Water management strategies and climate adaptation: Lessons from the 2014 drought in Jamaica

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Summary:*The potential increase in climate-induced hazards presents significant challenges for tropical agricultural systems, particularly those of small island developing states, where farmers are resource limited and depend on rainfall for cultivation. Under a worsening climate, water management strategies become essential to farmers' production fortunes. To illustrate some of the implications for a changing climate in the Caribbean, we examine the role played by different water management strategies deployed by farmers in St Elizabeth, Jamaica, in response to drought conditions in 2014. The paper draws on data collected using a mixed-method research approach, incorporating historic climate data, meteorological data from instruments on 12 case study farms and approximately 100 semi-structured interviews with farmers and agricultural officials in 24 different communities in the southern region of St Elizabeth. Results offer insight on the community-level implications of the assemblages farmers construct to access, store and distribute water on their farms. These assemblages are not just material, but are social, contingent on personal connections and sentiments of solidarity and community. While the material assemblages and social capital of farmers enable them to better negotiate droughts, increased stress on water resources may lead to an unravelling of social ties and an increasingly competitive water supply system.*

Key Words
CLIMATE CHANGE   IRRIGATION   SOCIAL CAPITAL   JAMAICA

Introduction

Small island developing states such as those in the Caribbean are particularly vulnerable to climate-induced hazards, including hurricanes and tropical storms, non-tropical storms, and drought (London, 2004; Caribbean Community Climate Change Centre, 2009; Verner, 2011; López-Marrero & Wisner, 2012). In the Caribbean, such climate events can occur because of interannual variability associated with global climate oscillations, but they may result also from global climate change (Poore *et al.*, 2016). Regional climate models predict that much of the Caribbean region will face increased temperatures and diminished rainfall, making drought a particular concern (Cashman *et al*., 2010;

Taylor *et al*., 2012; Taylor, 2015). The possibility of more frequent drought conditions poses particular challenges for the region's agricultural sector, which is characterized by a significant number of small-scale, resource-poor farmers who rely upon rain-fed cultivation (Barker, 2012; Ortiz, 2012; Hutchinson *et al*., 2013; Vergara *et al.*, 2014). The ability of farmers to adapt in the face of increasingly variable climate conditions, therefore, will be crucial to the ability of Caribbean countries to promote food security and rural development (Beckford & Campbell, 2013).

To provide an indication of some of the community-level implications of environmental change in the Caribbean, this paper examines farm-level responses to a significant drought event that occurred in Jamaica during the summer of 2014. Our findings draw upon results from a larger research project focused on farm-level vulnerability in southern St Elizabeth parish, a major farming region of Jamaica (Figure 1). Data for this project were collected using a mixed-method research approach, incorporating historic climate data, weather information from a network of meteorological instruments on 12 case study farms, and approximately 100 semi-structured interviews with farmers and agricultural officials in 24 different communities across the parish of St Elizabeth. Interview subjects were generally identified through snowball and convenience sampling, and farmers were often approached for an interview during reconnaissance trips through the farming areas. Purposive sampling was also employed to ensure that we captured a diverse range of farms in terms of size, location, crops grown, and irrigation technologies.

We have presented elsewhere a preliminary assessment of the drought and its possible causes (Poore *et al*., 2016). Here, we draw upon qualitative evidence to document some of its impacts on farming across the southern St Elizabeth region. Our account derives from fieldwork conducted over a period of seven weeks in June and July of 2014. Rainfall totals during this time were well below average, making access to irrigation water a vital concern for farmers. Our findings suggest that the ability of farmers to secure and deploy water during this particular drought was highly variable, and was determined in part by two factors: differences in farm-level irrigation technology; and the networks of social capital that shape water access and use. A better understanding of these factors, we argue, can help in assessing the potential vulnerability of Caribbean agriculture in the face of future climate stress.

