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Jamaica:
Assessing the Impact of Climate Change on Cocoa and Tomato

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Key messages

- *Given expected changes in temperature and rainfall patterns, Jamaica may suffer considerable losses in tomato crop productivity due to a reduction of more than 20% in the area suitable for the crop by 2050. In addition to this, there may be reductions in suitable growing areas due to other climate-related phenomena, such as increasing climate variability and frequency of extreme events such as hurricanes and land loss due to sea-level rise.*
- *Cocoa is likely to have small suitability reductions, affirming the high resistance of the crop in relation to temperature increases. However, the drier areas of the islands will face more severe impacts due to cocoa's high sensitivity to drought.*
- *Crops such as cassava, sweet potato, and yam are good diversification alternatives. Their climate suitability in Jamaica is expected to remain and even increase in the face of climate change.*
- *In 2050, the climate suitability of all crops monitored in this study will increase in certain areas, mainly towards the median altitudinal gradients situated around the high mountains of the islands. As these areas are currently used for forest conservation or the production of other crops with equal economic importance, land-use pressure is likely to increase.*
- *Although there are areas where the monitored crops will likely gain suitability, shifting climatic conditions mean their geographic distribution is expected to change in the coming decades. Long-term monitoring will be required to ensure the most suited crops are grown in each area.*
- *Climate variability is just as (if not more) important as long-term climatic changes. For example, extreme weather events such as hurricanes make it very difficult for farmers to plan and think long term.*

The relatively high sensitivity and exposure of Caribbean islands to both present-day and future projected climate change impacts are now well documented. With respect to future climate change projections, the Caribbean region is expected to transition to a warmer and drier climate regime over the course of this century. This represents a significant risk in terms of food security for Jamaica and the wider Caribbean. A progressively drier and warmer regional climate is expected to reduce crop productivity and increase instances of crop failure. This is made even worse by the fact that, currently, the productivity and resilience of Caribbean agriculture is limited by a lack of cultivars suited to local conditions. This problem is expected to worsen as global climate change increases the occurrence of heat waves and droughts across the region.

This policy brief explores the consequences of climate change on cocoa and tomato production in Jamaica. The report describes work carried out by the International Center for Tropical Agriculture (CIAT) in partnership with the University of the West Indies (UWI), which used climate predictions and crop suitability models to assess the likely impact of climate change on crops grown in Jamaica. Results from the study indicate that there will be a reduction in the area of land suitable for growing tomato (and several other annual crops), as the region's climate gets progressively warmer. The largest reductions in suitability are expected in low-lying areas, particularly along Jamaica's southern coast. However, in the case of cocoa, the impacts are less significant, suggesting its cultivation could be expanded as a response strategy to the projected changes in climate. Additionally, it was found that the higher areas of the island would gradually gain suitability for both tomato and cocoa over time.

Key recommendations for the Ministry of Agriculture and other key sector stakeholders include: implementing water efficient technologies; planting drought-resistant varieties; promotion of agroforestry practices; improving the use and management of soils; enhance protection of forested upland areas to prevent encroachment due to changes in land suitability at lower altitudes; build awareness among farmers regarding the use of natural resources and the importance of adopting new agricultural technologies.

Socioeconomic situation

Jamaica is the third largest island of the Greater Antilles with a land area of 10,830 square kilometers and a population of 2.7 million people. With a GDP of US$14.36 billion in 2013, Jamaica is economically classified as an upper-middle-income country. Although the country's GNI per capita (PPP) was US$8,490 in 2013, almost 18% of its population still lives below the national poverty line.

Agriculture

Jamaica's share of agricultural land as part of total land area was 41.5% in 2012. Almost half of Jamaica's population lives in rural areas, totalling over 1.2 million rural residents. As 26% of the male workforce and 8% of the female workforce are working in the agricultural sector, agriculture could be considered one of Jamaica's main livelihood activities. However, despite employing 18% of the workforce, in 2012 the agricultural sector generated 6.7% of the GDP. The main crops produced are sugar cane (37%), fruits (29%), vegetables (19%), and roots and tubers (12%). Dating back to the days of colonial rule, the agricultural economy is characterised by a dual structure, comprising a large-scale export-oriented sector, and a small-scale sector that produces for subsistence and the local market. Small-scale farmers are by far the most vulnerable to natural hazards, not least because the majority are resource poor and cultivate marginal lands. Although they engage in agricultural practices that are diverse, complex, and high risk; agricultural extension and development loans are often not available to these farmers.

