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ORIGINAL ARTICLE

# Factors affecting the innovation potential of smallholder farmers in the Caribbean Community

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**Abstract** The need for domestic smallholder farming systems to better support food and nutrition security in the Caribbean is a pressing challenge. The Caribbean Community (CARICOM) faces complex socio-ecological challenges related to historical legacies of plantation agriculture, small population sizes, geographic isolation, jurisdictional diversity, and proneness to natural disasters, all of which underscore the importance of fostering system-wide innovation potential. This paper explores the factors that are impacting the innovation potential of smallholder farming households in four CARICOM small island developing states (St. Lucia, St. Kitts-Nevis, Trinidad and Tobago, and Guyana) using data collected through producer household surveys, focus groups, and key informant interviews. Results indicate that a systemic lack of access to finance, markets, and knowledge networks is perceived as limiting smallholder innovation potential in the region. Compounding these challenges was a pervasive lack of trust reported between actors and institutions throughout the agricultural innovation system, hindering the potential for collective action. Our findings point to the need for more decentralized governance approaches that are capable of establishing stronger relationships between actors and institutions to enhance knowledge flows in support of regional rural development and food and nutrition security objectives.

**Keywords** Food security · Agricultural policy · Adaptive capacity · Resilience · Institutions · Innovation platforms

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## Introduction

Caribbean agriculture is undergoing substantial restructuring as it shifts from a system centrally organized around export production to one increasingly focused on domestic markets (Weis 2004, 2007; Saint Ville et al. 2015). Beginning with the rise in the plantation institution in the seventeenth century, Caribbean agricultural resources were primarily directed toward producing commodities for global markets (Axline 1986; Beckford 1972; Briguglio 1993). However, by the late 1980s, this export-oriented system began to struggle in the face of globalization and trade liberalization processes (Ford et al. 2007; Weis 2007). As a result, the large-scale production of many plantation cash crops, such as sugar, banana, and cocoa,

and the national institutions that supported their development, production, and marketing have collapsed (Weis 2007). While some farmers have begun the transition toward more locally oriented farming systems, others are leaving agriculture for employment in sectors such as tourism and construction (Clarke and Barker 2012; Pemberton 2005). However, as the global food economy becomes even more integrated, those continuing to pursue agricultural livelihoods struggle to compete due to disparities in scale, technology, and production support (Weis 2004). At the same time, the region's food import bill has been rising, totaling approximately 4.25 billion US dollars in 2012 (FAO 2013).

Agricultural decline is part of a broader set of development challenges facing rural communities in the Caribbean. While overall poverty levels in the region have fallen over the last several decades, the rural poverty rate remains about twice as high as that of urban areas (IFAD 2014). Furthermore, labor force participation rates remain low among youth and women, contributing to high rates of outmigration of rural youth and creating challenges for the future of rural economies (ECLAC 2005). Exacerbating these challenges is a lack of strong rural institutions, including low levels of public investment in education and health services (IFAD 2002), and the absence of a comprehensive rural development strategy to strengthen social and economic well-being and resilience (ECLAC 2012). Environmental change processes are also affecting the potential for sustainable rural development in the region's many small island developing states (SIDS) (Angelucci and Conforti 2010) due, primarily, to their small physical size, exposure to natural hazards, limited natural resources, small economies, and their deep integration into global markets (Pelling and Uitto 2001; Wong 2011). Annual climatic variability and worsening extreme weather events linked to climate change are further intensifying these regional challenges and underscore the importance of fostering system-wide innovation capacity (Birner and Resnick 2010; Blancard and Hoarau 2013; Gamble et al. 2010; Ganpat and Isaac 2014; Kydd and Dorward 2004).

Over the last two decades, the Caribbean Community (CARICOM), an economic grouping of fifteen countries, mostly SIDS, has paid increasing attention to the role that a revitalized agricultural sector can play in sustainable rural development and food security (CARICOM Secretariat 2004, 2007, 2011a). A landmark effort was the "Jagdeo Initiative," a strategy proposed in 2004 by the former President of Guyana for repositioning CARICOM agriculture in a framework of balanced rural development that meets domestic food security needs while supporting a competitive agricultural sector (CARICOM Secretariat 2004). The Jagdeo Initiative identified a number of binding constraints and accompanying interventions to enhance food security and agricultural development in the region, emphasizing the need for institutional realignment away from traditional structures to those better able to support diversified products and markets (CARICOM Secretariat 2007). Underlying the Jagdeo Initiative was a recognition that the unique limitations of individual SIDS, including their small natural resource bases, limited financial and human resources, and high transaction costs to trade, necessitated regional collaboration, particularly in a context of increasing environmental and economic changes (CARICOM Secretariat 2004; Ford et al. 2007). Following the Jagdeo Initiative, in 2010, CARICOM Heads of Government endorsed a Regional Food and Nutrition Security Policy in order to provide a coherent framework for food security action and collaboration across sectors and countries (CARICOM Secretariat 2011b).

