Coffee farming on the Old Town Coffee Estate, Jamaica Blue Mountains

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Agricultural development on islands

DAVID BARKER

University of the West Indies
Mona Campus
Jamaica

ABSTRACT

The challenges faced by agriculture and rural communities in small islands have entered a new era of vulnerability during the last 25 years as a result of the onset of global change — a range of external forces related to climate change and economic globalization. These transformative forces interact together in complex ways that have differential impacts on people, places, groups, and institutions. Remarkably, even within a small

island, such impacts vary significantly from place to place depending on local conditions. This can pose huge challenges for island planners with limited resources, especially in the field of agriculture and rural development. Double exposure provides a useful framework for examining how shocks and stresses associated with global change can create vulnerabilities in the agricultural sector at the island level, and within farming communities at the local level. In this paper, illustrations of the utility of such an approach are provided. The examples relate to export agriculture and domestic small-scale farming in the Caribbean region at the national and local level. In rural communities, spatial patterns of household vulnerability and adaptive capacity are not uniform across a small island, so their identification is critical to rural development: one size does not fit all in formulating rural development policy. Much of the current focus on adaptation to global change in tropical agriculture explores methods of strengthening resilience, particularly at the community level.

CONCEPTUAL FRAMEWORK: GLOBAL CHANGE AND DOUBLE EXPOSURE

The 2017 hurricane season brought into sharp focus the vulnerability of small islands to calamitous meteorological hazards, as the arc of islands on the northeast rim of the Caribbean Basin suffered two Category 5 hurricanes, Irma and Maria. The extent of the damage caused by these disasters is yet to be assessed, but for Dominica, Barbuda, Puerto Rico, and the British and US Virgin islands it will be catastrophic to their economies and GDP, to key sectors like tourism and agriculture, but, most importantly, for people and their livelihoods. Recovery will be measured in years, not months.

Climate change is taking centre stage in analyzing the vulnerability of small islands, but economic globalization and the restructuring of the world economy also have had far-reaching impacts in relation to agriculture and rural livelihoods, and the impacts of both are generally negative (Barker, 2012). We use the term "global change" to describe the combined effects of economic globalization and climate change, and these two broad sets of external forces have ushered in a new era of vulnerability for small islands (McGregor et al., 2016). In the colonial period, islands were locked into a system of dependence on the metropolitan power, but restructuring of the global economy changed the old order. Many islands felt the full impacts of trade liberalization in the 1990s, at the same time that the negative impacts of climate change began to be recognized.

O'Brien and Leichenko (2000) coined the term "double exposure" to describe the simultaneous, combined effects of global environmental change and global economic change. Double exposure is an analogy taken from conventional (pre-digital) photography, and used as a metaphor for the simultaneous exposure to risks associated with climate change and economic globalization. It can be applied to a country, a

community, a social group, or an organization, usually referred to as the "exposure unit." The outcomes of double exposure may be accidental or intentional, negative or positive, so there may be winners and losers (Leichenko & O'Brien, 2008). When outcomes are negative, double exposure is a lens through which vulnerability can be analyzed in a holistic way. McGregor et al. (2016) argue that double exposure is a useful framework to examine vulnerability at the island scale because it can apply at the national and community level of analysis.

The multiple impacts associated with global change are termed shocks and stresses. Shocks are fast-onset, abrupt events while stresses are more gradual conditions that develop over a longer period of time. Examples of environmental shocks are the impact of a hurricane or tropical storm, or a major flood event. The impact of a drought, higher temperatures, or gradual shifts in seasonal rainfall patterns are examples of environmental stresses. Examples of economic shocks include a currency devaluation or a fall in world commodity prices, whereas examples of economic stresses are a gradual reduction of tariffs through trade liberalization, or persistent rural outmigration in response to overseas labour markets.

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There is an extensive literature on how to conceptualize, operationalize, and measure elusively simple terms such as vulnerability, resilience, and adaptation (see, for example, Adger, 2006; Briguglio, 2016; IPCC, 2014, p. 5; Pelling, 2011). Vulnerability reflects susceptibility to the negative outcomes of global change, and a common theme is to distinguish between an external and an internal component (Chambers, 1989). The external component represents multiple economic and environmental shocks and stresses associated with global change which can impact an island, a community, or a household. The internal component is the adaptive capacity of the exposure unit to cope with and adapt to shocks and stresses.

The paper examines the challenges facing agriculture and rural populations resulting from economic globalization and climate change. It explores how the study of agricultural vulnerability at the island scale has been enriched and extended by studies of agricultural vulnerability at the community scale. The narrative is steered by two significant trends in the literature: increasing recognition of the ramifications of climate change as a driver of global change, and a scaling down of the research effort to focus on the vulnerability of rural communities.

Firstly we note how global economic change led to a decline in the role of agriculture in small islands as they transitioned to tourism-based economies; yet supply-chain linkages between the two sectors are weak. Next, we illustrate how agricultural vulnerability is constrained by the limited capacity of small islands to

adapt to international competition from large-scale producers. A case study of the decline of export bananas in the Eastern Caribbean shows how trade liberalization and climate hazards negatively impacted the economies of the Windward Islands and farmers' livelihoods. Then we briefly review how downscaling of global climate change models has produced more detailed climate change scenarios and allows rainfall and temperature projections to be made not only for islands, but for regions within an island. This enables vulnerability studies at the community level to be synchronized with predictions about changes in local climates, and how local cropping systems may be affected.

