CIAT policy brief

Haiti: Coffee and Mango Production in a Changing Climate

Anton Eitzinger, Peter Läderach, Stephania Carmona, Laure Collet, Ludger Jean-Simon, Patricia Dufane, and Andreea Nowak

Coffee and **mango** contribute significantly to Haiti's agricultural gross domestic product and export revenues. Generating income valued at US$11 million in 2011, mango has become one of the country's most important export commodities. In contrast, coffee exports steadily declined from $7 million to $1 million between 2000 and 2010, even though demand for high-quality Haitian coffee has actually increased on the global market. A recent study conducted by the International Center for Tropical Agriculture (CIAT) and Catholic Relief Services (CRS) revealed that future changes in temperature and rainfall patterns will have significant effects on the suitability of coffee and mango for production in Haiti. While mango will continue to be highly viable, coffee will become considerably less suitable for production at lower elevations. Changing climatic conditions could also lower quality and yields in current coffee-producing regions, such as Plaisance and Dondon in the North and Beaumont in the Southwest. To cope with the challenges that coffee and mango growers are likely to face, it will be important to promote the diversification of agricultural systems, introduce improved coffee varieties, offer financial incentives to adopt sustainable land use practices, build capacity among smallholders, and foster the sharing of expertise.

Key messages

- Haiti's agricultural production may be strongly affected by sea-level rise and more frequent extreme weather events (e.g., hurricanes) hitting coastal areas.
- The quality and yields of coffee in regions where it is currently produced (especially at lower elevations) may decline as a result of lower rainfall and higher night and daytime temperatures.
- A projected upward shift in the areas where coffee is suitable will increase the risk of high-altitude forests and protected areas being converted to cropland.
- Key ecosystem services provided by coffee must be protected through short- and long-term risk management strategies (e.g., crop diversification and full crop substitution).
- In areas where climate change will make coffee only slightly less suitable, farmers should adapt their production by investing in irrigation systems, improving shade management, and adopting drought-tolerant coffee varieties.
- In areas where coffee production will cease to be suitable, landowners should begin diversifying agricultural systems, with the aim of eventually switching to crops, such as cocoa, that are expected to remain highly suitable for cultivation throughout the country.
- Mango will also remain highly suitable for cultivation in Haiti and could, therefore, replace coffee and dry beans, which will become less suitable in areas between 500 and 1,000 masl by 2050.
- Sorghum and yam are also good options for crop diversification, since they are highly likely to become more suitable for future conditions in Haiti.

Haiti: Agricultural production and economic growth

Agriculture in Haiti accounts for 25% of the country's total gross domestic product (GDP). Agricultural land, with an area of more than 1.7 million ha, comprises more than 60% of Haiti's total land area. Just about 20% of its agricultural land consists of plains, which are the area most suitable for crop and livestock production. Many farms are situated in marginal areas (e.g., on slopes), where the soils have only limited capacity for cultivation. Almost 58% of the labor force is employed in agriculture. Average farm size is 1.5 ha, and most of the country's estimated 1 million farms are divided into several parcels, with some farmers holding more than 5 ha and others less than one-fourth of a hectare[1,2].

The major earthquake that struck Haiti in 2010 seriously damaged the country's economy, particularly, its agriculture. The massive shift of displaced people to rural areas seriously undermined food security, as host households struggled to provide enough food for additional relatives. A study conducted by the Haitian *Direction de Protection Civile*, reported that 85,750 people migrated to Grande'Anse Department and 89,000 to Sud Department[3], putting host families at risk. The same year a hurricane hit Sud Department, causing major damage to infrastructure and crops through widespread flooding.

In response, Haiti's Ministry of Agriculture, Natural Resources, and Rural Development (MARNDR) formulated the National Agricultural Investment Plan. It highlights the importance of agriculture for achieving domestic food security, facilitating the country's economic recovery, and encouraging social stability. The plan seeks to boost self-sufficiency in agriculture from the current level of 50% up to 60%, while also raising household incomes. In addition, it promotes agro-enterprise development, which is expected to increase agricultural exports by at least 40% from the 2011 baseline of US$30.74 million[4].

International organizations have embarked on major efforts aimed at enhancing the resilience of rural households under moderate drought and heavy rainfall. These organizations encourage practices, such as water storage and irrigation, adoption of stress-resistant crop varieties, improved soil management, conservation agriculture, and other sustainable approaches. They also promote the integration of crops, horticulture, aquaculture, and livestock production, while helping build skills in farm planning and the management of household and farm finances.