Natural hazards

The climate of Jamaica is tropical, consisting of diverse microclimates that are highly suitable for a range of tropical crops. However, the climate tends to be very unpredictable. As a result of several droughts and tropical cyclones, domestic food crop production declined by 40% between 1996 and 2004. Since then, Jamaica has been seriously affected by Hurricanes Dennis and Emily (2005), Hurricane Dean (2007), and Tropical Storm Nicole (2010), which alternated with periods of drought and heavy rains. This accumulation of meteorological hazards ravaged Jamaica's small-scale farming sector and decreased the resilience and food security of many small farmers, simultaneously endangering domestic food production. Given the small resource base of most of Jamaica's smallholders and the limited access to agricultural credit and extension services, the interaction between rural poverty and natural hazards results in short-term farm management planning that impedes agricultural sustainability.

General impact of climate change in Jamaica

Small island states such as Jamaica are expected to be severely affected by climate change because of their small landmass, fragile ecosystems, and concentration of infrastructure along the coast. Climate change models are predicting a temperature increase for coming decades. At the same time, annual rainfall is expected to decrease and the risk of natural hazards to increase, significantly affecting agricultural practices and already vulnerable rural livelihoods. Climate change is not only likely to cause a decline in yields of the island states' most important crops, the distribution of crop suitability within the current production areas will change as well.

According to analysis of climatic data for emissions scenario RCP 8.5 (a scenario of comparatively high greenhouse gas emissions), derived from the Fifth Report of the Intergovernmental Panel on Climate Change (IPCC, AR5), several changes in climatic characteristics on the island of Jamaica are to be anticipated:

- Models predict that by 2050 the annual rainfall will have decreased between 700 mm and 800 mm (currently 2219 mm average rainfall per year).
- In comparison to current temperatures, on average in 2050 the annual mean temperature will have risen between 2 and 2.1 °C.
- The average temperature of the warmest month potentially increases between 2.1 and 2.2 °C by 2050; while in the coldest month, the minimum temperature is forecasted to increase by 1.8 to 1.9 °C.
- Climate patterns are likely to show more variability in the future (changes in frequency and magnitude of events such as droughts or heavy rainfall periods).

All weather predictions forecast a gradual increase in temperature and a moderate decrease in rainfall. Predicted water shortages and increases in evapotranspiration will present a problem for agricultural production.

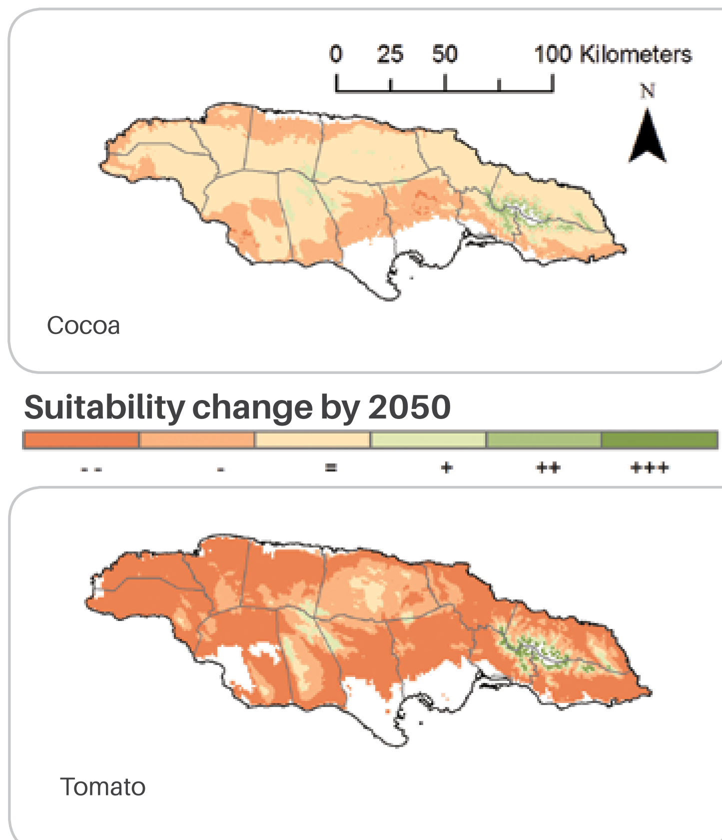


Figure 1 Modelled suitability change of cocoa and tomato in Jamaica by 2050. Green-coloured areas are predicted to have increasing (+ signs) suitability change in the future, red areas are predicted to have decreasing (– signs) suitability change for the specific crop. Number of signs shows magnitude of increase/decrease, equal sign (yellow areas in the map) means no predicted future change of suitability.

