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**Drivers and Disruptors Shaping the Future of Agriculture
and the Food System in LAC**

Climate Change and Trade Tensions

Valeria Piñeiro

Timothy Thomas

David Laborde

Eugenio Díaz-Bonilla

Markets, Trade, and Institutions Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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AUTHORS

Valeria Piñeiro (v.pineiro@cgiar.org) is a Senior Research Coordinator in the Markets, Trade, and Institutions Division of the International Food Policy Research Institute (IFPRI), Washington, DC.

Timothy Thomas (t.thomas@cgiar.org) is a Research Fellow in IFPRI's Environment and Production Technology Division, Washington, DC.

David Laborde (d.laborde@cgiar.org) is a Senior Research Fellow in IFPRI's Markets, Trade, and Institutions Division, Washington, DC.

Eugenio Díaz-Bonilla (e.diaz-bonilla@cgiar.org) is the Head of IFPRI's Latin America and Caribbean Program, Washington, DC.

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ABSTRACT

Agri-food production remains vital to the economies in Latin America and the Caribbean (LAC). Food systems are rapidly changing and are driven by income growth, (urban) population growth, shifts in dietary preferences, and agricultural productivity growth. Food systems are also under threat from disrupters like climate change and distorting policies (including trade wars).

This paper makes two quantitative, forward-looking assessments for the future of food and agriculture in the LAC region. The first focuses on the long-term prospects - given projected pathways for the main drivers and under the threat of climate change. The second focuses on current vulnerability of LACs agri-food system to short-term disrupters with special reference to impacts of global trade wars and the prospects for reducing that vulnerability. The implications are not uniform across the countries in the region, but vary greatly depending on economic and demographic size, contribution of the agricultural sector to national GDP, natural resource endowments, ecological and climatic characteristics, level of sophistication of rural and agrarian institutions, available technology, farm-size distribution and tenure systems. Policy interventions to address the challenges will need to consider those differences in initial conditions.

The foresight assessments are built on IFPRI's core global model frameworks, IMPACT and MIRAGRODEP. They allow to capture the complexity of agri-food system development and the scenario analysis helps quantify the relative importance of the drivers and disruptors of food system change, which in turn should be of essential to policymakers in setting priorities for steering towards sustainable and stable food systems capable of meeting twenty-first century challenges.

Keywords: Food system, Latin America, trade tensions, climate change

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1. INTRODUCTION

While agriculture's share in GDP has declined to around 5 percent in most LAC countries, the agri-food sector at large (including input provisioning, transport, distribution, processing, retailing and food services) remains a pivotal economic sector.

Agriculture used to have much greater importance in LAC than it does today. That is not to say, however, that agriculture is unimportant. It still registers more than 15 percent of national GDP for Nicaragua, for example. But for the region, 5 percent is closer to the average (World Bank 2019). However, it is important as a source of employment in countries like Peru, Ecuador, Bolivia, and Guatemala where agricultural sector employs between 25 and 30 percent of total population (World Bank 2019). Since much of the poverty that persists in LAC is found in the rural population, negative shocks to the agricultural sector can trigger rising poverty and food insecurity.

Due of the importance of agriculture and food systems in the LAC region, it is vital to understand how it will evolve in the next decade in response to long-term drivers of agri-food system change, such as income growth, (urban) population growth, shifts in dietary preferences, and agricultural productivity growth, as well as disruptors such as climate change and distorting policies, such as the recent trade wars.

In this paper we provide a forward-looking scenario analysis to assess possible pathways for LAC's agri-food sectors in the decades ahead. The assessment will build on two global model frameworks. The first is IFPRI's IMPACT model, which we use to assess pathways for the long-term drivers of food system change under alternative assumption of climate change impacts. IMPACT is a multi-market partial equilibrium model developed for long-term foresight assessments. The second framework is IFPRI's global computable general equilibrium (CGE) model (MIRAGRODEP) designed for short-, medium- and long-term analysis of international repercussions of policies on food security, poverty and economic growth. MIRAGRODEP is well suited to assess the implications of trade policy shifts, such as those associated with the trade tensions between the United States, China, and other major economies over the past few years. Annex 1 provides some more information on the two model frameworks. The scenario analysis was conducted as part of a larger study undertaken by The World Bank (Morris, Sebastian, and Perego, forthcoming).

Section 2 provides an assessment of long-term trends of the main structural drivers of food systems change (economic growth and demographic trends) under different assumption about climate change impacts, while Section 3 analyses the impacts on LAC's agri-food sectors of the current international trade tensions. Both sections provide further scenario analyses of how alternative agricultural investment strategies and policies could influence the projected pathways and steer those towards more sustainable and stable food system outcomes.

The implications are not uniform across the countries in the region, but vary greatly depending on economic and demographic size, contribution of the agricultural sector to national GDP, natural resource endowments, ecological and climatic characteristics, level of sophistication of rural and agrarian institutions, available technology, farm-size distribution and tenure systems. Policy interventions to address the challenges will need to consider those differences in initial conditions.

Section 4 summarizes the key findings and draws policy conclusions. Based on the scenario analysis, it is argued that LAC is a very diverse region and will face heterogenous challenges and opportunities. While the level of intra-LAC heterogeneity could be a major challenge to define a collective action agenda, it could be a great asset if properly used. At the regional level, there is a need to reduce market access costs and development of rural infrastructure appears to be a good mitigation option in our simulations for both the climate change and trade policy scenarios.

2. STRUCTURAL DRIVERS, CLIMATE CHANGE AND INVESTMENT STRATEGIES

This section provides quantitative projections, using simulation results from the IMPACT global food and agriculture model, for LAC agriculture in 2030. We look at alternative scenarios regarding structural drivers (economic growth and demographic trends) without factoring in the climate change impacts, then we provide information on the anticipated effects of climate change on agriculture and the potential for various investments to adapt to climate change and improve agricultural production in the region.

These results were developed from datasets that were developed for two key reports. The first report from Sulser et al. (2015) focuses on the base model and climate impacts for which the data can be found in IFPRI (2017). The second dataset used for evaluation of investment and policy options is from a report to USAID (Rosegrant et al. 2017) which is also being published as a series of articles in the journal Global Food Security.

