Agrarian change and the development of the greenhouse farming sector in Jamaica

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Summary: *The simultaneous impacts of climatic and economic changes have increased the vulnerability of small-scale farmers in the Caribbean. New technologies to improve the control farmers have over their production milieu have become a central feature of programmes for rural development and strategies devised by farmers themselves. Regionally, greenhouses have become the most distinctive innovation, introduced to enhance the resilience of farmers to increasingly capricious realities. Greenhouses enable greater efficiency in the management of scarce water resources and allow increased regulation of the conditions under which crops are cultivated. This paper reviews the development of the greenhouse farming industry in Jamaica. The research is based on data collected in 2014 from more than 100 semi-structured interviews with farmers, higglers, extension agents and government officials. The article draws specifically on 30 interviews with members of the Jamaica Greenhouse Grower's Association and consultants who have been engaged in government and donor agency development projects. The public statements of government and aid agency officials, project reports and other official documents are also considered. The introduction of greenhouses into Jamaican farming is changing the production and marketing dynamic and the agro-ecological dimensions of farming, and has implications for food security and resilience***.**

Key Words
AGRICULTURE CLIMATE CHANGE AGRO-TECHNOLOGY JAMAICA

Introduction

Caribbean agricultural production, particularly domestic production which is the remit of small-holders, has long been vulnerable to global changes. In the past two decades, however, the effects of these changes have been especially dramatic as the simultaneous impacts of environmental and economic changes ravage domestic food production and indeed the well-being of the peasantry (Weis, 2004, 2006; Barker, 2012). For Jamaican small farmers, particularly those in the traditional food producing region spanning south St Elizabeth and Manchester parishes—the so-called 'breadbasket'—the period has been characterized by repeated crop failures brought about by outbreaks of pest and diseases, such as the beet army worm, agro-meteorological droughts, record high mid-summer

temperatures and accompanying fires (Campbell *et al.*, 2011; Poore *et al*., 2016). The challenges farmers face are exacerbated by increasingly expensive fertilizers, pesticides, water and most other inputs which are imported (Weis, 2004; Crichlow, 2005; Timms, 2008).

Greenhouses are the most distinctive feature of the programme of agrarian transformation that the Jamaican government and development agencies have devised in the recent response to farmers' predicament. The widespread promotion of greenhouse farming technology commenced in 2004. Since this time, greenhouses have been adopted and adapted by farmers to produce select vegetable crops giving rise to a distinctive sector in the domestic production system (USAID, 2008; Selvaraju *et al.*, 2013). The discourses and dynamics that have guided the development of the greenhouse sector and the contours of greenhouse farming landscape, however, have remained underexamined (see St Martin *et al.,* 2008; Beckford & Norman, 2016; Moulton & Popke, 2017).

This paper reviews the development of the greenhouse farming sector and considers the implications of greenhouse farming for domestic food production. This review is not exhaustive but is intended to provide an overview of the timeline of major projects, initiatives which feature in the growth of the greenhouse farming, and a synopsis of the narratives accompanying and framing the promotion of greenhouse farming. It also provides a discussion of difficulties the sector faces as well as the implications of such issues for agrarian life and livelihoods.

The paper draws on data collected as part of a multi-year research project examining the vulnerability and resilience of small farmers in Jamaica. The primary aim of the project was to document the perceptions and responses of farmers to climate changes and economic changes. In the course of the broader research project, open-field farmers often pointed to the frequent promotion of greenhouse farming and shared their perceptions on the changes the innovation would have on farming. The research project in which the data for this paper were collected was designed to respond to the questions those farmers' comments elicited, including just how many farmers had adopted greenhouses, where they were, and what was being cultivated. To answer these and other questions about the state of the greenhouse sector, semi-structured interviews were conducted in the summer of 2014 with greenhouse farmers (17 with active greenhouses and 8 with inactive greenhouses), as well as 5 project consultants and stakeholders, using a combination of snowball and convenience sampling.

Greenhouse farmers registered with the Jamaica Greenhouse Grower's Association [JGGA] were contacted at random via telephone using data provided by the JGGA. Farmers across all parishes, listed as active and inactive with various sized greenhouses and registering the cultivation of different crops, were intentionally contacted to grasp the range of experiences of members of the JGGA. Snowball sampling was used to canvas for additional interviewees following each interview and in cases where scheduled interviews had to be cancelled. Additional interviews were conducted with over 70 open-field farmers. Interviews with both sets of farmers covered farming history, perceptions or experience of greenhouse farming, hazards to farming operations, perceptions of climate and economic changes as well as challenges and possibilities for farming in Jamaica.