Slight changes for cocoa in driest zones

Cocoa is typically produced by smallholders. According to our crop model, under the influence of climate change the crop-growing areas will not have significant suitability changes. This is because cocoa has a tendency to maintain its suitability level and will, at most, suffer suitability losses of less than 15% on the drier and lower zones in the context of projected temperature increases and decreased precipitation. Moreover, climate change is likely to result in suitability gains in elevations above 800 meters, especially around the main mountains of the island, which are currently generally utilized as forest conservation zones and for coffee production. Due to the wide temperature range of cocoa, the expected temperature increase is not expected to have significant effects on the crop. Reductions in rainfall and changes in precipitation patterns are the most likely direct causes of declining crop yield. To reduce the impact of climate change, small-scale cocoa farmers should implement efficient irrigation systems to ensure water availability during times of prolonged drought. Other indirect impacts of changes in climate, such as changes in disease prevalence, were not included in this work.

Expected higher impacts on suitable land for tomato

In Jamaica, the tomato crop is grown on a smaller scale, often with the assistance of greenhouse systems. While the precipitation rates render large parts of the islands suitable for the production of tomato, the major limiting climate factor is the high temperatures that characterise the coastal areas. In contrast to cocoa, more than 80% of the currently suitable areas for tomato growing will have negative changes in suitability as a result of climate change, with losses that exceed 30%. At the same time, in Jamaica, small areas above 1200 meters will become more suitable for tomato cultivation.

Majority of farmers believe Caribbean climate is changing

Community-level surveys were carried out with farmers operating in established cocoa- and tomato-growing regions in Jamaica. The surveys were aimed at collecting a range of baseline information – including data on existing agronomic practices and challenges associated with growing certain varieties of tomatoes and cocoa.

Fieldwork results indicate that the majority of farmers believe the climate is changing. Approximately 78% of the farmers reported observing changes in rainfall patterns over the last 20 years. An even greater number (84.7%) indicated experiencing changes in the timing of the traditional rainy season. Most farmers also reported a noticeable expansion in the length of the traditional dry season.

Approximately 70% of the farmers surveyed indicated that they have observed a noticeable change in mean temperature over the last 20 years. The large majority of farmers held the view that the mean temperature has increased over the period.

Despite these observed changes, only a small proportion of farmers reported taking any measure to adjust to the observed changes in rainfall and temperature. In fact, only 13% of cocoa farmers were found with irrigation on their land. The large majority of estates were rain fed. Coping strategies generally include practices such as:

- Mulching.
- Increasing the application of certain inputs such as fertilizers (very costly though).
- Employing a range of on-farm irrigation and water storage practices.

Main production challenges

In terms of production challenges, as much as 91% of all farmers indicated that their crops have been affected by disease in the past, and another 62% have experienced at least one major crop failure in the last 10 years. Other major environmental threats to the farming sector include hurricanes, droughts, and floods. The main challenge experienced by Jamaican cocoa farmers is disease, particularly the Black Pod disease. Black Pod, also known as Pod Rot, is caused by the fungus *Phytophthora* spp. The disease is widespread in Central and South America, causing significant losses even in favourable environments. Pods can be attacked at any stage of development, and the initial symptoms are small, hard, dark spots on any part of the pod. Internal tissues, including the beans, are later colonized and shrivel to form a mummified pod. Under humid conditions, a single mummified pod infected can produce up to 4 million sporangia which can then be disseminated by rain, ants, flying insects, rodents, bats, and contaminated pruning material. Breeding for resistance is believed to offer the best long-term management strategy. The occurrence of severe and frequent droughts was also a major issue amongst cocoa farmers. Unlike cocoa farmers, tomato farmers in Jamaica ranked hurricanes as their greatest threat.

Figure 2 Cocoa farmer in Jamaica showing example of the Black Pod disease.

