlation between fluctuations in temperature and agricultural output.

Figure 5:

Scatterplot of Agriculture, forestry, and fishing, value added (multiplied times 100) (annual%growth) versus Precipitation Deviation From the Median



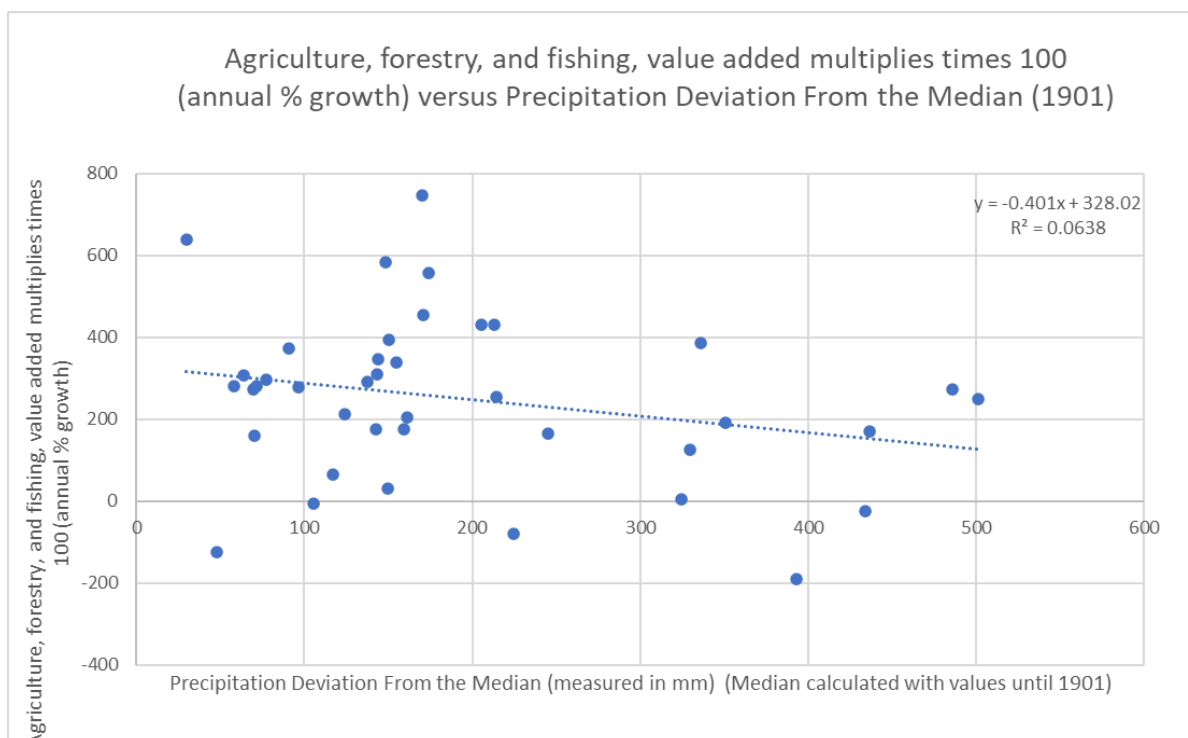
Data Source: World Bank Data Bank

From the scatter plot, we can see that the two variables: agriculture, forestry, and fishing, value added (multiplied times 100) (annual%growth) and precipitation deviation from the median have a weak negative correlation.

(Figure on Next Page)

Figure 6:

Scatterplot of 1 year lag on Agricultural, forestry, and fishing, value added (multiplied times 100) (annual%growth) versus Precipitation Deviation From the Median

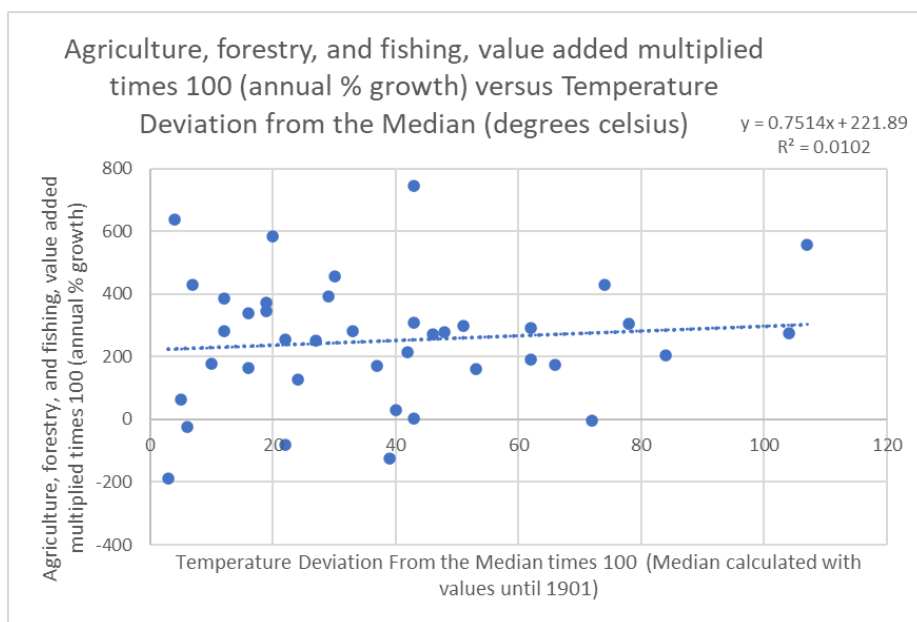


Data Source: World Bank Data Bank

From the scatter plot, we can see that the two variables: agriculture, forestry, and fishing, value added (multiplied times 100) (annual%growth) and precipitation deviation from the median have a weak negative correlation, however lagging the agriculture value added variable increased the R-squared value, as precipitation deviation affects both current harvests and future harvests (land and soil degradation) and often decreases in agriculture are accounted for only after a climate extreme occurs, as opposed to in real time.

Figure 7:

Scatterplot of Agricultural, forestry, and fishing, value added (multiplied times 100) (annual%growth) versus Temperature Deviation From the Median



Data Source: World Bank Data Bank

From this scatter plot, we can see that there is little to no correlation between the two variables, with a very low R squared value of .01. Despite the gradual increase in temperatures over the years, the temperatures are still within the ideal range for coffee cultivation and agricultural growth. However, it is predicted that by 2050, they will surpass the optimal range for several agricultural practices, including coffee (Solidaridad, 2021). The changes in temperature also have an impact on the ENSO rain patterns, which have a larger impact on agricultural productivity.

Coffee as the Cornerstone of Colombian Agriculture

Colombia's diverse climate enables it to cultivate a variety of different crops, including tropical fruits like bananas, plantains, maracuyá (passion fruit), Echuca (golden berry), Zapote

(Sapota), and Guanábana, among many others, totaling an export value of \$173 million in 2020. (OECD, 2020) Livestock production is also a large part of the agricultural sector. The flower industry is emerging at full force with a \$1.42 billion export value in 2020. (OECD, 2020) More than one-fifth of Colombia's population is employed in agriculture (Ramirez-Villegas et al., 2012) and almost half of the country's landmass (40%) is used for agriculture or livestock (Romero & Molina, 2015). The backbone of Colombia's agricultural sector is coffee, with an export value of \$2.54 billion in 2020 and making up roughly 8% of total exports. (OECD, 2020) Coffee is the country's third largest export, preceded by crude oil (1) and coal (2). Colombia is the world's 3rd largest producer of the crop, surpassed only by Brazil and Vietnam. Most of Colombia's rural employment is connected to coffee production (UPENN, 2013) and most of the country's poverty is concentrated in rural areas, thus coffee production is essential for improving this population's quality of life and financial standing.

Climate Change Effects on Coffee

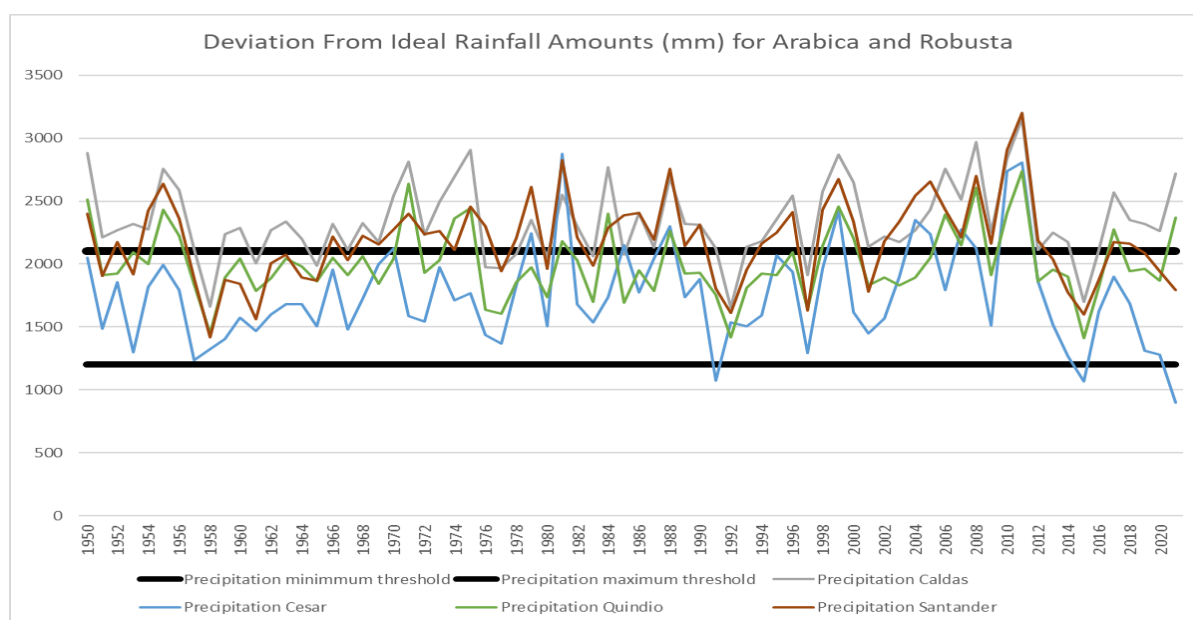
Coffee cultivation requires a precise environment. It is primarily grown in the following regions: Santander, Quindio, Risaralda, Tolima, Cuaca, and Caldas¹, all located in the smaller hills and lower portions of the Andes Mountains (FNCC, 2022), in elevations ranging from 3,300 to 6,300 feet. (Britannica) The combination of these regions is known as la Zona Cafetera. There are 90 different types of coffee, however the two main species that are grown for consumption are *C. arabica* L., arabica coffee, and *C. canephora* Pierre, robusta. (DaMatta & Ramalho, 2006). The amount of precipitation needed for coffee cultivation depends on several factors, such as the soil's capacity to retain water, air humidity, cloud presence, and agricultural techniques used when farming. Arabica coffee grows best with annual rainfall between 1200-2000 mm.(Alègre,

¹ In total, there are five regions and 19 subregions in which coffee is grown, however I will mainly focus on the 6 regions mentioned.