Greenhouse development: Agro-technology and rural evolution

Greenhouse production of vegetable crops in Jamaica has expanded in the past two decades in response to an aggressive promotion of the technology by international aid organizations working in the region, and by successive political administrations (USAID, 2008; IICA, 2008; McGlashan *et al.*, 2008; CFC, 2010; Beckford & Norman, 2016).

The industry, however, predates the formal introduction of greenhouses as part of what has been described by one minister of agriculture as a 'rural revolution' (Tufton, 2008). Greenhouses, or at least shade-houses and other simple covered structures have been used in Jamaica as early as 1874, to produce European vegetable crops on the Cinchona Garden plantation (Johnson, 1914; Edwards, 2014). However, the rise of the current greenhouse industry can be traced back to the 1980s when shade-houses became popular among horticulturalists engaged in commercial cultivation of flowers. The shade-houses and simple greenhouses were primarily wooden, partially covered structures, with few technological implements. However, the growth of the cut-flower industry and attendant increases in the use of greenhouses was curtailed by competition from South American producers and diseases. Since this time, efforts to resuscitate the flower industry have produced phases of greenhouse use and abandonment. The current stand of greenhouses is the outcome of a robust programme promoting protected agriculture and related technologies for vegetable production rather than for (or instead of) horticulture (USAID, 2008; St Martin & Brathwaite, 2012).

This recent 'greenhouse renaissance' was initiated in 2004 with the Jamaica Business Recovery Program [JBRP] funded by USAID, an emergency response project implemented in the aftermath of Hurricane Ivan (Charles, 2011). The hurricane passed near Jamaica as a Category 4 storm causing considerable damage to the agricultural sector, and as implied in its name, the JBRP was intended to facilitate rapid recovery of farming operations. Also, embedded in the formulation of the project was the sense that farmers ought to switch to a business-minded approach to farming, an approach that had come to characterize USAID projects in Latin America (Kohl, 1991). Under the project 11 greenhouses were constructed and handed over to lead farmers and 176 demonstration plots established in the parishes of Clarendon, Manchester and St Elizabeth. As the most affected region and the traditional leaders in domestic food production, these parishes were chosen as sites to showcase protected agriculture, yield-increasing strategies, coupled irrigation-fertilization technologies and integrated pest management (DAI, 2005; McGlashan *et al.*, 2008). In his recollection of the project, one farmer explained how '[USAID] said they don't want that every disaster the US have to be coming running bringing aid... they want us to do agriculture better'.

Similarly couched as a project to help farmers (and other rural people) better respond to adverse events, the tellingly named Rural Enterprise, Agriculture and Community Tourism [REACT] was launched in 2005 (USAID, 2008). These attempts to help farmers 'do better' entailed the transfer of not only technology, but mentalities, which have been examined in light of Foucault's notions of governmentality and

biopower: the encouragement of greenhouse farming can be considered 'a form of governmentality, aimed at reshaping existing agricultural rationalities, practices, and subjectivities through a biopolitical reconfiguration of the agencies and materialities constitutive of Jamaica's agrarian milieu' (Moulton & Popke, 2017: 717).

Passage of a hurricane was the impetus for another greenhouse project, Improving Jamaica's Agricultural Productivity Project [IJAP]. Funded by the Canadian International Development Agency [CIDA] and implemented by the Inter-American Institute for Cooperation on Agriculture [IICA], it featured the single largest construction and distribution of greenhouses locally by an aid agency. The 40 greenhouses built under the project were meant to revitalize the nascent greenhouse sector stunted in 2007, when Hurricane Dean destroyed most of the existing structures. A greenhouse unit was created within Rural Agricultural Development Authority [RADA], and training programmes on greenhouse fabrication and operation were introduced in vocational training centers (McGlashan *et al.*, 2008; IICA, 2009, 2010; Government of Jamaica, 2011).

The construction of an agro-processing facility under the project created an outlet for bulk sales and signalled the vision of CIDA and IICA, that farmers should pursue contract farming arrangements with bulk purchasers and use the certainty of contract prices to plan production. The scale of the greenhouse project and rhetoric of productivity and business-mindedness seems to indicate the rapid consolidation of thinking among development aid agencies (at least the USAID and CIDA) about the role that agro-technologies should play in modern farming and rural development (Beckford & Norman, 2016; Moulton & Popke, 2017). The rationality of this agro-technological model hailing greenhouses has been embraced by the Jamaica government.