The last section tells the story of how a community-based approach to agricultural vulnerability unfolded in Jamaican research. We documented farmers' local knowledge of changing weather patterns, which corroborated scientific projections of shifting and increasingly variable patterns of seasonal rainfall. Persistent drought and tropical storms were disrupting farmers' traditional methods of coping with their fragile farming environment, and their efforts to adapt were proving ever more difficult. In the last ten years, community-based approaches to climate change adaption have become increasingly important as a policy option for capacity- and resilience-building in developing countries. Caribbean researchers have embraced this approach and pioneered the use of double exposure and the Sustainable Livelihood Framework (Chambers & Conway, 1992) to develop participatory research methodologies in rural farming communities. One output of this community-based research is a variety of approaches to compiling community vulnerability indices.

ISLAND AGRICULTURE AND AGRICULTURAL VULNERABILITY

Decline of agriculture and the rise of tourism

During the colonial period, tropical islands tended to have a dual agricultural economy, comprising one or two export crops produced by large-scale plantations or estates, and a domestic food production sector dominated by small-scale farmers (Barker, 1993). It is less easy to generalize about agriculture today. Most islands have witnessed a general retreat from agriculture, and many have fully transitioned into a service economy dominated by tourism. McElroy and de Albuquerque (1990) partly attribute agricultural decline to low-cost rural labour attracted to relatively higher wages in the tourism sector. In larger islands like Jamaica and the Dominican Republic, rural migrants are drawn into coastal tourist areas from the interior upland farming areas, whereas smaller islands like the Virgin Islands attract rural migrants from neighbouring islands with larger populations.

In the Caribbean, commercial agriculture has virtually disappeared in very small islands with small populations, examples being the Virgin Islands and St. Martin/Sint Maarten. For medium-sized islands with populations between 100,000 and

Yam farming in central Jamaica

300,000, such as Barbados, Antigua, and more recently St. Lucia, fewer people are employed in agriculture and per cent contribution to GDP has declined. However in the larger islands of the Greater Antilles — Cuba, Dominican Republic, Haiti, and Jamaica — agriculture has also declined in contribution to GDP, but remains a significant source of employment. In the Dominican Republic, agriculture declined from 21% of GDP to 5% between 2000 and 2016, yet 16% of the population are still employed in agriculture. In Haiti, the poorest country in the western hemisphere, more than 2 million people work in agriculture, which accounts for 22% of GDP. In these islands, large rural populations are dependent on agriculture for their livelihoods. The majority of households are small-scale farmers who account for the bulk of domestic food production, so the sector is critical to food security. Although these rural households are to some extent food-secure, rural populations still live in a condition of persistent rural poverty as they did a generation ago (Barker, 1993).

Agriculture-tourism linkages

There are many linkages between agriculture and tourism, such as competition for cheap labour and for scarce land in coastal areas (McElroy & de Albuquerque, 1990). Terrestrial ecosystems are spatially interconnected to coastal ecosystems (Potter et al., 2004) such that farming contributes significantly to soil erosion and land degradation, and sediment from upland farming areas is carried by rivers into the coastal zone. Silt plumes can extend out to sea affecting the coral reefs, coastal fisheries, and tourism. Similarly, agrochemicals used in commercial farming can pollute water supply and coastal zones.

However, a critical but under-researched linkage is the food supply chain between local agriculture and the tourist sector. Surprisingly, such linkages are weak and underdeveloped, even on islands that have experienced mass tourism for 40 years. Why has the agriculture sector not taken better advantage of market opportunities afforded by tourism growth? Early studies lamented the absence of such linkages (Belisle, 1983) while later studies (Momsen, 1998; Timms, 2006) found only "some" improvement, as tourist destinations matured and there was more government support for tourist-related agriculture.

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There is a dearth of empirical research on these linkages, but insights from a detailed Jamaican study may have lessons for other islands. Rhiney (2011) collected and analyzed data on food production systems of small farmers, food inventories of hotels in a tourist resort, and operations of middlemen. He argued that problems occur at both ends of the supply chain, with small farmers and hotels. Small farmers were unable to supply high-quality, competitively priced produce to hotels on a consistent basis. They use traditional informal marketing systems whereas the hotel sector insists on a legal contract with a supplier, a system unfamiliar to small farmers. Other problems included farmers' poor access to technology and financial resources, and poor island infrastructure and transport systems. Competition from cheap food imports was another major concern. The supply chain issues for the hotel sector revolved around the lack of communication with the farming community in articulating their need for regular supplies of high-quality produce. Small farmers are not well-organized in Jamaica: there are few farmer groups and farmer co-operatives. Hotels prefer to deal with representatives from larger organizations or middlemen, rather than with individual farmers. Many hotels, particularly the larger all-inclusive hotels, tended to import cheaper and/or better-quality food from the US rather than source it from local farmers.