1959) Robusta coffee thrives within a similar range, however, it can handle rainfall exceeding 2100 mm better than Arabica. (Coste, 1992) Both species require 2-4 months with minimal precipitation in order to bloom. With climate change, “precipitation levels that would usually occur over three months have been concentrated over two weeks this year.” (Schiffmann, 2019), leading to a sizable loss of output since rain patterns no longer match up with the plant maturity timeline. In the following table, we can trace deviations from the ideal precipitation levels in Colombia’s coffee-growing regions:

Figure 8:

Deviation from Ideal Rainfall Amounts for Arabica and Robusta in Coffee Growing Regions



Data Source: World Bank Climate Knowledge Portal

The figure shows that the annual precipitation levels from the Cesar and Quindio regions were the most conducive to coffee growing between 1950 and 2020. On the other hand, Caldas and Santander had significant periods in which their precipitation levels were not conducive to coffee production. It is important to note that coffee farming has been adapted to be more resilient to

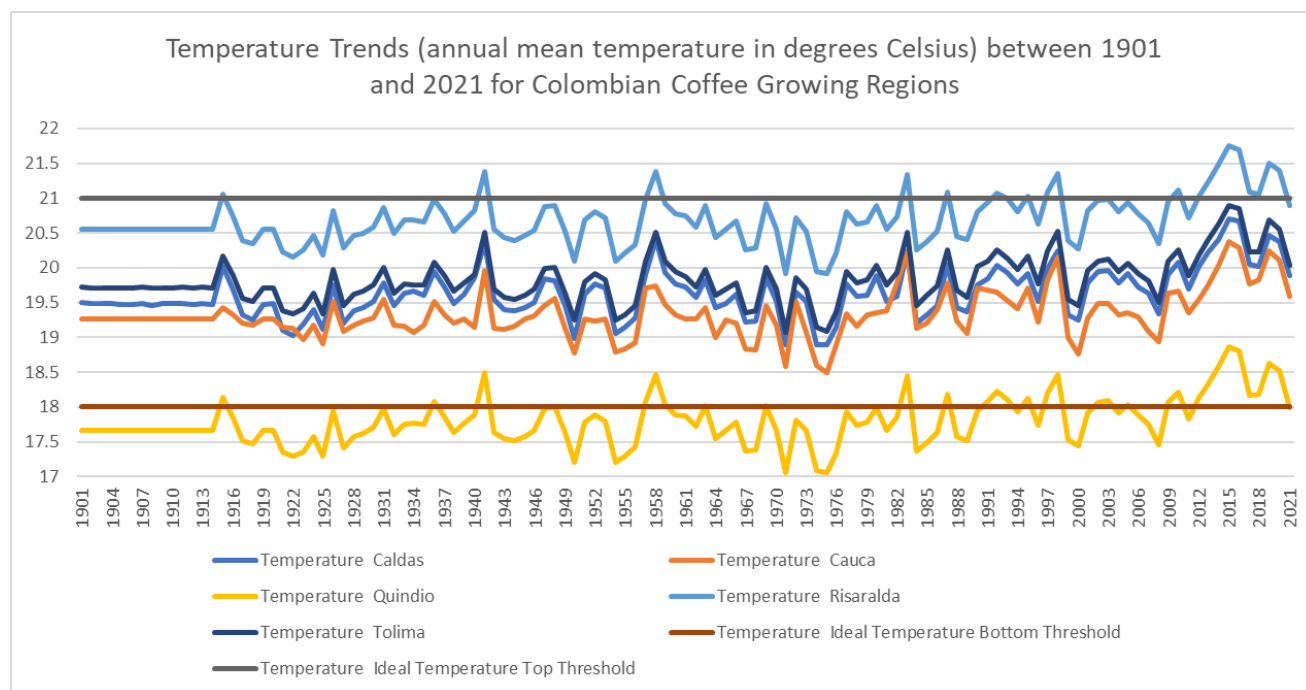
higher quantities of precipitation. However, periods of extreme rainfall, such as between 1998 and 2001 and 2010-2011 (where there are highest peaks in annual rainfall), are still not easy to manage and not ideal. Irregular precipitation patterns have led to flooding and droughts, with some areas facing an up to 80% decrease in coffee yields, particularly in areas that do not have proper irrigation and water management facilities (Damatta & Ramalho, 2006). Although there is still no data available after 2020, predictions for 2022 were as follows: The Colombian Institute of Meteorology estimated that coffee-producing areas were likely to experience rainfall that is 20-40% higher than historical averages until July 2022 (USDA, 2022) leading to a predicted decline in output by 6%.

The optimum temperature for farming arabica coffee is 18 to 21 degrees Celsius (Alègre, 1959). Temperatures higher than this cause the fruit to ripen more quickly (quality drops) or can also lead to yellow leaves (Damata & Ramalho, 2006). Temperatures in the Zona Cafetera have increased by .5 degrees Fahrenheit every decade, accompanied by a 20% reduction in sunlit hours (Baker, 2022). Because of these increasing temperatures, it is projected that available land for growing coffee will be reduced by 50% by 2050, which could add stress (in the form of more deforestation) to the Andean forest regions. (Solidaridad, 2021) The following figure illustrates in temperature in the last 120 in coffee-growing regions:

(Figure on Next Page)

Figure 9:

Temperature Trends between 1901 and 2021 for Colombian Coffee Growing Regions



Data Source: World Bank Climate Knowledge Portal

Figure 9 shows that the annual mean temperature for all five regions has progressively increased in the last 120 years. While the Quindio region mainly hovered below the minimum threshold for ideal coffee growth, it has slowly migrated to above that threshold within the timeframe. Meanwhile, the Risaralda region, which hovered below the maximum threshold for ideal coffee growth, is trending toward exceeding it. The other regions are still well within the thresholds but slowly trending upwards. The annual mean temperature in several of Colombia's coffee-growing regions is estimated to surpass the maximum temperature that allows for successful coffee growth by 2080. (Iscaro, 2014)

Increasing volatility in precipitation combined with warmer temperatures has led to the spread of fungus, agricultural diseases, and bugs in the coffee sector. Arabica coffee is

particularly susceptible to diseases because of its “lack of genetic diversity,” and it is predicted that the current trends of climate change could make this species of coffee could go extinct by 2080, which would be a severe problem in the future (Paramaguru, 2012 as cited in Iscaro, 2014). The population of the Hypothenemus hampei insect has been aggressively expanding within coffee plantations as this insect is immune to the effects of caffeine (Jaramillo et al., 2009). The Coffee leaf rust virus has increasingly become a big problem; the virus previously wiped out the entirety of Sri Lanka’s coffee sector in the 1860s (Koebler, 2013, as cited in Iscaro, 2014). The Coffee leaf rust virus, which was initially contained on the other side of the Atlantic, first infested South America in Brazil in 1970 and has been able to flourish due to higher levels of rainfall and warmer temperatures (USNEWS, 2022). The coffee leaf rust virus thrived in Colombia due to an unusually wet year in Colombia in 2008 brought on by La Nina. This led to a sharp decline in coffee production from 12 million 60-kilogram bags each year to only 7.5 million (USNEWS, 2022). More fungi and pests have led to increased use of expensive pesticides, which are damaging to the environment too, making the coffee farming industry less sustainable and less profitable in the long run. Thus, the demise of “environmental balance” (Wight, 2021) has resulted in a decline in yields and a loss of productivity, jobs, and livelihoods and will continue to have disastrous repercussions.

Measurable Economic Consequences

Insufficient productivity in coffee production in Africa and Latin America (due to climate change) led arabica prices to surge by 16% between 2009 and 2011. More recently, Colombia saw a decrease of 40,000 hectares of land used for coffee farming. This is because large numbers of farmers have started exiting the sector (Fedecafe, 2022) as a result of lacking profits and support from the government, potentially leading to a “humanitarian crisis” in rural Colombia.

(Reuters, 2022) In an interview from Eise 2021, farmers spoke on climate change problems with Coffee cultivation:

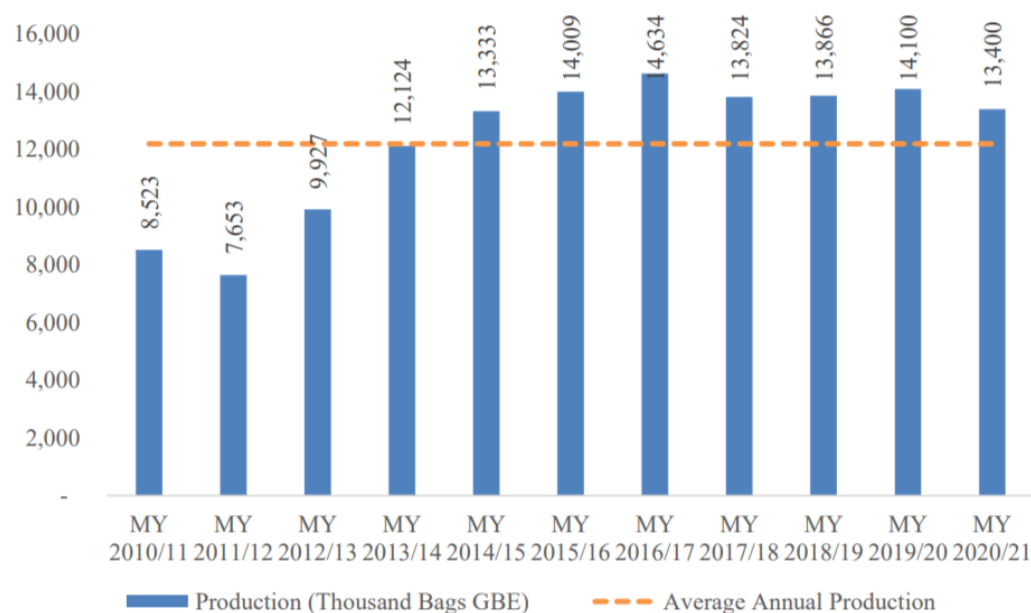
“In the period of flowering, there was summer. During harvest, there was winter. But from 2008 onward, this changed and we now don’t know when it will be summer, when the coffee will blossom. Our yearly production now varies by up to 40 percent.” (Translated from Spanish)

In 2021, Colombia produced 12.6 million 60-kg bags of coffee, a 9% decrease from the previous year. This was mainly due to climate change and farming strikes and protests against a neglectful government. (FNC, 2022) The subsequent harvests have maintained a downward trend in yields as well. Bloomberg reported that the production of coffee fell by 12% of coffee production in 2022 compared to 2021 - from 12.6 million 60-kg bags of coffee to 11.1 million bags. Continued declines for the coffee industry through the 2022-2023 harvest period have been predicted by the FDA, due to rising weather variability and other factors, such as increasing fertilizer costs. An increased need for fertilizers, can be attributed to the rise of bacteria and viruses stemming from climate change However, inflation and shortages are mostly to blame for price increases (USDA, 2022), overall leading to a decrease in crop productivity and a stagnant growth rate in coffee production, as seen in Figure 10:

(Figure on next page)

Figure 10:

Colombia's Annual Coffee Production



Source: USDA Colombia Coffee Annual Report 2022 (Data from Fedecafe)

From Figure 10, one can see that there was no consistent growth pattern between the years 2014 and 2021; instead, the amounts of coffee production fluctuated between the 13,000 and 16,000 range. In 2022 (not pictured as public data has not yet become available), there was a significant dip in production, adding to the stagnant growth pattern. Colombia underwent historic La Nina flooding in the latter part of 2022 which led to the lowest levels of coffee production since 2013 (USDA, 2022). The Colombian government announced a state of national disaster on November 1st, 2022. (World Bank, 2022) The country was given 300\$ million dollars of aid from the World Bank to recuperate from the climate disasters of 2022. The Colombian government also promised to subsidize all agricultural fertilizers - an attempt to decrease food prices which were inflated by 12.22% in 2022 (attributed to decreased food harvests) (Reuters, 2022). Reduced land

productivity can also be attributed to flooding. In the harvest year of 2021, productivity dropped by 3% to 19.3 bags per hectare, though planting density increased to 5,268 trees per hectare. (USDA, 2022) This has led to a decrease in exports by 6.7% in 2022 (USDA, 2022), and a stagnant growth rate both for that year of production and the proceeding year as well. All of these compounding issues have led to insecurity within the agricultural sector. Alongside decreasing exports, coffee imports to Colombia have increased (mainly from Brazil) to fulfill domestic demand, which stayed consistent at 2.2 million bags GBE (USDA, 2022). According to the USDA Colombia Coffee Annual Report from 2022, coffee imports are predicted to rise 13.5% in the 2022-2023 harvest period because of growing domestic demand and stagnant domestic production.

Chapter 2: Outlying effects and adaptations within the Rural Sector

In the previous chapter we examined the ways in which climate change is impacting agriculture in Colombia, specifically the country's coffee sector. By surveying the scientific data and connecting it to economic losses and market shifts, we can better comprehend the scope of this problem. This second chapter will more specifically review how climate is not only affecting the primary production of coffee beans, but also its implications on the value chain, rural development, and the economic organization of rural Colombia. Through a broader lens, we can assess how the rural economy is restructuring to these new realities and gain a more comprehensive understanding of the challenges and potential solutions.

