Improving the Nutrition and Health of CARICOM Populations

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Dr. Leroy E. Phillip and Dr. Isabella Francis-Granderson

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Trinidad and Tobago, Guyana, Saint Lucia and Saint Kitts and Nevis
Caribbean West Indies

The Royal Institution for the Advancement of Learning, McGill University
James Administration Building, Room 429
843 Sherbrooke St., West
Montreal Qc CANADA H3A 2T5

The University of West Indies
Department of Agricultural Economics & Extension
Faculty of Science and Agriculture University of West Indies
St. Augustine Campus TRINIDAD AND TOBAGO
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EXECUTIVE SUMMARY

Under the CIFSRF CARICOM Project (March 2011 to August 2014), research was conducted in four pilot countries (St. Kitts-Nevis, Trinidad and Tobago, Guyana and St. Lucia) in the Caribbean Community (CARICOM) aimed at improving nutrition outcomes among primary school children. The school lunch programmes (SFP) in St. Kitts and Trinidad were used as vehicles for improving the nutritional quality of lunch meals for over 1000 children who were offered enhanced portions of vegetables and fruits produced locally; farmers were equipped by the project with technologies to enhance agricultural productivity and diversity to meet the produce needs for healthy lunch meals to reduce childhood obesity. Technologies introduced and strengthened by the project in St. Kitts and Trinidad, and replicated and validated with additional studies in Guyana and St. Lucia, included drip irrigation, protected agriculture (green house), post-harvest-technology, and forage silage conservation. Social network analysis was undertaken to understand and strengthen farmer and institutional social capital for enhanced technology adoption and innovation aimed at improving food and nutrition security in CARICOM.

In this summary, we synthesize the key activities undertaken by the project and the major outcome findings in the areas of school feeding and agricultural technology and innovation; we conclude with key considerations for up-scaling a “Farm to Fork” model developed by the project in support of achieving long-term food and nutrition security in CARICOM.

School feeding: Prior to the project, less than 7% of school meals were prepared with locally-produced fruits and vegetables. For example, in St Kitts-Nevis, at the beginning of the project, pumpkin was the only locally produced vegetable used (on an occasional basis) in school lunch menus. After 15 months of nutrition interventions by the project, about 20 tonnes of 11 different locally-produced vegetables and fruits (including tomatoes, carrots, string beans, cabbage, cucumber, sweet potatoes and watermelon) were supplied to the SFP in St. Kitts for use in a new lunch menu designed to improve diet quality and diversity for over 800 children. Implementation of the improved lunch menu resulted in a doubling of the daily intake of vegetables by children in the intervention (0.60 servings per day) versus control schools (0.34 servings per day); fruit consumption by the children was not improved, however, due to challenges with domestic production and availability of fruits from farmers. In Trinidad, the combination of nutrition education and improved lunch menu led to increased daily consumption of total vegetables and fruits by children in the intervention schools (2.6 servings per day) compared to the control schools (1.8 servings per day). The proportion of children accepting to consume fruit and vegetables in the intervention schools ranged from 34% for carrots, 59% for string beans, 70% for tomatoes to 85% for watermelon. Although the nutrition interventions led to enhanced intake of total vegetables and fruit by children, even the maximum combined intake of vegetables and fruits (about 3 servings per day) met only about 60% of international recommendations; this indicates much room for improving the offering and consumption of vegetables and fruit by school children in the Caribbean.

In both St. Kitts and Trinidad, about 10 % of the children were obese and about 23% overweight or obese; based on WHO standards, only 1% of children were stunted (height for age) and about 4 % were underweight for height. This indicates that the problem of under-nutrition has given way to a growing problem of overweight and obesity among children in CARICOM. Despite improvements in intake of vegetables and fruit, rates of overweight and obesity among children were not affected by the nutrition interventions; this may have been due to the length of the study period and the persistence of non-nutritious snacks offered for sale within and in the vicinity of the schools. A key finding, however, was that, independent of the nutrition interventions, the rates of overweight and obesity among children in both St. Kitts and Trinidad increased from about 23% at baseline to about
30% at endpoint. Nutrition education on its own, as part of the project interventions, did not statistically improve a change in nutrition knowledge, intake of vegetables and fruits, nor prevalence of overweight or obesity among children. While steps are required to strengthen the nutritional quality of school meals, the project results underscore the urgent need for additional national and regional intervention strategies to reverse the weight trajectories among children in CARICOM populations.