To increase resilience in the face of extreme events, international agencies have incorporated disaster risk reduction into many rural development projects. In addition, they have collaborated with the government to increase first-responder capacity through community mapping and planning, and by prepositioning items such as water, food, and feed (following the example of Catholic Relief Services Agriculture for Basic Needs Projects in Central America and Mexico).

The Strategic Plan for Climate Resilience (SPCR), prepared by the Inter-Ministerial Committee for Land Use Planning, lists national and multilateral projects that are contributing to climate resilience in Haiti. The SPCR proposes programs and projects that seek to improve land use and local communities' resilience and capacity to adapt. It also suggests specific actions for protecting the environment in an integrated manner, improving people's incomes and living conditions, strengthening institutional capacity and the legal framework, and consolidating progress in building climate resilience. These activities are planned with local communities, with the aims of improving their land use and making them more adaptable and resilient[5].

Despite all these achievements, Haiti remains the poorest country in the Americas, with approximately 80% of the population living on less than US$2 a day. In 2012, economic growth slowed again as a result of declines in agricultural output caused by extreme weather events. Droughts hit during the planting season, causing agricultural losses estimated at about $80 million[6]. Then, in August, tropical storm Isaac caused losses to the country's economy valued at about $70 million. Later in the year, the already vulnerable agricultural sector was hit again, this time by hurricane Sandy, which caused $104 million in total damage. Agriculture alone suffered losses of more than $52 million, according to MARNDR estimates. The fall harvest (maize, beans, sorghum, pigeonpeas, bananas, tubers, nuts, vegetables, and rice) was either completely destroyed or severely damaged by winds and water. Provisional data provided by departmental directors indicate that 90,357 ha of cultivated land were damaged by the hurricane[7].

1 Ministry of Agriculture, Natural Resources, and Rural Development, MARNDR. 2010. National Agricultural Investment Plan.
2 Food and Agriculture Organization of the United Nations. FAOSTAT. 2011. http://faostat3.fao.org/home/index.html
3 UN Coordination Mechanism Report, January 2010.
4 Banque de la République d'Haïti. 2012. Exportations par produit. www.brh.net/exportproduits.pdf
5 Comité Interministériel d'Aménagement du Territoire (CIAT). 2012. H aiti: Strategic Program for Climate Resilience.
6 CNSA/MARNDR, Aba Grangou, FEWS Net. Haiti: Perspective sur la sécurité alimentaire. October 2012 – March 2013.
7 Système National de Gestion des Risques et des Désastres (SNGRD). Situation Report #8.

Despite Haiti's high exposure to climate risks, the country has no National Adaptation Programme of Action (NAPA), which is the means by which least developed countries can make their most urgent needs known through the United Nations Framework Convention on Climate Change (UNFCCC).

A recent study jointly conducted by CIAT and CRS analyzed the impact of future climate conditions on coffee and mango production as well as options for the diversification of farming. The six alternative crops considered already occupy more than 0.7 million ha (or about 60% of Haiti's agricultural land). This policy brief describes anticipated changes in the suitability of these crops and recommends actions for addressing the country's climate change challenges.

Climate risks will increase rural and coastal vulnerability

Based on analysis of downscaled data from the 19 General Circulation Models (GCM) suggested by the Intergovernmental Panel on Climate Change (IPCC), we expect to see the following climate-related changes in Haiti:

- Temperature is very likely to increase by an average of 0.9 °C by 2020 and 1.8 °C by 2050.
- The average temperature of the hottest month will increase from 30.9 to 32.9 °C by 2050.
- In the driest month, rainfall is projected to be 10% less by 2050.

According to the recently published Fifth Assessment Report (AR5) of the IPCC, future changes in climate are unavoidable: "It is virtually certain that over the 20th century sea level rose, with a very likely range of 2.8 to 3.6 mm per year between 1993 and 2010." The report further expresses "high confidence that the intensity of extreme precipitation events will increase with warming," while "it is likely that the global frequency of tropical cyclones will either decrease or remain essentially unchanged, concurrent with a likely increase in both mean tropical cyclone maximum wind speed and rain rates. More extreme precipitation near the centers of tropical cyclones making landfall are likely in North and Central America."