Coffee and Rural Development

Coffee production is rooted deep in Colombian history, dating back to the 1730s (FNCC, 2010). This sector has played a key role in the country's development and industrialization, particularly through the expansion of the railway system. Originally built to transport coffee, these railways were later used to transport other agricultural products, such as sugarcane and oil (Tirado & Mejia, 2017). In addition to the development of transportation infrastructure, the profits from coffee production have been used to fund and invest in other sectors of agriculture, including cacao and sugar, leading to the consolidation of multinational companies such as Colombina, a candy manufacturer, and Postobon, a beverage producer. (Dinero, 1997) 7.6 billion COP was spent on infrastructure between 1944 and 2015 as a result of a thriving coffee sector, with 61% of that going towards public services and raising the population's standard of living. (Velez, 2017 as cited in Laverde, 2020) The following chart from a publication by the National Federation of Coffee growers of Colombia (FNC), demonstrates the amount of money from coffee profits that has been invested in Colombian infrastructure:

Figure 11:**Infrastructure Investment through the Coffee Growers Committees**

Infrastructure investment through the Coffee Growers Committees					
Component	Indicator	1944-1962	1963-1989	1990-2015	1944-2015
Housing and public services	Infrastructure (number)	1,929,920	1,008,026	3,734,166	
	Investment (millions)	102,314	3,449,986	1,077,953	4,630,253
Roads and related works	Infrastructure (kilometers)	NDA	36,785	178,598	
	Investment (millions)	NDA	556,404	1,351,369	1,907,773
Education	Infrastructure (number)	5,035	15,528	9,336	
	Investment (millions)	NDA	189,597	339,402	529,000
Health	Infrastructure (number)	NDA	68 *	739	
	Investment (millions)	NDA	12,405	41,291	53,697
Other community infrastructure	Infrastructure (number)	282	NDA	1,482	
	Investment (millions)	391	97,065	247,941	345,397
Productive infrastructure	Infrastructure (number)	9,385	6,591 *	150,689	
	Investment (millions)	23,435	14,754	147,830	186,019
Total Investment	Trillion	0.13	4.32	3.21	7.65
Harvest value	Trillion	63.6	146.0	142.1	351.7
Harvest % value	Harvest % value	0.2%	3.0%	2.3%	2.2%

*Estimated figures. NA (non-available). Values in constant 2016 peso values.

Source: Meija, 2017, Colombian Coffee Growers Federation. Economic Investigations Directorate

The coffee industry remains a crucial contributor to the development of Colombia, in advancing and sustaining the poor rural populations through cooperatives like the FNC. Originally a private local organization, the Federación Nacional de Cafeteros de Colombia (FNC) expanded to become a nation wide organization that is backed by the national government. This organization continues to fund rural infrastructure projects today, through the National Coffee Fund (Meija,

2017). The FNC's funding alongside other public and private contributors have led to higher incomes and living standards within coffee growing regions in comparison to regions who sustain other types of agriculture (Meija, 2017) as demonstrated by the table below:

Figure 12:

Comparison of Quality of Life measures between Coffee and Non-Coffee areas

Component	Coffee areas	Non-coffee areas
Physically inadequate homes	14%	23%
Homes with critical overcrowding	8%	10%
Homes with inadequate public services	10%	18%
Homes with high economic dependency	11%	14%
Homes with kids of school age that do not go to school	2%	2%
Total unmet basic needs	31%	46%

Source: FNCC (2014) as cited in Laverde, 2020

The FNC has significant political power due to the magnitude of the coffee industry in Colombia, and with that, they actively advocate for government policies on rural development. Thus, a declining coffee sector due to climate change can severely affect rural populations, who may lack access to viable alternatives and resources to escape poverty.

Expansion of the Coffee Value Chain

The processing and retailing periods of coffee production are the stages where there is the most value-added: "Farmers add 21%, collectors add 10%, traders add 18%, processors add 29%, and retailers add 22%." (Laverde, 2020) To harness the potential of this sector, several actors, including the government, private corporations, and rural sector workers, have upgraded the coffee value chain. One key player in this process has been the FNC, which helped the Colombian coffee sector move towards advanced processing of coffee instead of just exporting

raw coffee beans. Fedecafe launched a large-scale marketing campaign through private and public funding to position Colombian coffee in "the minds of global consumers" (Reina et al., 2012, p. 14), propelling their products into the global export market. This was significant in instilling coffee into Colombia's national identity, especially through the Juan Valdez icon, representing Colombian farmers' "dedication and commitment" to making coffee of the finest quality. (Laverde, 2020) Over time, this brand expanded beyond its initial purpose, evolving into a Colombian coffee corporation that launched stores nationwide and abroad. Alongside the Juan Valdez icon, FNC also developed international commercialization strategies by creating the 100% Cafe de Colombia ® "ingredient brand" to increase demand for uniquely Colombian coffee among international consumers. These efforts led to more specialized coffee products in Colombia, increasing the value of production. Coffee was the most exported product from 1908 to 1989 (Laverde, 2020). Small farmers have increasingly ventured into the specialty coffee market through fair market practices, organic roasts, and other certifications, as well as by creating their own branded and roasted ground coffee as a means of safeguarding their incomes and diversifying their market opportunities in the face of unstable coffee prices in the global market. "During 2015, the cooperative coffee growers of the department of Caldas reported that out of 33,667 farmers, 13,400 were involved in the production and marketing of specialty coffees." (Gomez & Perez, 2022) As the coffee sector expands and modernizes, more risks emerge. The domestic concentration of coffee production and retail has led to a situation where the impacts of poor harvests and market fluctuations are felt more acutely and have more widespread consequences than before. Now, poor harvests affect farmers, processors, marketers, and smaller businesses in the value chain - all concentrated in Colombia versus distributing losses domestically and abroad.

Climate Adaptation through Government Support

The coffee sector has struggled due to increased production costs from climate change (need for more fertilizer and pesticides, harvest losses). In response, Colombia's President Ivan Duque announced a stabilization fund in 2019. The fund aims "to subsidize coffee farmers when production costs exceed international prices," as many farmers have been incurring negative cash flows from climate change losses and a significant decline in coffee prices on the New York Stock Exchange in 2019. (Reuters, 2019) This dip in international prices can be attributed to various factors, including trade disputes between the U.S. and China (major coffee consumers) and oversupply of the market by large-scale producers such as Brazil and Vietnam. The decrease in market price led to a loss of 1.4 trillion pesos in 2018 in Colombia. (Reuters, 2019) The coffee market is highly volatile and susceptible to the effects of uncontrollable externalities - weather conditions, economic and political instability, and disease outbreaks, among other things. Climate and political problems in other top-producing countries, like Brazil with its mass deforestation of Amazon (leading to environmental shocks), political instability under Bolsonaro's far-right political dominion, climate-caused droughts and other weather predictions (leading to both low yields or very high yields), have caused drastic fluctuations in global market supplies and coffee prices. These fluctuations make it difficult for small-scale Colombian coffee producers to plan and invest in their farms.

Thus emerged the National Coffee Fund (*Fondo Nacional del Cafe*), whose funding comes from a variety of sources, "including the general budget, state-backed debt securities, proceeds from royalties and contributions from international organizations." (Reuters, 2019) Colombia's coffee farmers also contribute to the fund through a tax (variable, based on market price). (FNC) Between 2013 and 2014, over 350\$ billion (COL pesos) were dispersed from the

fund for different projects to support the coffee sector, and in 2018 the government allocated \$100 billion (COL) towards the fund. This parafiscal account is managed by the National Federation of Coffee Growers (Federación Nacional de Cafeteros de Colombia - FNC). It is predominantly used for investments, infrastructure improvement, and subsidies (not free government handouts) that support the country's coffee sector. Subsidies to cope with market volatility take the shape of insurance coverage, subsidized loans for investment in new technologies, and price stability plans - FNC argued for a nationally set base price for Colombian farmers to sell at, regardless of the NY market price (Reuters, 2019) and has a purchase guarantee to all coffee growers in Colombia:

“We guarantee producers the purchase of their coffee at the best base price in the market, paid in the chase, calculated transparently, without intermediaries, in places close to their farms and throughout the entire year.” (Federación Nacional de Cafeteros de Colombia)

This purchase guarantee has benefited urban farmers in remote areas who lack the necessary resources and funds to process and transport harvests and ensures stable coffee prices when growers sell to wholesalers. This also helps coffee producers, who narrowly cover increased production costs - generating \$248 (USD) per 125-kilo bags, which incurs \$244 (USD) of production costs. (FNC) For farmers to remain profitable while also covering the cost of fertilizers, they need to generate an income of around \$1.40 to \$1.50 per pound (Velez, as cited in Reuters, 2018). The FNC also funds social initiatives and development in the coffee-growing regions, whose objectives are to increase these regions' education, health, quality of life, and long-term productivity.

Research and New Technologies

Through the National Coffee Fund, the FNC also finances climate resilience research and the development of new technologies - creating its own coffee research lab known as Cenicafe. Cenicafe has developed more efficient farming equipment, climate resistant coffee strains and promotes sustainable farming practices. For example, to minimize water waste, they innovated new wet milling technology, Ecomill®:

It enables growers to wash coffee with less than 0.7 liters of water per kg of dry parchment coffee using the Ecomill® technology, developed by Cenicafé to reduce water use in wet processing. Ecomill® prevents 100% of pollution by reusing coffee wet processing wastewater. (Fedecafe)

Cenicafe has also developed machinery that can repurpose coffee grounds boiler fuel (Fedecafe) making the existing coffee sector even more sustainable. Their most significant impact has been the research and development of rust resistant variants of coffee. Varieties such as “Cenicafé 1, general Castillo®, regional Castillo® and Tabi” have been contrived to be more climate resilient, through genome sequencing (Fedecafe). By using these rust resistance seeds, farmers are also able to use less pesticides. Farmers are now beginning to diversify their coffee crop makeup, as opposed to simply growing homogenous arabica varieties. Each bag of seeds that Cenicafé distributes to producers (at a subsidized cost) is comprised of 35 varieties of seeds, rather than just one genotype, guaranteeing that some plants will survive any potential climate challenges. (Schiffmann, 2019) These new seeds are resistant to climate-caused diseases, and have been engineered to be less temperature and elevation sensitive. They have also been modified to have smaller trees with more berries, resulting in denser harvests and a reduction in the amount of land needed to grow the same amount of coffee as before. (Fedecafe, 2018) Prior to this, coffee farming was expanding into new areas, leading to deforestation as a climate change response in attempts to keep coffee yield levels high. (Harvey et al. 2021)

The FNC has really pushed for farmers to adopt these new technologies and modified seeds instead of switching out of coffee entirely, promoting the “conservancy of natural ecosystems. (FNC) Through better access to equitable credit and loans as well subsidizing the costs of said adaptation measures, they were able to replant about 45% of the country’s total coffee plots in just 7 years (between 2008 and 2015). (Harvey et al. 2021²) The new seed varieties have allowed for more sustainable and efficient coffee cultivation, benefiting both the industry and the environment. In addition to subsidizing production costs and funding climate resilience research, the FNC has taken steps to disseminate the information necessary to utilize these resources. Recognizing that many Colombian farmers do not have access to a formal education, the government created a TV program, the Adventures of Professor Yarumo, to educate farmers on how to take necessary climate change measures.

Public research and development is an engine of innovation and plays an indispensable role in long-term economic progress. Through these types of initiatives, sectors are able to increase productivity and decrease costs, leading to greater earnings and even generating more employment. Moreover, this can lead to positive spillover effects in other sectors of the economy who adopt these new technologies, or who just benefit from the increased spending and economic growth. Private firms may not have an interest in funding research and development, due to lack of resources and the risk factor of other firms poaching ideas without incurring the same costs. Thus, public R&D is invaluable to the advancement of sectors - distributing resources and innovations in an equitable manner that adds to the public good. In the case of the Colombian coffee industry, these initiatives are paramount in salvaging their coffee sector from the effects of climate change. Accessible modern technology and knowledge has enabled farmers to continue producing coffee sustainably and efficiently. With this continued modernization and

² referencing van der Vossen et al. 2015

investment, the Colombian coffee sector could withstand climate change impacts well into the future despite previous predictions.