2.1 Effects on ongoing economic and demographic trends on LAC's agriculture in 2030

For economic analysis in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, five different economic and demographic scenarios were developed, referred to as shared socioeconomic pathways (SSPs). We use the demographic changes of three of the most plausible SSPs – ignoring the SSP with both high population and high-income growth and the SSP with low population and low-income growth. SSP2 might be considered the baseline or middle-of-the-road scenario with moderate population growth and moderate growth in income (i.e., GDP per capita); SSP1 might be considered the optimistic scenario (with low population growth and high-income growth); and SSP3 might be considered the pessimistic scenario (with high population growth and low-income growth). All three SSPs have very similar projections for total GDP in the region.

Figure 1a compares the yields for three socioeconomic scenarios already described (comparing the dots to the bar). There is virtually no difference in changes in yields between the socioeconomic scenarios, except for a very small increase in rice and bean yields for the pessimistic scenario, SSP3. This is largely due to global GDP being very similar across the three scenarios, which means that global food demand is similar, and ultimately supply will be very similar.

Figure 1a also highlights yield changes between 2010 and 2030 (the relative size of the yellow bars across crops). Cotton and vegetables are projected to have the largest yield growth in LAC, while bananas and temperate fruits are projected to have the smallest in LAC. Yield changes range from a low for bananas of around 14 percent to a high for cotton yields at around 38 percent. These differences in yield growth are mainly related to exogenous yield growth rates that are given by crop and country within the IMPACT model. The rates are guided by historical yield growth and estimates by experts on what is both likely and feasible.

More interesting is the regional heterogeneity in projections. Figure 1b shows change in yields that are projected by IMPACT for the different subregions of LAC, ignoring the effect of climate change. For several crops, Central America and the Caribbean subregions have lower projected growth rates than the other subregions (coffee, banana and tropical fruit). Brazil and Guyana have the highest growth rates for several crops (maize, beans, cotton, temperate fruits and vegetables). We note that maize yield growth should be relatively small for the Southern Cone and for the Andes.

Figure 1: Yield in 2030 relative to 2010 without climate change

Source: Sulser et al. (2015).

Notes: SSP2 is the baseline scenario; SSP1 is considered the optimistic scenario; SSP3 is considered the pessimistic scenario. Values of 0 mean that the crop is not grown in the particular subregion.

2.2 Effect of climate change on LAC's agriculture in 2030

This scenario focuses on climate change effects as identified by the IMPACT model results taken from Sulser et al. (2015). There were 62 climate models developed for the IPCC's AR5 report, of which five were selected for the AgMIP GGCM study (Rosenzweig et al. 2014), from which we have chosen four

(the fifth was downscaled later than the other four and is often not included in some analyses because of the delay).

Figure 2 shows the effect of climate change on yield seen in each of the four climate models compared to the scenario of no climate change. We see the largest negative of climate change is on sugar cane, followed by maize and then cotton. Climate change in LAC may even have a slight positive effect on some crops by 2030, including soybeans, vegetables, bananas, and temperate fruit. These increases are only found with the GFDL climate model out of the four models considered.

Each crop has a desired temperature and precipitation profile. As temperatures rise, many crops such as maize will start experiencing heat stress as they are currently grown under relatively ideal conditions and will become less ideal under climate change. Impact of precipitation on yields works similarly, where unlike warming temperatures, the direction of precipitation change is less clear in each location. In some cases, rainfall change (generally an increase) will improve yields.

Figure 2: Yield in 2030 relative to 2010 with and without climate impact, SSP2

Source: Sulser et al. (2015).

Notes: GFDL, HadGEM, IPSL, and MIROC are 4 climate models from CMIP5. Socioeconomic and demographic trends are from SSP2 from IPCC AR5, and based on RCP8.5.

Figure 3 shows the climate effect on yields across subregions. The yellow bars in this figure represent the median impact of the four climate models displayed in Figure 2. In all of LAC, most crops are under a 5

percent yield reduction, except for maize and sugar cane, which are projected to lose between 8 and 9 percent – and for rice, which is to experience a slight positive climate change effect (0.2 percent)¹.

For maize, wheat, and soybeans, the largest negative impact of climate change will be on Central America. Maize yield losses due to climate change through 2030 are supposed to be very high — 20 percent in Central America, 16.5 percent in the Caribbean, and 13 percent in Brazil and the Guyanas. For many crops in the figure, the largest negative impact is on Brazil and the Guyanas. This includes cotton, vegetables, and both tropical and temperate fruit. We also see that there is a non-negligible positive effect of climate change on the Andean subregion for many crops, including coffee, beans, rice, cotton, bananas, vegetables, and both tropical and temperate fruits.

The northern part of Central America, in particular, will experience higher temperature changes than most of the region, and since the temperatures in the region are already high during growing months, the future temperatures will likely cause heat stress to many crops, thus explaining the larger losses observed in Central America.

Changes in production of crops vary based on changes in yields and area. Figure 4 shows the difference in production in 2030 caused by climate change. Unsurprisingly, we found that reduction in wheat and cotton production from climate change is the highest, as for both crops, yield and harvested area were adversely affected by climate change. Harvest area of crops tends to decline with a reduction in comparative advantage in producing that crop with respect to future prices and changes in yields.

¹ Rice is a particular case given that while using irrigation makes the crop less vulnerable to climate change.

Figure 3: Change in yield in 2030 because of climate change

Source: Sulser et al. (2015).

Notes: The figure displays the median across the four climate models FDL, HadGEM, IPSL, and MIROC. Socioeconomic and demographic trends are from SSP2 from IPCC AR5, and based on RCP8.5.

Figure 4: Change in production in 2030 because of climate (median of percentage difference between results from four climate models and no climate change)

Source: Sulser et al. (2015).

Notes: GFDL, HadGEM, IPSL, and MIROC are 4 climate models from CMIP5. Socioeconomic and demographic trends are from SSP2 from IPCC AR5, and based on RCP8.5.

We also see that the increase in harvest area (due to improved comparative advantage, since much of the world will have their yields for those crops more adversely impacted than LAC) under climate change was not enough to offset yield reduction for maize and sugar cane.