In asserting the position of his administration on the matter, then Prime Minister Bruce Golding explained that what the state was 'saying to farmers was that there are better ways… more efficient ways of producing your crops where you use less inputs, produce more and make more money… We have to make sure that we bring farmers into this new framework of scientific approach' (*Jamaica Gleaner*, 2010). The most significant state action to bring this new and scientific approach into the mainstream has been the Rural Economic Development Initiative [REDI] implemented by the Jamaica Social Investment Fund [JSIF] with funding from the World Bank. Whilst REDI did not exclusively fund greenhouse projects, the initiatives funded reflect the broader agro-technological model of development in which greenhouses are situated (JSIF, 2017). Further, JSIF has partnered with the Jamaica Bauxite Institute for a 'Water Harvesting Cluster Greenhouse Project', to bring over 400 open-field farmers into the greenhouse era (*Jamaica Observer*, 2014).

The drive to develop the greenhouse sector and bring about broader agrarian change through agro-technology has been aided by several other initiatives of the government and development aid agencies. Table 1 offers a lists several of these projects that have been undertaken (JIS, 2009, 2012; USAID, 2008; IICA, 2010; Selvaraju *et al.*, 2013). Implicitly and explicitly, the projects, initiatives and public declarations of government officials constitute a discourse of agrarian transformation based on a change in the comportment of farmers and their mentality. This section explores three of the

TABLE 1: Major greenhouse projects

Project	Sponsor	Launch
Jamaica Business Recovery Program	USAID	2004
Rural Enterprise, Agriculture and Community Tourism	USAID	2005
Jamaica Farmers Access to Regional Markets Project	USAID	2006
Centre of Excellence for Advanced Technology in Agriculture	AECID	2009
Community-Based Adaptation	GEF-Small Grants	2009
Biodiversity Conservation and Alternative Livelihoods Projects	GEF-Small Grants	2009
Improving Jamaica Agricultural Productivity	CIDA	2009
Strengthening Jamaica's Food Security Program	European Union	2009
Rural Economic Development Initiative	World Bank-JSIF	2009
Caribbean Local Economic Development Project	CIDA	2012
Water Catchment and Greenhouse Cluster Program	JSIF-JBI	2014

dominant themes (resilience, productivity, and entrepreneurship) emergent from the discourse framing the promotion of greenhouses since the mid-2000 resurgence (see Moulton & Popke, 2017, for a critical examination of this discourse).

The theme of resilience presents greenhouse farming as climate-smart agriculture and has been articulated in the discourse since the very first projects of the recent renaissance. Projects such as JBRP and REACT for example, even in their acronyms, connote that greenhouses redefine a farmer's capacity for rapid recovery from or reaction to agro-meteorological hazards. One mission director of the USAID speculated that in the short-term, greenhouse (and other agro-technologies encouraged under JBRP) would enable farmers to 'recover' and 'build back better' farming operations, and in the long-term would 'reduce vulnerability to catastrophic damage in future hurricanes' (JIS, 2004). An evaluation of USAID's projects later posited that '[Greenhouse production] represents not only the best opportunity for disaster recovery in the horticulture subsector, but also for lowering risks during future disasters' (DAI, 2005: 20).

In this narrative greenhouse farmers are ostensibly able to absorb the disruptions to production and reorganize production without the need for changes in their livelihood amidst more unpredictable climate conditions. The greenhouse farmer is presented as having the unique advantage of disassembling the greenhouse (and storing away plants, depending on the media in which they are being propagated) and reconvening it once threats such as hurricanes are passed (USAID, 2008). It is further argued that 'even in the event of weather damage to the structure, the increase in yields and sales help offset repair costs' (DAI, 2005: 25).

As a resilient model of farming, greenhouse production is presented as the 'saviour' according to one farmer, practically removing the need for farmers to be concerned about adverse events. This theme of resilience is not unproblematic; the literature on

resilience presents conflicting conceptualizations and implications of the concept (Adger, 2006; Folke, 2006). The championing of greenhouses for livelihood resilience leaves uncritiqued the social, political and economic factors which mediate the exposure of individuals and their capacity to adapt to and recover from the impacts of global change. Thus, a resilient development paradigm privileges rational self-adjusting responses and technological solutions attuned to neoliberal conceptualizations of responsibility and efficiency. Consequently, while greenhouse farming might enable individual farmers to become more resilient, the extent to which this will translate into resilience of the broader farming system is debatable (Popke *et al*., 2016; Rhiney, 2015, 2017).