The Small Scale Farming Paradigm

Coffee cultivation in Colombia has a unique organization of small-scale family-owned plantations, unlike its competitors in Brazil and Vietnam. This organization has been pivotal in sustaining the country's impoverished rural populations as local community members directly employ one another and generated profits remain within the community. Unlike other models of farming that may funnel profits to large foreign corporations, Colombia's coffee industry has enabled local communities to benefit from the value created by their labor and resources. Furthermore, these small farms utilize more sustainable farming practices, which help preserve the natural ecosystem and prevent soil erosion. These farms often use traditional knowledge and techniques to manage their crops, employing natural methods to control diseases and pests rather than damaging chemical pesticides and fertilizers. This leads to a higher-quality product (hand-picked beans at optimum ripeness) and more involvement of coffee growers in the sector because they have to employ a lot of small fincas (coffee estates) to produce the large amounts of coffee demanded. According to the USDA's 2022 report on Colombian coffee, most plots (96%) are categorized as small, meaning they have less than 5 hectares of land. A small percentage of plots (3%) are medium in size, ranging from 5 to 10 hectares, while only 1% of plots are classified as large, having more than 10 hectares of land (USDA, 2022)

In 2011, UNESCO nominated Colombia's coffee-growing region, la Zona Cafetera, a World Heritage site, praising it as an "exceptional example of a sustainable and productive cultural landscape." (Schiffmann, 2019) While this small-scale farming is more environmentally friendly, it is more vulnerable to climate disasters as it does not have the large-scale preventative

measures or funding to bounce back from extreme weather events, "Coffee plants are especially vulnerable to climate change because the majority of coffee is grown in developing countries," (Iscaro, 2014, p.47) Even just one unprofitable year can cause these small farms to shut down, as many of them are already on the precipice of bankruptcy. Currently, coffee cultivators generate meager profit margins, of which 15% is taxed on a farmer's income to fund government research in creating a more climate-resilient coffee sector. (Iscaro, 2014) Adapting to climate change is nearly impossible for those living in poverty since climate change only adds to the already overwhelming stress of being poor (Eise, 2021), creating a difficult situation where those who are most vulnerable to climate change are also the least equipped to deal with its impacts, creating a vicious cycle.

Climate change is not the only aggressor against Colombia's coffee sector - a significant decrease in coffee prices in the New York market has contributed to a decline in profits and a reduction in the amount of farming. The National Federation of Coffee Growers reported that the amount of land used for coffee farming has decreased by 20% since the 1990s due to the low price of coffee on the New York exchange. (Schiffmann, 2019) "Robusta coffee slumped to a nine-year low on the New York market, while arabica touched a 13-year low of 88 cents per pound on Tuesday, as output exceeds global demand." (Reuters, 2019) These factors have resulted in meager to no profits for coffee farmers. In an interview with Reuters, Roberto Velez, head of the National Federation of Coffee Growers, revealed that Colombian farmers earned 688,000 pesos (\$209) for every 125 kg (275 lb) shipment in the domestic market, which is insufficient to cover production expenses, which are around 780,000 pesos (\$237) (2019). Moreover, the 2016 peace settlement signed with the FARC guerillas, expected to benefit the Colombian coffee industry, had an unexpected negative impact. The peace settlement led to a

stronger and more stable Colombian peso, making Colombian coffee more expensive than coffee produced in Brazil and Vietnam, where large-scale production kept prices low. This has resulted in consumers in the global market preferring to purchase coffee from other producers, further adding to the woes of the Colombian coffee industry (Schiffmann, 2019). As a result of all these negative setbacks, Colombia's coffee and agricultural sector has experienced significant changes in recent years.

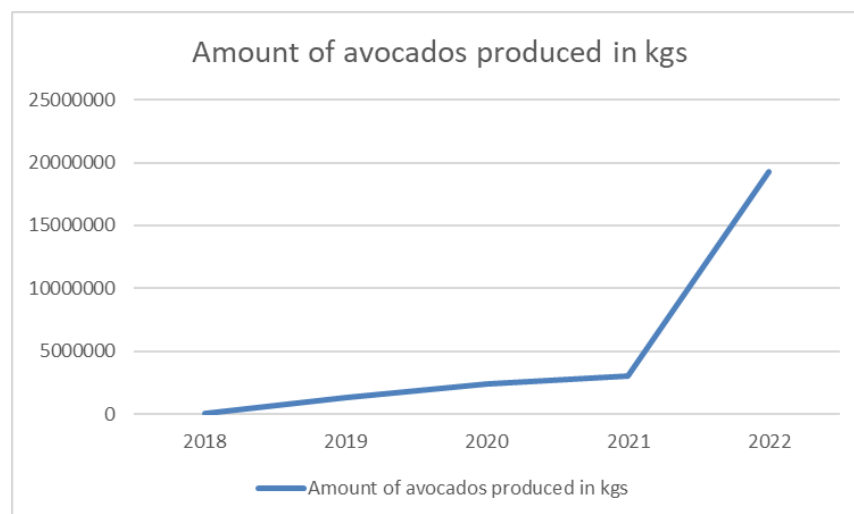
Reconfiguring Crop Composition through Avocado Farming

As climate change reduces the profitability of the coffee sector, farmers are turning to alternative crops whose opportunity cost has decreased. This shift has led to a transformation of the rural landscape as new forms of agriculture emerge such as livestock and fruit farming (Acevedo et. al. 2020). One crop that has had a burst of popularity is the avocado, which began to rapidly expand in 2014, with farmers exporting 1,408 tonnes of Hass avocados in that year. Since then, the industry has grown significantly, with exports reaching 544,933 tonnes in 2020. (Jenstsky, 2021) Colombia saw a significant increase in land use for avocado planting, occupying 35,211 hectares in 2011 and then 66,921 hectares in 2016. (Serano and Brooks, 2019) The following figure displays the exponential growth within the avocado industry in the last 4 years.

(Figure on Next Page)

Figure 13:

Increased Avocado Production in Colombia since 2018



Source of data: USDA Movement via Agronometrics

Healthy lifestyle trends have gained popularity in North America and Europe, driving up demand for avocado. The avocado's global wholesale prices rose by 50% in 2017 (Butler & Jones, 2017), and demand for the fruit remains high as suppliers and retailers face difficulties in keeping up with demand (Serano & Brooks, 2017). With avocado's newfound status as a cash crop, farmers in the coffee growing regions have quickly ditched their old ways and frantically converted their coffee plants to avocado, which requires a similar habitat: "The region of Antioquia (a typical coffee growing region) offers soils that make possible the cultivation and production of avocado during almost all the year." (CORPOHASS, 2018). Besides being a more profitable crop, as prices have maintained more stability in comparison to coffee (Serano & Brooks 2019), avocado plants are also more climate resilient than coffee. A study conducted by Gruter (et al., 2022) compared climate sensitivity of three tropical crops: coffee, cashews (not relevant to this paper) under both current and predicted climate conditions. Future climate conditions suggest an

increase in global temperatures between 1.2 to 3.0°C by 2050 (as estimated by the Intergovernmental Panel on Climate Change), as well as more erratic weather patterns such as prolonged drought flooding. In this study, coffee was found to be the most vulnerable to climate change, experiencing a drastic decrease in land that is highly suitable for production (97%) and moderately suitable (51%) by 2050 in comparison to avocado.(Gruter et. al, 2022) Avocado was found to be more resilient to higher temperatures and lower temperatures, as well as long periods of drought in comparison to coffee. Both crops responded negatively to long periods of extreme rain, though avocado still performed slightly better than coffee. Thus, avocado has emerged as a promising replacement for coffee, due to its higher climate resilience, resulting in more profitable crop yields

The expansion of avocado in tandem with a reduction in coffee production is not without its problems. Firstly, it represents the beginning of the end for coffee cultivation in Colombia, a crop and industry of great historical and cultural significance to the country. Regions that have been traditionally known for their coffee plantations are slowly disappearing:

The department of Caldas, considered a traditional coffee region, has seen a decrease of 15000 ha dedicated to coffee production between 2009 and 2018 (Granados & Valencia 2018). In contrast, there have been more than 8000 new ha planted in avocado, which makes this phenomenon one of the most evident impacts in the agricultural economy of the country. (Garcia et. al, 2018)

Other regions like Antioquia, Risaralda, Quindido, and Valle del Cauca (typical coffee growing regions) are projected to increase avocado production to more than 404,700 tonnes by the year 2030 (Horticultural Association of Colombia). (Garcia et al., 2018) Avocado farming is not only encroaching on land previously used for coffee cultivation, but is also posing challenges for continued coffee production, as its production has been especially damaging to the natural resources of its surrounding areas. It requires humid soil that has been heavily fertilized, and

since this crop is fairly new to the regions, farmers are not employing the traditional sustainable farming practices that are used in coffee cultivation.

As previously discussed, coffee is quintessential to Colombian history and identity, because of its small scale organization. Farms and cultivation practices have been passed down through generations of families, thus, for communities that have traditionally relied on coffee cultivation, the switch over to avocado can lead to a diminished feeling of community identity and estrangement with the land. Cultural and ecosystem impacts of reconfiguring crop composition are interrelated: generational farming practices such as intercropping, the usage of organic fertilizers and the integration of the natural resources that the land has to offer into the production process (growing coffee under existing shaded trees) are no longer employed when farming avocado - having damaging effects on the surrounding ecosystems. For example, the frenzy of expanding avocado cultivation driven by the promise of higher profits has led to a large increase deforestation in the Andes and Amazon forest, including felling Colombia's endangered wax palm, which has far reaching consequences in the Andean ecosystems, such as putting other endangered bird species such as the Yellow-eared parrot at even greater risk of extinction. (Monsalve, 2021)

A 2019 survey conducted by Velez and Monsalve found that 80% of avocado farmers in Colombia made use of harmful chemical fertilizers such as potassium, magnesium, sulfur, iron, copper and nitrogen. Nitro oxide is released when used as a nitrogen fertilizer, and it is one of the most potent contributors to global warming according to Garzón and Cárdenas. (2013 as cited in Velez and Monsalve, 2019) Avocado farming is not only responsible in polluting the air, soil and water resources in the lower Andean regions, but it also culprit for water shortages in these regions as it requires enormous amounts of water for its cultivation in comparison to other crops

typically grown in these regions, “While a banana is grown with 160 liters of water, the avocado requires 227 liters.” (Monsalve, 2021) These high usages of water and fertilizers have been further exacerbated by the rapidly rising demand for avocado that drove farmers to quickly overhaul their previous crop. This quick expansion of avocado farming resulted in unorganized bursts of avocado growth in areas that have less than ideal climates to support avocado growth resulting in an even greater need for water and fertilizers. While avocado *has* initially shown promise as an alternative to coffee due to its higher profitability and climate resilience, its rapid expansion and growth requirements pose several challenges in the long run. Avocado’s long-term sustainability must be considered to ensure the continued prosperity of both the environment and the local economy. Responsibility in exploiting natural resources and its implications for rural communities and ecosystems must also be taken into account, especially considering that avocado is replacing coffee which has a historical and economic significance in Colombian culture, and also plays a vital role in preserving the Andean foothills.

Economic Implications: Free Trade Agreements and Foreign Investment

Avocado’s emergence is both transforming Colombia’s rural sector landscape and economic organization. The Colombian government is proactively encouraging avocado exports through policies which are heavily influencing agricultural practices, resulting in new farming patterns in northeast Santander and altering relationships between smallholders, agricultural capital and the state and subsequently affecting the livelihoods of pre-existing farmers. (Serano & Brooks, 2019) In an interview with Caracol Radio in 2017, Colombia’s former president, Juan Manuel Santos discussed the new government approach towards agriculture - steering away from just subsistence farming and entering the foreign market headstrong.

