CIAT policy brief

Colombian Agriculture: Adapting to Climate Change

Charlotte Lau, Andy Jarvis, and Julián Ramírez

Climate change will likely have significant impacts on the agricultural sector in Colombia, which accounts for over one-tenth of the country's GDP and employs over one-fifth of its population. Analyses indicate that by 2050, there will likely be significant temperature rises, more erratic precipitation, and higher pest and disease prevalence. To address the extensive socioeconomic implications of these effects, the government must prioritize adaptation, investing in regionally-based assessments; research and development; and technology transfer to and training for farmers.

Key Messages

- Both the annual mean temperature and precipitation will likely rise by mid-century, with **significant impacts on agriculture**. This has broad repercussions on the national economy, rural poverty rates, and food security.
- **Crop changes** and **diversification**, along with **better resource management** and **husbandry practices**, are key to bottom-up change.
- Climate scientists must focus on more **detailed climate mapping** to understand vulnerabilities and impacts. Biologists and agronomists should develop **climate stress-resistant crops**. Special attention should be given to water stress issues.
- The government should put together a **National Adaptation Plan** that identifies goals; divides responsibilities; includes strategies for monitoring and measurement of adaptive capacity; and enables farmers to take advantage of new technologies.

What's at stake

In the past decade, climate variations related to El Niño and La Niña have posed serious challenges to Colombian agriculture, demonstrating that many farmers are unable to effectively manage risk of and adapt to climatic fluctuations and shocks. Anthropogenic climate change is likely to exacerbate this situation. Scientists project increases in climate variability, higher temperatures, and erratic precipitation.

In Colombia, the expected average increase in annual mean temperature by 2050 is estimated to be 2.5 °C, and precipitation is likely to rise by 2.5% by mid-century. Indeed, without accelerated adaptation, climate change is likely to translate to:

- Soil degradation and organic matter losses in the Andes hillsides.
- Flooding in the Caribbean and Pacific coasts.
- Niche losses for coffee, fruit, cocoa, and bananas.
- Changes in the prevalence of pests and diseases.
- Melting of glaciers and water stress.

Projections show that, **by 2050, 80% of crops will likely be impacted in the majority (>60%) of their current areas of cultivation**, with particularly severe impacts on high value perennial crops. These projections have significant socioeconomic implications: the agricultural sector accounts for 40% of Colombian exports, and 21% of the population directly depends on agriculture for employment. Climate change would therefore have far-reaching effects on agroindustries, supply chains, and food and nutritional security.

In addition, **resource-poor, small-scale producers may be especially hard-hit** by climate change's effects. Small farmers represent the large majority of food producers in Colombia: for export crops (generating 41% of agricultural GDP), only sugarcane is grown largely on large farms; and for cereals, coffee, cocoa, and *Musa* (e.g., banana and plantain), 50%-90% of the producers are smallholders, with farm sizes fewer than 10 ha each.

What's coming

Temperature rise

By 2050, the average estimated increase in annual mean temperature is expected to be 2.5 °C, with a maximum of 2.7 °C in the Arauca department and a minimum of 2 °C in Chocó and Nariño. For those crops or departments experiencing temperature increases higher than 2.5 °C, the impacts on agriculture will likely be severe (Table 1).

Water stress

Higher temperatures will be accompanied by melting glaciers in the Andes (perhaps fully gone by 2030) and the disappearance of important moorlands (perhaps 56% gone by 2050), which today act as important sources of water. Meanwhile, annual precipitation variability will continue to be an issue for the entire country, so water storage will be important.

Erratic precipitation

The driest periods throughout the year will likely be less dry, while the wettest periods

Table 1. Production data and anticipated climate impact for some Colombian crops, organized by production area.