Through these policy processes, the need for greater innovation[1] in the region's diverse smallholder agricultural systems has been identified (FAO 2013; Saint Ville et al. 2015). Importantly, the innovation potential of social actors and institutions in smallholder farming systems is closely related to their adaptive capacity in the face of shocks (Eriksen et al. 2009; Olwig 2012; Walker et al. 2004). According to Amaru and Chhetri (2013), adaptation *is* innovation, with the ability to innovate representing a key adaptive mechanism that is "mediated through existing social and institutional factors and may be executed by multiple actors" (p. 129). Agricultural system innovation can therefore occur at many scales (individual, household, community, national levels) and along many dimensions including technology adoption, institutional change, supply chain reorganization, and market development (Klerkx et al. 2010). Despite the recognized importance of innovation across the diverse food and agriculture systems operating in CARICOM, few empirical studies into the factors affecting agricultural innovation potential in the region are available. This paper responds to this knowledge gap, focusing on the challenges and opportunities facing smallholder farming households in four CARICOM SIDS: St. Lucia, St. Kitts-Nevis, Trinidad and Tobago, and Guyana.

## Methods

Working within an exploratory multiple case study research design (Yin 2003), we employed a mixed method approach to data collection and analysis in each country (Creswell and Clark 2011). Due to the dearth of contemporary empirical research on smallholder famer innovation

[1] Here, we understand innovation as an idea, practice, or process perceived as novel by a social actor (Rogers 1983).

and adaptive capacity issues in the Caribbean, an exploratory research approach was the most appropriate to enable flexibility, (Mills et al. 2010) and to generate more integrative insights.

## Study areas

Each of our study countries (Fig. 1) has a large rural population (in proportion to total population), and each lists agriculture among the major industries supporting their economy (Table 1). More importantly, each is a member of CARICOM and therefore working toward the same set of regional food and nutrition security objectives. As former colonies, these countries also share institutional and historical legacies, most notably slavery and plantation-based agricultural production and strongly hierarchical systems of authority (Mintz 1985; Saint Ville et al. 2015; Thomas 1988).

Importantly, there are also a number of differences among the four study countries that allow us to capture some of the socio-ecological diversity present in CARICOM. First, in contrast to the three island countries, Guyana has considerably more arable land and relatively abundant water resources available for agricultural production. Among the three island countries, Trinidad and Tobago is larger in land size and less reliant on its agricultural sector, with substantial economic revenue being derived from oil and gas development. The study countries also capture the cultural and ethnic diversity characteristic of the region. For example, in Guyana and Trinidad and Tobago, a large proportion of the population is of East Indian origin, while in St. Kitts-Nevis and St. Lucia the majority of the population is of African descent. This level of diversity allowed us to explore the critical factors influencing agricultural system innovation in different settings (Yin 2003), thereby strengthening the reliability of our findings and their applicability to regional food security policy discourse (Miles and Huberman 1994).

## Data collection and analysis

Data collection involved surveys, focus groups, and in-depth interviews, all conducted between 2011 and 2014. A producer (farmer) household survey was designed to capture information on the specific challenges and opportunities smallholder farmers experienced in relation to food production in each country. Focus groups and in-depth interviews were conducted with smallholder farmers and other actors in the agro-food systems in each country, to gather further information and details helping to contextualize the results of the survey. This resulted in a broad and integrated base of evidence from which inferences for regional policy and practice could be drawn (Creswell 1994). Combining qualitative and quantitative methods