In Jamaica, as much as 96% of the cocoa farmers indicated that they were not satisfied with the performance of current cocoa varieties. Farmers' perceptions of the ability of existing cocoa varieties to cope with harsher growing conditions were generally mixed. Only approximately 56% of cocoa farmers believe current varieties would cope well under drier conditions compared to 84% of cocoa farmers who believe current varieties would cope well under warmer conditions. Despite these results, only 52% of farmers surveyed indicated an interest in trying out new cocoa varieties.

Impact of climate change on alternative crops

With the aim of providing efficient crop diversification strategies to ensure farmers' food security in the face of eventual climate change, five other crops of economic importance were identified on the basis of the islands' national production data reported by the Food and Agriculture Organization of the United Nations (FAO). The crops selected were yams, bananas, sweet potato, cassava, and ginger. By calculating the climatic suitability index based on temperature and precipitation ranges (optimal, absolute) for each crop, an analysis was performed to estimate potential suitable areas and the impact of climate change on the crops.

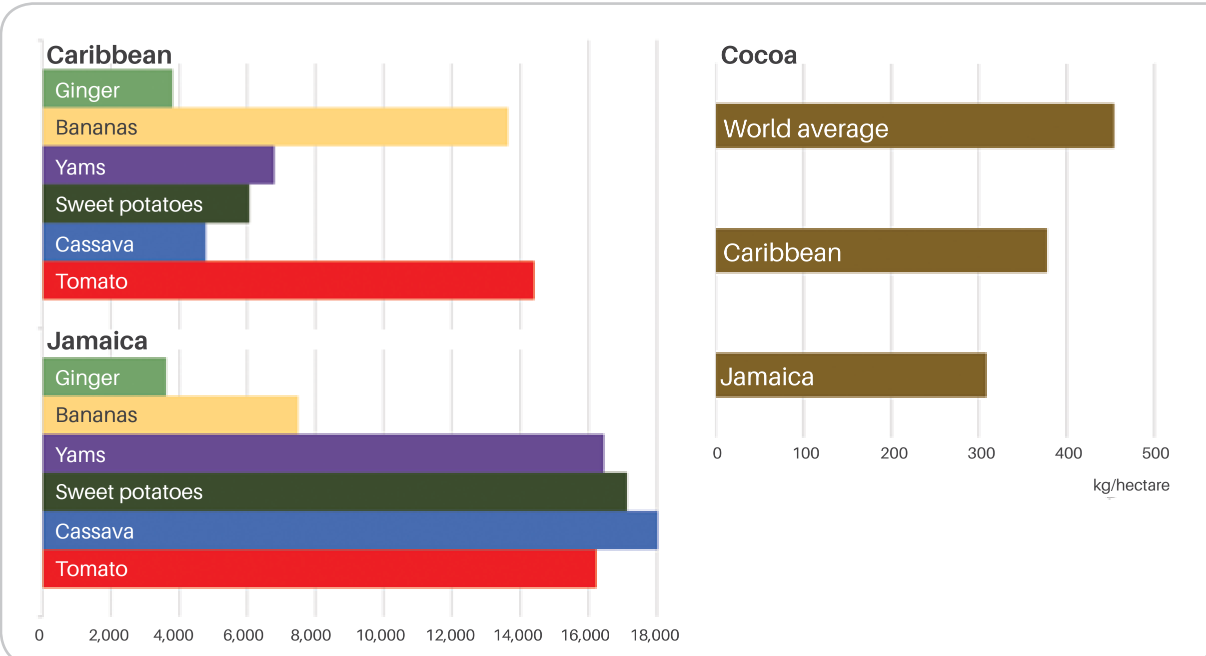


Figure 3 Comparison of average of historical yield (2008–2013) for cocoa, tomato, and alternative crops in the Caribbean.

The climate suitability assessment under the RCP 8.5 scenario shows that large areas will have increased suitability for most crops in Jamaica. In contrast, some areas show decreased climate suitability for more than three crops, coinciding with the driest areas of the island (annual rainfall < 1500 mm): the north-western coast and a large part of the Clarendon, Saint Catherine, and Saint Elizabeth parishes.

In order to identify the agricultural potential in the soil–plant–atmosphere interactions, the climate suitability results obtained in relation to the percentages of soil use and availability were analysed (Box 1).