Current data *Red indicates that the crop ranks high for that column*				Crop	*Colors indicate how the majority of each crop's yield will be impacted*				
					% anticipated to have temperature change in range of…		% anticipated to have precipitation change in range of…		
Depts.* (No.)	Surface (%)	Prod.* (%)	Value (%)		2.0-2.5 °C	2.5-3 °C	-3% to 0%	0%-3%	3%-5%
31	16.6	6.1	2.7	Maize/corn	80.5	19.5	27.7	37.1	35.2
17	16.3	3.1	17.3	Coffee	84.7	15.3	8.2	28.8	63.1
26	12.2	11.1	9.0	Rice	64.6	35.4	15.7	23.6	60.7
31	9.9	13.7	9.2	Non-export plantains	79.8	20.2	7.2	36.1	56.6
6	6.2	14.5	4.4	Sugarcane	99.6	0.4	1.1	0	98.9
24	5.8	5.3	2.6	Panel-sugar cane	77.8	22.2	6.1	33.8	60.2
31	5.1	9.3	4.0	Cassava	70.9	29.1	39.8	41.4	18.9
18	4.7	7.1	12.6	Fruit trees	72.5	27.5	7.7	22.5	69.8
13	4.3	12.8	5.9	Potatoes	71.5	28.5	2.6	27.1	70.4
14	4.1	2.7	4.2	African oil palm	54.8	45.2	54.2	36.3	9.5
25	3.3	0.6	1.6	Common beans	84.6	15.4	10.7	40.4	48.9
27	3.0	0.3	0.9	Cocoa	40.2	59.8	17.3	53.2	29.5
15	1.5	0.6	1.2	Cotton	98.0	2.0	14.6	55.7	29.7
14	1.2	0.6	0.3	Sorghum	97.0	3.0	33.8	3.8	62.4
2	1.2	6.9	5.0	Export bananas	100.0	0	26.9	73.1	0
14	0.5	1.2	8.3	Vegetables	84.9	15.1	16.1	28.7	55.2
2	0.2	0.97	8.4	Flowers	100.0	0	0	16.1	83.9

* Depts.: Departments (states); Prod.: production.

are projected to become wetter. Predictions show an average increase of 2.5% on a national scale by 2050, with a minimum change of -1.4% in Cesar and a maximum of 5.6% in Huila. The only exceptions are the dry regions in the Caribbean coast, whose likely decreases in precipitation constitute a major cause for concern.

Scientists forecast that 36% of crops will face precipitation of above 3% in at least 60% of the areas in which they are grown. Changing precipitation patterns may alter flowering dates; affect biotic factors (e.g., pests, diseases, weeds) in different production systems, thus raising production costs; and change soil water availability. Heavy rains can lead to flooding, soil erosion, and massive crop loss. This may be exacerbated in the Pacific coast, where sea level rise may also cause flooding and salinization of soils.

Pests and diseases

Pests and diseases have already increased, and under progressive climate change, this situation will likely worsen. Crops currently facing these issues include *Musa* (e.g., bananas, plantain) in areas above 500 meters above sea level (m.a.s.l.), coffee in areas above 1500 m.a.s.l., potato in areas below 2500 m.a.s.l., as well as cacao, maize, and cassava. Strong chemical treatments can represent high economic costs for small farmers and long-term costs to the agroecosystem environment.

Livestock

Heat, degraded lands, failing feed supplies (from plants not resistant to climate change), and limited water supply will likely impact livestock. Attempts to intensify livestock production may inadvertently lead to infectious diseases in livestock, which could then affect farmers and/or end consumers.

Adaptation pathways

Bottom-up approaches

At the *farm level:*

- **Crop changes:** varietal/species change; diversification of crops or into livestock/aquaculture; new seeds/breeds (e.g., heat-resistant or drought/flood-resistant types).
- **Water management:** rainwater capture, storage systems, irrigation and water distribution pathways, trees along waterways to prevent erosion, desalinization programs, wastewater recycling.
- **Soil management:** reduce compaction, improve drainage, change tilling strategies to lower inputs.
- **Improvements in farming practices:** conservation tillage, shading coffee plants, green manure, crop rotation, calendar adjustments.
- **Improvements in livestock practices:** mobility, vaccinations, replanting rangelands, breeding, fodder banks, silvopastoral systems.

At the *local or community level:*

- **Pooling of resources** to spread risk.
- Local **grain storage** for emergencies.
- Investments in **infrastructure**—e.g., coastal walls to prevent sea level rise flooding and salinization.
- **Market strategies** to stabilize prices and offer financial support.

