CIAT policy brief

No. 2, December 2010

Mesoamerican Coffee: Building a Climate Change Adaptation Strategy

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In Mesoamerica, coffee production is an important part of economies and societies, forming the backbone of thousands of families' livelihoods and contributing significantly to national agricultural GDPs. Yet it is in Mexico and Central America that climate forecasts predict severe impacts from climate change. Climate models and crop-niche suitability predictors show considerable changes in both the quality of coffee beans and the altitudinal zones suitable for production. Unless additional efforts are made to strengthen adaptive capacity today, there will likely be heavy economic losses across the coffee supply chain, as well as the disappearance of important ecosystem services.

Key Messages

- In Mesoamerica, coffee is an **important part of agricultural GDP** and export revenues, supports about half a million farmers and **employs millions** of people on the farms and all along the supply chain.
- Traditional coffee agroforests provide **important ecosystem services** and conserve significant carbon stocks.
- **Climate change threatens coffee production**, as projected increases in temperature and changes in rainfall will likely reduce crop suitability in most current growing areas. Options include adaptation (e.g., agronomic interventions), alternative income sources (e.g., crop substitution), and migration (e.g., to more suitable higher altitudes).
- Supply chain actors must collaborate and make **strategic, collective investments** to respond to these new threats. Given the **long lead time** for investments, actions must be taken now.

An overview

There are over half a million coffee growers in Mesoamerica today, the large majority of whom are smallholders growing on lots smaller than 5 ha each. The sum of these small farms, however, is impressive: coffee is the largest contributor to agricultural GDP in Latin America, and **many families depend on the crop for employment** as farm hands and laborers along the extensive coffee processing and export chain. Coffee represents 20%-25% of export revenues in Nicaragua and Honduras, two of Latin America's poorest countries. Despite the economic prowess of this network of supply-side actors, coffee is subject to price volatility and market stresses. Global climate change will likely compound these stresses.

Anticipated changes by 2050

Hotter climate

Climate models predict that the mean annual temperature in Mesoamerica will rise 2-2.5 °C. Honduras, Mexico, and Nicaragua will likely experience the greatest increases (see Table 1 and Figure 1). Higher ambient temperatures speed up the ripening of coffee berries, leading to **poorer cup quality**. Moreover, high value Arabica coffee, especially the type that meets the qualifications of more lucrative specialty markets, requires lower temperatures. Areas currently growing Arabica may therefore need to be replaced by (lower value) Robusta coffee, cattle pasture, and food crops.

Less (and more erratic) precipitation

Models predict lower annual rainfall in most of Mesoamerica. Honduras and Nicaragua will experience the most drastic changes, decreases on the order of -5% to -10%. **Reduced water supply** could constrain coffee cultivation and some methods of processing.

Less conclusive projections also predict that rainfall will continue to be erratic and exhibit greater extremes, which could significantly impact coffee, whose production cycle is highly dependent on rainfall patterns. Coffee flowering is triggered by the first rainfalls at the onset of the rainy season, but if precipitation drops off or becomes too heavy, both coffee flowers and fruits may drop from the tree. This stunted fruit growth would result in fewer, smaller beans of lower quality, which would in turn fetch lower prices. Harvesting often represents the majority of production costs, so if erratic flowering and ripening cycles require additional harvesting cycles, these changes could drastically and unsustainably raise costs.

Pests and diseases

Changes in temperature and rainfall will increase pest and disease prevalence, expanding the altitudinal range in which the fungal disease **coffee rust** (*Hemileia vastatrix*) and the **coffee berry borer** (*Hypothenemus hampei*) can survive. Already, the area affected by the coffee berry borer has gradually increased over the past decade, and to date, the only effective pesticide is Endosulfan, known to pose health risks to the farmers who apply it.

Table 1. Projected changes in crop suitability, temperature, and precipitation in Mesoamerica by 2050.

Change in crop suitability *Red indicates how the majority of each country's coffee yield will be impacted*				**Contrib. to GDP (%)**	**Country**	*Colors indicate how the majority of each country's coffee-growing areas will be impacted*					
						% with likely temperature change in the range of…		**% with likely precipitation change in the range of…**			
-40% or more	**-40% to -20%**	**-20% to 0%**	**>0%**			**2.0-2.25 °C**	**2.25-2.5 °C**	**> -10%**	**-5% to -10%**	**-5% to 0%**	**0% to 5%**
55.4	40.5	2.7	1.4	1.3	Costa Rica	100.0	-	-	-	100.0	-
45.5	43.7	10.9	-	2.5	El Salvador	78.3	21.7	-	1.1	98.9	-
12.9	25.5	54.2	7.4	4.2	Guatemala	60.8	39.2	-	17.4	82.6	-
38.2	49.8	11.0	1.0	8.2	Honduras	5.4	94.6	5.8	94.2	-	-
18.2	34.6	46.9	0.3	5.0	Mexico	20.6	79.4	-	49.0	50.5	0.4
35.3	32.1	32.5	0.1	7.2	Nicaragua	7.9	92.1	1.2	98.0	0.8	-