The increases in the Southern Cone subregion due to climate change are highest for maize, rice, and soybeans, with the Andean subregion increasing the most in the majority of other crop commodities. Harvest area is most adversely affected in Central America for maize, wheat, and soybeans, while Brazil and the Guyanas decrease the most for fruit and vegetables; all due to climate change. The Caribbean is also significantly and negatively affected by the ecological imbalance for maize, beans, sugar cane, and cotton.

We do not see a lot of variation among beef, dairy, and poultry, but Mexico is expected to expand production of eggs and pork more than any of the other subregions.

2.3 Assessing agricultural investment options for LAC agriculture in 2030

In this section, we present IMPACT model results taken from Rosegrant et al. (2017), which considered various investment options to improve agricultural productivity. Three categories of policies are analyzed: productivity enhancement (3 different levels are presented), mainly through R&D spending in CGIAR; improved water resource management (2 types of interventions are presented); improved infrastructure; and a comprehensive intervention that includes investments in all the categories. Figure 5 shows the impact of these multiple investment options on yields of various crops and gives the meaning of the scenario codes used.

Appendix C of Rosegrant et al. (2017) contains a table spanning six pages detailing the yield growth obtainable by crop and region from the HI investment option. These were developed by international experts from the 15 centers that are part of the CGIAR. The HI+RE assumes that the research efficiency improves alongside higher investment, resulting in 30 percent higher yields than in the HI option. The MED assumes yield gains between the reference and the HI options.

The irrigation expansion (IX) option assumes that most of the irrigated land comes from land that is currently under rainfed cultivation. For purposes of the simulation, yields will then be assumed to attain the

higher yields possible from irrigated agriculture. Water use efficiency is a measure of how much of the water drawn for irrigation helps the crops. The improved water use efficiency (WUE) option assumes that the efficiency increases by 15 percentage points from its current level, up to a maximum of 85 to 90 percent efficiency.

The improved soil water retention (ISW) option assumes an increase in the amount of water that is available to crops by 5 to 15 percent over the 2015 to 2045 period. In the RMM option, investment is made in infrastructure that reduces the transportation and other transaction costs for the agricultural sector. The authors (Rosegrant et al. 2017) do not provide details about the level of margin changed by region but explain the cost of infrastructure investment.

The costs differ between investment options. However, in LAC, the base package that is part of all investment options has an average annual investment cost of \$770 million (constant 2005 US dollars) – divided between \$580 million for the electric network, \$130 million for the rail network, and \$60 million for the road network. Above the cost of basic investment, in LAC the estimated additional average annual cost of the MED investment option is \$90 million. For the HI and HI_RE² options, the cost is \$110 million per year.

Changing the focus to water, the IX_WUE option costs an additional (above the basic investment) \$1.53 billion, of which \$810 million goes towards expansion of the irrigation system and \$720 million is for improving the water use efficiency. Improving soil water holding capacity (ISW option) will be an additional \$870 million per year in the LAC region.

In the scenarios here, the RMM option assumes an additional \$2.04 billion per year investment cost, in energy and transportation infrastructure. Adding HI+RE, IX+WUE, ISW, and RMM together in the COMP investment option ultimately would cost LAC \$4.55 billion per year above the basic level investment.

²

HI High increase in R&D investment across the CGIAR portfolio

HI+RE High increase in R&D investment across the CGIAR portfolio plus increased research efficiency

Figure 5: Change in yield in LAC in 2030 with climate change and various investments

Legend

MED	Medium increase in R&D investment across the CGIAR portfolio.
HI	High increase in R&D investment across the CGIAR portfolio
HI+RE	High increase in R&D investment across the CGIAR portfolio plus increased research efficiency
IX+WUE	Irrigation expansion plus increased water use efficiency
ISW	Investments to Increase soil water holding capacity
RMM	Infrastructure improvements to improve market efficiency through the reduction of transportation costs and marketing margins
COMP	This comprehensive scenario is a combination of 4 scenarios: HIGH+RE; IX+WUE; ISW; and RMM

Source: Rosegrant et al. (2017).

Notes: Socioeconomic and demographic trends are from SSP2 from IPCC AR5. Assumes climate of HadGEM with RCP8.5.

As shown in Figure 5, yields responded quite effectively in some crops that were within the CGIAR portfolio, especially wheat, maize, and beans, along with bananas and rice. There was some yield response to investment in irrigation for rice and sugar cane. Little yield response was noted for investment in reducing marketing costs or improving soil water holding capacity since they are not the primary targets of such policies.

While not seeing much of a yield response for fruits and vegetables, irrigation results in expanded cultivated areas for vegetables and temperate fruits at the expense of area cultivated in maize and wheat. Therefore, expanding irrigation results in a change in production from lower value crops to higher value crops.

With reducing marketing margins, we also see an area response in LAC. RMM leads to the highest amounts of cultivated land under any scenario. The intuition behind this is that while reducing the cost of doing business can motivate farmers to cultivate more intensively, the real gain is bringing in production lands that were not previously profitable to farm.

These yield enhancements managed to deliver some important land saving outcomes. Indeed, while yields were either expected to rise or fall marginally, most of the area responses to investments result in less area devoted to agriculture. This is mostly due to global demand for food being largely inelastic, so less land is required to produce the same quantity of commodity. Notable exceptions are the increase in land devoted to temperate fruit and vegetables with the expansion of irrigation. In general, maize area grows under most investment types, perhaps due to LAC maize becoming relatively more productive and profitable than other crops in other regions.

3. INTERNATIONAL TRADE TENSIONS AND LAC'S AGRI-FOOD SECTOR

The end of 2016 and the beginning of 2017 saw a dramatic change in the global trade picture. Protectionism has resurfaced, fostered by a dying Doha Round (Bouet and Laborde, 2010). Following on the heels of the British referendum supporting the exit of the United Kingdoms from the European Union, the U.S. presidential election that resulted in the victory of Donald Trump, making many protectionist statements during the campaign, and in particular threatening China, Mexico, and Germany with import duties. At various points, President Trump expressed imposing tariffs amounting to 35 percent on Mexican imports and 45 percent on Chinese imports to protect American jobs from unfair foreign competition. In 2018 concrete actions from the US, China and other countries have been observed and the impact of these actions (see Box 1) have had a spillover effect in other regions of the world.