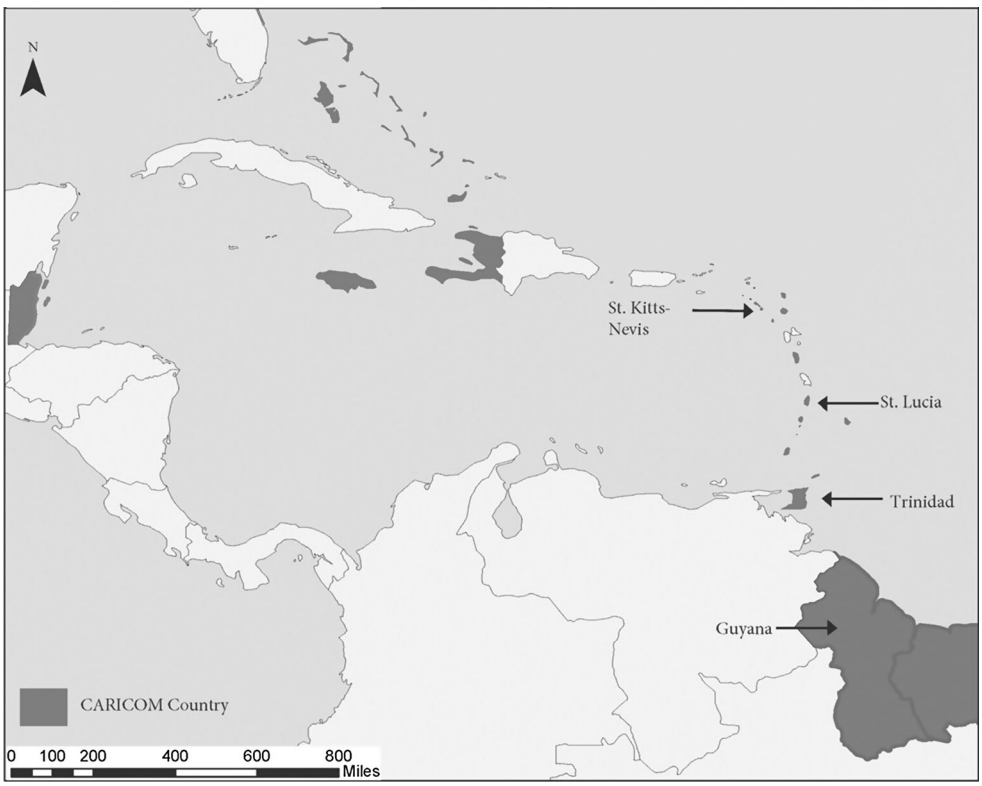


**Fig. 1** Regional map of case study countries

**Table 1** Comparative summary of the key characteristics of each study country

| | St. Lucia | St. Kitts-Nevis | Trinidad Tobago | Guyana |
|---|---|---|---|---|
| Location | Island country in the Windward Islands | Two-island country in the Leeward Islands | Two-island country in the Windward Islands | Country on the north coast of South America |
| Land area | 616 $km^2$ | 261 $km^2$ | 5,128 $km^2$ | 214,969 $km^2$ |
| Population (2014) | 163,362 | 51,538 | 1,223,916 | 735,554 |
| Urban population | 17.5 % of total population | 32 % of total population | 14 % of total population | 28.4 % of total population |
| Economy (2013) GDP | $1.4 billion USD | $767 million | $27 billion USD | $6.6 billion USD |
| Per capita income | $13,100 USD | USD $16,300 | $20,300 USD | $8,500 USD |
| Major industries | Tourism, light manufacturing, service, agriculture | USD service, tourism, agriculture | Oil and gas, mining, construction, service, agriculture | Agriculture, mining, service |

*Source*: CIA The World Fact Book 2014. Retrieved online https://www.cia.gov/library/publications/the-world-factbook/geos/sc.html

**Table 2** Qualitative research activities

| Research activity | Participants | Theme | St. Lucia | St. Kitts | Trinidad | Guyana |
|---|---|---|---|---|---|---|
| Interviews | Smallholder farmers | Social capital, farmer innovation | $n = 25$ | $n = 39$ | | |
| Interviews | Policy-makers, community members and leaders | Social capital, institutional innovation, policy change | $n = 64$ | $n = 26$ | $n = 19$ | |
| Focus groups | Smallholder farmers | Social capital, farmer innovation | $n = 75$ | | | $n = 163$ |
| Focus groups | Farmers, policy-makers, community members, and leaders | Social capital, institutional innovation | | $n = 13$ | $n = 35$ | |

also facilitated data triangulation (Creswell and Clark 2011; Hancké 2009).