- While all future predictions indicate only moderate decreases in rainfall, these could cause serious water deficits if accompanied by increasing night and daytime temperatures. Such increases might result from higher evapotranspiration rates in plants, which would trigger soil water deficits and heat stress.
- Increased temperature stress, especially higher nighttime temperatures and drought, could have substantial effects on biomass production and the reproductive stages of several crops and other plants.

Less coffee in lower altitudes

Coffee plantations in Haiti are generally situated at altitudes ranging from 400 to 1,300 masl. According to our predictions, changes in temperature and rainfall patterns will cause a general reduction in the areas suitable for coffee and particularly in the area that is currently considered highly suitable for this crop (Figure 1, left side). The area suitable for coffee will climb up altitudinal gradients to elevations that now have cooler climates. The models predict that coffee will become less suitable at lower altitudes (up to 1,200 masl) and more suitable in higher areas, with maximum suitability occurring at 1,500 to 1,800 masl by 2050. Changing climatic conditions in Haiti could also lower quality and yields in current coffee-producing regions, such as Plaisance and Dondon in the North and Beaumont in the Southwest, while permitting the intensification of coffee production at higher elevations, e.g., Thiotte in the Southeast and Savanette in the center of the country.

Mango to remain suitable under future climate conditions

In contrast with coffee, mango will remain highly suitable for production in many regions, especially in the Artibonite and Centre Departments. Some areas will see slight reductions in the suitability of mango and shifts in the areas suitable for its production from near the coast to higher altitude areas, such as the Sud, Artibonite, and l'Quest Departments. Areas at 500 to 700 masl will benefit from increasing suitability for mango, mostly due to increased temperatures (Figure 1, right side).

Suitability of alternative crops under a changing climate

Climate change will impact crops differently, depending on their distinct characteristics (such as tolerance to heat and water stress), soil requirements, and management. Crop production conditions are geographically variable in Haiti, and most of the production constraints are related to climatic conditions, the soil's limited productive capacity, and poor management practices.

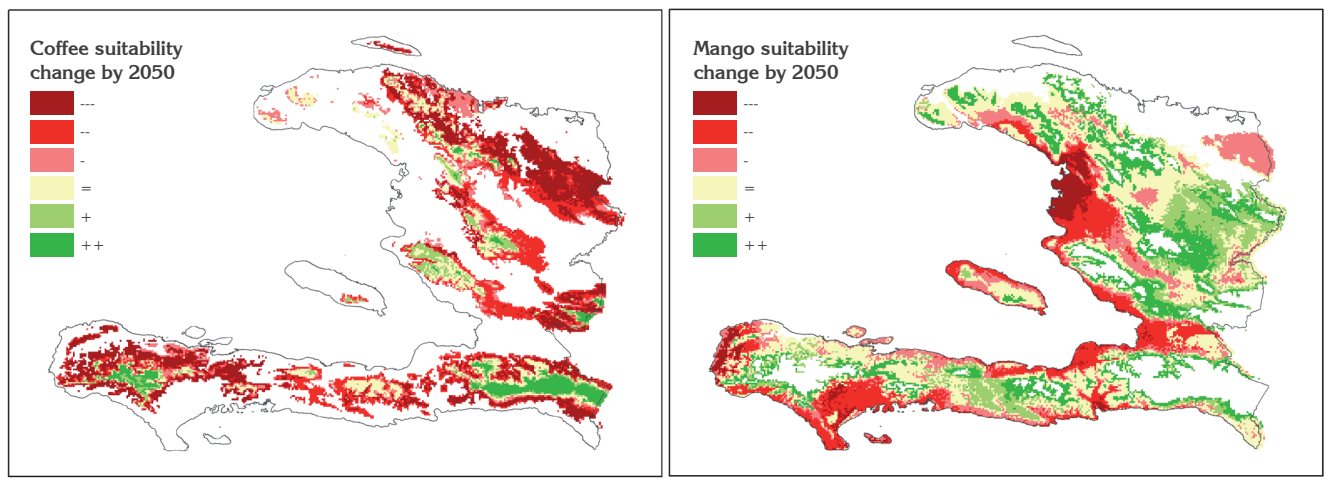


Figure 1. A species distribution model was used to assess changes in coffee and mango suitability under future climates in Haiti. Red areas show reductions in suitability, while green areas show increases by 2050.