In the past, Colombia has generally been led by center-right neoliberal governments, employing market-oriented economic policies, such as privatization and trade liberalization. Colombia has established significant trading and investment ties with the US, with Biden deeming the country as the “linchpin...to the whole hemisphere - north and south” and even designating the country as a Major Non-NATO Ally in March of 2022. (From White House Briefing) This relationship with the U.S. has been greatly influential in shaping Colombia's export and development trajectory as well as in fighting against Colombia's internal violence. In 2019, “U.S. foreign direct investment (FDI) in Colombia was \$8.3 billion...led by mining, manufacturing, finance and insurance.” (Office of U.S Trade Representative)

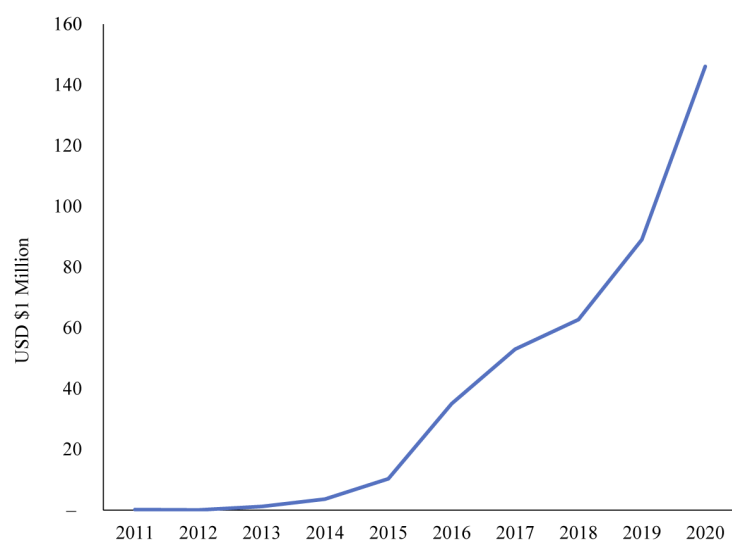
Since the 1900's, there has been a shift away from a tightly controlled economic system towards a more open access market (US Department of State Archive, 1996). This was achieved through the economic liberalization program known as “apertura” which reduced tariffs, removed trade barriers, restructuring tax and foreign exchange laws, as well as foreign investment regulations. Free trade agreements were also proactively sought out through this program. “Apertura also led to the privatization of state enterprises, ports, railroads and banks.” (US Department of State Archive, 1996). During the presidency of Alvaro Uribe (2002-2010), “Uribismo” emerged as a new political ideology (right-wing), as a result of a troubled history ravaged by civil war, political corruption, and poverty, not to mention a collapsing bordering economy. This political ideology is characterized by aggressive anti-drug and national security measures, with an emphasis on a strong centralized government and free market policies³. During Uribe's presidency, Colombia implemented several free trade agreements with the U.S. and other countries, promoting domestic economic expansion and foreign trade relations.

³ It is worth noting, that while effective in many ways, this political ideology has been criticized for its controversial conservative philosophy regarding women's rights, education and culture.

The Colombian government recognized that the agricultural sector could play a crucial role in generating employment, promoting technological innovation, and enhancing global competitiveness. (Bancoldex, 2012) Thus, the Minister advocated for the reconstruction of the Southern Atlántico, converting the impoverished rural economy into an ‘agricultural export model.’(Camargo, 2022) This strategy had positive effects on the coffee industry that were hopefully predicted to have similar effects on the avocado industry as well, “We managed to open the market for Colombian avocados, which is a golden opportunity for thousands and thousands of farmers and trade in general.” (From Serano & Brooks, 2019) Colombian avocado exports have grown significantly due to these policies, as export values of avocado surged from 1.2 million USD to over 146 million USD between 2013 and 2020 as pictured in the following figure: (Perez & Gomez, 2022)

Figure 14:

Increase in Avocado Exports (2011-2020) from Colombia measured in USD



Source(s): Departamento Nacional de Planeación (DANE), Corpohass

Graphic retrieved from Perez & Gomez, 2022

New policies have emphasized the need for farmers to adopt new production methods in order to export avocados and meet international market demands. The main policy in transforming rural agricultural infrastructure through modernization and internationalizing the Colombian economy is the Ministry of Trade's Productive Transformation Program (PTP) (Serano & Brooks, 2019) The Ministry of Agricultural and Rural Development alongside Asohofrucol, which administers and disperses national horticulture funds, have especially focused on modifying avocado cultivation towards having better "standardization of production quality, market expansion and consolidation, fruit transformation and industrialization' for the purpose of better satisfying international buyers. (MADR, 2009⁴). As a result of these export oriented policies, the amount of Hass avocados that are available for domestic consumption is relatively low. Out of the total amount produced in the area, 90% is earmarked for exports while only 10% is reserved for domestic sale (Serano & Brooks, 2019)

Accompanying agricultural export policies, foreign investors have begun to infiltrate the Andean foothills, as much of Colombia's agricultural land is extremely cheap and fertile due to poor land distribution policies. These policies were enacted after the peace deals with the FARC in 2016, when several agricultural lands were relinquished to the national government by the FARC despite having small holders settled on them. Therefore, foreign companies from Chile, Mexico and Peru were able establish active presences in agricultural regions, like Antioquia, by acquiring large tracts of land for relatively cheap from the government (Velez & Monsalve, 2019). In the Pijao municipality, avocado farming has expanded from 230 hectares to 2,000 hectares between 2016 and 2020 as foreign firms purchase land solely for the purpose of cultivating Hass avocados (Monsalve, 2021) Companies like *Green SuperFood*, a Colombian company that is a subsidiary of Inversiones Benjamin, a *Chilean conglomerate*, and Anglogold,

⁴ as cited in Serano & Brooks, 2019

which owns 5,000 hectares of farming land (very large amount of land compared to typical smallholders having at most 10 hectares of land) are big culprits in this phenomenon of land outsourcing (Meija, 2021⁵) These foreign companies have had an especially troubling presence, as they do not care about their environmental impacts within a foreign country, and are encroaching into the higher regions of the Andes causing mass deforestation (Perez, 2022⁶) Misalignment with international markets due to small holders organization, culture, and business models have led to limited amounts of certified producers for export. (Bustos, 2018) A majority of these certified exports are larger companies, both Colombian and foreign owned, leaving small holder's behind, leading to a rise in inequality and resulting in land ownership disputes(Richani, 2013; Thompson, 2011⁷) .

Though these issues were already pre existing, they are now being exacerbated by the large inflow of foreign investors into rural regions who encourage land grabbing and exclude small holders from export market advantages. Since many smallholders do not have formal land rights, they are at an even greater risk of being displaced. These smallholders tend to be those who have been previously displaced by rural conflict and therefore are the ones meant to be compensated with land and resources, as opposed to having it sold to foreign entities. This cycle of marginalization and displacement has sparked several instances of violent land ownership conflicts and protests. Rural reforms meant to address rural inequalities have been largely neglected or have been implemented much slower than previously promised, (Reuters, 2022) Just 4% of the peace agreement's rural reform provisions had been fully implemented as of

⁵ as interviewed in Monsalve, 2021

⁶ as interviewed by Janetsky & Al Jazerra, 2022

⁷ as cited in Serano & Brooks, 2019

November 2021, 14% had been partially implemented and 67% had seen 0 progress. In the fifth year of the agreement, land distribution only achieved 8% of the entire target (Reuters, 2022)

Smallholder setbacks

Avocado's post harvest processes - value chain and transportation - highly contrast with that of coffee. The former is rapidly perishable and does not require any post harvest processing while the latter is more lasting, but requires post harvest processing and more commercialization. In this new industry, small-scale farmers have been disproportionately impacted by a number of challenges: these farmers have limited value chain relations due to the relative market's relative newness, resulting in challenges in accessing wholesale markets and grocery stores. As a result, intermediaries called cacharreros have come into play. They travel through agricultural regions and buy the stock of small scale farmers to sell to wholesalers. Whereas with coffee, the government purchases supplies at fair stable prices in areas that have poor transportation access, with avocado, these cacharreros buy their stock at variable, non negotiable prices, to farmers who are unable to transport their product. Small-scale farmers who cannot generate enough income from their harvests to cover transportation costs to other markets are particularly impacted by the combination of unstable trading conditions and low payment. (Serano & Brooks, 2019) Issues include low regulatory framework provided by cooperatives and lack of investment available to small scale farmers resulting in inadequate internal transportation infrastructure resulting in less profit margins for these smallholders. Avocado farming requires substantial capital investment, to have temperature control in storage and short transportation time due to its perishable nature. (Bustos, 2018) Avocados are exported via maritime freight, which are the 'fifth largest contributor to air pollution and carbon emissions', these ships discharge last amount of wastewater due to their refrigeration and steering systems, disrupting the ecosystems of the

Colombia's coasts which sustain coastal economies through fishing and tourism. (Eslava, 2019) Though other exports are transported via the same means, those crops (like avocado as opposed to coffee) require much more refrigeration, in turn expelling much more pollutants.

In addition to transportation issues, the quick conversion of cropping to avocado has led to a lack of "smart" farming practices (Garcia et al., 2018), which are gained through long-term research and generational knowledge. Whereas coffee farmers have attained a deep understanding of their surrounding ecosystems through centuries of growing the crop on native lands, avocado farming is relatively new and does not have this sort of generational knowledge. Thus, the knowledge that is used in avocado farming relies more on global trends and methods that are not suited for the unique circumstances in Colombia. For example, avocado farming is organized in large monoculture farms, which do not integrate organically with their surrounding environment. Meanwhile, coffee farming *is* integrated with its local ecosystems through intercropping and by growing it under the shade of existing trees and shadows - peacefully coexisting with the local floral and wildlife, as opposed to creating mass deforestation.

Research in improving technologies and efficient farming practices when it comes to avocado farming in Colombia is limited or non-existent, leading to the cultivation of products which do not necessarily meet international standards. Avocado crop yields from small scale are not perfectly homogeneous and uniform, and thus many of them are deemed unfit for export and wholesale domestic markets, leaving smaller holders behind. Large supermarkets only purchase standardized fruits from 'well capitalized producers' and international customers pay for orders only once received, leading to a gap of between 2-6 weeks where growers must be prepared to cover the costs of producing and shipping avocados. (Serano & Brooks, 2019)

Only growers with the capacity to afford the financial outlay, located in areas suitable for Hass avocado, which produce sufficient yields, and implement the

required managerial practices, are able to benefit from the opportunities presented by European and other overseas markets. (Serano & Brooks, 2019)

In short, the combination of challenges *currently* faced by avocado growers favor large scale, well capitalized farmers who are better equipped to participate in and profit from this emerging market.