*Household survey*

Between October 2011 and August 2012, we conducted a non-probabilistic producer household survey (PHS) of smallholder farmers ($n = 606$) in St Kitts-Nevis ($n = 91$), St. Lucia ($n = 118$), Trinidad and Tobago ($n = 93$), and Guyana ($n = 304$). Smallholder farmer households were selected from local agriculture registries provided by local project partners in each country. An initial version of the questionnaire was pretested in all four countries to improve clarity and to reduce the potential for survey bias. For details on PHS design, sampling and results, consult (Laszlo et al. 2013) and Thompson-Colón (2013). The main survey respondent was the person in the household who owned, managed, or cultivated a parcel of land used for farming and/or raising livestock, and who was responsible for most daily farming decisions. Farmers were asked socio-demographic and health questions regarding themselves and all members of their household. They were also asked questions related to household food sufficiency, household income, household decision making, farming practices, technology adoption, access to markets, and attitudes toward risk. It is important to note that our household survey was designed to be exploratory in nature, and that, subsequently, the results are appropriate for generalization to theory, rather than to populations (Yin 2003). We therefore present the results in a descriptive rather than explanatory manner and rely on other data sources to triangulate the survey findings and assess reliability.

*Key informant interviews and focus groups*

Key informant interviews and focus groups were undertaken in each country with a range of actors in the smallholder agricultural innovation system including farmers, policy-makers, and community leaders and members. Specific research tools and participants varied by country, reflecting the different regional research contexts and the exploratory nature of our research. However, data in each country were collected around common themes of smallholder farmer innovation (including access to resources and knowledge), social capital, and institutions and policy. Table 2 summarizes the qualitative research activities conducted across our

four study countries. Qualitative data were transcribed and analyzed using content analysis (Morgan 1993), with grounded theory's constant comparative method used to guide memo writing and coding (Glaser and Strauss 1967). Throughout the results and discussion, we present illustrative quotes wherever possible to capture the overall sentiment in our dataset and better contextualize the findings.

## Results and discussion

### Challenges facing smallholder agricultural innovation systems

Table 3a–d presents the demographic characteristics of the surveyed farming households. Results indicate a number of characteristics that can be associated with low levels of innovation potential, including relatively low levels of formal education and land ownership across the region. Overall, just less than half (48 %) of all surveyed farmers had completed secondary school (average values ranged from 19 % in Saint Lucia to 68 % in St. Kitts-Nevis). Previous research suggests that low levels of formal household education constrain farmers' capacity to adopt new practices and technologies and acquire more specialized skills and training (Dahkil and Clercq 2004; Huffman 1999). Our survey also revealed variable patterns in land and farm ownership among farmers. Currently, government is the largest landowner in CARICOM, and many countries have introduced various land reform programs and policies to address historically uneven land ownership patterns (IICA 2013; Williams 2003). However, across the region, uncertain title to land for agricultural and residential use persists (IICA 2013; Williams 2003). Specifically, our survey indicated that although the level of dwelling ownership is high at 91 % (ranging between 78 % in St. Kitts-Nevis and 95 % in Guyana), the level of ownership of the land on which the dwelling was located is considerably lower at 67 % (ranging between 35 % in St. Kitts-Nevis and 78 % in Guyana). Land tenure is an important factor shaping household vulnerability to environmental and socioeconomic shocks (Reale and Handmer 2011; Williams 2003) with households living on land with insecure tenure often particularly vulnerable to displacement following natural disasters and low levels of access to credit (Reale and Handmer 2011).

Our survey results also show relatively low levels of farm ownership among our sample (65 %). However, this varies considerably between countries, with only 8 % of surveyed farmers in St. Kitts-Nevis owning their farm, compared to 89 % in Guyana. More secure farmland tenure is generally associated with more profitable and sustainable agricultural