While resilience might be associated with the initial wave of greenhouses, productivity became more explicit in the second wave of greenhouses starting in 2009. Arguably, the emergence of productivity as a theme reflects a shift in the theme of resilience given the vulnerability of greenhouses that became clear after Hurricane Dean in 2007. The projects since Dean, both in naming and descriptions, speak of improved production (in yield and quality), food security and improved marketing outcomes (see for example Kuennen *et al.*, 2008; CFC, 2010; IICA, 2010). In a description of IJAP, for example, greenhouse farming is presented as 'an opportunity to change the current landscape in the Jamaican agricultural sector to a technology driven sector with increased efficiencies and productivity' (IICA, 2009: 6). The state expressed a similar framing, noting that greenhouses 'address issues related to low production and productivity, high prices, inconsistent supply and variable quality which has characterized local vegetable production for decades' (Government of Jamaica, 2011).

The theme of productivity of course is not unrelated to resilience, at least as expressed in the discourse; improved productivity is cast as the beneficial outcome of adapting to the vagaries in the agricultural system induced by climate and economic changes. Coupling productivity with greenhouses, and by extension, new agro-technologies indicates the vision of a techno-modern agrarian landscape, whereby the resilient farmer is the one best able to convene the latest innovations and strategies in regulating the factors of plant growth and production outcomes. Social variables mediating productivity and production are absent from these considerations.

The discourse around greenhouse farming celebrates practitioners as new kinds of farmers demonstrating a spirit of free enterprise and savvy. This theme of entrepreneurship extols respectability and wealth, something peasants are caricatured as not having. Indeed, Jamaica's subsistence farmers, from their emergence after emancipation, have been depicted as poor and backward. Such characterizations have been used to justify programmes aimed at improving record keeping, increasing use of technology and inculcating business-mindedness among smallholder farmers as a corrective to subsistence farming (Mintz, 1979; Crichlow, 2005). Greenhouse farming, suggested one official of the Jamaica Agricultural Society indicates that the days of the 'dirty shirt, tear up trousers' farmer had come to an end. This view aligns with broader endorsements of greenhouse farming as 'sexy and desirable, particularly for young people who are hooked on technology' who have seen the potential for 'tremendous financial opportunities in the

marriage between cutting edge greenhouse technology and the age old profession food production' (RADA, 2015).

In this narrative, greenhouses are tied to neoliberal rationalities—farmers are solely responsible for their fate and must be savvy in the self-regulating market place if they are to be successful. With the promotion of this rationality among farmers, the state and aid agencies are continuing a pattern of agrarian reform that has defined post-independence Jamaica in which sections of the population are made structurally irrelevant (Crichlow, 2005; Weis, 2005; Timms, 2008). Greenhouses are therefore for 'people who recognize that farming is a business… the approach you take to agriculture is not different than you take to running a factory or whatever'. The person who takes on greenhouse is seen as ready to make a 'transition from farming the hobby, to farming the business'. The discursive framing of the greenhouse as an agrarian technology that enables rural development portends implications for farmers' relationships with the state, their farms and other farmers, and the multiple other actors in agriculture (Moulton & Popke, 2017).

Agrarian transition: Greenhouse adoption and restructuring of production

This section combines data from an analysis of greenhouse farming operations registered with JGGA, site visits, and interviews across the island. Field observations and interviews revealed that there are several discrepancies in data on registered greenhouse operations. However, this data provides the best picture of the broad contours of the greenhouse landscape. Furthermore, the stock of greenhouses have been added to given projects since 2014.

The net change in the number of greenhouse or the area under cultivation as a result of these projects is beyond the scope of this paper. As at June 2014 there were some 275 greenhouses totalling 2.2 million sq. ft., of which 71 percent (approximately 1.8 million sq. ft) were active. The majority of the inactive greenhouses, 94 percent, are listed as simply vacant or idle, with the remainder being identified as operations abandoned or destroyed by adverse weather. Among farmers interviewed who had inactive greenhouses, 75 percent identified structural damage preventing viable operations as the primary reason. The other reasons included costs of operation and decline in interest. The distribution of the total cultivable area and area being actively used in each parish is shown in Table 2. The table also shows that greenhouse production is primarily concentrated in the parishes of St Ann, St Elizabeth, St Mary and Manchester.