These policies have challenged the stability and predictability of the global trading system, which challenges the multilateral principles. With the strong participation of LAC countries to global and regional food markets, such disturbances could jeopardize existing investments and will require a new set of policies to guarantee a national and international enabling environment of the agricultural sector.

3.1 Are global trade wars relevant for LAC agricultural sector?

Before discussing the needs of LAC actors to adjust to a changing landscape of global trade policies, we must assess the relevance of these changes for the region. Indeed, a 'trade war' between the US and China may have real effects only for these two economies and not affect other countries. As discussed in this section, this is not the case. The two largest economies in the world are key partners for the region: they are both important importers and exporters and their trade policies shape their domestic markets as much as the global dynamics. As pointed by Bouet and Laborde (2018) in their initial assessment of these trade tensions, the tit-for-tat game between the US and its trade partners will generate a mix of opportunities and threats for LAC countries, both in the short- and in the long-term.

On the short-term, some LAC countries, not impacted by punitive tariffs, could replace either US or China exports on their reciprocal markets. Assuming that LAC countries are already specialized in these products,

it will generate strong export opportunities. However, these short terms gains could be easily reversed when considering dynamic effects: the exporters punished by the tariffs can try to dump their exports on third markets creating more distortions and can lobby for subsidies by their national government, increasing global distortions; also, the fake comparative advantages coming from punitive tariffs will disappear when the trade wars will be finished, leading to unfruitful investments, making the global economy suffer from these uncertainties, reducing the demand for every producer and triggering more protectionist policies leading to a major systemic risk.

3.1.1 Disturbances on external food markets: opportunities and threats

In order to understand how LAC countries will be impacted by the current trade tensions by the US and China it will be necessary to analyze how the economy of these countries are connected through trade.

As shown in Figure 6, China represents 13 percent of total agricultural exports from LAC and the US represents 21 percent of that total percentage. On the imports side, we can see the key role that US plays with 44 percent of agricultural LAC imports coming from the US and the insignificant role of China. It is important to notice that intra-regional trade is important as it represents 21 percent of agricultural trade (inclusive of imports and exports).

Figure 6: LAC Agricultural Trade: China and the US as key partners. Average 2014-2016

Source: Authors, Computations based on COMTRADE

While we understand the importance of these two partners for LAC countries, we should not forget the high level of heterogeneity within the region: different countries have different degree of engagement with these

partners but also have very different product specialization: therefore, they are exposed at different degrees to change in tariffs on various markets and products. Indeed, when tariffs are increased in trade wars, it creates an opportunity for a country not involved in war to export to the country that is an actor in the trade tensions. We analyze the export structure of LAC countries to see which ones are competitive when it comes to the same goods and hence could replace the country involved in the trade tensions in the other country involved in the trade tension.

We can address part of this question by looking at the Export Similarity Index (ESI) in Figure 7, developed by Finger and Kreinin (1979), that measures the similarity between exports of any two countries to a third market. The index is based on the share of each product in each country's total exports and is calculated as the sum of the minimum value for each product. An index value very close to unity can be interpreted to suggest that the two countries analyzed are perfect competitors in the third market. An index value very close to zero can be interpreted to suggest that there is no competition at all between the two countries in this market³.

Argentina and Brazil are very similar to the US in the Chinese agricultural market (soy). Instead, when looking at LAC and China on the US agricultural market, the numbers are more homogeneous and smaller, showing less competition between China and LAC in the US agricultural market. Chile, Argentina, Jamaica, Peru and China sell fish products (aquaculture) and vegetables and fruits to the US.

3

$$ESI(ab,c) = \sum_j \min \left[\frac{X_{j(a,c)}}{\sum X_{j(a,c)}}, \frac{X_{j(b,c)}}{\sum X_{j(b,c)}} \right]$$

where $ESI(ab,c)$ refers the export similarity index of countries a and b in the common market (c), $X_{j(a,c)}$ refers the exports of product j from country a to country c and similarly $X_{j(b,c)}$ refers the exports of product j from country b to country c, $\sum X_{j(a,c)}$ and $\sum X_{j(b,c)}$ are total exports of country a and b to country c, respectively.

Figure 7: Export Similarity Index of LAC countries compared to the US and China

Source: Authors, Computations based on COMTRADE

Thinking about the direct effects of tariffs increase on the markets of countries directly involved, it should not obfuscate the overall effects on international markets: through a domino effect, the imbalances created on one market will impact other economies, potentially triggering adverse policy response. For instance, the impact of the trade tensions between US and China has led US soybean prices to fall drastically: the price difference between the US (New Orleans) and Brazilian (Paranagua) soybeans reached a historical difference on September 2018⁴, with a diverging trajectory while they were used to move together before the start of the trade tensions at the end of January 2018. This fall in prices has led to a surge in US exports to Europe at low prices, increasing foreign competition for EU farmers and triggering in the US specific aid package, distorting subsidies to their local farmers.

3.1.2 The impact on global growth and long-term demand

Escalating trade tensions may bring with them a reduction in global economic growth and stability. According to the latest forecast from the IMF's World Economic Outlook, the global economy will experience 3.7 percent growth in 2018 and 2019; this represents a reduction from the July forecast of 3.9 percent growth for both years.

⁴ US prices were 25 percent lower than Brazilian prices.

Box 1. Trade Wars : a Tit for Tat story

In March 2018, the US administration, through the Presidential Proclamation 9704 and 9705 announced that steel product will have a 25% import tariff increase and a 10% increase for aluminum products.

On August 18th, 2017, US trade representative Robert E. Lighthizer self-initiated an investigation of China under section 301 of the Trade Act of 1974. On March 22th, 2018, the Office of Trade Representative released its report concluding that China's acts, policies and practices related to technology transfer, intellectual property, and innovation under the investigation was determined to be unfair, discriminatory and thus, hurting the commerce of the United States. One month later, on April 3rd, 2018, the Trade Representative proposed a list of 1,333 products made in China under the consideration of an additional 25% tariff, which had an estimated worth of \$46.2 billion. One day later, China quickly retaliated with its own list of 128 US products under the consideration of a 25% tariff, which covered \$49.8 billion of China's imports from the US.