**Table 3** Characteristics of smallholder farming households surveyed in St. Lucia, St. Kitts, Trinidad, and Guyana

| Variables | Mean | SD |
|---|---|---|
| (a) Household head | | |
| Female (0/1) | 0.16 | 0.371 |
| Married (0/1) | 0.72 | 0.451 |
| (b) Education | | |
| Primary (0/1) | 0.38 | 0.485 |
| Secondary (0/1) | 0.48 | 0.500 |
| College/University | 0.09 | 0.280 |
| (c) Home and property ownership | | |
| Owns home (0/1) | 0.91 | 0.279 |
| Owns land on which home is located (0/1) | 0.67 | 0.470 |
| (d) Farm characteristics | | |
| Years of farming | 20 | 11.9 |
| Farm size (acres) | 8.3 | 42.2 |
| Farm ownership | 0.65 | 0.478 |
| (e) Agricultural production constraints | | |
| Lack of finance (0/1) | 0.60 | 0.491 |
| Lack of information (0/1) | 0.20 | 0.403 |
| Lack of technical assistance (0/1) | 0.26 | 0.440 |
| Weeds, pests, diseases (0/1) | 0.64 | 0.481 |
| Humidity, heat (0/1) | 0.11 | 0.314 |
| Flooding (0/1) | 0.46 | 0.499 |
| Drought (0/1) | 0.14 | 0.351 |
| Larceny (0/1) | 0.19 | 0.393 |
| Wildlife pests (0/1) | 0.23 | 0.419 |
| Government agriculture policy (0/1) | 0.20 | 0.397 |
| Timely availability of inputs (0/1) | 0.16 | 0.368 |
| Marketing (0/1) | 0.29 | 0.454 |
| Farm accessibility (0/1) | 0.09 | 0.288 |
| (f) Access to markets: farmer buying contracts for crops | | |
| Formal (0/1) | 0.20 | 0.399 |
| Informal (0/1) | 0.49 | 0.500 |
| None (0/1) | 0.31 | 0.464 |
| (g) Technologies and assistance | | |
| New technology adopted in past 12 months (0/1) | 0.38 | 0.486 |
| Technical assistance sought* (0/1) | 0.26 | 0.441 |
| Source of technical assistance* ($n = 160$) | | |
| Friend | 0.16 | 0.365 |
| Ministry of Agriculture | 0.02 | 0.150 |
| University | 0.002 | 0.041 |
| Retailers (e.g., agricultural input stores) | 0.11 | 0.318 |
| Internet | 0 | 0 |
| Research institutions—Caribbean Agricultural Research and Development Institute (CARDI)/ National Agricultural Research and Extension Institute (NAREI) | 0.20 | 0.400 |
| Other (e.g., family member) | 0.03 | 0.165 |

*Data Source:* PHS 2012; Total $n = 606$

* Only farmers who had adopted a new technology were asked this question

production, with positive implications for household income and food security (Maxwell and Wiebe 1999; Reale and Handmer 2011). Insecurity in land tenure may deter investment in agricultural infrastructure, and, if a tenure system allows the sale of land, could result in the loss of livelihood in the event of a severe shock (Maxwell and Wiebe 1999; Reale and Handmer 2011). Our study also indicates that land tenure interacts with environmental change in complex ways. For example, in St. Kitts, 73 % of surveyed farmers identified wildlife pests, and in particular monkeys, as a constraint to successful production. Wildlife pests have become worse in recent years as the measures used to previously control them in the export-oriented agricultural system are no longer in place. In interviews, some farmers indicated that this environmental problem is compounded by not owning farmland, making them unable to live on the farm and thereby potentially scare away wildlife pests.

Table 3 shows that 16 % of the farming households surveyed were headed by women. Research in many developing area contexts has shown that women face a unique set of livelihood vulnerabilities related to constrained access to agricultural resources, including land, credit, and inputs (FAO 2011). Focus group discussions also indicated that women often labor on other farms because they cannot access the resources needed to farm on their own. For example, a female farm laborer in Guyana said, "…most of us labour under the, let's say the merchants. That is how we get our income, that is how we get our resources. We are living on the surplus."

In terms of agricultural production constraints (Table 3e), our survey results indicate that smallholder farmers perceive a range of barriers to successful farm production, with access to finance, markets, and information and knowledge emerging as the key barriers to smallholder agricultural innovation.

*Financing*

Lack of access to financing was a key constraint to smallholder production in our sample of farmers and can serve as a barrier to agricultural innovation. For example, in our interviews with crop farmers in St Kitts-Nevis, the issue of financing was raised often, described as limiting their ability to diversify into livestock production due to the need to invest in fencing and shelter for animals. Lack of finance was also described as a barrier to improving water infrastructure for irrigation which would allow farmers to diversify and increase crop production. Many farms are rain-fed, and long dry seasons strain production and contribute to crop losses. Compounding this challenge was that many smallholder farmers did not own farmland to use as collateral in securing a loan (Table 3d) for irrigation and other infrastructure.