Shocks and variability

Climate change models for Mesoamerica also predict greater frequency and intensity of extreme weather events. Hurricanes can sometimes irreversibly destroy coffee zones by causing **landslides, soil erosion, floods, and damage to transport and processing infrastructure**. For example, Hurricane Stan in 2005 resulted in the loss of 20% of the Pacific Guatemalan coffee harvest, worth US$4 million. Droughts can also be damaging, especially through increased risk of **wildfires**.

Constant climate shocks and general variability also have effects lasting beyond just one growing season. The impacts of these climate shocks leaves farmers indebted, unable to invest in production, and **trapped in poverty**. In addition, unpredictability can inhibit cooperatives from engaging in and honoring long-term sales contracts, leading to further income uncertainty and economic losses.

Anticipated effects

Decreased suitability

Changes in temperature and rainfall will **decrease the area suitable** for coffee and effectively move crop potential up the altitudinal gradient. At the national scale, Costa Rica, El Salvador, and Nicaragua have the highest percentage of land affected most drastically, with drops in suitability of 40% or greater. Losses in suitability will affect huge swaths of current growing areas. For example, in Sierra Madre de Chiapas, Mexico, current growing zones with high suitability (60%-100%) will decrease from 265,400 to 6,000 ha—a loss of productivity in 259,400 ha, or over 97%.

Since temperatures are higher at lower altitudes than at higher ones, climate change will **most severely affect coffee production in lower-altitude zones** (<1500 meters above sea level, or m.a.s.l.). Crop suitability will effectively travel up the altitudinal gradient to cooler climates. Models predict that, in Central America as a whole, the optimal coffee-growing elevation will shift from 1200 m.a.s.l. currently, to 1600 m.a.s.l. in 2050.

Lower quality beans and prices

In addition to affecting crop yields, climate change will likely also affect coffee bean quality. Higher quality beans fetch higher prices, but there are also other methods to secure better returns, including "Denomination of Origin" (DO) status. As coffee in current DO zones become less suitable for producing high-caliber, or any, yields, producers in such regions **may lose DO certification**.

Economic losses

Falling yields, lower cup quality, and loss of certificates of DO will likely amount to significant economic losses. Moreover, producers losing specialty status will not only be forced to accept lower prices, but will also have to compete with low-cost producers like Brazil and Vietnam. Consequently, projections of the economic impact in Nicaragua show a loss of over US$74.7 million for 2050 alone. Such gross level statistics signify **hardship at the farm level and for laborers all along the supply chain**. The vulnerable poor will be especially hard hit, due to their generally low adaptive capacity to shocks, poor access to new technologies, inadequate knowledge of pest and disease management, and shallow market linkages. A World Bank study found that the fall in coffee prices between 2000 and 2003 led to a 10% increase in poverty in the coffee regions of Nicaragua.

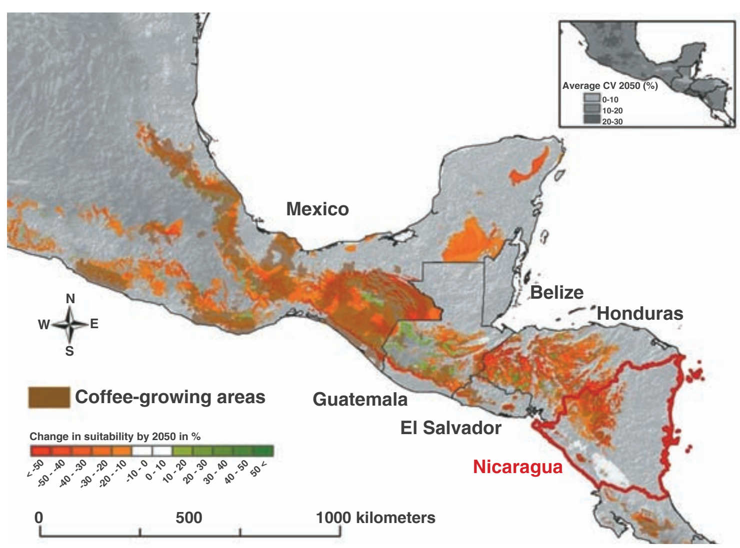

Figure 1. Projected changes in suitability in Mesoamerica by 2050 and coefficient of variance of 18 different Global Circulation Models (GCM) used for the analysis (small map).