Later, on June 15th, the US Trade Representative revised the proposed list based on the public comments received and the hearing. The original list was narrowed down to 818 products with an estimated value of \$34 billion. An additional 25% tariff was to be implemented starting on July 6th. At the same time, the Trade Representative also identified another 279 products that the imposition of an additional 25% tariff was being considered. This second tranche had an estimated value of \$16 billion, making a total of \$50 billion of goods that was affected. The second tranche eventually went into effect on Aug 23rd.

On the same day, China issued its own updated list of \$45 billion worth of products with July 6th as the effective date as well.

In response to China's retaliation, President Trump instructed the Trade Representative to identify an additional \$200 billion worth of Chinese goods for an additional tariff rate of 10%. Following the request from the President, the Trade Representative released a proposed list of \$200 billion of imports from China on July 10th.

On September 2018, the US announced a 10% tariff on a list of products worth \$200 billion of imports from China that would begin on September 24, 2018, increasing to 25% by the end of the year. China retaliated on September 18 with 10% tariffs on \$60 billion of US imports.

The US and China agree to a temporary truce to de-escalate trade tensions at the G20 Summit in Argentina on December 1, 2018. According to the agreement, both the US and China will refrain from increasing tariffs or imposing new tariffs for 90 days (until March 1, 2019), as the two sides work towards a larger trade deal. Last February, President Trump announced an extension to the March 1 trade deal truce deadline, citing progress in trade talks.

However, in Latin America the projected growth is a lot smaller. It is expected to have a modest increase of 1.3 percent in 2017 to 1.6 percent in 2018, and further to 2.6 percent in 2019, with differences by country (the most notorious being Mexico at 2.3 percent growth rate and Brazil at 1.8 percent in 2018). Higher commodity prices continue to provide support for commodity exporters in the region, but difficult prospects for key economies are playing against them—tighter financial conditions and needed policy adjustment in Argentina; political uncertainty in Brazil; and trade tensions and the policy agenda of the new government

in Mexico. The spillover effect created by the ongoing US-China trade war will have a clear impact on the multilateral trading system. It can affect the export-led economies through increases in the level of uncertainty, higher costs of the import contents of their export, increased tariffs on their exports, costs associated with supply-chain disruptions; slower growth on partner countries and sectors; and negative impact on investment inflows.

More specifically, a decline in economic growth in China and the US will depress their demand for commodities and other products, with a negative effect on many developing countries including Latin America and the Caribbean (LAC) since these two countries are key partners for the region.

3.2 Trade tensions scenarios

The situation surrounding global trade remains very uncertain, making it very difficult to predict how things will develop. However, in broad terms we could see several scenarios shape up, all with very different consequences for the global economy and (political) relations between countries. For this report we analyze the following three scenarios:

1. ***US vs China: a status quo.*** This scenario focuses on the economic consequences of the current trade tensions between the US and China. The current state of trade dispute with tariffs proposed and/or implemented by the US and China governments up to December 2018, agricultural and non-agricultural products⁵ will be considered. It captures the situation reached by the two countries during the Argentina G20 presidential meeting last December;
2. ***Extended US trade tensions.*** This scenario includes the measures listed in the first scenario, plus the additional tariffs announced by the US and China and initially scheduled for implementation by January 1st, 2019, and currently under moratorium. We also include the various tariffs increase initiated by the US steel and aluminum tariffs and we include the retaliation from Canada, India, EU, Mexico and Turkey.

⁵ Considering the difference in sectoral aggregation between the tariff announcement and the sectors represented in the model. It was necessary to estimate the sectoral trade weighted average tariffs based on tariff line level data.

3. ***Escalating trade wars:*** This scenario explores the possibility of an escalation of trade wars through tit-for-tat scenario between the US, China and other countries. This scenario mimics non-cooperative behavior as seen during the global collapse episode in the 1870's or 1930's. This scenario reflects a contagion scenario using the game theory approach developed in Bouet and Laborde (2018).

While this report focuses on the agricultural and agri-businesses sectors, it is quite important to capture both agricultural and non-agricultural elements of the trade wars. On one hand, tensions generated in non-agricultural sectors (e.g. steel tariffs) could lead to retaliation in agriculture in order to hurt a partner on its main exports. On the other hand, several macroeconomic constraints, both domestically (investments, labor mobility) and externally (global growth, exchange rate) are not specific to agriculture but directly impact the agricultural system (see a discussion of these issues in Díaz-Bonilla, 2015).

Using the MIRAGRODEP model, we can assess the economic impacts of these scenarios from 2018 to 2030 for various LAC countries on a large number of economic variables: exports, imports, production, GDP, household consumption, adjustment costs through changes on labor markets. In this section, we will focus on a limited number of indicators for sub-regional and sectoral aggregates.

Figure 8 shows that the first round of the rise in protectionism will benefit LAC countries exports and agricultural exports in particular (+2.1 percent vs +1.2 percent for non-agricultural goods). Still, this average pattern is the result of more heterogeneous impacts within the region, while the Andean region maintains a balanced profile, the MERCOSUR countries will strengthen their agricultural exports while reducing their industrial exports to benefit from more attractive commodity markets in Asia, and Central America, Mexico and the Caribbean will increase their specialization in non-agricultural products to occupy the space created by the trade restriction on Chinese products in the US market.

It is interesting to notice that pulled by the soybean markets (+11 percent of total exports by LAC countries), the agricultural exports of the MERCOSUR countries increased by 3.6 percent. However, processed food products, including soybean oils and meals will slightly decline due to the specific appetite of the Chinese markets for beans. This will challenge the crushing strategy of some countries in the region (e.g. Argentina).

The increase in the level of the trade conflict, captured by the Extended US trade tensions scenario, start to moderate these impacts. We can see that the overall agricultural exports increase now by less than 2 percent, at the same time as higher distortions on global markets increased. While LAC products escape direct tariff increases, they expand their market opportunities replacing US products on additional third markets, however they are also negatively impacted by a contraction of global demand. A particular case is the Mexican economy, while still benefiting from preferential access in the US, they see an increase in non-agricultural exports but at a slower pace.