Agricultural vulnerability and characteristics of SIDS

The seminal approach to the study of vulnerability at the island scale is illustrated by the pioneering work of Briguglio (1995) who examined the vulnerability of Small Island Developing States (SIDS). Sources of island vulnerability which constrain economic development include open economies dependent on external trade and natural disasters such as hurricanes and tropical storms. These may be considered elements of the external component of vulnerability in the double exposure framework, within the broader guise of economic globalization and climate change. Other vulnerability constraints on SIDS include physical constraints such as a relatively small land area, limited amounts of good arable land, limited natural resources, limited scope to exploit economies of scale, and fragile agro-ecosystems (Briguglio, 1995). These can be considered part of the internal component of vulnerability at the island scale in the double exposure framework, and reflect the limited internal capacity of an island to adapt to global change.

The limited capacity of island agriculture to adapt to economic change is aptly illustrated by the decline of sugar production in the Caribbean. In 2005 St. Kitts became the latest Caribbean island to abandon sugar after a 300-year history of production (Clarke, 2014). In 1961 the Caribbean region produced 20% of the world's exports of sugar, but by the turn of the century it produced less than 4% (Potter et al., 2004). The decline can be measured as volume produced and per cent contribution to global sugar exports. Caribbean sugar was unable to compete on the world market after the entry of large-scale producers such as Brazil and Indonesia. The limited supply of good arable land restricts an island's ability to exploit economies of scale. Caribbean sugar industry is undercapitalized and constrained by outdated technologies: sugar cane is still harvested by hand and sugar factories are antiquated.

Agriculture's capacity to adapt to global change is also compromised by land degradation and soil erosion which negatively impact agricultural productivity. Degraded hillside farming areas are susceptible to flood rains, landslides, and other forms of mass movement which disrupt farming systems, transport and communications, and agricultural marketing networks. Haiti is an extreme case where land degradation impedes agricultural production and rural poverty is chronic. In Jamaica, 10 of the island's 26 watersheds are classified as critically degraded (NEPA, 2011). The impacts of land degradation on farm output and productivity are almost impossible to quantify, but degraded uplands are important farming areas in terms of household and national food security. In some cases such farming regions make a significant contribution to foreign exchange earnings, as in the case of Jamaica Blue Mountain Coffee and yams (Barker & Beckford, 2006), Significantly, these uplands are areas of persistent rural poverty, so analysis of agricultural vulnerability needs to

be grounded in studies at the community level, and focus on how to provide more dignified sustainable livelihoods for their rural populations.

Trade liberalization and export bananas in the Windward Islands

After political independence, many SIDS benefitted from protected trade agreements in overseas markets for critical export crops like sugar and bananas. The Lomé Convention in 1975 established preferential access for Caribbean bananas into Europe. In the Windward Islands of St. Lucia, St. Vincent and the Grenadines, Dominica, and Grenada, export banana production soared, and bananas were so lucrative they became known as "Green Gold" (Klak et al., 2011). But the islands became dangerously dependent on a single crop export; bananas accounted for 40–50% of island exports, 30–35% of employment, and 10% of GDP.

FAIR TRADE is an "ethical" trading system based on alliances between producer associations in developing countries and consumer organizations in developed countries, and is seen as an alternative to conventional "free trade."

The onset of neoliberalism involved the gradual dismantling of protective trade tariffs to promote more open, free-trade economies. In what came to be known as the "banana wars" (Klak et al., 2011), lobbying by the larger Latin American producers and the United States led the WTO to dismantle preferential entry for bananas into the EU. In the Windward Islands, 85% of producers were small hillside farmers with farm plots of less than five acres. They were unable to compete with Latin American producers working in partnership with multinational corporations, utilizing highly mechanized plantations on flat, fertile land, some of which were 10,000 acres in size. Island banana producers could not scale up production to reduce costs. In the 1990s the world price of bananas was around 450 USD per tonne but production costs in the Windward Islands were over 500 USD per tonne. The Windward Islands could not quickly adapt to this rapid series of economic shocks; banana production went into steep decline, and the number of banana farmers declined from 23,000 to 4,000 by 2007 (Barker, 2012).

In the face of such economic challenges, the Windward Islands adapted by shifting into Fair Trade in an effort to take advantage of niche market opportunities. Fair Trade is an "ethical" trading system based on alliances between producer associations in developing countries and consumer organizations in developed countries, and is seen as an alternative to conventional "free trade." It provides a guaranteed price to farmers which includes a social premium, paid to fair trade farmer groups, and invested in local community development (Fingal, 2008). The Fair Trade movement gained traction among European consumers who seemed prepared to pay a higher price because profits were seen to go more directly to small farmers in developing countries.