**Agricultural technology and innovation:** The project introduced and developed collaborative arrangements between farmers in St Kitts-Nevis and Trinidad and Tobago and the school lunch programs in both countries. This included support for improved agricultural technologies in order to increase year-round productivity and diversity of farmers’ produce. Over a two-year period, the project introduced the use of drip irrigation on selected crops; as a result, tomato yields increased from 18 to 32 tons/ha, pumpkin from 17 to 25 tons/ha and string beans from 3 to 10 tons/ha. Farmers were able to produce vegetables all year round, including during the dry season, and could therefore be depended on to offer a consistent supply of produce for school lunches. In so doing, they gained a reliable and rewarding market. The application of the computer simulation soil-water balance model, McGill-IRRIMOD©, to calculate irrigation requirements for vegetables in St. Kitts and Guyana enabled farmers to irrigate according to crop requirements (previously, many had over-watered). The use of the water balance model, a novelty in the CARICOM region, facilitated irrigation scheduling and identified an irrigation treatment for vegetable crops that increased water use efficiency by 20%.

When evaluated under greenhouse conditions in CARICOM climate, two of seven cultivars of tomato (IT 71 and Versatile) exhibited the best crop yield when a local by-product (coconut coir), rather than an imported product, was used as the growing medium. Under open field agriculture, two lines of pumpkin developed in CARICOM exhibited greater yields and superior taste qualities than an imported variety. The research shows that enhanced productivity of tomato and pumpkin, as well as sweet pepper and other horticultural crops, could be achieved through the adoption of improved crop varieties and the use of local waste products as growing media for greenhouse crop production. Unfortunately, up to 60% post-harvest losses were recorded for tomato and other crops from the farmer to the consumer. On-farm post-harvest losses of tomato were substantially less under greenhouse production than under the open field cultivation. Simple interventions, such as the use of umbrellas to protect produce from direct sunlight and high temperature, could reduce post-harvest losses along the supply chain.

Animal source products are an integral part of a diverse diet. Mutton is a popular food item in St. Kitts-Nevis but the local supply falls short (supply is 12% of demand) of consumer demand due, in part, to low productivity of the small ruminant sector. Introduction and conservation of Mulato II grass for dry season feeding was not enough to achieve high rates of weight gain by local sheep and goats. Our findings with sheep fed Mulatto II grass conserved as silage and supplemented with wet brewers grains (a no-cost brewery by-product) revealed that an undersupply of dietary protein and gastrointestinal parasites are proving to be major factors constraining productivity of small ruminants raised on natural pastures or “cut and carry” forage systems in St. Kitts-Nevis.

To further understand some of the factors influencing and limiting innovation towards regional food security goals, including adoption of new agricultural technologies among farmers, research on social networks and social capital was undertaken by the project. Two key findings emerged from this work: 1) Most farmers obtained their knowledge from other farmers; extension workers from government institutions were less of a source of knowledge to farmers; 2) There are differences between farming communities in terms of the nature of knowledge flows. Farmer knowledge
networks appeared to be based either on “weak ties” (bridging social capital) providing sources of new information within the community or on “strong ties” (bonding social capital) which foster group identity and cohesiveness but are less responsive to innovation and change. These findings suggest that CARICOM food security policy needs to appreciate heterogeneity of social relationships within communities, and build on these community resources of social capital and trust to enhance knowledge exchange and innovation towards improved food security. The project also gained knowledge on how farmers made decisions and whether to adopt a technology; women farmers played a key role in this process. Our project findings suggest that in providing technical assistance to farmers, policy makers might consider targeting their information to groups of farmers, particularly women, and allowing the knowledge and technology diffusion process to take place within their social networks. A key application of this social science knowledge and farmer innovation initiatives was the formation, for the first time in St. Kitts-Nevis, of a Small Ruminant Farmers Association to capture markets and stimulate innovation and economic growth of the small ruminant sector in this country.

Further, focus group research undertaken in St. Kitts-Nevis and in Trinidad and Tobago identified trust, clear communication, co-learning and knowledge sharing, amongst other factors, as being critical conditions for fostering collaboration across different CARICOM countries, organizations and institutions, and in addressing complex problems such as food and nutrition security. As a result of the project, new forms of “institution capital” (“linking social capital”) were generated among diverse actors (e.g. farmers, scientists and policymakers) and institutional capacity to collaborate on food security goals was enhanced. For example, building social and institutional capital among farmers, teachers, community, and institutions of agriculture, health and education in an integrated effort to address childhood obesity in St Kitts-Nevis and Trinidad and Tobago proved key to facilitating technology adoption, collective action and innovation in the development of a functional “farm to fork” model for CARICOM food security; this was a novelty for the region.