In the context of group-based capital raising initiatives, interview data revealed that some groups were able to access financing to purchase tools and equipment that they could not have done individually. However, in other cases, groups faced a new set of constraints in accessing finance. For example, a member of a registered farmers' cooperative in St. Kitts-Nevis explained that eligibility for financing and other sources of funding required the cooperative to maintain a minimum number of paying members. However, collecting membership fees from farmers, many of whom face financial constraints or are only farming part-time, is a challenge that hinders their ability to access financial support. The imposition of external accounting standards and other regulations has been recognized as a barrier to agricultural cooperative development in many parts of the world (Markelova et al. 2009). Our data support the increasingly recognized potential for micro-financing institutions to enable farmer innovation through an appropriate policy and regulatory framework (Ellis 1999; Olaitan 2006).

*Markets*

Market access emerged as a second significant constraint facing smallholder farmers in our study. Across our sample, smallholder farmers were selling their produce primarily to local domestic markets, including supermarkets and public markets. However, as highlighted by our survey results, only 20 % of farmers surveyed had formal contracts for accessing these markets, with nearly all farmers relying on informal arrangements or no contracts at all (Table 3f). This finding points to a key vulnerability in the domestic food production systems of CARICOM, with a lack of established formal market connections restricting access to the information that smallholders need to participate effectively in markets, such as current prices and product demand (Robbins et al. 2005; Markelova et al. 2009). In interviews, many smallholder farmers described their vulnerability to inconsistent purchasing on the part of supermarkets and receiving a viable price for their produce. In reference to having to accept the price offered by supermarkets, a female farmer in Guyana said, "We can't do anything." Similarly, a female farmer in St. Lucia said, "What else would you do? Even if everybody has the same thing, when you want your produce to sell, you just sell it cheaper." A recurring challenge associated with markets was the need to compete with imported foods, particularly fresh fruits and vegetables. Key issues included the contractual agreements between supermarkets and food importers that were seen as limiting the willingness of supermarkets to sign contracts or purchase more produce from local farmers. For example, a farmer in Saint Lucia said: "I know there are sometimes [locally produced]

tomatoes spoiling… and go into the supermarket you would still see imported tomatoes."

Economic and trade liberalization reforms beginning in the 1980s have had the effect of reducing domestic controls on trade and import tariffs which are needed to protect smallholder farmers in SIDS (Ford et al. 2007). During these reforms, many government-owned agricultural enterprises were sold to the private sector (FAO 1995). A senior policy-maker in St. Kitts-Nevis described how the country's Central Marketing Agency, established in the early 1980s to buy food crops from farmers, was "the first one [government enterprise], easiest one to close" as the country shut down public entities due to structural adjustment programs. This closure resulted in the removal of a key marketing support institution for domestic smallholder farmers.

As smallholder farmers around the world are increasingly vulnerable to liberalizing markets, a growing body of research is examining how collective action can be supported among farmers to improve market access (Devaux et al. 2009; Markelova et al. 2009). Sandler (1992) described collective action as taking place "when the efforts of two or more individuals are needed to accomplish an outcome" (p. 1). Drawing on a range of international agricultural case studies, Markelova et al. (2009) found that smallholder farmers acting collectively may be able to reduce transaction costs of accessing inputs and outputs, obtain market information, tap into high-value markets, and potentially improve their bargaining power with buyers. While most farmers in our sample described selling independently to supermarkets and public markets, there is evidence of successful group marketing efforts on the part of small commodity groups or farmers' cooperatives in the region. For example, the Black Bay region of St. Lucia has an active Farmer's Cooperative originally launched as a pilot project in 1974 to boost economic activity in the region and increase farm production through collective farming and product marketing (IICA 1989).

Nonetheless, qualitative results in all four countries indicated that getting smallholder farmers' to work together, including responding to a market demand, was extremely challenging. A senior policy-maker in Trinidad and Tobago spoke to this difficulty: "We have serious challenges with implementation of anything and carrying it forward…our farmers are not organized. Biggest ingredient is having farmers organized whether it's an association or a co-op." Low level of trust among farmers was a recurring theme in our data, resulting in fragmentation between individual farmers and within farmer groups. For example, a female farmer in Guyana explained, "The people [farmers] need to get up and network and that unity together is an issue." A senior policy-maker in St. Kitts-Nevis pointed to the historical dimensions of trust and working together: "Everybody just wants to be independent. It's a culture. If you go back to history, our ancestors came to work on sugar plantations as slaves. After you had a period of indentured servitude where you're expected to work for somebody. I think it comes from that culture. They don't trust one another." While getting farmers' to work together can be difficult, a female farmer active in organizing farmers in St. Kitts-Nevis suggested that a proliferation of "too many small groups, each doing their own thing" further hindered broader collective action.