	2002 thousand tonnes	2008 thousand tonnes	2011 thousand tonnes
Dominica	17.5	14.1	4.1
St Lucia	49.3	34.9	12.1
St. Vincent and Grenadines	36.9	23.8	11.0
Grenada	0.2	0.2	0
Dominican Republic	114.7	205.6	303.8

TABLE 8.1: **Banana exports for selected Caribbean countries**

Source: FAO (2014) Banana Market Review and Banana Statistics, 2012-2013

Fair trade banana exports began in 2000, but banana production has continued to stagnate and decline (Table 8.1). St. Lucia, the biggest producer, is transitioning rapidly into a tourist economy (Walters, 2015). But the problem is that bananas are particularly susceptible to strong winds, so any rain-producing weather system can cause serious crop loss, and full recovery will take nearly 12 months. Tropical storm activity over the last 15 years had devastating impacts on an industry already reeling under the impact of trade liberalization. Tropical Storm Lili impacted St. Vincent in 2002. Grenada stopped exporting bananas after Hurricane Ivan in 2004, followed by Hurricane Emily in 2005. In 2007 Hurricane Dean caused extensive damage to banana production in St. Lucia and Dominica, then Hurricane Tomas in 2011 wrecked the industry again in St. Lucia and in St. Vincent. Following the 2017 direct hit on Dominica by Hurricane Maria, export bananas there will suffer yet another crippling blow.

Windward Islands has had only limited success with Fair Trade bananas, but neighbouring Dominican Republic shifted into Fair Trade and has also become the world's largest exporter of organic bananas, with 15,000 certified small farmers (Raynolds, 2008). She cites the important role of international NGOs in providing training as a contributory factor to success, but government support was critical, too. Local collection and marketing systems are well-organized through producer associations, but the number of small banana producers is declining relative to larger producers.

CLIMATE CHANGE AS A DRIVER OF AGRICULTURAL VULNERABILITY

Nurse et al. (2014) document an alarming picture of how climate change is likely to affect small islands in the future. While rising sea level is an existential threat for many low-lying islands, the main concerns here are the threat of an increase in the frequency and magnitude of tropical cyclones, and the wider regional implications for farming systems as a result of increasing temperatures and shifting seasonal rainfall.

Hurricanes and tropical storms

In the Caribbean, there appears to be an increase in the intensity and severity of hurricanes, linked to a rise in sea surface temperatures, though there is still debate as to whether climate change will increase hurricane frequency and magnitude (Gamble, 2009). Storm activity has broken records over the last two decades. At the time, the 2005 hurricane season was the worst on record. But it was surpassed by the 2017 season, not only for the number of Category 5 hurricanes, but for their rapid intensification due to ocean temperatures higher than normal. Hurricane Irma, and then Hurricane Maria, formed within a short space of time and followed similar tracks. Puerto Rico and the Virgin Islands had direct hits twice in a couple of weeks.

Tropical cyclones have damaging impacts on agriculture. Economic assessments of damage after a storm impact provide ample evidence of their debilitating effects on production. Moreover, a single storm can inflict economic damage to several territories in an island chain, depending on its track. In 1998, Hurricane Georges destroyed 90% of the agricultural sector in the Dominican Republic and Haiti, 95% of Puerto Rico's banana crop, and 50% of St. Kitts' sugar crop (Potter et al., 2004). Hurricane Ivan in 2004 devastated the Cayman Islands and Jamaica, but wreaked havoc on Grenada, which suffered damage equivalent to double the annual GDP and destroyed the island's valuable nutmeg industry (Barker, 2012). Another example of multiple strikes in a single season was Haiti in 2008, hit by an unprecedented series of four slow-moving, high-rainfall tropical storms, Fay and Hannah, Ike and Gustav. Flooding was widespread with loss of life in Gonaives in northern Haiti (Barker, 2012). Together, the storms caused estimated damage of 900 million USD, equivalent to 15% of GDP and 70% of the country's crops were destroyed. For Haiti, 2008 was a classic case of double exposure: in April of 2008, before these calamitous storm events, world food prices spiked at unprecedented levels and caused food riots in Port-au-Prince. All this was two years before the devastating 2010 earthquake; and since then Haiti has been impacted by Hurricane Matthew in 2016 which caused more than 500 deaths. Puerto Rico's terrible ordeal in 2017 is another example of double exposure in its most extreme form, hit first by Hurricane Irma, then an even worse direct hit by Hurricane Maria two weeks later, at the time of its much-publicized debt crisis estimated at over

70 billion USD. Recovery is painfully slow and the long-term social, demographic, economic, and political ramifications are problematic.

Downscaling regional climate change models

We can use the Caribbean Basin to illustrate how, at the regional scale, climate has measurably changed since the 1960s, with a rise in surface air temperatures and declining rainfall. But trends are not geographically uniform across the region (Taylor et al., 2012) so different islands will be affected in different ways. Climate modelling suggests the northern Caribbean will have a wetter November to January period, while the southern Caribbean is projected to be drier. The general scientific consensus is that the Caribbean region is experiencing a more variable climate of stronger dry season droughts and more-stormy wet season conditions (Climate Studies Group, 2012; Taylor et al., 2017).

Advances in climate change modelling over the last 15 years have allowed climate scientists to make projections about temperature and rainfall changes in much greater detail, and reproduce scenarios for local climates. The procedure is called downscaling, and uses data about climate change at a large scale to make predictions at a smaller scale. Detailed climate change projections can be made for island regions, for individual islands, and for regions within islands. Thus the spatial impacts of climate change vary not only across a region (Lopez-Marrero & Wisner, 2012) but also within an island.