Small-scale farming in St Elizabeth parish

St Elizabeth parish, Jamaica's 'breadbasket region', has been widely studied, and the basic contours of its distinctive agricultural system are by now well known. The area sits in a rain shadow and is subject to variable weather conditions, and previous researchers have detailed the development of a number of specialized dry-farming techniques, particularly the use of guinea grass mulch as a means of conserving soil moisture (Barker & Beckford, 2008; McGregor *et al*., 2009). Farmers in the study area grow a wide range of crops (chiefly fruits and vegetables for the national market), and deploy an array of individual and locally-specific planting and water management strategies, depending upon their available resources and the local microclimate. Barker (2012: 56) has reviewed the literature on these local innovations and adaptations, and concludes that this 'clearly

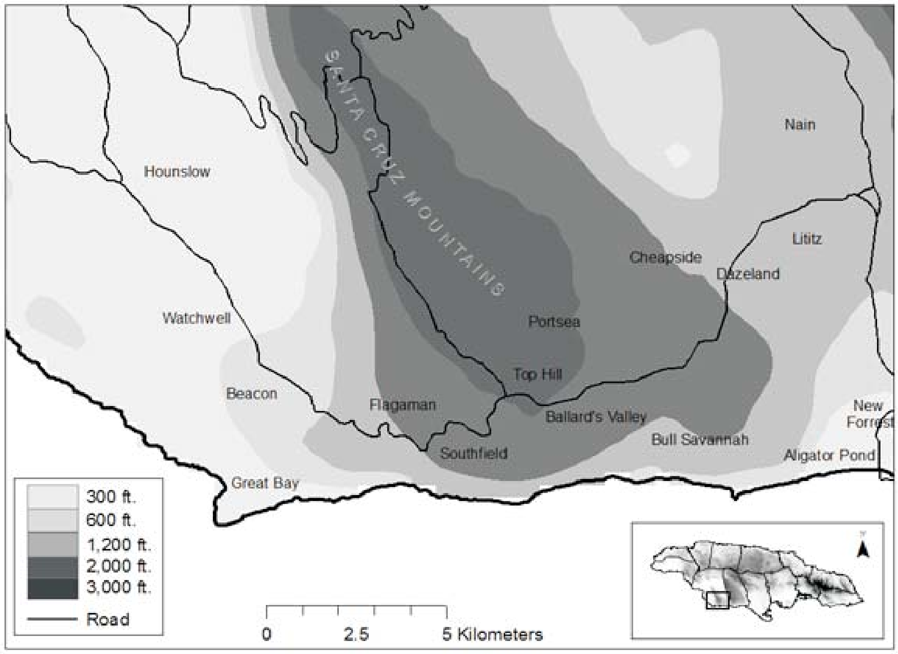

FIGURE 1: Location of study area

demonstrates the importance of indigenous knowledge in coping with climate change' (also see Beckford *et al*., 2007; Campbell & Beckford, 2009).

Although climate change may exacerbate a number of different climate hazards faced by farmers in St Elizabeth, including hurricanes and flood rains (Barker, 1993; Campbell & Beckford, 2009), the prevailing growing conditions mean that the area is particularly susceptible to drought. Recent work examining farmer perceptions of drought has illustrated the multiple adaptations farmers employ to cope with the effects of scarce rainfall (McGregor *et al*., 2009; Gamble *et al*., 2010; Campbell *et al.,* 2011). These include alterations to planting strategies and methods, actions to retain soil moisture, and new strategies for water management. In their detailed examination of a 2008 drought event, Campbell *et al*. (2011: 150) sum up the diverse range of coping strategies by noting that 'farmers in southern St Elizabeth have perfected the art of growing crops in drought conditions'. This may be so, but the ability of particular farmers to adapt in the face of climatic hazards such as drought varies significantly according to their geographic location and the resources they are able to command. This is particularly the case when it comes to the ability to acquire and make use of irrigation water.