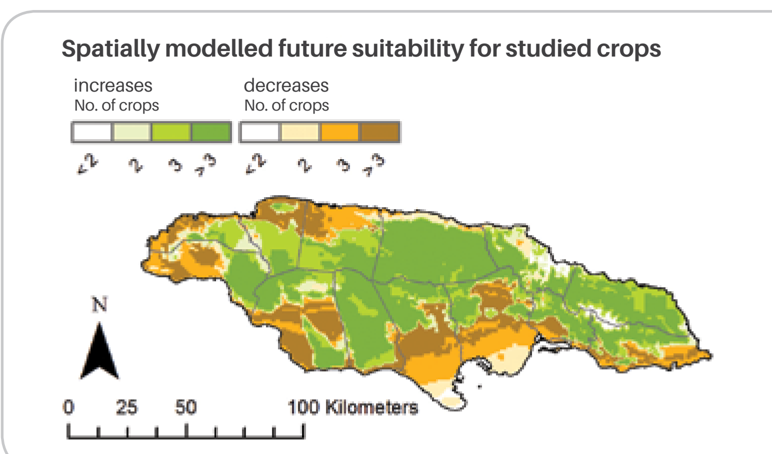
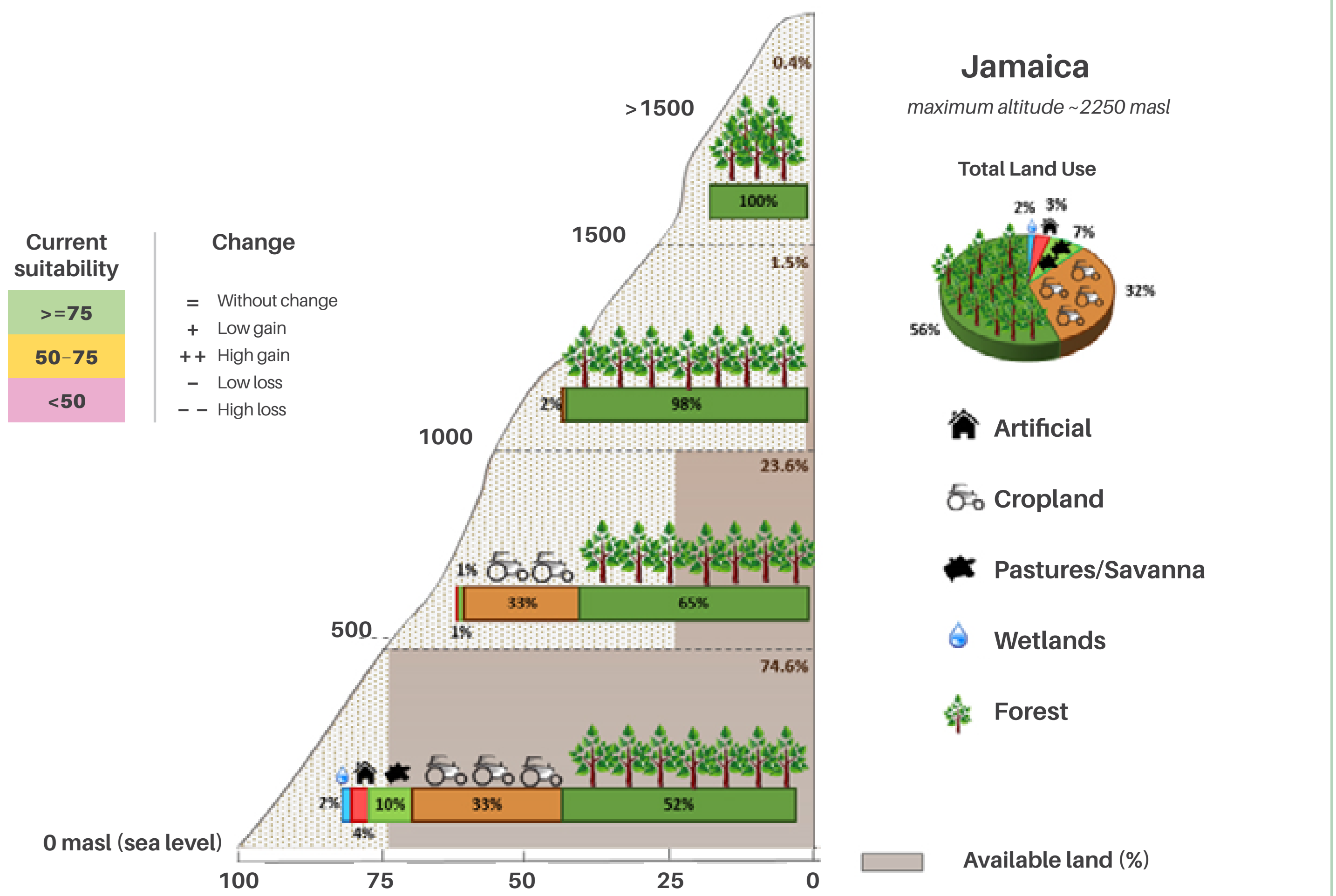