As the capacity to innovate becomes increasingly linked to an ability to act collectively (Adger 2010; Subramaniam and Youndt 2005), there is a crucial need to build social capital among farmers to overcome mistrust and social fragmentation (Agrawal 2001; Lowitt et al. Accepted; Nahapiet and Ghoshal 1998). Enhanced social capital among farmers may not only improve the capacity for collective action in marketing, but also support the social cohesion necessary for addressing other production constraints identified by our sample of farmers, such as larceny. For example, research indicates that social capital, manifested in terms of improved social connectivity and shared norms, can play an important role in reducing crime in poor and rural regions (Barnett and Mencken 2002; Warren et al. 2001).

### *Information and knowledge*

Another challenge to smallholder production in the region was access to information and technical assistance, supported by interview, focus group, and survey results (see Table 3e). For example, a farmer interviewed in St. Kitts-Nevis, when asked about where he goes for information, explained: "I don't go to anyone….because there's no group around here. No one to ask a question about what to do, what not to do." The survey results related to seeking technical assistance and adopting new technologies provide further insights into the fractured nature of agricultural knowledge networks for smallholder farmers in the region. Farmers were asked whether they adopted any new technologies (including a new crop, irrigation technique, pesticide, fertilizer, recording-keeping technique) over the past 12 months. Results indicated a fairly low level of technology adoption at 38 % (ranging from 18 % in St. Kitts-Nevis to 51 % in Guyana), with only a subset of these farmers seeking technical assistance (Table 3g). Among farmers who did seek technical assistance, research institutes (20 %) and friends (16 %), including other farmers, were the most common sources of assistance. The importance of friends as a source of technical assistance points to the significance of decentralized knowledge networks and social learning for accessing information, a theme that is emerging in the study of natural resource management

issues around the world (Berkes and Ross 2013). For example, a farmer in St. Kitts-Nevis explained: "I try to keep contact with certain farmers. We discuss and share ideas and methods, seeds, and different things." Some said they learn through farming knowledge passed down from other farmers as well as their parents and grandparents. A young farm worker in St Lucia explained, "When a farmer has just entered into farming, he has to gain experience from the more mature farmers and set about learning how to go about the process correctly."

As many farmers move into horticultural crop production from plantation crop export agriculture, access to knowledge networks is key to increasing their innovation potential and adaptive capacity (Ganpat et al. 2014; Hagmann and Chuma 2002; Ingram 2008; Isaac et al. 2007). Our interviews identified instances of farmers' experimenting with new vegetable crops and not continuing with their production because of weed, pest, and diseases problems, a key constraint identified by surveyed farmers (Table 3e). In these interviews, a lack of knowledge emerged as a barrier to improved growing practices; many farmers described operating in an agricultural knowledge and information vacuum, significantly undermining their adaptive capacity in the event of environmental or market-related shocks. For example, a farmer in St. Lucia, when asked about how they decide what to grow, said: "For me, anything I can plant, I plant, as I can make a dollar. As long as it comes to my mind…Yes I try anything I can lay my hands on." Another farmer in Guyana likewise described learning about farming as "luck and chance."

These findings point to the need for new approaches to agricultural research and extension in the region that more explicitly embrace decentralized knowledge networks better capable of accounting for the complexity of the smallholder farming systems (Foran et al. 2014; Isaac et al. 2007).

## Opportunities for fostering smallholder agricultural innovation systems

Overall, very low levels of trust were consistently reported among the different actors and institutions involved in the CARICOM smallholder agricultural innovation system. This is a key finding of our research and an area that warrants urgent research and policy attention in the region, particularly in the context of fostering interinstitutional collaboration in pursuit of household food security and sustainable rural livelihood goals (Lowitt et al., Accepted). More specifically, there is a need to better consider how institutional structures—from local cultural norms to formal government policy (Foran et al. 2014)—influence the innovation potential of smallholder agricultural innovation systems in CARICOM. According to Kilelu et al. (2013), innovation occurs through the collective interactions among farmers, researchers, extension officers, service providers, and others, who are all influenced by diverse interests, values, norms, technologies, markets, institutions, and infrastructural resources. As a result, there is a need to facilitate interactions between multiple actors in order to enable them to embrace the perspectives of others and think reflexively about their interactions with a view to strengthening cooperative relations within their given institutional context (Hall et al. 2003).