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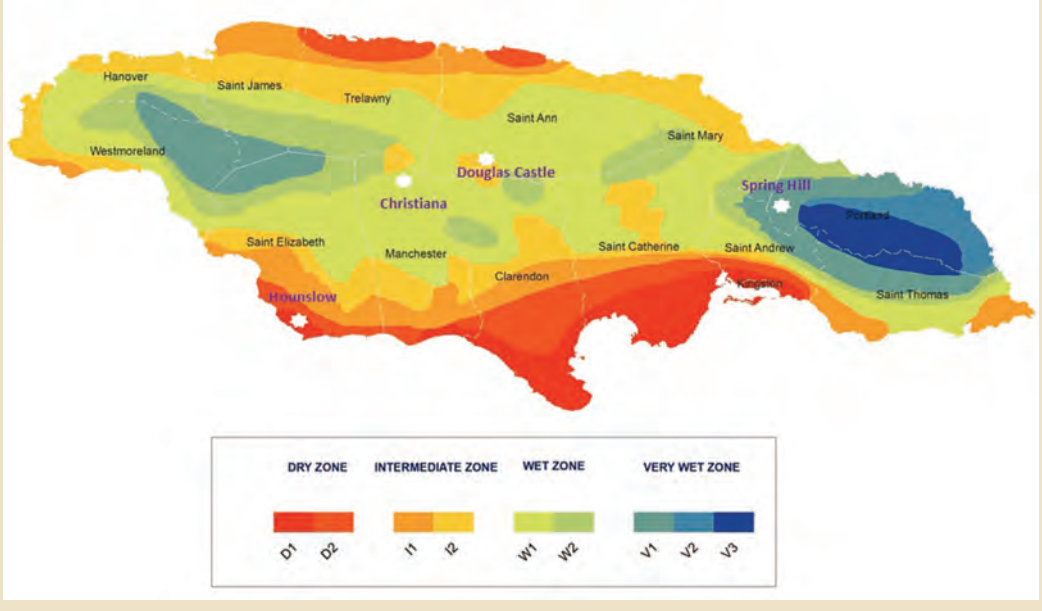
For an island like Jamaica, projections about local changes in temperature and rainfall presently are available at the scale of 50km grid squares (Climate Studies Group Mona, 2012). This is important because Jamaica is topographically and geologically complex, with small-scale farming practised in upland and lowland areas. Figure 8.1 (following page) depicts Jamaica's agro-ecological zones which represent agricultural production potential and its constraints based on local climatic conditions. Partly as a result of agro-ecological conditions, different geographical areas specialize in export crops such as coffee, bananas, and sugar, while other areas are more important for domestic food production. There are even distinctive root crop and vegetable-producing regions. The impacts of a tropical storm and flood rains may be experienced island-wide, but the extent of the damage will depend on the track of the storm, so that some farming areas will be more affected than others. High winds may affect particular crops like bananas and tree crops significantly more than ground-level

FIGURE 8.1: **Jamaica's agro-ecological zones**



SOURCE: Adapted from Batjes (1994) and Campbell, Barker, and McGregor (2010)

vegetables, which are more prone to flood rains. The impacts of drought on lowland farming areas are different from those in highland farming areas. Thus, different areas of the island will be affected in different ways by different combinations of environmental shocks and stresses.

What are the ramifications for cropping systems given increasingly detailed scenarios for climate change? Food production systems are highly dependent on weather and climate, and rain-fed, labour-intensive cropping systems are highly susceptible to periodic impacts from meteorological hazards (Rhiney, forthcoming, 2018). Local increases in temperature will increase rates of evapotranspiration and reduce the amount of water available to food crops (McGregor et al., 2009). As ambient temperatures increase, the productivity of many crops could become compromised due to enhanced heat and water stress. More indirect effects of climate change may be an increase in the geographical range and spread of agricultural pests and disease. There appears to be some evidence of this in relation to the spread of coffee leaf rust in the wider Caribbean Basin (Birthwright & Barker, 2015). Furthermore, long-term changes in temperature and rainfall are likely to reconfigure the map of agro-ecological zones.

In effect, there is a worrying increase in inter-seasonal and inter-annual variability (Taylor et al., 2012) and this is probably true of other oceanic island regions.

Climate change projections all point to an increasingly unpredictable and risky climate for farmers (Campbell et al., 2011). Shifts in seasonal rainfall patterns could have serious consequences, particularly for small farmers living in rural poverty. For rain-fed, open-field farming systems, it begs the question: what is now a "normal year"? If you are a poor farmer, how do you to plan your farming activities for the months and year ahead to support your family under such conditions of increased uncertainty?