Our analysis of the variable impacts of drought among Jamaican farmers is informed by two different strands of literature that can be applied to irrigation. The first examines the materials, technologies and practices that come together in different irrigation configurations to manage water's flow, or agency (Birkenholtz, 2011; Gibbs, 2013;

Lavau, 2013; Sultana, 2013). Such work has tended to draw upon theories of networks or assemblages to examine the ways in which particular orderings of nature and society shape processes of social action and change (Latour, 2005; Anderson *et al*., 2012). As Gibbs (2013: 481) puts it: 'conceptually framing water as part of an agentic assemblage encourages a more nuanced understanding of highly complex systems, and acknowledges the role of and interactions between various human and nonhuman actants'. In our analysis below, we investigate the ways in which access to different irrigation assemblages affects the ability of farmers to respond in the context of drought.

The second body of literature focuses not on the material components of irrigation, but on the ways in which access to water is shaped by social bonds and personal relationships, or what is often referred to as social capital (Mustafa & Qazi, 2007; Hoogesteger, 2013). As Mustafa & Qazi (2007: 1799) define it: 'social capital refers to social networks and associations through which social actors exercise their agency to enhance livelihoods, manage resources, articulate subjectivity, and attempt to affect change within specific political economic/ecological and social structural contexts'. As Adger (2003) has noted, the networks and associations comprising social capital can be particularly important to climate change adaptation, because they help to frame the ability to respond collectively when faced with environmental stress. In the present context, then, we are interested in examining the extent to which social capital can be seen to play a role in the different strategies taken by Jamaican farmers during the 2014 drought.

Agricultural assemblages and irrigation

Interviews and field observations during 2014 substantiate the extent and magnitude of the drought event, which was characterized by farmers as a dry period during the typical April–June short rainy season, and a drier than average dry season between July and August. Data collected from 13 rain gauges also confirmed that during June and July the region received only 20 percent of the 30-year average rainfall (Poore *et al*., 2016). The stress to plants from these conditions was exacerbated by high temperatures and strong winds, both of which resulted in increased rates of evaporation and transpiration. The devastating effects of the combination are attested to by one farmer, who related that:

> 'last year we had rain now in the July month, but this year there is a constant breeze and the high temperature….You see the earth there, when you throw water on it, it actually fizzes. You know, like extra thirst' (Farmer in Hounslow, 2014).

Our visits to farms across the region provided visual confirmation of the negative impacts of the drought, with entire fields of shrivelled and dead crops. As a carrot farmer in Southfield lamented:

> 'we want rain but we don't get no rain. The things, them, just start crisp, crisp and lay down … to me, this is the wickedest drought mi ever believe that we ever go through' (Farmer in Southfield, 2014).

As these quotes suggest, the unusually dry and windy conditions present in the summer of 2014 made securing water for irrigation a primary concern for farmers. As prior research has noted, there are a number of different irrigation systems and strategies that farmers can employ (Beckford *et al*., 2007; McGregor *et al*., 2009), but the ability of different farmers to deploy them varies considerably and is dependent in part on the resources that different farmers command (Popke *et al*., 2016). At the heart of the water management framework are three primary components; access and availability, storage, and methods of water distribution.

Even under normal circumstances, farm-level vulnerability is determined to a significant degree by access to irrigation water, which varies in terms of both location and cost. Some communities within the parish have access to government-built irrigation infrastructure. Farmers in these areas can request a hook-up from the National Irrigation Commission [NIC], and pay a monthly water bill for the water they use. Some farmers use treated household water despite prohibition notices from the National Water Commission that stipulate that potable water should not be used for uses other than domestic purposes. Since the potable water is more expensive, its use is generally limited to smaller fields or for limited duration. Farmers along irrigation lines generally use overhead sprinkler systems (or 'rainers') to irrigate their fields, which facilitates the cultivation of crops with spreading growth habits, such as peanuts, sweet potatoes, and field peas. Rates for irrigation water vary significantly across the different schemes, but are generally low enough that farmers with access have few restrictions on the amount of water they use. Indeed, in areas with irrigation, it is not uncommon to see rainers irrigating fields of grass and weeds intended for livestock, even as drought is causing crops in nearby communities to wither and die. This ready access to inexpensive irrigation gives farmers in certain areas an obvious advantage during times of drought. Here is how one farmer, who cultivates in Beacon (one of two communities served by the Beacon-Little Park irrigation scheme), puts it:

> 'Well, I mean, drought getting worst you know … but as we with this irrigation system, we have the boost. We have many privilege than another person … Some places in south St Elizabeth still dry, but we going on. It is dry here, you know, but at least we have some water to really give us that boost'.