Internationally, the concept of "innovation platforms" has been emerging as a potentially powerful approach to supporting actor-driven innovation in different institutional contexts (Foran et al. 2014). Kilelu et al. (2013) defined an innovation platform as a "multi-actor configuration deliberately set up to facilitate and undertake various activities around identified agricultural innovation challenges and opportunities" (p. 66). Innovation platforms work to build capacity among actors, including communication, participatory planning, and network facilitation, and have the potential to act as models for broader agricultural research and development planning (Adekunle and Fatunbi 2012; Foran et al. 2014). Based on our findings, we can conceptualize how innovation platforms might enable different forms of social capital to be developed in the smallholder agricultural innovation system in order to foster trust and collaboration among actors. First, bringing together farmers and farmer groups in innovation platforms may assist with developing the bridging social capital necessary for farmers to better access wider networks of information and support for the issues they face. Bridging social capital essentially connects normally distinct groups, such as different farmer groups or farming communities, with similar levels of power (Sabatini 2009). Our results suggested that many farmers were not accessing support when attempting to innovate with new technologies. The development of stronger peer-to-peer connections between farmers in different communities has the potential to improve agricultural knowledge flows and improve opportunities for social learning (Pretty and Smith 2004). Enhancing the bridging social capital among farmers in CARICOM SIDS may also help facilitate the wider dissemination of technical knowledge from other sources, such as extension officers or training workshops provided by other organizations. Here, decentralized approaches to social learning, such as farmer field days and informal networking events, may prove valuable for building trust and networks between farmer-level actors (Lyon 2000; Megyesi et al. 2010). An example from our data was the organization of monthly group hikes to promote networking and teambuilding among government employees and others working in the agricultural sector. As bridging social capital forges new

links between farmers and other farmer-level actors, it may help generate the social cohesion and trust that is necessary for collective action on issues such as financing, marketing, and political lobbying, enabling farmers to work together to address their shared production constraints (Cramb 2005; Woolcock and Narayan 2000). A senior policy-maker in Trinidad and Tobago said, "There's a wide number of small farmers that all contribute to food security, but we have to try to get them to understand if we bring them together it will be better."

Second, institutional change at levels higher than the farm and community is also needed for agricultural innovation (Hounkonnou et al. 2012; Shiferaw et al. 2009). Here, building linking social capital through innovation platforms—that is the vertical linkages among actors with different levels of power (Grootaert et al. 2004), such as farmers, scientists, and policy-makers—will be key to establishing institutional environments that are more supportive of innovation (Foran et al. 2014). Linking social capital among these actors can encourage the "productive cross-fertilization of ideas, methods and expertise" in support of institutional change (Brooks and Loevinsohn 2011, p. 195) and help ensure a wider range of factors are taken into account in decision making (Tompkins and Adger 2004). Further, enhanced communication among farmers, scientists, extension officers, and policy-makers can help generate more integrated knowledge, drawing on scientific and local bases, to better enable farmers to realize their capacity to innovate (Eidt et al. 2012; Eriksen et al. 2009; Klerkx et al. 2012; Reed et al. 2007). For example, a government technical officer in our study identified a need for better linkages among researchers, extension officers, and farmers so that "we can use it [research] to empower people." However, putting innovation platforms into practice is complex and will require significant institutional and policy support (Klerkx et al. 2010). As noted by Foran et al. (2014), innovation platforms have "inherent complexities and tensions" as different interests and actors need to coalesce around a shared innovation goal (p. 90) and subsequently require explicit efforts to ensure the meaningful representation of all actors, especially smallholder farming households and communities. Here, the use of "innovation brokers"—key individuals or organizations that may help connect different parts of an innovation system (Klerkx and Leeuwis 2009)—may assist in developing shared innovation goals, in supporting the innovation network as it gets formed, and in facilitating multi-directional stakeholder interaction (Klerkx et al. 2010). Such an approach has the potential to foster the kinds of collective action that will be required to achieve the long-term rural development and food and nutrition security objectives of CARICOM.

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