AGRICULTURAL VULNERABILITY AT THE COMMUNITY LEVEL

Drought and small-scale farming in Jamaica

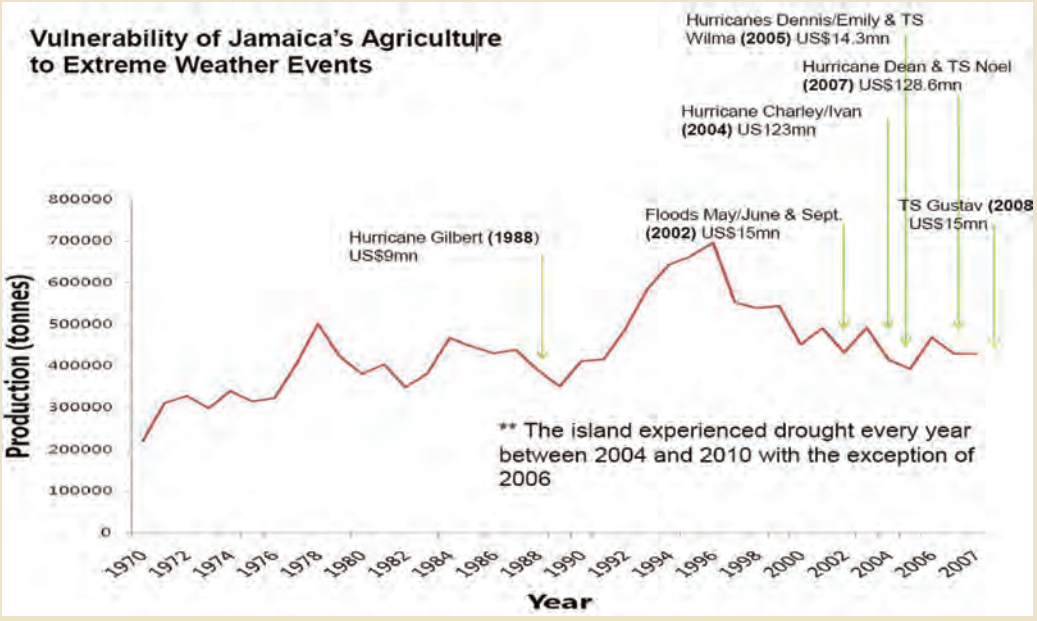
Trade liberalization had negative impacts on domestic agriculture. Progressive dismantling of protective trade barriers on imported food was part of Structural Adjustment Programs to which countries like Jamaica were subjected in the 1980s and 1990s (Dodman & Newstead, 2008; Weis, 2004). Caribbean islands traditionally had high food imports bills, especially for cereals which are not grown in the region, but vegetable imports into Jamaica were negligible before 1990; by 2004 they constituted 4% of food imports. Trade liberalization ushered in a flood of cheap "fresh" food produce from North America, which competed directly with items grown by small farmers as their principal cash crops. Between 1995 and 2004, the production of local potatoes fell by 62%, carrots by 35%, red kidney beans by 80%, and onions by 89% (Beckford et al., 2007). Even local garlic disappeared from supermarkets and produce markets — and still is imported from China.

DOUBLE EXPOSURE to trade liberalization and climate hazards was negatively impacting national food security and farmers' rural livelihoods.

However, McGregor et al. (2009) noted that the general decline of domestic agriculture in Jamaica from the mid-1990s was only partly due to trade liberalization. Domestic food production declined by 25% in 1997 due to a severe drought, and has never climbed back to its 1996 peak. Significant year-on-year declines occurred in 2000, 2002, and 2004. Figure 8.2 (following page) illustrates the decline of domestic food production between 1996 and 2005, associated with the lethal impacts of a series of successive combinations of droughts followed by storm activity (Campbell et al., 2010). Double exposure to trade liberalization and climate hazards was negatively impacting national food security and farmers' rural livelihoods.

The research was part of several community-based projects on small farming, natural hazards, and food security in St. Elizabeth parish in Jamaica (Campbell et al., 2010; McGregor et al., 2009; Rhiney, 2011). It is a low-rainfall, rain shadow area, where farming systems are finely tuned to a wet and dry season regime and a fragile environment. Farmers have developed traditional methods to cope with low rainfall,

FIGURE 8.2: **Impact of extreme weather events on Jamaica's agricultural production**



SOURCE: Adapted from Campbell, Barker and McGregor (2010)

including the extensive use of guinea grass mulching to conserve soil moisture. The cropping systems are rain-fed, and watering is mainly by hand, or simple low-cost, drip-feed irrigation. Despite the low level of technology, farmers have used their traditional skills and knowledge to great effect such that the area is the most productive vegetable farming region on the island.

Integral to this research was ethnographic, field-based data collection involving detailed questionnaires and focus groups to compile information on cropping systems, local knowledge, farming skills, and decision-making. Farmers' coping strategies and trial-and-error methods of trying to adapt to various economic and environmental stresses were documented. Other information compiled related to household assets, community infrastructure, institutional support, social networks, and remittances from abroad. Critical insights came from farmers' knowledge about changing weather patterns. The baseline survey of 252 farmers (Campbell, 2011) reported that two-thirds of the farmers said there had been long-term changes in weather patterns, 40% of whom believed there was an increase in the frequency and magnitude of extreme flood rains. On the other hand, lower-intensity and longer-lasting rains (which are more crop-friendly) were significantly decreasing according to farmers. Further, 65% said droughts were longer and more frequent than in the past, and the timing and duration of the short rainy season had become more variable and unpredictable over the last 20 years.