The typical greenhouses introduced by development agencies featured galvanized metal frames, covered with plastic (polyethylene or polycarbonate), with insect meshing often incorporated for ventilation. However, greenhouses in Jamaica are today as diverse as the farmers who operate them, and reflect the financial and material resources with which farmers are endowed. The greenhouses are themselves agricultural assemblages and, as one farmer reasoned 'it's how you put it together to make it work the best for you'. This 'putting together' involves the arranging of structural components, technological implements, techniques, and social networks. For registered greenhouses, information on the structural material is only available for 32 percent. The greenhouses for which data

TABLE 2: Distribution of greenhouse capacity (sq. ft).

Parishes	Under Cultivation	Out of Cultivation	Total	Per cent of Total
Clarendon	41,500	61,500	103,000	4.6
Hanover	35,500	0	35,500	1.6
Manchester	396,140	240,000	636,140	28.4
Portland	3,600	6,000	9,600	0.4
St Andrew and Kingston	18,185	9,500	27,685	1.2
St Ann	545,570	21,520	567,090	25.3
St Catherine	80,840	3,600	84,440	3.8
St Elizabeth	393,270	33,400	426,670	19.0
St James	15,600	13,500	29,100	1.3
St Mary	223,740	0	223,740	10.0
St Thomas	3,000	20,700	23,700	1.1
Trelawny	27,100	12,000	39,100	1.7
Westmoreland	12,000	24,400	36,400	1.6
Total Capacity	**1,796,045**	**446,120**	**2,242,165**	**100**

are available are primarily wooden, just 28 percent are metal-frame houses. Among the greenhouse farmers interviewed, 64 percent had metal-frame structures while 36 percent had wooden greenhouses. However, the latter are likely more common and account for a higher proportion because aid projects and initiatives such as the JBI-JSIF greenhouse cluster programme encourage low-cost wooden structures.

The array of greenhouses can be classified into four main categories based on design: the high tunnel or Quonset style design were popularized under JA FARMS and JBRP (Figure 1); double-ridged, vent style was introduced under IJAP (Figure 2); the single-ridged, vent gable roof style was typical of greenhouses under REDI (Figure 3); and gable roof, in popular use by farmers who build their own greenhouses (Figure 4). The ridged roofs enable passive ventilation and moderate the temperatures inside the greenhouse (St Martin & Brathwaite, 2012; USAID, 2008).

Table 3 shows the frequencies and distribution of greenhouses according to sizes. Greenhouses of size up to 6,000 sq. ft. account for 72 percent of structures but only 30 percent of the total area of greenhouse production. Conversely, while only 10 percent of greenhouses are over 15,000 sq. ft., such structures account for 48 percent of the area of greenhouse production. This pattern reflects the longstanding dualism entrenched in the food production system in Jamaica. Most greenhouses (80.7 percent) are operated by individual farmers, and most greenhouse farmers (82 percent) are male. Groups, including faith-based organizations and cooperatives operate 12 percent of the registered greenhouses, while 7.3 percent are registered to research or educational institutions.

All the farmers interviewed indicated that the production of vegetables in their greenhouses is tied to water management systems as much as it is to the protection that an enclosed structure offers. The water management strategies used by greenhouse farmers

FIGURE 1: High tunnel or Quonset greenhouse, St Ann

FIGURE 2: Double-ridged vent greenhouse, St Elizabeth

FIGURE 3: Single ridged vent gable roof greenhouse, Clarendon

FIGURE 4: Gable roof greenhouse, Manchester

TABLE 3: Greenhouse size frequencies and distribution

Greenhouse Size (sq. ft.)	Frequency	% of Total Greenhouses	% Total Capacity	% Total Active Capacity
Up to 6,000	198	72	30	14
6,001 - 9,000	24	9	10	8
9,001 - 12,000	16	6	7	14
12,001 - 15,000	10	4	5	14
Over 15,000	27	10	48	50

are not unique to them; water storage in drums and tanks, and conveyance by drip irrigation is in use by open field farmers (Beckford *et al.*, 2007; Campbell *et al.*, 2011; Moulton *et al.*, 2015). However, all farmers interviewed, both greenhouse and open field, indicated that the assemblage for water management configured in greenhouses enables greater control over the usage of water, reduction of evapotranspiration and most effective coupling of nutrient supply with irrigation or fertigation (see also St Martin & Brathwaite, 2012; Beckford & Norman, 2016; Popke *et al.,* 2016). The sophistication of these assemblages though, are not uniform and vary based on farmers' financial resources and technological savvy. While wealth was not explicitly discussed in interviews, field observations indicate it is an important variable in type and sophistication of structure. Consequently, as one consultant noted, some farmers 'have gone to the other level, by growing in hydroponics…integrating more computerized control systems', while 'most people plant into the soil', and utilize gravity driven fertigation. Among farmers interviewed who had active greenhouse operations, 58.8 percent plant directly in soil with or without plastic mulch as shown in Figure 5 (though guinea grass mulch was observed in one greenhouse in St Elizabeth) A further 11.8 percent plant in 'grow bags' containing soil or other growing media, and 5.9 percent utilize a soilless/hydroponic system. Data are not available for the remaining 23.5 percent of farmers.