Figure 4 Spatially modelled future suitability of alternative crops in Jamaica, showing areas where most crops have increasing (green colour gradients) or decreasing (orange colour gradients) climate suitability by 2050.

Box 1 Change in crop suitability across altitudinal ranges and land cover.



Country	Altitude	< 500 m			500 – 1000 m			1000 – 1500 m		
	Crops/Land use	Croplands	Forest	Pastures	Croplands	Forest	Pastures	Croplands	Forest	Pastures
JAMAICA	Cocoa	–	–	–	=	+	=	++	++	
	Tomato	– –	– –	– –	–	++	–	++	++	
	Banana	–	–	–	+	+	+			
	Cassava	–	=	=	+	+	+	++	++	
	Sweet potato	=	=	=	+	+	+	++	++	++
	Yams	+	+	+	++	++	++			
	Ginger	–	–	–	=	+	=	++	++	++

The graph in this box shows the current distribution of land cover and climate suitability with losses (-) to gains (+) coupled with the availability of land (%) in each altitudinal range.

The results indicate that climate change may represent negative impacts for some crops in Jamaica, especially in areas between 0–500 meters above sea level (masl). Meanwhile, the production of yams, cassava, and sweet potato crops can be maintained and even gain suitability.

Cocoa farming shows a minimal suitability loss for territories located within 500 masl. It is expected that this cultivation will be maintained and will progressively become more suitable in areas with higher altitudes. However, the percentages of national territory under these conditions only correspond to 25.5% in Jamaica. Considering that over 98% of these high-altitude zones are currently intended as forest cover, the potential change in land use could increase the pressure on the forests. In the future, there is a risk that forest lands will be converted in order to serve the aim of agricultural production.

In Jamaica, crops can gain or maintain suitability in areas with altitudes greater than 1000 masl. However, these conditions are not very representative as only 1.9% of the island represents this type of topography. According to numbers reported to FAO, the current land use is characterised by a division of over 50% for forestry purposes and about 30% for agricultural production. It is expected that climate change will alter this tendency by offering incentives for converting forest areas into land for crop production. An effective strategy to avoid this situation is to diversify current agricultural areas with crops that are resistant to high temperatures, such as yam, cassava, and sweet potato, in order to ensure higher yields within smaller areas.

Further recommended actions

The following recommendations are targeted primarily at Jamaica's Ministry of Agriculture and Fisheries, and related agencies such as the Rural Agricultural Development Authority (RADA). Policy makers and practitioners should seek to:

- Promote crop diversification as a short-term risk management strategy and a long-term bridge to full crop substitution. Crops such as cassava, sweet potato, and yam are good diversification alternatives.
- Promote the use of water-efficient technologies where feasible. The adoption of more efficient and cost-effective crop irrigation schemes, including rainwater harvesting and drip irrigation, can play a crucial role in reducing the sector's vulnerability to droughts and variable rainfall patterns.
- Inform farmers on suitable planting dates for crops in the context of climate change, possibly through an agricultural extension system.
- Initiate testing of alternative crop species and varieties to ensure that the most climate-resilient crops are available to farmers. This could be achieved by introducing testing for heat and drought resilience as part of the Caribbean agricultural research programme, e.g., by systematic consultation with growers to determine the resilience of available varieties under production conditions, or by direct testing of new crop varieties under experimental conditions (this system is currently under development at the University of the West Indies [UWI]-St. Augustine).
- Monitor changes in climate to determine the most suitable growing areas into the future.
- Initiate participatory environmental strategies and policies to ensure the preservation of forested areas. This will have numerous benefits, in particular carbon sequestration and protection of water resources.
- Strengthen farmers' capacity to absorb and incorporate new technologies and scientific information in their decision-making processes. The promotion of farmers groups or more participatory forms of agriculture extension services that can better facilitate the transfer of scientific and other technical knowledge.

Further reading

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