To assess the potential impact of climate change on Haiti's agriculture and food security, we selected six crops – dry beans, yams, maize, groundnuts, sorghum, and cocoa – which together occupy almost 60% of the country's total agricultural land (or about 0.7 million ha).

Often grown together with coffee and/or mango, these crops contribute importantly to the food security of smallholder farm families and are critical for diversifying rural livelihoods in the future (Table 1).

Table 1. Harvested area (in hectares) of six selected crops in Haiti.

	Dry beans	Yams	Maize	Groundnuts	Sorghum	Cocoa	Total
2009	102,240	58,582	379,000	25,000	120,000	21,963	**706,785**
2010	98,196	54,846	402,000	22,280	166,678	21,966	**765,966**
2011	90,804	46,240	430,000	24,521	149,935	21,971	**763,471**

SOURCE: FAOSTAT. 2013. http://faostat3.fao.org/home/index.html

We calculated a climate suitability[8] index based on the precipitation and temperature requirements of these six crops. The results show that, under the predicted climatic conditions, some crops will gain in terms of suitability, while others will lose by 2050. As shown in Figure 2, the areas where most crops will become more suitable (green) are concentrated in Grand'Anse, especially around the Pic Macaya National Park and in Centre and Nord Departments (e.g., the area near Plaisance). In contrast, most crops will become less suitable for production in Nippes, L'Artibonite, and Nord-Ouest (red).

We compared the climate suitability index for each crop with an index measuring the availability of agricultural land[9]. The land availability index consists of a combination of the land-cover layer[10] and soil capacity layer[11]. We then reclassified the layers into five main categories, as indicated in Table 2.

[8] Crop suitability analysis does not take into account the risk of crop failure caused by extreme weather events or pest and disease threats.

[9] Land availability index is based on current land cover and land health expressed by soil capacity for agricultural production.

[10] Haitian National Centre for Geospatial Information (CNGIS), downloaded from: http://haitidata.org, Haiti Landcover (Occupation du Sol), SPOT-CNIGS [04.1998] – polygon.

[11] Haitian National Centre for Geospatial Information (CNGIS), downloaded from: http://haitidata.org, Haiti Soil Capacity (Capacité des Sols), CNIGS [04.1998], reclassified into: medium to excellent soil capacity (category I to IV), soils are poor or have lower or medium limitations (category V to VII) and soils are very limited (category VIII, Eau).

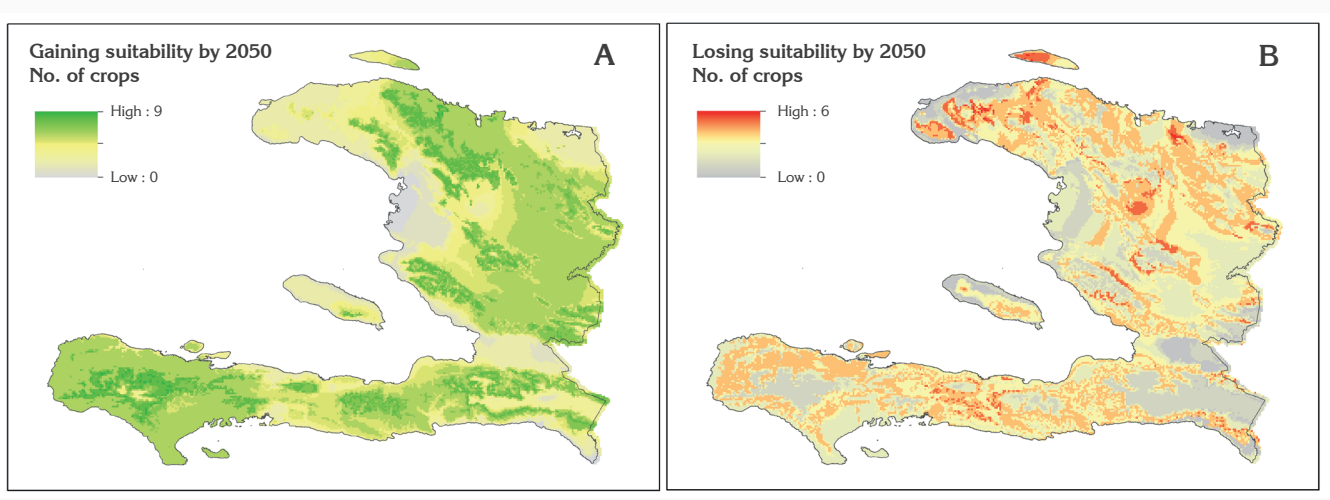


Figure 2. Spatial distribution of crop suitability by 2050: (A) Areas that gain suitability and (B) Areas that lose suitability.