Coloured bell peppers or sweet peppers are the most popular greenhouse crop, grown in 70.6 percent of registered greenhouses, while tomatoes are grown in 34.5 percent. The production of lettuce is registered for 8.8 percent of greenhouses, with broccoli in 5.7 percent, exotics such as strawberries, ginger, ornamental flowers and herbs and spices cultivated in 4.1 percent. Further, cabbage is grown in 1.5 percent of greenhouses, hot peppers are produced in 1.5 percent, and squash and cucumbers each being produced in 0.5 percent of greenhouses. The data and field research indicates that St Ann growers dominate in the production of bell peppers, lettuce and broccoli, while Manchester leads in tomato cultivation. The precise amount of area dedicated to the cultivation of each crop is not available from the JGGA data, nor are these figures expected to be static, since farmers rotate crops and combinations of crops.

The marketing arrangements associated with greenhouse production are more varied than that characteristic of small-scale open field production. Rather than relying

iance on informal arrangements with higglers and sale at municipal markets (where price volatility is high), greenhouse farmers can access hotels, agro-processors and supermarkets (St Martin & Brathwaite, 2012; Beckford & Norman, 2016). Among the farmers interviewed, 46.7 percent disposed of their produce solely through formal or informal contracts directly with hotels or supermarkets or middlemen (commercial suppliers with whom farmers have more formal relationships than higglers), 26.7 percent sold all their crops to higglers for sale at municipal markets, 20 percent sold to higglers as well as to supermarkets and hotels, while 6.7 percent had both contracts and also sold their crops themselves at local markets.

Marketing arrangements are influenced by the crops that farmers grow, how much produce they have, and when they have it. The marketing decisions and arrangements around bell (or sweet peppers) is illustrative of the kinds of decisions farmers have to make in disposing of greenhouse produce. Greenhouse farmers are practically the sole producers of coloured sweet peppers because of the seed varieties and environmental control necessary for their production. In open field operations, bell pepper begins to deteriorate before ripening and most open field farmers forego purchasing the more expensive seed varieties from which coloured peppers propagated (most commonly, yellow and red, though the red is simply a ripened green pepper). Access to these marketing niches (high-end supermarkets, hotels and agro-processing plants) are important if greenhouse farmers are to recoup the costs associated with their operations. For example, during the period of fieldwork, the prices reported by the Jamaica Agricultural Marketing Information System [JAMIS] indicates that modal municipal market prices (per kilogram) for green sweet peppers from greenhouse were 21.4 percent lower than locally produced non-greenhouse variety, while modal prices for the red and yellow greenhouse sweet peppers, were on average 84.4 percent and 95.7 percent higher than the locally produced non-greenhouse varieties.

Agro-ecological and agro-logistical challenges

The programme of greenhouse-driven development has unquestionably changed Jamaica's agrarian landscape; greenhouses are now a common feature of the agrarian landscape of rural parishes as well as the corporate area. This section considers several of the ramifications of the new landscape.

The issues surveyed reflect those frequently mentioned by farmers as being especially pertinent for the sustainability of greenhouse farming and the impacts the budding sector might have on traditional domestic agriculture. This discussion is a necessarily limited review and excludes some important issues plaguing farming in general which have been examined elsewhere, such as the access and affordability of water for irrigation and costs of imported agricultural inputs as the Jamaican currency devalues (see St Martin & Brathwaite, 2012; Beckford & Campbell, 2013; Beckford & Rhiney, 2016). Certainly, greenhouse farmers are not immune to these hardships and in the case of water and use of high-quality seeds and some chemical inputs, they might face even greater hardship than their open-field counterparts given the volume required for production at scale. Similarly the availability of capital at competitive interest rates is particularly

FIGURE 5: Plants grown directly in soil under plastic mulch, St Elizabeth

important given the initial investments for establishing greenhouse operations. It is in this regard that the prospects of a new era of farming driven by greenhouse might be critiqued.