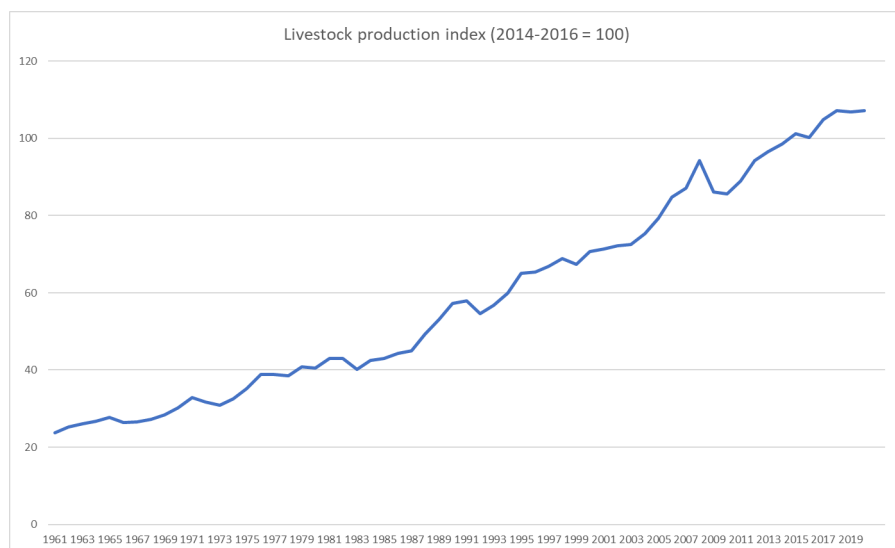
Reconfiguring Crop Composition through Cattle Ranching

Cattle ranching has also been a strong contender in substituting coffee farming, “Those who have failed to successfully adapt to climate extremes have replaced coffee plantations with livestock and cattle ranching.” (Perez, Gomez, 2022) The expansion of this field has also been driven by persistent rising demand for meat and dairy products to support population growth and urbanization (OECD). Livestock farming can be more convenient for farmers as it requires less employees than coffee cultivation - only needing few herders versus several cultivators to hand harvest coffee beans. In a 2005 study, Carmargo and Cardona found that 14,000 hectares of coffee crops had been replaced by cattle pastures and other livestock processing systems within just 4 years (1992 - 1996), due to rising production costs within the coffee sector. Another study found a 120% increase in land allocated for livestock production in the last 30 years, accompanied by a 35% reduction in land allocated for coffee production (Carrasco et al., 2021). The following figure demonstrates, this rapid increase in livestock production in the last 70 years:

(Figure on Next Page)

Figure 15:

Colombia Livestock Production Index between 1961 and 2019



Source: World Bank Data Bank

Environmental Implications and Sustainability

Of the various pathways for climate change adaptation in regards to a diminishing coffee industry, increasing livestock production is arguably the worst option for the collective good. Cattle ranching requires 1.5 to 2 hectares of land per cow and between 3,000 to 6,000 liters of water per day, consuming much more natural resources than coffee or avocado. (CORPOICA, 2014) Livestock production has been the leading cause of deforestation in the Colombian Amazonas, (Taylor, 2023; Galengo et al., 2018) over 1 million hectares of forests from the Orinoquia region were cleared between 1990 and 2015 to make way for pasture lands, leading to a significant increase in carbon emissions in Colombia. (World Bank, 2020) 26% of the country's total Greenhouse gas emissions came from the livestock sector in 2012. (Tapasco et. al 2019) Increased livestock has also led to the overuse of natural resources - 15.6% of Colombia's total area is overexploited, going beyond the soil's natural capability for production (DNP, 2015)

Cattle ranching is *just as climate vulnerable* as its predecessor (coffee), “Livestock is highly impacted by climate change and has suffered a 1.8 billion US dollars loss over the last decade due to ENSO.” (FEDEGAN, 2018) A 2015 study found that predicted temperature increases would lead to significant heat stress on cattle and in turn decrease milk production by 2.2% and beef production by 7.6% by 2040 (Topasco et al.) This transition towards increased livestock production has neglected the limits of Colombia’s natural resources and should be reformed promptly in order to survive just the next 2 decades (Tapasco et al., 2015)

Political conflict interlaced with Agriculture

Despite the clear transformations in agricultural Colombia, the ability to track these and understand their full scope is limited. This is in part due to the remoteness of these agricultural sectors and lack of funding, but also largely due to the long lasting internal conflict that ravaged rural Colombia. (Harvey et. al, 2021) Prior to the signing of the peace agreement in 2016, a large portion of agricultural lands were under control of FARC guerilla groups, around 42% of Colombian municipalities had experienced FARC land acquisitions (Perez, 1998), with regions such as Valle and Cordoba losing up to 80% of their land to narco-trafficking groups (Feola, 2015), thus making it difficult to track shifts in agricultural makeup. During this time, coffee plantations in FARC controlled regions were experiencing declining profits, leading many farmers to switch to coca cultivation, which is used in the production of cocaine.⁸

Coca crops supported by the FARC are a profitable alternative to economic uncertainty in coffee production, greater profitability in coca production has resulted in coffee farmers selling their lands...(or) converting their lands to the cultivation of coca leaves. (Dube & Vargas, 2006)

⁸ It is however important to note that this crop transition was influenced *both* by guerilla pressures to produce cocaine, and the decreasing profitability of coffee due to climate change:

48 coffee municipalities experienced a significant increase in coca production between the years 1994 and 2002 (Dube & Vargas, 2006) which has led to increased violence and instability in agricultural regions. Since cocaine farming is illegal, it is not actively regulated by the government, thus growing coca plants is much more environmentally degrading than other crops, as many coca farmers spray large amounts of unregulated pesticides (Handwerk, 2011) and use large amounts of gasoline in manufacturing the recreational form of cocaine from coca - contaminating surrounding land and consuming a significant amount of Colombia's gasoline reserves (Mowbray, 2022).

Once Colombian armed guerilla forces signed peace agreements with the government in 2016, these agricultural lands were turned over to the state who aimed to eradicate coca cultivation. This was done through the National Comprehensive Program for the Substitution of Illicit crops:

Broadly speaking, the idea was that the government would sign agreements with coca-growing families so that they would, voluntarily, eradicate their coca crops. In return, they would receive subsidies from the government to develop alternative projects which would allow them to live without growing coca. But most of these families have not received these payments from the government. (Perez & Gavlis, 2021)

Problems with redistributing these newly acquired agricultural lands emerged when foreign investors swooped in to purchase the property at cheap prices, spearheading large scale deforestation for cattle ranching. While FARC governance of agricultural lands *was* extremely detrimental to the welfare of the Colombian people, their period of rule was, *perhaps*, less environmentally degrading in terms of ecological landscape. The FARC prohibited large scale deforestation because they needed the cover of trees and the jungle. The group also prohibited commercial fishing and hunting, tearing down vegetation along rivers and discarding trash in the water. (Perez & Galvis, 2021) Now, livestock production has taken over these areas, requiring

more land, resources and deforestation than coffee and coca production, “A rural farmer can live off three or four hectares of coca. Farming cattle requires far more land ...between 163 and 220 hectares are needed per family.” (Perez & Gavlis, 2021) In sum, several agricultural municipalities have transitioned from coffee to coca and then to livestock, however the causes of these crop substitutions are complex and stem from a blend of several environmental and political factors.

Smallholder Setbacks

Violent conflict has been linked to agricultural productivity losses ranging from 13.3% for permanent crops to 25.9 % for temporary ones, with smallholder coffee and fruit crops being the most affected (Pinilla, 2013). These losses have also been exacerbated by climate change and increased weather disasters resulting in further crop failures and the neglect of smallholder financial needs. Now, in “post conflict” Colombia, the transition to livestock farming has been accompanied by formal land ownership issues and capital investment obstacles, leaving small holders even further behind. Similarly, these issues are also aggravated by climate change which led to higher production costs, harvest losses, decreased profits and capital acquisitions. This has ultimately prevented smallholders from owning their own cattle and being able to raise them in a sustainable manner. A 2005 study of smallholders in Piedmont, Antioquia, and la Zona Cafetera found that a significant portion of them were forced to sell their at least a small portion of their cattle (i.e. 50% of smallholders in Piedmont) because of urgent financial needs such as family health bills, unforeseen expenses, or just to survive crop failure caused by extreme weather events. (Rivas et al., 2005) ⁹

Because of informal property rights, many small holders have had their lands relinquished by the government and resold to other owners and weak current land ownership

⁹ From Feola, 2015

policies have led to widespread inequality and exclusion: “In a country where 21 percent of rural properties hold formal titles, illegal land grabbing has become widespread due to the lack of legal protection and power imbalances at the local level.” (Valero 2015) Gaps in legislation - such as the Law 160 land ceiling of one Family Agricultural Unit (which has been easily bypassed) - have allowed large corporations to obtain land above permitted amounts through schemes including setting up several shell companies - resulting in few businesses acquiring huge tracts of land. For example, the company Cargill obtained 52,576 hectares of land (30 times more than the legal limit) in the Altillanura regions within just 2 years through the use of 36 shell companies. Several other domestic and foreign companies have employed the same tactics in land acquisitions:

This tactic, facilitated by the law firm Brigard & Urrutia, has also been used by Colombian company Riopaila Castilla and Brazilian company Grupo Monica, which have acquired 42,000 hectares and 13,000 hectares, respectively, through the creation of shell companies (Oxfam 2013, 18). This is a relatively easy loophole to utilize, particularly for large multinational corporations, rendering the land ceiling seemingly ineffective (Mckay, 2017)

Land ownership concentration increased significantly within 2000 and 2009, leading to greater inequality with a larger Gini coefficient for land ownership from .877 to .8855 (Mckay, 2017). Incompetence, lack of coordination between levels of government, corruption and pressures from local elites have also led to a lack of credibility and effectiveness in land distribution projects and policies. The problem is not lack of policy, rather it is lack of coordination and accountability in executing proposed land redistribution initiatives:

Recent data from the Land Restitution Unit (URT) reveal that only a small fraction of those who apply for land restitution are actually considered. As of the end of 2014, for example, there were 72,623 applications for land restitution, of which just 25,215 (34.7%) were located in the micro-focalised ‘eligible’ zones. (Mckay, 2017)

Livestock has especially added to problems in land distribution equality, an example of this being Article 99 of Law 1448 which prioritizes upholding the current agricultural systems and business as opposed to equitably distributing land:

One provision within Law 1448 the agro-industrial project is prioritized over the right of the displaced victim to return to his or her land. The agro-industry must, however, offer the displaced victim a contract to work for the industry as a wage laborer on his or her own land. The alternative is to offer the victim adequate financial retribution, but in no circumstance will the displaced victim regain control over their lands if an occupant acquired it “in good faith” (Mckay, 2017)

In sum, addressing land tenure issues, promoting sustainable agricultural practices, and providing financial support for smallholders affected by climate disasters are crucial steps to ensuring smallholders longevity in post-conflict Colombia.

Exiting Agriculture Entirely through Migration

Instead of switching crops, or adopting new climate resilient technologies, some farmers are transitioning out of agriculture entirely through climate migration. While much of climate migration is still predictive, there have been some observational studies tracing the phenomenon. A study done by Issacman and Martinez in 2018 tracked changes in population in Uribia municipality in which there was a severe drought in 2014. They did so by utilizing phone records, weather data and home detection and found that approximately 90% of climate migrations in these regions tended to relocate to nearby areas where they were more likely to have better access to basic needs such as food, water and more consistent utilities during this period of extreme weather. The study concluded that migrants tended towards moving to neighboring states as opposed to densely populated cities like Bogota (which was the main exception to the trend). The coffee region and the Atlantic coast are projected to be highly vulnerable to climate change impacts in the future. (Isaacman & Martinez, 2018)

Migration out of rural areas is however attributed to many factors, as transitioning away from agriculture is happening in the context of urbanization. Young people make up the largest proportion of the people moving out of rural areas into urban centers, seeking out higher paying employment and advancement opportunities. These populations have tended to be less drawn into agriculture due to diminishing incentives and lack of infrastructure, educational opportunities, transportation, recreation and connectivity to the rest of the world. (Perez & Gomez, 2022) Besides urbanization, civil conflict has also resulted in a large amount of migration away from rural areas and farming. 5,921,924 people (13% of the total population) were forcibly displaced during the armed conflict between 1985 and 2013 (Nuñez and Hurtado 2014). According to the Information System of Displaced Population, 76 per cent of those forcibly displaced between 1996 and 2011 migrated from rural to urban areas (Nuñez and Hurtado 2014). As previously mentioned, the FARC has disrupted many coffee plantations - replacing them with coca, resulting in land degradation, more violence and socio-economic challenges for rural communities, leading to more amounts of migration. (Feola, 2015) Rural farmers are also isolated from help when dealing with armed conflict and lack of policies to alleviate its effects have left these populations even more vulnerable (Perez & Gomez, 2022)

Increased rural–urban migration caused problems of landlessness and the growth of urban slums (Mckay, 2017) as has led to labor shortages in rural areas (Schiffmann, 2019) As Colombia’s cities continue to rapidly expand, resources are drained from rural areas into sustaining populations in wealthy urban centers - such as construction materials, food supplies and so on. Poverty induced migration is also occurring alongside wealth driven migration. However, it is often better for these poor rural migrants to remain in their previous agricultural areas as opposed to relocating to urban centers where they are inadequately prepared to be

successful (lack of education and starting funds). More often than not, these migrants end up contributing to slum expansion and are especially subjected to the extremes of climate disasters as slums are mainly located in the unregulated, hazardous areas¹⁰. “Additional migration to cities is likely to exhaust pre-existing vulnerabilities related to inequality, poverty and indigence and informality.” (Mckay, 2017) With agricultural productivity and profits declining due to climate change, climate migration will inevitably continue to increase, creating strain on Colombia’s big cities, more so than it already has.