Table 2. Agricultural land availability index for Haiti.

Category	Description of index category
A	Land is available for agriculture and is currently used for crops or pasture; soils have medium to excellent productive capacity.
B	Land is available for agriculture, but the soils are poor, with low or medium productive capacity.
C	The land has soil of medium to excellent productive capacity. Land cover currently consists of forests, agroforestry systems, and savannas but would need to be changed for crop production.
D	The soils have low or medium productive capacity, and land use would need to be changed for crop production.
E	Land is not available for agriculture, because it is currently used for other purposes (i.e., it is occupied by a population center or water body or is barren) or because soils have very limited productive capacity (e.g., due to advanced erosion).

The land availability index calculated for Haiti shows that about 400,000 ha (14% of the country's agricultural land) currently fall into category A; 530,000 ha (19%) into category B; 300,000 ha (11%) into category C; 650,000 ha (23%) into category D; and almost 900,000 ha (32%) into category E. In other words, most of the country's land is not available for agriculture, either because it is dedicated to other uses or has very poor soils. The land that is used for agriculture (including cropland and pastures) and has soils with medium to excellent productive capacity represents only a small proportion (14%) of Haiti's total agricultural land (see Box 1).

In summary, climate suitability analysis for specific crops shows that cocoa is, in general, highly suitable for production in Haiti and is likely to remain so, despite long-term changes in the climate.

Our analysis also shows that beans will become substantially less suitable, especially in the Nord-Ouest, Nord, Nippes, Grand'Anse, and Nippes Departments. Areas with land currently falling into category A (see agricultural land availability Index, Table 2) will see their suitability for bean production decline by up to 70%, while suitability for beans in areas belonging to category B will drop by as much as 60%. In Central America and the Caribbean, maximum temperatures are currently the main limitation in terms of the suitability of environments for common bean production. There is thus an urgent need for improved varieties that are less susceptible to heat but also for alternative cropping systems, which farmers can adopt in areas that will cease to be suitable for bean cultivation.

Studies on maize yields indicate a strong negative yield response to accumulated days above 30 °C and to changes in seasonal rainfall within the growing season. For this reason, appropriate crop improvement and management strategies for dealing with extreme heat in maize production should receive high priority in future work for Haiti, with the aim of maintaining current production volumes.

This study also took into account two varieties of sorghum – one grown at higher altitudes and another at lower ones. In general, the suitability of sorghum for Haiti will increase by 4 to 8% on land falling into category A (Table 2) under the climatic conditions prevailing by 2050.

Results also show that, of the three main yam varieties grown in the Caribbean – *Dioscorea trifida* (cushcush), *Dioscorea rotundata/cayenensis* (yellow and white yam), and *Colocasia esculenta* (malanga) – cushcush yam will become slightly less suitable in most areas; while white and yellow yam will become more suitable; and malanga will decline in suitability for most areas (those remaining suitable for malanga are located mostly in Sud Department).