Put differently, while greenhouses are championed as the emblems of a new agrarian reality in which farmers have improved standing as respectable, modern, and entrepreneurial subjects, the possibilities of wide-scale adoption are circumscribed by high costs that are prohibitive for most small-scale farmers (Beckford & Norman, 2016; Popke *et al.,* 2016). The observations and anecdotal evidence from the field reveals that the most successful greenhouse operations are those run by 'new farmers', a cadre including retired individuals and middle-class persons with formal education and other non-farm employment (some in the civil service). Among the farmers interviewed, 40 percent fall into this category of new farmers (some even self-identifying as such), for whom the greenhouse operation serves as supplemental income.

For resource-limited farmers access to greenhouses and other agro-technologies might only be possible through grants, which given the capacity of most small-scale farmers will prove difficult to acquire. However, none of the farmers interviewed identified any grants that prohibited potential 'new farmers' from accessing funds, though it was commonly suggested that some grants require that individuals be members of the Jamaica Agricultural Society, or otherwise registered with RADA or Department of Co-operatives and Friendly Societies. This tendency among development agencies to provide aid to farmers' groups rather than individuals only narrows the possibilities for some farmers. For while cooperatives were popularized in the 1930s as part of democratising Jamaican society, they have been undermined by the class antagonism and

individualism encouraged by neoliberal reforms (Stone, 1983; Crichlow, 2005; Weis, 2006). Consequently, as one greenhouse farmer admitted 'what is happening now is that those who are like doctors and lawyers… [who] have more capital, more cash to put up front' can establish greenhouses and relegate operations to hired farm labourers.

Greenhouse operations of this absentee owner type are not without problem since disenchantment among owners or poor management by paid labourers can result in crop failure and abandonment. One greenhouse farmer opined that 'persons have high expectations…It was sold to persons as this wow nice dandy thing… and you will make all the money in the world. But when persons actually went into it and recognized the challenges that come with it, which they didn't tell us before'. Greenhouse farmers critical of the rhetoric of 'quick and easy' money noted that even among those who decide to remain, particularly those who were traditional farmers, operations have to be scaled back in sophistication and adherence to best practice to remain profitable. For one farmer 'doing the soil test and the water test and all of those…you have to make sure say all of those appropriate… but you don't have the funds to really do all or get all'. Since the practices and implements that farmers sometimes decide to avoid affect the production of crops, these decisions can have serious effects on the profitability of the operations.

Greenhouse farming has changed not just the demography of the farmer, but also the mentalities and agro-logistical arrangements and ecological aspects of farming (Moulton & Popke, 2017). Greenhouse farmers enjoy access to niche markets and premium prices for the high-value vegetable crops they produce. They are advised, as a best practice of the JGGA, to concentrate on those niches and avoid competing with traditional open field farmers in their primary growing season. However, as one RADA official noted, in practice 'what is happening now, is that the greenhouse growers are competing with the open field farmers and so they complain about the pricing. They still not following the prescribed model'. The rationale for competing with open-field held by some greenhouse farmers is based on imaginations of a total transition of vegetable production into the remit of greenhouse farming, as one farmer declared 'we want to drive the open field farmer out of the vegetable business and into root tubers'. Similar visions of transformation, all be it with a different explanation, are expressed by development agencies. One FAO report noted that greenhouse 'development is freeing up fragile landscape, for example, tomato is no longer being produced on sloped lands'. (McGlashan *et al.,* 2008: 33). Given the sensitive nature of the municipal markets, increases in production and competition stand to exacerbate price fluctuations already associated with drought/rainfall-scarcity/glut cycles. Such long-termambitions of changing the rhythm of local open field production are to be gauged, since at least for now, direct sale of greenhouse produce to the municipal markets would limit profits.

There at least three dimensions to the difficulty that greenhouse farmers will face in targeting municipal markets. The vignettes below reference specific crops but might more generally illustrate the marketing complications. 'Tomato is tomato', one greenhouse farmer warned, 'open field farmer can bring you a nice tomato…People not looking at it and say 'wow greenhouse tomato has a longer shelf life'…they are just seeing a tomato'. First, therefore, in focusing on municipal markets greenhouse farmers

stand to face resistance by open field producers who can match the quality of production in some crops. In southern St Elizabeth, field observations and anecdotal evidence from several years reveals that drip irrigation and, in some instances, fertigation systems are being implemented by open field farmers and coupled with improved field management practices. Such developments improve production fortunes of open field farmers.