The major changes are reached with the full-blown tariff wars scenario with large tariff increases and world trade in goods shrinking by 27 percent. LAC countries are slightly better off than the world average with a decrease of their exports of only 24 percent for non-agricultural goods and 16 percent for agriculture. The resilience of agricultural exports to such shocks has been observed during the “Great Trade Collapse” of 2008, when world trade fell by about 30 percent. These results can be explained by the fact that food demand is less elastic and some importing countries could not cut themselves off from food markets. Looking at LAC, we can see that due to their limited market size, LAC countries could not use high tariffs to strengthen their situation in a tit-for-tat game and they do not disconnect themselves from world markets on the import side either. All sub-regions of LAC will be negatively impacted but with some slight variations within the region. Two interesting findings are on one side Mexico is the country that will be most impacted (-26 percent for agro-food exports and -35 percent for other industries), given that it increases its tariffs to retaliate against the US and limits the terms of trade costs imposed by the US policies, and on the other side, MERCOSUR agricultural exports will fall more than their non-agricultural exports due to their specialization in commodities that are more sensitive to price variations.

Figure 8: LAC Export value variations driven by trade wars scenarios

Source: Authors, MIRAGRODEP CGE simulations

Focusing on exports remain a highly mercantilist approach of trade policy issues, in Figure 9, we look at two other variables of interest for policy makers: household real income (economic welfare) and the amount that is being reallocated on the labor markets. This last variable is a good proxy for adjustment costs and show the average amount of jobs eliminated and created in the economy to adjust to the trade shock. First, all the LAC subregions appear to win from the first two scenarios, especially the MERCOSUR countries (+ 0.19 percent) and Mexico (up to 0.27 percent in the intermediate scenario). Still, individual countries within each region may lose (e.g. Bolivia, Nicaragua, and Paraguay and some smaller Caribbean countries). Second, while the first two scenarios are linked to potential gains, they are also associated with important labor reallocation, especially for the overall Central America region to seize these potentially short-term opportunities. MERCOSUR and the Andean countries, while operating at two different scales, manage to

grasp potential benefits without too much reallocation. While moving to the full trade wars scenario, the story is once again different: all regions experience losses, but MERCOSUR countries manage to limit such welfare losses (-1.19 percent vs -2.4 percent in average for LAC and -4.4 percent for Mexico). Adjustment costs will also be significant in Mexico, 6 percent of the workers will lose their jobs and will have to find ones in other sectors. In the Andean region, this figure reaches 3 percent.

Figure 9: LAC Real Income changes vs Adjustment costs on labor markets, by trade wars scenarios

Source: Authors, MIRAGRODEP CGE simulations

Figure 10 shows the impact of the three trade wars scenarios on real GDP, this variable follows the same direction as the household income already discussed. Both variables can be seen as an economic welfare measurement. Figure 10 emphasis the fact that with the first two scenarios bring some potential gains for some countries while the third scenario brings an economic contraction in the region and within the region.

Figure 10: LAC real GDP variations driven by trade wars scenarios

Source: Authors, MIRAGRODEP CGE simulations

4. CONCLUDING REMARKS

Using quantitative models to look at the future of the LAC Agri-food systems has allowed us to capture complex mechanisms and provide estimates of potential costs of growing uncertainties on these economies. This exercise is quite important to identify what should be the priorities and identify the key issues for decision makers to focus on.

A diverse region...

Thanks to various datasets and complementary economic models, we have managed to grasp the reality of the region in its complexity: an economic region of nearly 700 million people and spanned over 21 million squared kilometers, combining a wide range of agro-climatic conditions. Whatever the trends or shocks we consider, both in the short and long run, we see that the different LAC countries will face heterogeneous challenges and opportunities. Indeed, we project some important differences in rates of change of production and productivity across agricultural commodities in even the relatively short span from 2010 to 2030.

Changes in climate will add to this heterogeneity, and unfortunately to the uncertainty as well. This analysis, however, did point to the importance of having a higher focus on helping Central America in response to how climate is likely to negatively impact staple crop yields.

Analogous to how climate change affects each subregion differently, LAC countries have dissimilar trade specialization (e.g. fruits in Central America, cereals and oilseeds in Mercosur countries) and as such will be affected very differently through changes in international prices and changes in trade patterns on specific markets (trade diversion).

... that should adopt a dynamic approach of risk and uncertainty management...

Policy makers and others concerned with agriculture in the LAC region should not invest too heavily on any strategy predicated on a climate model being correct, or a certainty of what the future of trade policy will be (unilateral, regional or multilateral). Rather, a better strategy would be to develop investments that enhance resilience and provide a broader menu of options for producers experiencing climate change and trade policy uncertainties, for instance through rural infrastructure improvements.

Some sectoral lessons could still be drawn. The development of some value chains like temperate fruit and vegetable production will be driven by investment in irrigation. On the other side, improvements in maize, wheat, and beans are driven by investment in agricultural research resulting in more productive seeds for the climate. These strategic directions are important while combined to the trade agenda: indeed, countries with a more diversified portfolio of products and an export structure including high value products (e.g. fruits, wine, etc.) appear to be more resilient: the nature of their products make them more immune to tariff wars where price competition dominates. At the opposite, the commodity producers (e.g. soybean) will be exposed to larger gains or losses depending on the trade policy fluctuations and will have to develop alternative risk management tools.

... and use its heterogeneity as a strength.

While the level of intra-LAC heterogeneity could be seen as a major challenge to define a collective action agenda, it could be a great asset if properly used. Risk management requires having a diversified portfolio. The LAC region has such asset. At the regional level, there is a need to accelerate market integration: reducing market access costs and developing rural infrastructure appears to be a good mitigation option in our simulations for both the climate change and trade policy scenarios.

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ANNEX 1

A.1 The IMPACT model

How the model works

The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) has been used since the mid-1990s to study future global supply, demand, and trade in the agriculture and food sector. Now in version 3, it has climate change embedded as a fundamental component. Details of the model can be found in Robinson et al. (2015), but in this introduction we will give a brief overview.