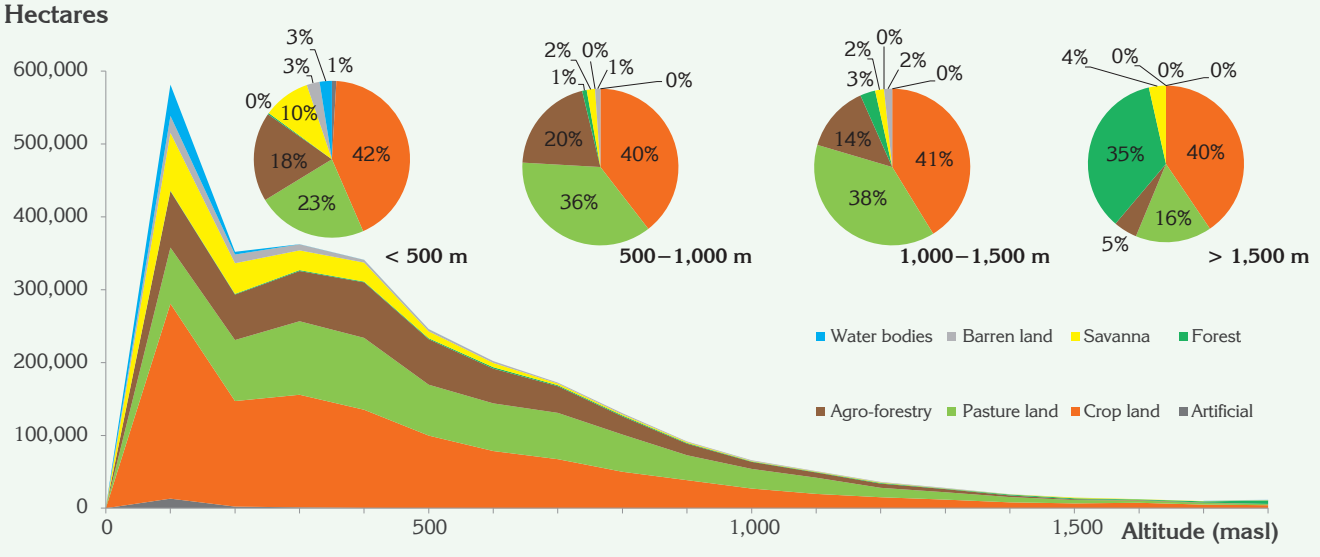
Groundnuts offer the country an important opportunity for agricultural development, since they are expected to remain suitable for production in almost all regions. Moreover, climate change will make the land that is currently suitable for groundnut and falls within category A (Table 2) even more suitable for this crop in the future.

Box 1. Change and altitudinal shift in crop suitability

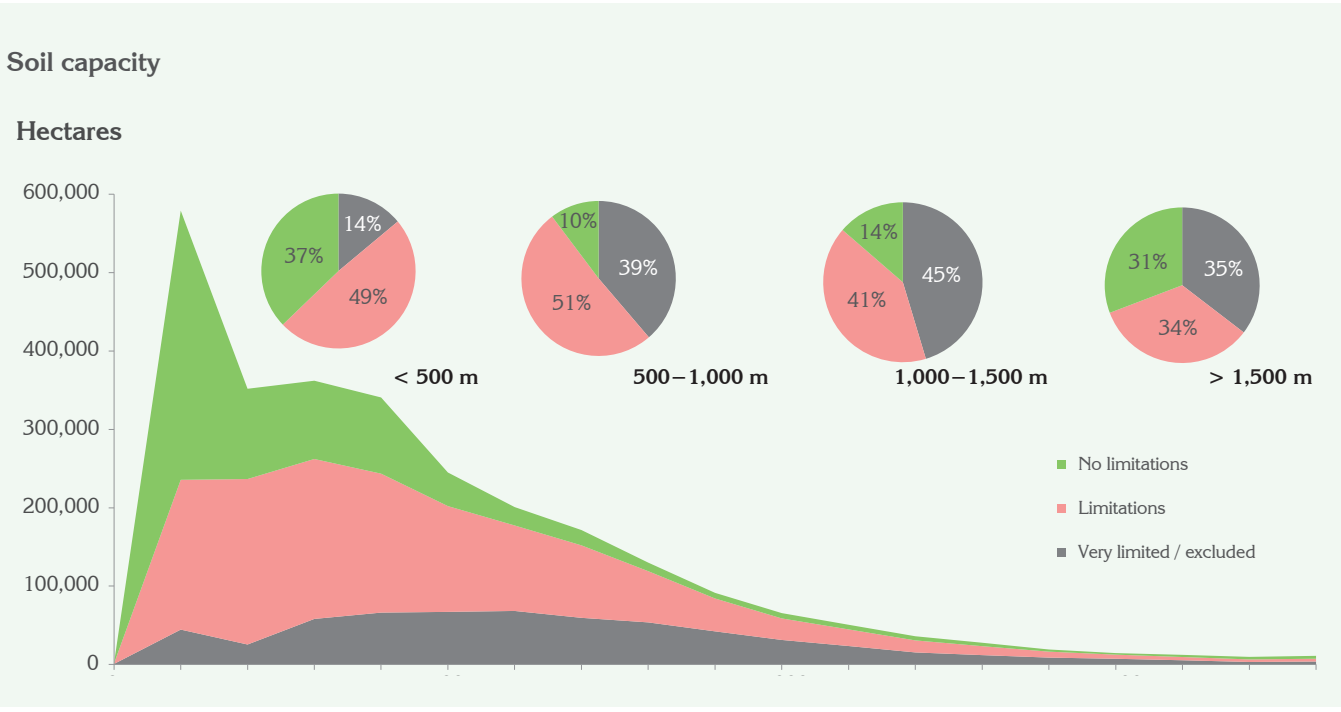
Climate change will have different impacts on Haiti's crop production. The graph in this box shows current land-cover distribution and climate suitability – from losses (-) to gains (+) – together with land availability (categories A to E) and limitations in soil capacity for agricultural production. It also compares all analyzed crops for different altitudes. In areas below 500 masl, dry beans and cushcush yam will become less suitable.