Further, as another farmer notes 'higglers don't buy ripe sweet pepper. Go into a little household and you bring a ripe pepper, they will ask you 'is what this?' Because that is not the sweet pepper which them know. They know green sweet pepper'. Thus secondly, for some crops, the consumer preference will require reduced prices if greenhouse farmers are to dispose of their crops. In other cases, some consumers fear that greenhouse production entails a 'whole heap a chemical', because it is not uncommon for 'one cucumber weigh four or five pounds'. The caution about the safety of greenhouse crops therefore represents a third obstacle to the use of municipal markets as a venue for sale. Arguably, the anxieties about food safety point to a much broader question about the ecological changes that greenhouse farming will effect. The chemical and food regimes, seeds and relationships between farmers, higglers and the physical environment—the entire metabolism of agricultural life—is reshaped by greenhouse farming and agro-technologies (Barker & Beckford, 2005; Beckford & Barker, 2007; Moulton & Popke, 2017).

The tethering of greenhouses to themes of resilience raises questions that should be contemplated regarding the viability and practicality of a greenhouse dominated domestic agricultural system. Pointing to the vulnerability of the food system if it were to become reliant on greenhouse production, one farmer questioned 'how can you be pushing greenhouse, where if you get a Category 5 storm then your nation will be starving?'. Greenhouses are susceptible to damage from seasonal hurricanes, and other extreme wind events common to Caribbean agriculture. Promoters of greenhouses envisioned that the structures would be disassembled and plants secured in the face of an approaching hurricane. However, only a handful of the structures observed both in interviews and field observations could be practicably disassembled. Greenhouse farmers with wooden structures were all resigned that, in the event of a storm, they would have to leave structures standing rather than attempt dismantling. Furthermore, depending on the stage of a crop, it would be impractical to attempt moving plants to a secure area, presuming that they are being propagated in containers rather than directly in the soil.

Other questions of practicality include the discomfort that farmers at lower elevations and on the south coast (notably southern St Elizabeth) encounter in performing greenhouse labour. Among the farmers interviewed, only one had a greenhouse which did not rely on passive ventilation. For the other farmers, reliance on passive ventilation renders the greenhouse a hazard when heat builds up inside. Lamenting the unpleasantness one farmer offered that greenhouses in Jamaica are 'closer to hell', no different than 'when you are in a fire ball and you drop the heat in there'. These challenges with temperatures are however not uniform but geographically mediated, and can vary even with altitudinal changes on the same farm. The ability to modulate temperatures in tropical greenhouses is also important for crop production, and while farmers could not exactly value the effects temperature differences had on their production, their intuition and

experience was that production is seriously inhibited in passively ventilated houses during the summer months when water is also difficult to access (see Eitzinger *et al.*, 2013).

There are a number of other areas of the growing greenhouse sector that have not have been fully examined, but which seem pertinent to the sector's expansion. Among them, the role that greenhouse farmers might play in the still embryonic legal marijuana industry, whether and how greenhouses have affected gendered relationships in the production and distribution of crops, and the environmental impact of low-cost greenhouses projects involving the felling of trees from forests. The projections for rising temperatures and increased stresses on water systems raises important questions for the greenhouse sector, not only as it concerns crop suitability but the nexus of water, food and energy (for powered ventilation and condition control). Given the investment required to establish a greenhouse and the risks of damage from extreme wind events, exploration of insurance schemes might prove important in the viability of the sector.

Conclusion

Greenhouses are now found across Jamaica, the result of an aggressive promotion campaign by both the Jamaican government and development agencies in the past one and half decades. The structures and associated innovations and practices have been hailed as central to a new model of farming that is resilient to adverse climatic hazards orientated around technology, entrepreneurialism, and essential to rural development. The extent to which the envisioned transformation of agriculture has been realized is debatable. More concretely, the changes that greenhouse farming have0 effected say much about the approach that has been taken to climate smart agriculture and development.

The strategy and discourses around agrarian change emphasize resilience as an end goal to be reached through changes in mindset and level of innovation. However, underlying socio-economic and cultural realities have remained largely unproblematized. Consideration of these realities is important since vulnerability is not simply a product of sensitivity to hazards, but a product of forms of capital, interpersonal networks, access to information, and relationships of power. The promotion and marketing, wealth and resource endowments, and location all mediate who can establish greenhouse production and maintain successful operations. Moreover, the model of development to which the promotion of greenhouse follows, implicitly and explicitly, derides the traditional farmer who is caricatured as insufficiently technologically and market savvy. The case seems to be that farmers are acutely aware of their vulnerabilities and the challenges to their success but are inadequately supported to address those issues autonomously.

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