¹⁰ Such as the favelas in Brazil, and in the case of Colombia, the slums in Bogota are prone to landslides.

Chapter 3: Implementations for the Future, Balancing Financial and Political Realities

In the previous chapter, we surveyed the climate adaptations that are currently being employed in agricultural Colombia - investment in research and new technologies, government support through subsidies and other mechanisms, crop substitution, and migration. These methods have seen varying levels of success in ensuring the long term sustainability of Colombian coffee cultivation and agriculture, however, many of these adaptation pathways have been more detrimental than effective. Upon further analysis, it seems clear that smallholders were the most at risk when it comes to sustaining their livelihoods in the face of increasing climate extremes, economic uncertainty and political instability.

This chapter will broadly outline potential solutions to implement, focusing on a cooperative approach that improves relations between large corporations and smallholders. Government policy also plays a useful role in maintaining an equitable and resilient agricultural sector. In Colombia, several stressors are present, such as political instability and rural violence; climate change adaptation occurs within these constraints (Cárdenas & Rodriguez, 2013). Effective frameworks aimed at improving climate change resilience in agriculture should take an integrated approach, considering the political and economic realities at hand. Treating these issues in a combined manner, as opposed to isolating them, is more likely to ensure the prosperity for all parties involved - not just those at the top of the ladder.

A Future with Avocado

The emerging avocado market can offer a new future for Colombian coffee growers, who will have to face climate change consequences regardless. Similar to coffee in the 1900s, this new cash crop has the potential to spearhead rural development in the 21st century, through public policies and better coordination between market buyers, small scale growers and large

corporations - ultimately benefiting and improving the livelihoods of poor rural populations (Perez & Gomez, 2022) The main issues include certification for export, improving the homogeneity of crops and lack of transportation infrastructure - 3 issues which the National Avocado council is addressing through collaboration with small holders in building transportation infrastructure and providing subsidies for export certifications (Serano & Brooks, 2019). The equitable and sustainable expansion of avocado farming was a specific target in the 2015 'Colombia Siembra' Program which administered 522.7 million USD for agricultural expansion and support in increasing food security and rural development. This policy was especially geared towards uplifting small-scale farmers, generating 155,000 jobs alone in 2016, and benefiting 614,300 people, exponentially improving sustainable productivity (El Espectador, 2016):

These results are really from the peasants, indigenous and Afro-descendants, who are the ones who work the land, and who, thanks to social dialogue and the definition of investments in the regions, have managed to give the 'slap' that was needed to dynamize the agricultural economy", pointed out Irigorri. The program has registered some 391,108 producers, of which 359,391 are peasants, 20,063 black communities and 10,612 indigenous. (El Espectador, 2016)

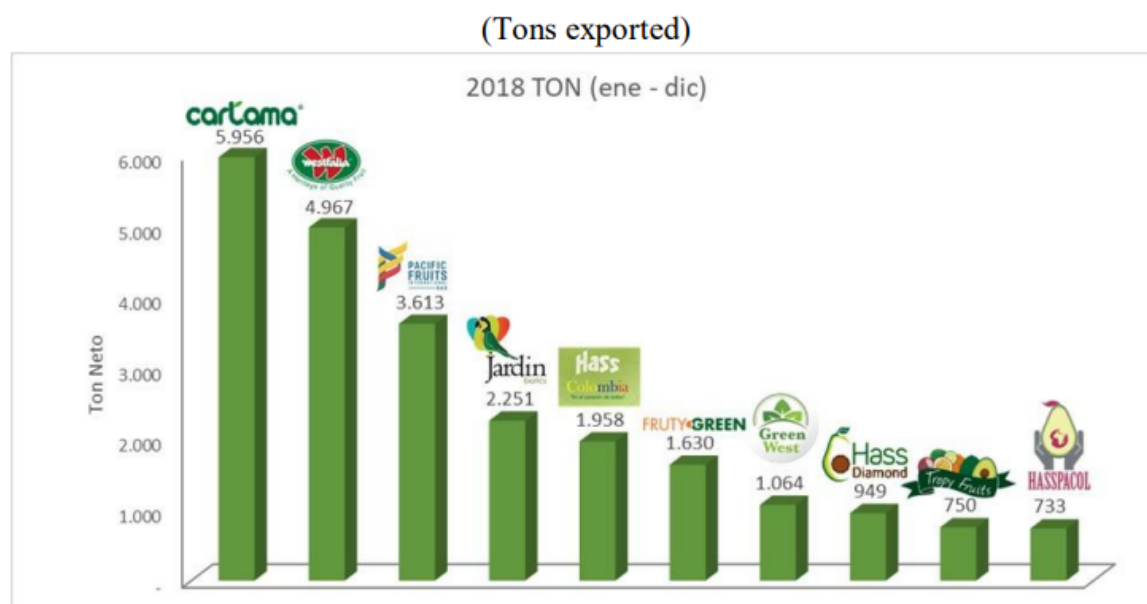
This policy also aimed to improve smallholder access to credit and fair loans. Other organizations such as Asohofruchol (Asociación de Horticultores y Fruticultores de Colombia) are also aiding in promoting the development and expansion of Colombia's agricultural industries through policy advocating, technical support, research funding and promotion. Like Fedecafe for the coffee sector, Asohofrucol (2012 report) helps to train smallholders - many of whom have not gone through formal schooling - to better farming practices, business operations and pest management, among other things. (Perez & Gomez, 2022) All of these policies aim to

not only improve food security and horticulture productivity, but also to increase the number of smallholders taking part in large scale international trade.

Several foreign firms have entered the Colombian agricultural sector and landscape, however this field is still mainly dominated by Colombian firms. The following figure demonstrates the top avocado exporters in Colombia from 2018, the majority of which are still Colombian owned:

Figure 16:

Leading Avocado Exports in Colombia in 2018



Source: Perez & Gomez, 2022 from CARTAMA

Of these companies only 2 are foreign conglomerates: Westfalia (owned by a South African Conglomerate) and Pacific Fruit, (recently acquired by an Israeli conglomerate in 2022) representing a minority in Colombian avocado exports. The problem is that combined, these two foreign firms *do* export a very large percentage of avocados (56% as of 2018, Figure above), indicative of the large amounts of land that they have been able to amass for cheap. With more

coordination between small scale farmers and Colombian exporting firms, improved farming practices, transportation, and policy support, smaller domestic firms would be able to represent a larger amount of exports.

Integrating Sustainable Livestock Practices

Alongside avocado, measures can be taken towards improving the longevity of livestock farming. A 2020 World Bank paper delineated some strategies for sustainable agriculture - “considering both socioeconomic and environmental factors in land use planning” through silver pastoral ranching. This form of ranching integrates trees, forage plants and cattle in livestock production practices, ultimately aiming to lessen deforestation and promote small scale subsistence farming within livestock - as of now, livestock production has mainly been supported by large scale production due the large initial costs of acquiring lots of land and cattle. Silverpastoral systems also promote a more heterogeneous crop composition - which allows for better odds against climate change variations, as opposed to an entire homogeneous crop yield suffering. This form of farming lends itself to reduced carbon emissions and environmental degradation (World Bank, 2020):

And there is perhaps no better example of the project’s success than Gladys’ seven-hectare farm, which has become a textbook example of silvopasture at work. She has developed a cocoa crop around the perimeter of her land that provides shade for her livestock of cattle, chickens and rabbits. She has planted hedges as a sort of ‘living fence’ around her pastures. And she is growing plants, such as the meadow buttercup, that provide a high protein supplement for her ten cows while they graze. (World Bank, 2020)

This mode of farming is still fairly limited in scope, backed by initiatives such as the World Bank’s BioCarbon Fund Initiative for Sustainable Forest Landscapes, however much more rapid expansion should occur in order to ensure the longevity and sustainability of cattle ranching in Colombia.

Integrating Modern Coffee Farming

Despite enduring several challenges, from climate change to fluctuating market prices, coffee farming continues to be a significant contributor to Colombia's domestic and export economy. Of the current agricultural endeavors, coffee farming has received the most attention in supporting smallholders and ensuring future harvest success through researching climate adaptation measures. By reducing negative externalities - such as land degradation, pollution and resource drainage caused by sectors like livestock and avocado - through better aligned business models, more sustainable agroforestry practices, and water management, longevity in all of these fields will be improved. For coffee farmers, adopting climate resilient coffee variants is the most essential adaptation measure for continuing production. Integrating coffee farming into other agricultural endeavors through intercropping and silvopastoral systems (remaining small scale) will also lead to better and more robust farming systems for the future.

Utilizing a Cooperative Model

Government policies can help tackle fundamental issues and large scale deficiencies such as lack of transportation infrastructure and barriers to capital accumulation within the avocado sector; cooperatives can help better align business models and communication between smallholders and larger companies. Colombia has a long history of using cooperatives in agriculture, typically created when smallholders organize together to compile resources, knowledge, information and skills and collectively market their products. A 2010 study by Lizarralde, examined the use of cooperatives in Colombia as a "vehicle for reconstruction" - specifically, in coffee growing regions which were hit by an earthquake in 1999 and were suffering from violence and displacement. During this period, cooperatives were especially effective in executing rapid reconstruction in rural areas with faltering economics - due to

insufficient state presence and lack of substantial land reform. These areas had been previously sustaining themselves through these cooperatives which made up for the lack of governmental support and infrastructural investment in these communities. By decentralizing control over these huge projects, individual communities had a greater say over their own development, as opposed to a more centralized approach which frequently resulted in concentrated benefits. The article demonstrates that through cooperatives, communities were able to participate in more transparent decision making, eliminate clerical slowdowns, and strengthen democratic structures within small communities.