Ecosystem deterioration

In areas like the Sierra Madre de Chiapas in southern Mexico, where cultivation is traditionally managed in coffee agroforests with complex shade canopies, coffee production also provides important ecosystem services. The variety of shade tree species can serve as both **carbon sinks** and **wildlife habitats** with high biodiversity value. The Sierra Madre biosphere also **provides water** for several municipalities downstream.

The shade canopy benefit coffee production by **maintaining soil moisture, protecting against erosion and landslides**, and **shading coffee plants** from harsh daytime sun and heat (reducing temperatures by approximately 4 °C). However, already market and climate pressures have led to the simplification of many production systems in the region—a counterproductive strategy that deconstructs rather than builds adaptive capacity to future climatic change.

There is concern that future incentives will lead to ecosystem deterioration. As unprofitable coffee farms abandon the crop, **land will likely be converted for other uses, leading to fragmentation and loss of agroforest habitat**. A study by the Guatemalan National Coffee Association (ANACAFE) found that 9% of coffee agroforests in Pacific Guatemala were converted to other land uses during the low coffee prices between 2000 and 2004. Finally, pressures to migrate coffee production to higher elevation may lead to pressure on forest reserves that protect water sources for much of Mesoamerica.

Focus on Nicaragua

In Nicaragua, coffee is the largest national export, and over 30,000 coffee farmers' families rely on its production. As of 2002, about 280,000 others were employed full-time or seasonally in the industry. Declines in prices at the beginning of the decade significantly affected production, and the sector's recovery was likely compromised by climate variability in later years, e.g., during El Niño of 2006. Climate models predict increasing stresses in years to come.

The projected mean annual temperature increase is 2.2 °C by 2050, while annual precipitation will likely fall from 1740 to 1610 mm, a decrease of over 7.4%. Indeed, the predicted national production area for 2050 is 16,700 ha, down from 114,600 today. This equates to a 98,200 ha, or 85%, decrease. Coffee production is expected to shrink from 60,900 to 11,200 tons—an 81.6% decrease. All this translates to an expected income loss of over US$74.7 million in 2050 alone, an 82.9% decrease from 2010.

However, opportunities exist to adapt to such changes. Part (67.9%) of the current production areas where coffee will likely lose suitability will remain apt for a range of other crops. In these regions, programs to promote the productive diversification may be successful. However, there are also regions (28.6%) where both coffee and other crops will lose suitability, mainly due to decreased rainfall. In such cases, non-agronomic options for economic diversification will have to be pursued. Figure 2 shows the projected suitability of coffee in 2050, alongside 30 of the other most harvested crops in the country by land area, including palm oil/nut, agave, cotton, rice, and banana.

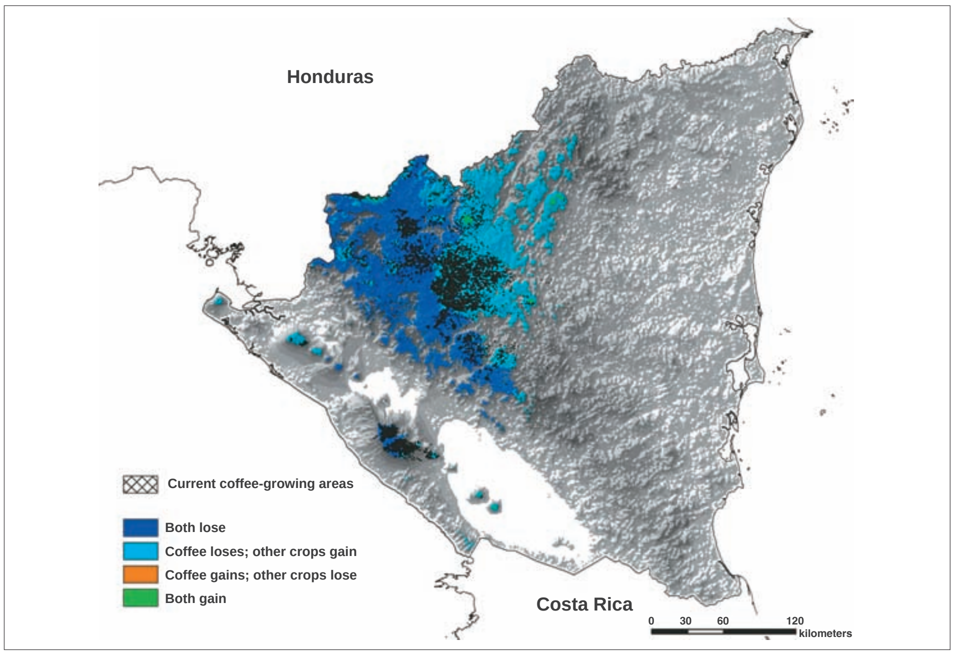

Figure 2. Projected suitability of coffee and 30 other potential diversification/substitution crops in Nicaragua in 2050.