These observed changes in weather patterns were significant to these farmers who were familiar with periodic drought and had learned how best to cope with such adversity. But more frequent droughts were something new. Farmers plant their main cash crops just before the main rainy season. But they also plant short-term "quick" cash crops in the early rainy season to provide a modest income and household food supply to get them through a difficult period during the summer. So the timing and length of the short rainy season is critical to household survival. More frequent droughts were occurring in the first half of the year, so the onset, length, and duration of the early rains (or their absence) affected the success of the early planting season. The research concluded that farmers' perceptions of drought are not only being driven by the magnitude and frequency of dry months, but, more importantly, the timing of drought (Campbell et al., 2010).

The wider significance of the original doctoral research in the area (Campbell, 2011) should not be underestimated. What began as a study of the impact of hazards on small-scale farming systems in rural Jamaica expanded in scope to examine the interaction of multiple economic and environmental stressors on the vulnerability of small farmers' livelihoods. It provided a wealth of information on the capacity of households to adapt to these stressors given their limited resources, and limited institutional support. The combined negative impacts of drought and deteriorating market conditions were overwhelming traditional coping and adaptation strategies. External intervention was needed to help farmers strengthen their adaptive capacity and build resilience at the community level. Drought was the new face of climate change for these farmers.

Significantly, the St. Elizabeth research attracted the attention of climate scientists working on the Caribbean Basin. Their models suggested that the mid-summer drought was deepening in the western portion of the Caribbean Basin (Gamble, 2009), so, for them, here was the empirical evidence that drought was indeed negatively impacting local farmers. Further collaborative work deepened our understanding of the issues involved (Gamble et al., 2010).

One interesting story illustrates the usefulness of collaboration between scientists and local farmers with respect to climate change adaptation. We compared farmers' perceptions of changing rainfall patterns with estimates of precipitation from satellite data, derived from computer-based models. At first there was a discrepancy between long-term rainfall trends derived from scientific data and changing weather patterns reported by farmers. Farmers reported the early rainy season had become much drier over the last 25 years, whereas this drying trend was not evident in the scientific model. Then, a new version of the software was calibrated, using updated rain gauge data and new scaling coefficients. It produced more accurate estimates of rainfall totals. When the new model was applied to satellite imagery it confirmed there was, indeed, a drying trend in the early rainy season

between 1980 and 2007, just as our farmers had reported (Gamble et al., 2010). The accuracy of the information reported by older farmers about changing weather patterns was validated.

The story underscores the value of incorporating traditional knowledge about changing weather patterns into climate change scenarios. The IPCC Report (2007) placed local traditional knowledge at the epicentre of discussions on adaptation options because farming communities have long used their local knowledge of weather, crops, and soils to fine-tune their farming practices to local environmental conditions.

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Community-based adaptation

Poor people are the most vulnerable to climate change and the least able to cope with its risks and adapt successfully to change. Rural communities in SIDS are among these most vulnerable groups. The Jamaican research clearly demonstrated the value of scaling down the analysis of vulnerability to the level of the community and household. Over the past decade, community-based adaption (CBA) has emerged as one of the most widely used approaches to climate change adaption by international funding agencies. Across the Caribbean, there are hundreds of community-based adaptation projects focused on local farming and fishing communities. Invariably, they involve partnership among local community groups, international agencies and funding donors, and national government.

Community-based adaptation is based on the idea that climate change adaption should be symbiotic with sustainable development in order to increase the resilience of vulnerable groups. It is a bottom-up participatory approach which involves local stakeholders such as farmer groups, and local development and disaster risk practitioners (Reid, 2014). It builds on community needs and capacities and is argued to be a cost-effective way of tackling climate change because it captures and builds upon community knowledge and experience in dealing with climate hazards (Ayers & Forsyth, 2009). Vulnerability reduction efforts can be downscaled from the national level to utilize local community-based studies, local knowledge, and locally appropriate solutions.

The emphasis on community-scale vulnerability is timely, given the increasing attention to the consequences of climate change on agriculture (Rhiney, 2015). Just as the impacts of climate change are not uniformly distributed in time and space, vulnerabilities also vary between communities within an island, and between social

Guinea grass mulching in St. Elizabeth, Jamaica

groups within a community, as in the case of differential gender impacts (Clarke & Barker, 2012). Community vulnerability will depend on local cropping systems and social, economic, and environmental conditions, among other things. Local variability in exposure to risk from climate change and in the capacity of different communities to respond can pose huge challenges for island planners with limited financial and human resources: one size cannot fit all when formulating appropriate policies at the community level. Rhiney (2015) argues that capturing local variability and targeting geographic pockets of vulnerability is critical to policy formulation. Capacity-building and strengthening resilience may involve doing different things in different islands, and in different communities in a specific island.