Capacity building and Partnerships: The ‘Farm to Fork’ model - built on the three key pillars of enhanced school feeding, agricultural technologies and procurement of local produce- functioned to supply up to 90% of produce needs for nutritionally-enhanced school lunch meals for over 800 children. Prior to the project, almost no local produce was used in school lunch menus. A test of the model for environmental sustainability and food safety, based on international standards, revealed no unacceptable food safety practices on farms or with school meals service. Based on extensive monitoring of soil and water samples, high levels of phosphorus and nitrogen suggest overuse of fertilizer, with implications for environmental quality. An economic assessment of the model, based on key outcomes from the agricultural technologies and school feeding interventions, revealed net benefits for farmers, and for strengthening the nutritional quality school feeding programmes.

Sustainability and upscaling of this ‘Farm to Fork’ model are critically dependent on human and institutional capacity to take up the technologies introduced by the project, capitalize on its outcomes, and adapt the farm to fork model to evolving conditions beyond the life of the project. In this context, institutional and human capacity building was a major achievement of the project. Over 2000 local and regional individuals benefitted from the project; these include about 700 field personnel and farmers who gained skills and knowledge training, through over 30 workshops and training events in drip irrigation, protected agriculture, forage conservation, environmental quality assessment, nutritional status assessment, and food service and food safety. Farmers increased the cropping area under drip irrigation by 32% increase (from 1.84 ha to 2.43 ha) and initiated a five-fold expansion (2 ha to 10 ha) in the area used for cultivating Mulatto II grass for small ruminants. The project produced over 210 knowledge and communication outputs for use by local and regional stakeholders; integrated packages of scientific results and emerging outcomes were presented to
leading CARICOM policy makers and regional stakeholders for evidence-based decision making. Through extensive national and regional media events, public awareness of the project’s contribution to solving problems of CARICOM food insecurity was progressively enhanced.

Another significant outcome of the project was the development and strengthening of national, regional and international partnerships to address the problem of CARICOM food and nutrition insecurity. For example, new partnerships between the National Agricultural Research and Extension Institute (NAREI) in Guyana and McGill University in Canada led to the innovation of a CARICOM water balance model to improve conservation and efficiency of usage of water resources for vegetable crop production. Under the project, and for the first time in St. Kitts-Nevis, a national and regional partnership for improving small ruminant productivity was established; local farmers, along with institutional partners (the Caribbean Agricultural Research and Development Institute, Ross University School of Veterinary Medicine in St Kitts-Nevis, the Ministry of Agriculture of St Kitts-Nevis, and McGill University) collaborated to establish the Small Ruminant Farmers’ Association to access markets and enhance technology adoption among farmers. The project also strengthened an existing research collaboration between Group for the Analysis of Development (GRADE) in Peru and McGill University, and extended this partnership for project research in Guyana, thereby allowing CARICOM farmers to benefit from ‘lessons learned’ in Latin America on barriers to agricultural technology adoption. These multilateral and bilateral institutional partnerships will allow stakeholders to capitalize on achievements and outcomes of the project beyond its life, and advance the gains and potential upscaling of the “farm to fork model” for continued improvements in CARICOM food security.

1. RESEARCH PROBLEM

Food insecurity in the Caribbean has taken the form of overweight and obesity. The rising prevalence of obesity in CARICOM countries, particularly among women, and the increasing prevalence of childhood obesity and overweight, rather than under-nutrition, have become major public health concerns (Henry, 2007). Obesity is a major risk factor in chronic non-communicable diseases (NCDs), including heart disease, stroke, cancer and diabetes, and the Caribbean region has the highest rate of NCDs in the Americas (Hospedales et al 2011). This places a significant burden on regional health systems, which currently absorb up to 8% of GDP, double the global average for lower and middle income countries (Chao, 2013).