IMPACT is a multimarket and partial equilibrium model that solves for global prices that equate supply and demand for every year and commodity in the model. Production is computed at the level of IMPACT's FPU's (food production units), which are the intersection of regions (which are in most cases countries) and major water basins. IMPACT has 159 regions and 154 water basins, which combine for 320 FPU's. IMPACT has 62 commodities, including 39 crops, 6 types of livestock, and 17 processed foods. IMPACT solves annual for 2005 through 2050.

IMPACT draws on inputs from other models, as shown in Figure 11 . Underlying the analysis are climate models that are taken from the CMIP5 models used by the IPCC (Intergovernmental Panel on Climate Change) in their Fifth Assessment Reports (AR5). The climate models feed into the crop simulation models (for this study and for IMPACT in general, the Decision Support System for Agrotechnology Transfer [DSSAT] software package is used) and water models (hydrology, water basin management, and water stress models). DSSAT relies on demographic and GDP projections used as part of the IPCC AR5 report. For this report, we use the projections associated with the SSP2 (the baseline or “middle of the road” shared socioeconomic pathway of the AR5).

We also tried analyzing two other SSPs: SSP1, which is the low population growth and high GDP per capita growth scenario; and SSP3, which is the high population growth and low GDP per capita growth scenario). Unfortunately, all three SSPs had similar GDP growth (population times GDP per capita), and so the differences in total demand were very small between scenarios and there was very little to comment on with such small differences.

IMPACT has been used in national analyses of food security (Thomas et al. 2018; Rosegrant and Sombilla 2018; Waithaka et al. 2013; Hachigonta et al. 2013; Jalloh et al. 2013; Ye et al. 2014; Dube et al. 2013; Takle et al. 2013); regional analyses of food security (Sulser et al. 2011; Rosegrant, Cline, et al. 2005; Ignaciuk and Mason-D’Croz 2014); commodity analysis (Rosegrant, Leach, and Gerpacio 1999; Scott, Rosegrant, and Ringler 2000; Delgado et al. 1999); and thematic and interdisciplinary analysis (Rosegrant, Cai, and Cline 2002; Nelson et al. 2010); and in multiple global assessments, including the International Assessment of Agricultural Science and Technology for Development (2009), World Development Report 2008: Agriculture for Development (World Bank 2007), CGIAR’s Strategic Results Framework (SRF 2009), and the Agriculture Model Intercomparison and Improvement Project (Nelson et al. 2014; Wiebe et al. 2015).

Figure 11: Yield in 2030 relative to 2010 without climate change

Source: Robinson et al. (2015).

This report is developed from datasets that were developed for two key reports. The first, which we use to focus on the base model and climate impacts, is from Sulser et al. (2015), for which the data can be found at (IFPRI 2017). The second, which we use for evaluation of investment and policy options, is from a report to USAID (Rosegrant et al. 2017). While the datasets have been used in previous studies, the studies neglected to bore down to see the implications for the LAC region. This report is the first time that the data has been analyzed for LAC and by particular subregion.

How climate change is modelled

The climate analyses in this report are based on the RCP 8.5 (the high emissions representative concentration pathway used by the IPCC AR5). The studies chose to use the high emissions scenario to

provide an upper bound on climate change impacts and because it is the scenario that is currently emerging in the context of challenges in maintaining an effective international coalition of focused reduction in emissions.

There were 62 climate models developed for the IPCC's AR5 report, of which five were selected for the AgMIP GGCM study (Rosenzweig et al. 2014), from which four were chosen (the fifth was downscaled later than the other four and is sometimes not included in some analyses because of that lateness) for analysis here. The climate models were used by Sulser et al. (2015) and hence in this report are those used in Müller and Robertson (2014), which used downscaled versions of four CMIP5 (Taylor, Stouffer, and Meehl 2012) GCMs: GFDL-ESM2M (Dunne et al. 2012, 2013); HadGEM2-ES (Collins et al. 2011; Martin et al. 2011); IPSL-CM5A-LR (Dufresne et al. 2013); and MIROC-ESM-CHEM (Sakamoto et al. 2012). They represent a diversity of possible future outcomes.

In Figure 12, we see maps which reflect projected changes in precipitation for LAC from these climate models. In the models, we see that there are areas that have large projected changes in rainfall. Some of the changes are positive while others are negative. We also see that the models differ significantly in projections for any given area. For example, the IPSL model projects that much of Brazil will become wetter while the MIROC model projects that much of Brazil will become drier.

Figure 12: Change in annual rainfall, 1960-1990 period to 2055, millimeters

Source: Müller and Robertson (2014).

Notes: Top row: GFDL-ESM2M (Dunne et al. 2012, 2013); HadGEM2-ES (Collins et al. 2011; Martin et al. 2011); and IPSL-CM5A-LR (Dufresne et al. 2013). Bottom row: MIROC-ESM-CHEM (Sakamoto et al. 2012). GFDL, HadGEM, IPSL, and MIROC are 4 climate models from CMIP5. Based on RCP8.5 emissions.

Figure 13 shows the projected impacts of climate change on temperature. For the figure, we chose to use changes in the mean daily maximum temperature of the warmest month. We chose this statistic to emphasize potential heat stress problems for both livestock and vegetation. Heat is a very important productivity constraint for agriculture.

Unlike the case for precipitation, except for very small geographic areas, the direction of change in temperature is almost always positive. However, like the case for precipitation, there is significant geographic variation and significant disagreement between the models. As an example, compare Brazil's Center-West region in the MIROC model, with temperature increases exceeding 7 degrees Celsius, to the same region in the IPSL model, with increases in the 2- to 3-degree range.

With such a high degree of variation between models in both precipitation and temperature, we might expect a high degree of variation in projections for impact on agriculture. Policy makers and others concerned with agriculture in the LAC region should take care to not invest too heavily on any strategy predicated on a climate model being correct. Rather, a better strategy would be to invest strategies that enhance resilience and provide a broader menu of options for farmers experiencing climate change.

Figure 13: Change in the mean daily maximum temperature of the warmest month, 1960-1990 period to 2055, millimeters

Source: Müller and Robertson (2014).