The most notable cooperative in Colombia is the Federation National de Cafeteros (FNC) which began as a small scale co-op, and eventually expanded to become a government backed entity, influential in policy making. As previously discussed, this organization spearheaded rural development in coffee growing regions and funds social programs, infrastructure improvement, better access to loans and the promotion of local coffee products in the international market. The FNC also facilitates purchase guarantees - a mechanism which ensures regular incomes to coffee producers and markets. Through this organization, which represents over 300,000 small holders, coffee farmers have been able to obtain fair trade certifications for their products and enter specialized (and more profitable premium) markets, both domestically and internationally. The FNC has enabled more widespread knowledge sharing, through investment in educational programs and research. Other examples of other current cooperatives include: Cooperativa Multiactiva Agropecuaria del Común. Located in Tolima and comprising 142 associates, this cooperative aims to improve market access through transportation administration (shared trucks) This *small* organization also has an emphasis on maintaining peace in violence plagued

agricultural regions, sharing information and knowledge surrounding productive and sustainable poultry and livestock farming practices (COPAGROC):

Figure 17:

Picture of COPAGROC members



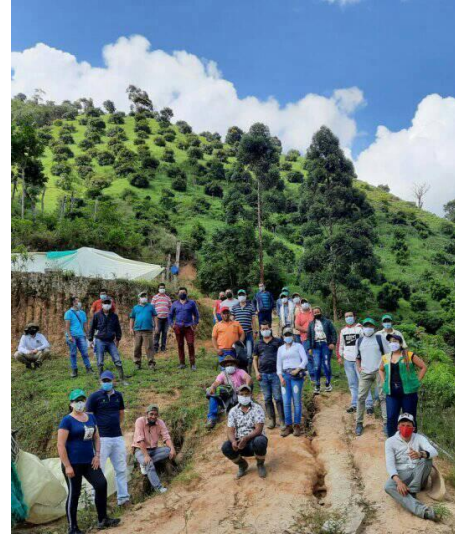
Source: COPAGROC Page

Another cooperative, in the avocado industry, is the Samaria Hass Avocado Producers Multiactive Cooperative (*Cooperativa Multiactiva de Productores de Aguacate Hass de Samaria*). Located in the Samaria area (in Antioquia, Colombia), this small scale organization emphasizes promoting gender equity within agriculture (as a majority of their members are women) knowledge sharing surrounding environmentally responsible avocado growing practices (organic pesticides, composting, reusing materials when possible) and community development. (Samaria Hass)

(Figure on Next Page)

Figure 18:

Samaria Hass Cooperative Members and their avocado farms



Source: Samaria Hass Page

Lastly, while not a cooperative, Hass Colombia, (the fifth largest Avocado exporter in Colombia, works in similar ways as a cooperative) works in similar ways. Hass Colombia is a large scale corporation headquartered in La Ceja, Antioquia, distinguishing themselves as an agricultural society, who collaborate with smallholders in providing avocados for export. Since this corporation is native to Colombia and works with smallholders, they employ both generational knowledge and sustainable farming practices, whilst having large scale funding and resources needed for global exporting. This cooperation also emphasizes fair trade practices, environmental sustainability and agricultural equity - by establishing connections with deeply rooted farmers residing in Antioquia. (Hass Colombia)

Figure 19:

Hass Colombia Logo



Source: Hass Colombia

In a country like Colombia, where the state has historically been unstable and absent from rural development, cooperatives play essential roles in sustaining rural communities themselves and promoting development. When utilized under the right circumstances, they enable farmers to overcome obstacles that hinder them from improving their living conditions. (Gutierrez, 2014) Cooperatives allow smallholders to benefit from economies of larger scale collaborative production processes (horizontal integration) and greater revenues via collaborative marketing (vertical integration). Furthermore, they lead to stronger community trust, interpersonal relationships within members, and other intangible advantages such as better conflict resolution and collaboration. (Gutierrez, 2014) Through cooperatives, smallholders can gain better bargaining power, and decrease middleman exploitation and profit losses. They also facilitate knowledge sharing, access to new information surrounding farming practices and pool funds for research, as seen in the coffee industry. Cooperatives also reduce negative externalities issues, such as contamination and land overexploitation as seen in the avocado and livestock industries, through collaborative production. Cooperatives can enable farmers to access markets

that they otherwise would not have been able to, (Gutierrez, 2014) as seen COPAGROC, who provides transportation or even with the FNC who facilitated the entry into global and specialized markets) Lastly, through cooperatives, smallholders and community members become more actively involved in local politics and public affairs, and can even expand to influencing federal level policy (as seen with the FNC).

Obstacles to Cooperatives and Small-holder Agriculture

Colombia has a long history of employing cooperatives in the face of weak governance. However, several studies have indicated that large proportions of these agricultural organizations do not function efficiently and are not likely to achieve long-term success. (Acosta et.al, 2021; Gutierrez, 2014) A 2021 study by Acosta-Hemthrot (et al.) assessed the efficiency of Colombian cooperatives by using Data Envelopment Analysis on a sample of 42 agricultural cooperatives. This study found that most organizations were functioning *well below* capacity and had *substantial* room for improvement. Another paper by J.D Gutierrez (2014) argues that Colombia does not possess the infrastructure and conditions necessary for cooperatives to function effectively. Rural populations lack formal access to land, credit, technological improvements (and support), and markets. The study also stated that deficiencies in executive and collective action capabilities greatly hindered cooperative abilities. (Gutierrez, 2014.)

Significant land ownership disparities exist, as a large proportion of Colombia's fertile lands are concentrated in the hands of few. The rural reforms outlined in the 2016 peace agreements have been poorly executed by the government, resulting in even more land tenure issues and inequality - Colombia had a Gini coefficient of 51.50% as of 2021 (indicating high inequality). High amounts of land ownership concentration also reduce the likelihood of forming agricultural cooperatives (Orozco et al., 2013, as cited in Gutierrez, 2014). Improvements in

making equitable credit accessible for smallholders have been marginal compared to the significant market failures in recent years. High-interest rates have also prevented farmers from taking out loans (Deininger, 2001 & Gutierrez, 2014). Legal land ownership issues have prevented farmers from accessing credit, as many do not have the collateral necessary for taking out loans. As of 2014, more than 40% of “landowners” did not have formal property rights (Gutierrez, 2014). Improvements in accessing technology have also been marginal due to low amounts of capital accumulation and risk aversion - smallholders often only engage in subsistence farming or only produce small quantities of surplus yields (to sell for profit), ensuring minimal and steady returns (as opposed to larger scale risk and investment). High transportation costs, lack of infrastructure, and lack of standardization have deterred many smallholders from accessing markets. In addition, many current cooperatives have been short-lived due to capital limitations, lack of information, leadership issues, and low participation of members. (Gutierrez, 2014)

The problems outlined impact smallholders rather than the actual agricultural collectives. However, failing to attain these conditions decreases the likelihood of forming long-standing, efficient cooperatives. These conditions largely depend on external variables such as (but not limited to) economic stability, government regulation, the availability of public goods, the state of the real estate market, and other macroeconomic factors (Gutierrez, 2014)¹¹. Government policy can address these issues and create better conditions for cooperatives to be successful. However, in the last two decades, policy has been geared towards expanding large-scale production, giving large-scale landowners better access to capital, credit, and markets, leaving smallholders behind, and confining benefits to those at the top without trickling down profits and

¹¹ Gutierrez, 2014 citing Brizzi et al., 2002; Kalmanovitz and López, 2006; Mondragón, 2006; PNUD, 2011, 2012

increasing employment (Gutierrez, 2014)¹². Adopting a bottom-up approach to climate adaptation and the development of the agricultural sector, centered on supporting smallholder farmers through cooperatives, would be much more effective and beneficial in reducing poverty and building a sustainable future. This can be done by addressing the previously mentioned deficiencies in lack of formal access to land, credit, markets, technical assistance, and collective action capabilities. Gutierrez (2014) outlines measures such as progressive land taxation, which would lessen land value inflation and tax landowners proportionally. Rural reform that addresses the equitable distribution of relinquished land from the FARC and dispensing legal property rights would greatly support smallholders. Other measures include boosting government spending on rural infrastructure, transportation, upgrading technology and technological services, and promoting regional credit cooperatives (Gutierrez, 2014)¹³. Improving transportation infrastructure would make markets more accessible to isolated smallholders. Measures can also be taken (boosting public spending) towards increasing human capital in rural areas (by improving access to public education in these areas) (Gutierrez, 2014).¹⁴

Cooperatives have been beneficial to rural Colombian farmers in providing new economic possibilities and communities as seen with the previous examples of CORPAGROC, FNC, and others. They empower communities, encourage collective action towards goals and development, and increase community resilience in the face of adversity, serving as “a positive tool for post-conflict reconstruction.”(Lizzaralde, 2010) Currently the conditions that facilitate the development of agricultural cooperatives are not adequately achieved in Colombia (Gutierrez, 2014) and most cooperatives are running at levels less than efficient (ratio of output to input for

¹² Gutierrez, 2014 referencing the following works: Brizzi et al., 2002; Deininger, 2001; Hirschman, 1965; Kalmanovitz and López, 2006; PNUD, 2011

¹³ Citing Carroll, 1971; Figueroa, 1993

¹⁴ Referencing Büchler, 1975; Sudarsky, 1977

evaluating agricultural cooperatives (Hemothrot, 2021) Previous initiatives (from the 1960s-1980s) attempting to promote the usage of cooperative's have been largely ineffective, instead creating agricultural organizations that are depending on state intervention and crash once left on their own (Gutierrez, 2014)¹⁵ Learning from their previous mistakes, and adopting a holistic approach towards rural development and climate adaptation will ensure long-term success for smallholders in the agricultural sector. (Lizarralde,2010)

¹⁵ Referencing Fals Borda, 1971; Findji, 1970; Ochoa and Rojas, 1970; Sudarsky, 1977

Conclusion

As presented in the first chapter, climate change is occurring in Colombia, and as a result, the rural economy is undergoing significant reconfigurations. Whether it be towards avocado cultivation, livestock farming, migration, adjustments towards current coffee production, or other new endeavors not discussed in this paper, changes are occurring and are inevitable - leaving rural smallholders and the most vulnerable populations behind. The agricultural sector can be reorganized more smoothly through the proposed solutions that better integrate new adaptation strategies with the old ways of farming, benefiting all stakeholders. A comprehensive and proactive approach toward creating and enacting policy is necessary and has not been the case in the past. Colombia has undergone several tumultuous decades marred by pervasive violence, civil war, crippling political corruption, and serious human rights issues. Peace agreements between the government and the most influential left-wing guerilla forces were struck in 2016; however, there have still been several challenges in maintaining order and enacting the provisions outlined in the 2016 accord. (Freedom House) Turning a new page, Colombia recently inaugurated its first leftist president, Gustavo Petro, in August of 2022. From an urban guerilla background, Petro has caused concerns about a radical rule. However, his more progressive views also serve as an emblem of hope - a “historic opportunity” for having more competent governance that will finally resolve deep-rooted issues (Carnegie Endowment). Alongside Petro, Francia Marquez serves as Colombia’s first black vice president representing the emergence of feminist activism within the federal government. Unlike the governments of Mexico and Venezuela, Petro has an ambitious agenda - aiming to reduce fossil fuel dependency drastically, instead promoting sustainable energy sources and restricting further exploration for oil and gas exportation. (Council on Foreign Relations) He also pledged to “develop capitalism in

Colombia” Council on Foreign Relations). In a sharp departure from previous policy, Petro aims to forge stronger connections with Latin American neighbors while minimizing the influence of the United States on trade agreements, export expansion, and drug eradication:

They promised to lead the country through a dual transition: from the status quo of simmering violence to a state of “total peace” and from an economy dependent on fossil fuels and the illicit drug trade to one grounded in green energy and sustainable development. In its first hundred days, their new government took ambitious steps toward implementing total peace and passed significant tax reform. (Council on Foreign Relations)

The aftermath of covid, growing inflation, Colombia’s expensive foreign debt, and impending global recessions pose challenges for Petro. Coca production is still a looming problem as Colombia continues to be the world’s most prominent producer of the drug (CSIS, 2022). This has had detrimental effects on agricultural productivity and has compromised rural stability and peace. Petro has voiced his position on dealing with these issues, which differs from previous (ineffective) measures. He has also proposed ambitious plans to increase rural development and land reforms alongside aggressive drug eradication.

Thus, with Colombia's current political climate, research and literature into rural and agricultural development in the face of climate change are more relevant now than ever. A proactive approach towards climate change adaptation and poverty within rural smallholders is far more prudent than a reactionary approach that often comes too late. While Colombia serves as a case study for this problem, similar challenges and solutions are present in other countries with extensive rural agricultural sectors - especially within Central America. Colombian agriculture is entering a period of “greater connectivity, productivity, and expansion” (Perez & Gomez, 2022, p. 44). The emergence of avocado and livestock farming as a response to a struggling coffee industry does have several problems: it uses unsustainable farming practices, drains, and contaminated natural resources, and has led to a more prominent presence of bigger

companies and foreign conglomerates within the previously smallholder led sector. However, with increased research in developing more sustainable farming and transportation practices (and subsequent disbursement of this information through government-funded programs), better incorporation of smallholders through cooperatives, investment in infrastructure, and policy support, these new agricultural endeavors could become valuable tools for rural development and for diversifying the crop composition of Colombia's coffee growing regions. Agriculture supports much of the poorest rural economy and can serve as an instrument for development and solving inequality issues in the poorest areas. At the same time, the country is shifting towards urbanization and development. Integrated government policy supporting smallholders and cooperatives can spearhead a new agricultural era in Colombia. Given the current political climate, these issues are more relevant, and make meaningful change more feasible than before.

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