There is a strong argument to develop locally appropriate methodologies built upon detailed data collected at the household or community level as a necessary condition for developing external support (Rhiney et al., 2016). Another lesson from the Jamaican research was the value of working closely with local communities to fully understand their livelihoods, asset base, and resource management decisions and support levels. Locally appropriate methodologies are strongly reflected in the surge of interest in community-level research in the Caribbean (Birthwright & Barker, 2015; Campbell, 2015; Clarke, 2014; Smith, 2016). The hallmark of this research is an ethnographic focus based on residence in local communities to help

build trust, and rigorous field-based methodologies. The research framework combines double exposure with the Sustainable Livelihoods Framework (Chambers & Conway, 1992). The latter is particularly useful given the IPCC (2007, p. 56) reminder that the capacity to adapt is dynamic and influenced by a society's productive base, including natural and man-made assets, social networks, human capital and institutions, health, and technology.

One interesting output of these studies is the compilation of innovative community vulnerability indices. The pioneering work on such indices was by Hahn, Reider, and Foster (2009), where a Livelihood Vulnerability Index (LVI) was used to compare rural communities in Mozambique. The procedures are versatile and flexible and can be adapted to suit local socio-cultural, economic, and environmental conditions. Quantitative data includes information on household assets, cropping systems and land use, water and soil management methods, marketing, use of farm labour, and available capital. Qualitative data includes information on farmers' coping and adaptation strategies, farmers' traditional knowledge, attitudes and perception of extreme events, changing weather patterns, and economic problems. Other data on community-related issues relating to transport and communications, marketing, and infrastructure are also compiled. The indices are computed using multivariate procedures for each household, then aggregated to analyze and graphically depict community vulnerability in terms of a number of summary composite variables (see, for example, Clarke, 2014; Campbell, 2015). Rhiney et al. (2016) have used such techniques to compare the vulnerability of four communities in contrasting agro-ecological zones in Jamaica.

CONCLUDING REMARKS

The challenges facing agriculture and rural populations in small tropical islands have been contextualized in terms of their vulnerability arising from double exposure to economic globalization and climate change. The challenges of coping and adapting to global change are daunting both at the national and community levels.

The long-term impact of economic globalization on agriculture has been mainly negative. Impoverished rural populations have been attracted to higher wages in urban centres, tourist resorts, and overseas labour markets. Traditional export crops were unable to compete with larger producers on the world market. In terms of policy response, the old mantra was to adapt by diversifying, to mitigate dependence on one or two export crops. A more strategic adaptive response is to take advantage of new market opportunities arising from economic globalization. Successes have been few, though the Dominican Republic has exploited opportunities in organic bananas and cocoa (Raynolds, 2008), while Jamaica is the world's leading exporter of yams to its diaspora in the UK and North America (Barker & Beckford, 2006) and Jamaican

Sherwood Content, Jamaica, in the rural community where Usain Bolt grew up

Blue Mountain Coffee is world-renowned for its quality, though it is now almost entirely dependent on the Japanese market (Birthwright & Barker, 2015).

Economic globalization and international tourism have the potential to buttress island agriculture by strengthening tourism-agriculture linkages to better support local farmers and to reduce food imports. There is a discernible shift by policy-makers in seeking greater integration of the agriculture and tourism sectors to take advantage of changing western food consumption habits towards ethnic diversity. In the Caribbean, this is reflected in the tourist industry's rather belated efforts to promote local food, for example, through food fairs and more local dishes on hotel menus. Another significant policy shift is to promote agro-processing in an effort to move local producers up the value-added chain. Local food companies, start-up small businesses, and cottage industries based on community groups produce an increasing array of specialty products such as spicy sauces, chutneys and pickles, jams and preserves, and cosmetics and essential oils which target niche markets in local urban centres, tourist resorts, and overseas.

With respect to mitigating the impacts of climate change, little can be done in

the face of a Category 5 hurricane. However, there is considerable experience and expertise in the Caribbean region for mobilizing support within the CARICOM community of countries to cope with less severe storms, while international agencies and foreign governments often target the agriculture sector in recovery programs.
Crop insurance is often seen as one solution to help farmers. But a cautionary tale was recently reported by Knudson (2016). He investigated the introduction of compulsory crop insurance for banana farmers in Dominica after Hurricane Hugo in 1989. While the adaptive capacity of farmers increased as a result of crop insurance because they could replant without financial loss the following year, their vulnerability actually increased. He attributes this to an insurance trap, a financial hazard associated with the cost of re-insurance premiums on the global financial markets. Affordable crop insurance depends on the cost of re-insurance premiums in global financial markets, which, in turn, is based on assessment of the global risk of disasters rather than local risk. What price will crop re-insurance premiums be on global markets after the 2017 hurricane season?

THE AGRICULTURE sector, from the viewpoint of sustainable development, is at the intersection of climate change, food security, and poverty, so it is not surprising that the greatest efforts to adapt to climate change are targeted at vulnerable communities in rural populations which urgently need outside supports.

The agriculture sector, from the viewpoint of sustainable development, is at the intersection of climate change, food security, and poverty, so it is not surprising that the greatest efforts to adapt to climate change are targeted at vulnerable communities in rural populations which urgently need outside support. Community-Based Adaptation is currently the most popular approach to building resilience at the community level. It invariably involves international agencies working in partnership with governments and targeted local communities to build resilience by focussing on best field practices in dealing with meteorological hazards and land degradation, while promoting more diversified rural livelihoods to generate sustainable incomes.

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