Notes: Top row: GFDL-ESM2M (Dunne et al. 2012, 2013); HadGEM2-ES (Collins et al. 2011; Martin et al. 2011); and IPSL-CM5A-LR (Dufresne et al. 2013). Bottom row: MIROC-ESM-CHEM (Sakamoto et al. 2012). GFDL, HadGEM, IPSL, and MIROC are 4 climate models from CMIP5. Based on RCP8.5 emissions.

A.2 MIRAGRODEP model

MIRAGRODEP is a Computable General Equilibrium (CGE) model based on the MIRAGE (Modelling International Relationships under Applied General Equilibrium) model. In its standard version, MIRAGRODEP is a recursive, dynamic multi-region, multisector model. In MIRAGRODEP, the government is explicitly modeled as different from private agents. Government income consists of taxes collected on production, on factors of production, on exports, on imports, on consumption, and on households' income.

This model allows for a detailed and consistent representation of the economic and trade relations between countries. International economic linkages are captured through international trade in goods and services, as well as through capital flows. A dynamic, recursive solution is obtained by solving the model sequentially and moving the equilibrium from one year to another. In our study, we assume perfect competition in all sectors

In each country, a representative consumer maximizes a CES-LES (Constant Elasticity of Substitution – Linear Expenditure System) utility function under a budget constraint to allocate expenditures across goods. It is equivalent to replacing the Cobb-Douglas structure of the Stone-Geary function (that is, LES) by a CES structure. The LES system allows for different income elasticities of demand, with those for food typically lower than those for manufactured goods and services. The demand system is calibrated on the income and price elasticities estimated by Muhammad and al. (2017).⁶ Once total consumption of each good has been determined in the top level, the origin of the goods consumed is determined by another CES nested structure, following the Armington assumption of imperfect substitutability of imported and domestic products.

On the production side, value added and intermediate goods are complements under the Leontief hypothesis that intermediate inputs are used in fixed proportion to output. Total value added is represented as a CES function of unskilled labor and a composite of skilled labor and capital; this allows us to specify a lower

⁶ The Influence of Income and Prices on Global Dietary Patterns by Country, Age, and Gender, by Andrew Muhammad, Anna D'Souza, Birgit Meade, Renata Micha, and Dariush Mozaffarian, ERS, March 2017

degree of substitutability between the last two production factors. In agriculture and mining, production also depends on land and natural resources. New capital is perfectly mobile across sectors, while installed capital is immobile. Skilled labor is perfectly mobile across sectors, while unskilled labor is imperfectly mobile between agricultural sector and non-agricultural sectors. For the present scenario analysis, we assume that investments are savings-driven, and that the real exchange rate is flexible, that is it adjust endogenously such that the current account of the balance of payments remains constant as a share of each individual country's GDP. To guarantee supply and demand for external financing match in the global capital market, capital inflows towards countries with a current account deficit are “scaled” up or down by a homogenous factor to capture the scarcity or abundance of international capital. Hence, we assume portfolio preferences and capacity to borrow on international markets remain constant for all countries. For this study, the main source of data comes from GTAP 10 version with 28 sectors and 33 regions (23 individual countries or subregions in LAC).

ANNEX 2

Table A.2.1: Extended results for Trade policy scenarios

	Household Real Income (changes)	Real Value Added			Trade with LAC partners	Total Exports	Labor reallocation	
		Agro-food	Food Processing	Primary Agriculture	Agro-food	Agro-food	Other Industries	
LAC								
US vs China	0.16	0.62	-0.26	1.01	-1.61	2.09	1.23	0.41
Extended US trade tensions	0.21	0.63	-0.08	0.95	-1.36	1.91	1.56	0.43
Escalading Trade Wars	-2.36	-4.91	-4.47	-5.12	8.79	-16.53	-24.39	2.56
Andean								
US vs China	0.04	0.18	0.06	0.24	-1.13	0.81	0.04	0.13
Extended US trade tensions	0.07	0.16	0.10	0.19	-0.84	0.83	0.45	0.15
Escalading Trade Wars	-2.20	-3.94	-4.86	-3.49	9.57	-16.07	-16.18	3.05
Caribbean								
US vs China	0.04	-0.27	-0.29	-0.25	-1.32	-0.25	1.08	0.13
Extended US trade tensions	0.18	-0.36	-0.34	-0.38	-1.55	-0.56	2.79	0.31
Escalading Trade Wars	-2.77	-3.68	-4.24	-3.30	10.76	-20.20	-16.30	2.46
Central America ex. MEX								
US vs China	0.04	-0.35	-0.27	-0.37	-1.31	-0.37	1.06	0.27
Extended US trade tensions	0.18	-0.72	-0.53	-0.78	-1.28	-0.90	3.77	0.78
Escalading Trade Wars	-3.22	-4.51	-1.82	-5.38	7.31	-14.77	-12.77	4.73
Mexico								
US vs China	0.27	-0.96	-0.50	-1.43	-4.28	-1.96	2.82	1.04
Extended US trade tensions	0.37	-0.49	0.02	-1.00	-2.77	-2.66	2.66	1.01
Escalading Trade Wars	-4.37	-3.62	-4.82	-2.43	25.56	-26.06	-35.99	5.92
MERCOSUR								
US vs China	0.19	1.89	-0.32	2.49	-0.97	3.62	-0.80	0.38
Extended US trade tensions	0.20	1.81	-0.28	2.37	-0.85	3.52	-0.36	0.37
Escalading Trade Wars	-1.19	-6.56	-4.81	-7.04	4.64	-15.16	-13.66	1.22
Rest of LAC								
US vs China	0.01	0.05	0.07	0.04	-1.55	0.13	0.07	0.03
Extended US trade tensions	0.03	0.04	0.07	0.02	-1.62	0.03	0.36	0.04
Escalading Trade Wars	-2.22	-0.66	-1.03	-0.41	5.21	-15.01	-15.09	1.39

Source: Authors, MIRAGRODEP CGE simulations

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IFPRI HEADQUARTERS

1201 Eye Street, NW
Washington, DC 20005 USA

Tel.: +1-202-862-5600

Fax: +1-202-862-5606

Email: ifpri@cgiar.org