For farmers who do not live along irrigation lines, water must be secured through rainwater harvesting or by purchasing water by the truckload. Trucked water originates from one of several wells in the region, some of which are operated by the NIC and others owned privately. Some farmers pick up water using their own truck, but most purchase water from the NIC's Rapid Response Unit or a private vendor. The price for trucked water varies, and depends upon distance from the source, quality of roads, and regional demand. Not surprisingly, the 2014 drought served to increase the regional demand for irrigation water, and at the time of our research, which included site visits to wells and interviews with truckers, a thriving private water supply sector had developed in the parish. An August 2014 story in the *Jamaica Observer* noted that 'residents who are able to afford it are paying as much as J$15,000 (roughly US$150) to private truckers for a load of water while operators of small wagons and open-back vans have done a thriving business delivering in much smaller quantities' (Myers, 2014). From our observations, trucks of various sizes typically line up hours in advance of a well's opening (at times

FIGURE 2: Water vendors lined up at well

even the night before), taking up positions for what can be a five-hour wait to obtain a load of water (Figure 2). Larger trucks need fewer loads to make their rounds, but take longer to fill up, which can be a source of contention when lines remain long as closing time approaches.

Regardless of the source of irrigation water, farm-level vulnerability is significantly reduced if farmers have access to adequate onsite storage, which generally takes the form of an in-ground concrete catchment, a lined pond, or an above-ground plastic tank (Figure 3). A number of towns are served by large, community-based catchments that are filled via rainwater harvesting from a concrete 'barbecue'. Many of these are in disrepair, but there are plans underway to refurbish a number of them, including a recently-restored tank in the community of Portsea, which is now expected to serve an estimated 1500 residents (*Jamaica Observer*, 2014). For most households, however, the ability to store water requires the expense of building or purchasing a tank or pond. Storage of water is particularly important for farmers who rely on the purchase of trucked water, because it allows for irrigation to be applied to the field strategically according to the conditions and needs of the crop. Farmers without adequate onsite storage may be forced to apply an entire load of water onto their fields at once, irrespective of the plants' stage of growth or water demands (Figure 4). High wind and temperatures lead to rapid evaporation of this water from the surface, necessitating a repeat of the process in a matter of days and increasing costs of production. Farmers can mitigate this to some extent by resorting to the familiar practice of storing modest quantities of water in standing 'blue

FIGURE 3: top left - concrete catchment; top right - pond with liner; bottom left - black tank; bottom right - 'blue barrel' for hand watering

barrels' within their fields, but this requires labour-intensive hand-watering of crops, which tends to limit both the scale of production and the range of crops that can be successfully grown.

A third important component of on-farm water management is the distribution system, which enables the farmer to regulate water use as appropriate for a particular crop and its stage of growth. A number of options are available, including the aforementioned sprinkler/sprayer system, drip irrigation (gravity fed and/or enabled by pump) and hand watering. Most farmers view drip irrigation as the most efficient method of conveyance, but the costs of implementation are prohibitive for many small farmers. As one farmer described it to us:

> '[The drip system] more expensive to deal with, but we have to try … you can't buy the amount of drip at the same time, so that's why mi just gradually add. Every year I might get some profit… I can buy another roll when I get some money again. Maybe later on down, mi get the whole thing under drip' (Farmer in Little Park, 2014).

Farmers with black tanks can set up gravity-feed drip systems, whereas those accessing an in-ground pond or storage tank must bear the added costs of purchasing and running a pump. Electric pumps are most common, but the high cost of electricity can add a significant cost to a farm-level irrigation scheme.