Top-down approaches

The Colombian Ministry of the Environment's National Development Plan includes a framework on climate change and various conservation programs, but it does not focus enough on the agricultural sector, and leaves out vital projects that would evaluate current and expected agricultural vulnerability of agriculture to climate change, and accordingly define and evaluate specific adaptation strategies.

Therefore, what is needed instead is a **National Adaptation Plan (NAP)** that clearly:

- Divides responsibility among different governmental (national and local) offices.
- Initiates a climate change network to share information and assess adaptation strategies.
- Creates measuring and monitoring mechanisms.
- Includes concrete mechanisms for technology transfer to farmers, with special attention given to (vulnerable) smallholders.
- Acknowledges the special importance of water resources and management, particularly through investments in water storage.

Examples of impacts and potential adaptation measures

Expected impacts	Adaptation measures	Crops likely to be impacted
Changes in crop phenology and subsequent impact on product flows to markets and supply chains	Changes in harvest and sowing dates. Infrastructural changes for perennial crops (irrigation, drainage).	Coffee, *Musa* crops, upland rice, maize, soybeans, common beans, fruit trees
Flooding of agricultural lands due to increases in sea level and salinization of underground water	Re-location of activities according to new territorial ordering plans. Walls and barriers construction to prevent salinization and protect coastal ecosystems.	African oil palm (Pacific coast), *Musa* crops (Urabá), and Caribbean coast livestock systems
Changes in pests and diseases: increases and displacement to new regions	Research on resistant and/or tolerant materials. Implementation of monitoring and early-warning systems in order to implement sustainable management.	Coffee (below 1500 m.a.s.l.), *Musa* crops (below 500 m.a.s.l.), potatoes above 2500 m.a.s.l., cassava, fruit trees
Intensification of land degradation processes and desertification	Improved and sustainable agronomic management to increase soil resilience.	Potatoes and cassava in Andean mountain hillsides, livestock systems in lowlands (Amazon, savannah and Caribbean coast regions)
Increased vulnerability of small producers to climate variability and climate change	Creation of adaptation subsidies and an agricultural insurance system for mountain hillside producers and for very dry Caribbean areas. Industry and the government should invest on research, extension, and technology transfer to support smallholders.	All crops (sectors with significant dispersion within the country should be addressed in the first place)
Risk of loss (extinction) of plant genetic resources that are under-represented or not currently *ex-situ* conserved	Government funding and incentives to stimulate conservation of plant genetic resources. Analyses of high risk areas. Collection of genetic resources. Prioritization of activities that require genetic improvement (see right).	Priority: wild and cultivated landraces of fruit trees, and many crop wild relatives including wild cassava, beans, potato, tomato, amongst others.
Gradual loss of crop and pasture suitability and productivity, including possible abandonment of current crop lands	Research on heat resistant genetic materials and crop improvement programs for most vulnerable crops. Development of new practices for agricultural systems that can deal with increased temperatures.	Sugarcane, coffee (above 1500 m.a.s.l.), potatoes (below 2500 m.a.s.l.), *Musa* crops (below 500 m.a.s.l.), citric fruit trees (highlands), livestock

Governments, non-governmental, and civic groups, and the private sector should work together and utilize:

- **Training workshops and technology transfer** to improve best farming practices.
- Innovative instruments **like index-based insurance and microfinance** to address poverty and farmer risk-adversity.
- Other **financial transfer tools like subsidies** to incentivize uptake of resistant crop varieties and adaptive farming practices, e.g., silvo-pastoral systems (see text box).

Research and technology

Given the extent of uncertainties regarding the effects of climate change, Colombia should continue to invest in **climate modeling** under different climate scenarios, at a detailed geographic scale and a long time scale. Understanding the extent to which different systems, departments, and crops will likely be affected would enable scientists and policymakers to then draft appropriate adaptation plans. Meanwhile, further research into creating **climate-, pest-, and disease-resistant crops** is needed (see "Colombian rice" box for example). Towards this end, **preservation of agrobiodiversity** and genetic resources is crucial.