Adaptation pathways

Coffee producers in zones with decreasing climate suitability will have three options: adapt, switch livelihood sources, or migrate upwards.

Adaptation

For those farms whose suitability will drop but not decrease prohibitively, adaptation is crucial. Many adaptation strategies consist of ***technical, "no-regret" measures*** that would be beneficial regardless of the magnitude of climate change. Improved agronomy and sustainable management of resources —including the use of **drought- and heat-resistant varieties, irrigation, and shade cover**—are good first steps.

Beyond the field, ***the entire coffee chain* must restructure itself** to prepare for changes in production. All impacted parties should **build collaborative networks** that share knowledge and costs for strategic investments. Unfortunately, in some areas there may be significant cultural obstacles: Mexican coffee farmers, for example, tend to associate farmer organizations with fraud and manipulation. However, there are examples of successful collaborations as well: in Nicaragua, 12 marketing cooperatives formed the Association of Small Coffee Producer Cooperatives of Nicaragua (CAFENICA), through which they collectively invest in capacity building to meet common economic and environmental challenges. One strategy may be to **expand the use of ecolabels**, which are already well developed within the industry and may help compensate for the costs of adopting sustainable practices.

Policymakers must also acknowledge the gravity of the situation and make early investments to help farmers adapt. First and foremost, **capacity building** is necessary to raise coffee growers' awareness of climate change and encourage improved management. In many cases, **financial transfer tools** will also be necessary to incentivize best practices. The government could offer **payments for ecosystem or watershed services**, thus promoting agroforest shade cover, and/or **subsidies** for resistant coffee varieties and water-efficient technologies. Governments or civil organizations could also help reduce risk by providing **affordable crop insurance** or promising income relief following extreme weather events. For example, presently only 10% of the Mexican coffee crop area is insured, largely because of prohibitively expensive insurance plans from private providers. Lastly, policymakers could develop and implement **wildfire management plans**, in preparation for drier future climates.

Migration

In cases where coffee production is no longer possible, farmers will have to either **move up the altitudinal gradient**, or switch income sources. When families are willing to migrate, more suitable climates may await. However, **high altitude areas are often protected forest reserves** that provide important environmental services to lowland populations, so there may be legal constraints to altitudinal migration (e.g., property rights), and/or environmental concerns regarding the sustainability of expansion. Perennial crops like coffee are also more difficult to move. In cases where migration is logistically possible, **research must be done on how to best shift infrastructure, knowledge and capacities** from current to potential growing areas—and how to financially support or incentivize such adjustments.

Abandonment and substitution

Diversification in the short term can turn into complete crop substitution in the long term. For example, a **range of fruit trees, cocoa and Robusta coffee** are more suitable for the projected climatic conditions. Moreover, some communities and farms that have diversified into **orchid and flower production** have reported that this alternative income source is often higher than their coffee incomes, but as market demand for such initiatives is limited compared to coffee, these represent only local solutions.

An **ecosystem services payments scheme** would be an ideal strategy synergizing the goals of emissions mitigation, biosphere preservation, and poverty alleviation. It could prevent the otherwise likely fragmentation or exploitation of current coffee agroforests. However, setting up such schemes may represent significant costs, and the possible levels of funding (less than US$100 per hectare per year) are unlikely to significantly impact the economics of production.

Crop abandonment affects more than just farmers. In many cases, there have been substantial investments in coffee processing and drying facilities, so efforts should be made to use these facilities for other crops better adapted to projected future climates.

Policy recommendations

Given the importance of coffee to Mesoamerican economies, adaptation to climate change should be made a priority. In particular, states should invest in and utilize research to create site-specific adaptation policies, which may involve:

- Developing climate stress-resistant coffee varieties; validating agronomic management strategies; and improving market links.
- Providing financial assistance via subsidies, insurance, and ecosystem payments (through either direct remuneration, or the development of markets to reward sustainable land practices and forest conservation).
- Promoting diversification as a short-term risk management strategy and a long-term bridge to full crop substitution.

Challenges and constraints

- **Long lead times:** Investments in coffee production have long lead times, so change enacted now may not come to fruition until 10-15 years later. Even simple practices require time: shade crops, for instance, take several years to grow big enough to provide ample protection.
- **Collective action costs:** Tackling the impacts of climate change will require collaborative networks across the supply chain, yet the current structure of the conventional coffee chain is not conducive to sharing investments or making joint decisions.

Further reading

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Correct citation

Läderach, P.; Haggar, J.; Lau, C.; Eitzinger, A.; Ovalle, O.; Baca, M.; Jarvis, A.; Lundy, M. 2010. Mesoamerican coffee: Building a climate change adaptation strategy. CIAT Policy Brief no. 2. Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. 4 p.

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