FIGURE 4: Load of water being sprayed onto field from the back of a truck, Flagaman

Farmers without irrigation or the means to set up a drip system must resort to hand watering in times of drought. This practice allows for a more regimented and precise use of water, and can be an option for farmers cultivating crops that are planted at discrete intervals, such as peppers and melons. But hand watering takes significant time and may require the purchase of additional labour, and the practice is not ideal for broadcast crops such as carrots. During times of drought, hand watering can be less efficient than a drip system, as the high temperatures and wind tend to lead to rapid evaporation. Here is how a scallion and thyme farmer in the Bull Savannah community described the challenges:

> 'If you pour the water out there, [it's] just like you put on the water on the fire and boil it … Because I throw the water there and I just see them just dry up and die. Because the heat with the water, it come like boiling water. So it just bubble up and die. So I have to stop. This year is the one that I don't know what to say. It is the worst, the worst, worst one. Everything dry down' (Farmer in Bull Savannah, 2014)

We can see from this discussion that the ability of farmers to cope with drought is determined to a large extent by agricultural assemblages, the particular configurations of nozzles, pipes, tanks, trucks, barrels, buckets and other materials and technologies that allow farmers to deploy water for irrigation. The assemblages that farmers have at hand depend upon a combination of geography (access to irrigation lines, distance from a well) and the resources that different farmers can command (such as the ability to purchase a drip system). The variable landscape of water assemblages suggests that future climate hazards such as drought are likely to have uneven impacts, as some farmers will be better able than other to undertake measures of adaptation.

Social capital and water management

The networks that supply farmers with water are not only comprised of materials, but also associations of individuals, social ties, agricultural practices and knowledge, assets that are generally referred to as social capital. Access to social capital has been widely recognized as a key determinant of resilience in the face of climate change (Bebbington, 1997; Kelly & Adger, 2000; Adger, 2003; Pelling & High, 2005; Pelling, 2011). Drawing on prior research in St Elizabeth, Campbell *et al*. (2011: 156) have argued that 'the importance of assets and economic and social capital is magnified during a drought'. The events of the 2014 drought would appear to bear this out, and our research suggests that social capital has played an important role in shaping access by St Elizabeth farmers and communities to water for irrigation.

Some farmers, for instance, indicated that personal connections can be leveraged to gain quicker access to trucked water. Because of the high demand, customers placing an order for water were facing as much as a month-long delay. But farmers reported that knowing a truck driver can reduce waiting periods to a day or two. One farmer in Flagaman celebrated this fact, recalling how:

> 'It was my luck. My friend was driving the truck, and yesterday I said "man I need some water". He said "you not gonna get it now". Then yesterday, even he stopped by and say "alright I'll let you get it today or tomorrow"... and then him call me and tell me get ready' (Farmer in Flagaman, 2014)

Farmers who truck their own water also sometimes give away loads of water to friends or neighbours, even if this means forgoing potential income. One such farmer explained:

> 'when we do get some of the water, we need money for food too, so we have to sell it … [But] then, other people need it for survival, so you have to bring it and help them with it… Because is a precious commodity right now' (Farmer in Dazeland, 2014).

Drivers of private water trucks also rely on social networks at the various facilities where they acquire water for distribution to their customers. One common practice is for truckers waiting their turn to have their trucks filled up to leave their vehicles in line, even overnight, and have them moved up in the line by fellow truckers. Once trucks are filled, truckers must then speedily deliver the water to their customers in order to get a spot in line to be refilled and thus capitalize on the demand for the precious commodity.

Another example that highlights the value of social connections concerns access to a new spring in the community of Great Bay. While Great Bay has not traditionally been a farming community, local residents recently discovered a small natural well in a wooded area. The lands are privately owned, but residents known to the owner have managed to secure permission to use the land, and have subsequently taken up farming, with water conveyed to crops by individually-owned pumps and drip irrigations systems. Not only has this provided farmers with a new, free source of water for irrigation, it has enabled them to bring virgin lands in a flat area under cultivation. One of the new farmers explained that:

> 'This is our little diamond in the rough right here …there are quite a few springs on this side. We asked permission and [the owner] said go ahead. People used to plant like a little back yard, plus a little handful of some-

> thing. But I would say in the last 5 years people start gravitating towards it more and more. Because originally Great Bay is a fishing area. But fishing is so bad, that everybody steering away from that, and going to farming' (Farmer in Great Bay, 2014).