Challenges and constraints

- Colombia is characterized by **significant temporal and spatial climatic variability**, which makes it difficult to assess adaptation pathways on a national scale. However, local efforts could be integrated to permit information sharing.
- The majority of producers are **poor smallholders**, so government support (i.e., agricultural insurance, loans, and subsidies), as well as tax protection, may be necessary.
- In 2007, **coffee** accounted for 17.3% of the value of crops produced, or over $2 billion. Given the crop's national economic importance, it will require special attention. Shading may be a key

Silvo-pastoral systems

Silvo-pastoral systems (SPS) offer an alternative to traditional cattle production systems in Latin America, which have long been correlated with deforestation, soil erosion, and loss of biodiversity. In contrast, SPS mix deep-rooted, perennial vegetations into a livestock production system. The plant diversity in SPS—which often combine ground grass species, bushy legume species, and upper shade layers of timber or other legumes—provides greater resilience to climate variability. The plants can therefore act as diet supplements and as backup fodder, and SPS has been shown to increase milk and meat production. SPS also offer provide ecosystem services (soil nutrient recycling, carbon sequestration, biodiversity corridors/refuges), while creating shade that maintains soil moisture and lowers temperatures for livestock.

Colombian rice

One of the major obstacles to rice improvement in Latin America and other regions is the stagnation of crop yield potential, which conventional breeding has been unable to surpass. Several major diseases and pests in both lowland and upland environments, and the prevalence of infertile acid soils in the latter help explain this yield gap. Researchers are working to close that gap by broadening the genetic base of rice production and incorporating useful features from wild relatives. For example, hybrids between the wild *Oryza* species and improved varieties have produced offspring with yields 10%-20% superior to their cultivated parents.

Rice lines are also being evaluated for other traits, such as plant architecture, grain type, and resistance to biotic and abiotic stresses. In particular, scientists have used breeding and pathology research to develop crops with durable resistance to pests and diseases. This task is often complicated by the diversity among the many variations of some pathogens, which allow them to mutate, diversify and duplicate quickly and make it more difficult to develop crops with adequate resistance.

Between 1967 and 2005, Colombia has released 41 different rice varieties, which have generated economic benefits estimated in the hundreds of millions of U.S. dollars, due to increased yields and reduced pesticide expenditures. Recently developed varietals are resistant to the sogata pest, white leaf, and rice blast, three of the rice crop's most destructive pests and diseases.

strategy, but may be insufficient on its own. Coffee may require altitudinal migration of cropped lands, in which case policies and regulations must be in place to ensure that shifts in production occur in environmentally and socially sustainable ways (e.g., do not convert natural ecosystems or infringe on land rights).

- Many of these investments constitute **significant up-front costs**. Continued and active political support is therefore vital.

Policy recommendations

The government should formulate a **National Adaption Plan** with clear objectives that defines and divides tasks; and details investment needs and financial flows. In particular, the NAP should prioritize:

1. Detailed, comprehensive, and regionally-based impact assessments.
2. Vulnerability assessments for the agricultural production systems crucial to national exports and rural food security.
3. Priority research and development initiatives, including climate modeling and crop breeding.
4. Technology transfer to and training for farmers. Uptake may require policies that address smallholders' poor resources (e.g., agricultural insurance systems, land subsidies).

In all cases, data and information should be made public, to facilitate both climate research and the sharing of institutional and traditional knowledge.

Further reading

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About the authors

Charlotte Lau is an officer of the CGIAR Mega Program on Climate Change, Agriculture, and Food Security (CCAFS) and a visiting researcher at CIAT, Cali, Colombia. **c.lau@cgiar.org**

Andy Jarvis is the leader of CIAT's Policy Analysis and Climate Change Program, Cali, Colombia. He is also a theme leader of the CGIAR CCAFS Program. **a.jarvis@cgiar.org**

Julián Ramírez is a researcher and geographer in CIAT's Policy Analysis and Climate Change Program, Cali, Colombia. **j.r.villegas@cgiar.org**