In areas between 500 and 1,000 masl, coffee and dry beans will become less suitabile but can be replaced with cocoa, mango, sorghum, or yam. Climate change will generally enhance the suitability of areas above 1,000 masl for cocoa, groundnut, and yam production by 2050. In areas above 1,500 masl, there will be a higher risk of forest conversion to crop production, given the increasing suitability of coffee, dry beans, groundnuts, and yams in these areas.

Land cover



Crops	Altitude	< 500 m					500–1,000 m					1,000–1,500 m					> 1,500 m				
	Current land use	Crop/past		Wooden		Bare	Crop/past		Wooden		Bare	Crop/past		Wooden		Bare	Crop/past		Wooden		Bare
	Soil limitations	no	lim	no	lim	very	no	lim	no	lim	very	no	lim	no	lim	very	no	lim	no	lim	very
Availability-index (category)		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Coffee	by 2020						-	-	-	-	-	=	=	=	=	=	+	+	+	=	+
	by 2050						- -	- -	- -	- -	-	=	=	=	=	=	++	++	++	++	++
Mango	by 2020	=	=	=	=	=	+	+	+	+	+										
	by 2050	=	=	=	=	=	+	+	+	++	+										
Cocoa		=	=	=	=	=	=	+	+	+	+	++	++	++	++	++					
Dry beans		--	--	--	--	--	--	--	--	--	--	=	=	=	=	=	++	++	++	++	++
Sorghum high							-	-	-	-	-	=	=	=	=	=	=	=	=	=	=
Sorghum low		=	=	=	=	=	++	++	++	++	++										
Maize	by 2050	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
Groundnuts		=	=	=	=	=	=	=	=	=	=	+	+	+	+	+		++		++	+
Yam (cushcush)		-	-	-	-	-	=	=	=	=	=	+	+	+	+	+	++	++		++	++
Yam (white & yellow)		=	=	=	=	=	+	+	+	+	+	+	+	+	+	+		=		=	=
Yam (malanga)		=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=



Three strategies for adapting agricultural systems to future climate change

Agroforestry systems, including coffee production, play an important role in supplying key agricultural commodities and generating cash income for smallholders but also in performing important ecosystem services. A decrease in suitability for coffee is likely to threaten the provision of these services, including soil cover, carbon sequestration, biodiversity conservation, and water storage. A strategy is needed to maintain ecosystem services, and for this purpose, cocoa is a promising option. We propose three interlinked strategies for adapting to future changes in the suitability of coffee for production in Haiti, each of which would need to be implemented successively over time:

- Invest strategically in areas that will become more suitable for coffee, taking into account the need to conserve natural resources.
- Maintain coffee production in areas that will become slightly less suitable through targeted measures, such as irrigation, shade management, and the adoption of drought-tolerant varieties.
- Start to diversify agricultural systems in areas where coffee suitability is likely to decrease significantly, eventually switching to crops such as cocoa, once coffee ceases to be suitable.

Further recommended actions

Given the agricultural sector's vital importance for Haiti's food security, economic recovery, and social stability, the adaptation of production systems to current and future risks posed by climate change must receive high priority in the coming years. We recommend the following actions in particular:

- Develop climate stress-resilient coffee varieties; validate agronomic management strategies; and improve market linkages within the supply chain.
- Provide financial assistance via subsidies, insurance, and payment for ecosystem services – through either direct remuneration or the development of markets to reward sustainable land practices and forest conservation.
- Promote diversification as a short-term risk management strategy and a long-term bridge to full crop substitution.
- Foster the exchange of knowledge and expertise with specialists in climate change adaptation outside Haiti to strengthen capacity and build linkages with regional and global networks, sources of climate financing, and research programs.

Further reading

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