This particular case also serves to highlight the precariousness of the water management assemblage, since farmers only enjoy use of the new spring until the owner decides to proceed with other uses for the land. In the long-term therefore, the farmers in Great Bay, like elsewhere in the region, have little assurance of continued secure access to water and must rely on the goodwill of neighbours.

A more common practice that illustrates the importance of social capital is the sharing of even small amounts of stored water. In a number of instances, farmers with storage report sharing the water they do have with neighbours who are unable to buy it. In the community of Ballard's Valley where even water for domestic use is unavailable, one farmer explains how:

> 'Right now it's very bad sir. People carrying water on their head, from distance to distance. I have a tank. Somebody might come, and I might give a pan of water. Another person come, before you know it, it dry. But its water, you can't say no. I buy water here and I give it away because they come all the while and beg me a pan of water'.

In contrast to these examples, there are also cases where drought-induced stress on limited water resources has had a negative impact on community bonds and social capital, serving to undermine a sense of solidarity and resulting in conflict. One example concerns a farmer with a cement water tank, who, at the onset of the drought, offered to share water in the tank with a few members of the community. As the drought endured, the farmer was left with little to irrigate his own fields and was forced to rescind the offer to share. Within a few days, the bodies of two dead animals were discovered in the tank, forcing the farmer to abandon it temporarily. A similar tension was evident surrounding a new irrigation scheme established in the New Forest community in neighbouring Manchester Parish. Initially, access was granted to water trucks owned by members of surrounding communities, but this was eventually cut off at the request of farmers on the irrigation scheme, who feared that the increased demand would place too much stress on the infrastructure and put their production in jeopardy. As one former beneficiary put it:

> 'The farmers, them, that have the farmers organization there, them entitled to the water. But them claim to say when the truckers come down, like we go down there to pull water, it cut their volume of water. So, it seem like them don't want be fair enough to share the volume of water' (Farmer in Comma Pen, 2014)

These and other tensions arising from the drought suggest that social capital can be eroded by the desperate need for water and the uneven ability to secure it.

Conclusion

The experiences and responses by farmers in southwestern Jamaica during the summer drought of 2014 offer insight into how climate hazards might impact Caribbean agriculture in the future. If climate models and predictions are correct, future climate conditions are likely to result in added stresses on the resource-poor farming systems of the region. The responses by small-scale Jamaican farmers documented here suggest that the impacts of future climate change will be highly variegated, and mediated in part by access to the assemblages that facilitate farmers' ability to acquire, store and distribute water. As this paper has illustrated, these assemblages are, on the one hand, material and technological, consisting, for example, of irrigation pipes, black tanks, and water trucks. The ability of particular farmers to acquire and utilize the various irrigation systems is determined primarily by geography and access to financial resources.

On the other hand, however, we have seen some of the ways that water and irrigation networks are assembled through social relations, embedded in the social capital of personal networks and community bonds. The store of social capital within households and communities can serve an important function in reducing vulnerability to climate change, by facilitating the sharing of access to scarce resources. But the stresses resulting from less favourable growing conditions also can have the opposite effect, fraying the bonds of social capital and intensifying competition. The tensions between these different outcomes highlight a long-standing discussion within Jamaica about the challenges of getting small farmers to act more cooperatively (Stone, 1978; Crichlow, 2005; Weis, 2000; 2006; Rhiney, 2009; Sammonds, 2014). In the face of increased environmental challenges brought on by climate change, it is worth asking to what extent we might view access to water as a collective good and a shared responsibility, as opposed to a matter of individual fortune (Pretty, 2003; Zwarteveen & Boelens, 2014). In the absence of a more co-operative understanding of irrigation infrastructure and more robust networks of community social capital, we may see self-interests and a desire to get ahead diminish the bonds of rural solidarity that may be necessary to increase the resilience of Caribbean agricultural communities.

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