Among other factors, poor quality diets and lack of physical activity contribute to high rates of obesity. Consumption of vegetables and fruit can contribute to weight control and a reduction in rates of obesity (Shields 2006). However, in CARICOM countries, the availability and consumption of vegetables and fruits is low and the intake of fats, oils and sugar is high (Henry, 2007). These patterns in food availability, diet quality and diversity are due mainly to limitations in local production capacity and historical trade and institutional arrangements that have stymied domestic production and marketing of vegetables and fruits, and instead favoured production and exports of plantation crops (sugar, bananas, coffee, cocoa). As a consequence of continued importation of food, particularly energy-dense and processed foods, the CARICOM region confronts an escalating food import bill (over US$ 4 billion annually) and an epidemic of NCD’s leading to a “double burden” that threatens population health and economic development. In dealing with prevention of obesity and NCDs, it is now known that once a child is overweight, it becomes difficult to reverse the trend; hence, early interventions (Shields 2006) to encourage healthy eating among children is a sound approach to addressing the public health problems of obesity and NCDs within CARICOM.
Over the last 3 years, project research was conducted in four CARICOM countries (St. Kitts-Nevis, Trinidad and Tobago, Guyana, and St. Lucia) to improve nutrition outcomes of 5-12 yr old children by enhancing the nutritional quality of school lunch meals and equipping local farmers with technologies to boost productivity and diversity of fresh produce for school feeding programmes and other domestic markets. The project linked producers (farmers) to consumers (children) as part of an integrated and market-driven “Farm to Fork” approach to address the problem of food and nutrition insecurity in CARICOM. This was accomplished, for the first time in the Caribbean, through partnership with institutions of agriculture, health and education in St Kitts-Nevis and Trinidad and Tobago, in an integrated effort to utilize the “Farm to Fork” model to address childhood obesity. Research data for model building relied, principally, on experimental work on agricultural production and school feeding in St. Kitts and Trinidad, but the model and its regional utility and applicability were strengthened by research in Guyana and St. Lucia.

2. PROGRESS TOWARDS MILESTONES

Previously unrealized milestones (24-36 months)

Milestone 4.2 Food Chemical Analysis (UWI)

This milestone has been achieved. Food chemical analysis was conducted on seven lunch meal samples. Cooked food samples were collected from the three caterers assigned to the project. The food samples selected for analysis were: 1) three samples of curried channa and potato, mango, pumpkin and para-roti; 2) two samples of callaloo, stew chicken, plantain and rice; 3) one sample of pink bean, rice, hot slaw and pumpkin roast; and 4) one sample of lentil peas, saffron rice, and stew chicken. The analysis was carried out by the Caribbean Industrial Research Institute (CARIRI), Trinidad. The results revealed variation in food portions served among caterers for the same menus. Generally, the content of protein, fat, iron, calcium and dietary fibre met requirements, while the content of sodium, total fat, and saturated fat exceeded requirements. This suggests the need for closer monitoring of the standardization process and meal preparation practices utilized by caterers. A report on the results of Food Chemical analysis is provided in Annex 4, appendix 1 and 2.

Milestone 4.3 Nutrition Education teaching tools for CARICOM use (UWI)

This milestone has been achieved. In June 2014, nine instructional videos were completed; 7 videos deal with “The Six Caribbean Food Groups”; one deals with “School gardening” and one with “Understanding the food labels.” The videos were piloted at the St. Joseph Government Primary School and evaluated among other Primary School children in standards 1 and 2 with very good reviews. The videos are included in Annex 2, Output 1, and in Annex 1.

Milestone 4.4 Environmental Impact Assessment of Sorghum and Mulato grass forages (UWI)

This milestone has been achieved. The environmental impact assessment on Mulato II grass (Brachiaria hybrid CIAT 36087) revealed that its introduction and establishment in St. Kitts, as part of the project interventions, caused no significant changes in the ecosystem, based on soil and biodiversity measurements. The natural pastures (control area) and the mulato field possess the same insect orders. Measurements in the forage sorghum plot (Sorghum bicolor) showed significant changes in soil pH, salts and ion exchange capacities, but not major disruptions were caused to soil fertility or insect diversity. Overall, both tropical grasses ecosystem were scored as sustainable, and therefore have potential for small ruminant production. These results and detailed discussion can be found in Annex 13 Thematic Report.
Milestone 4.6 Produced “Farm to Fork” healthy eating and food purchasing guide manual (UWI):
This milestone has been achieved. “A Guide to Meal Planning and Purchasing Local Fruits and Vegetables” has been produced. A copy of the guide is provided in Annex 1. The Guide is an education tool for consumers. It provides general information on meal planning and useful tips for purchasing selected locally grown fruits and vegetables. The Guide was developed out of a need, identified by caregivers, for information on buying local fruits and vegetables and meal planning. The guide is designed to improve awareness and understanding by consumers of their responsibilities when selecting and purchasing locally grown fruits and vegetables, and to assist consumers with the planning and preparation of healthy meals to reduce NCDs. The Guide will also help consumers to better understand the food value chain, including some aspects of food safety as it relates to buying, handling, cooking and eating foods.

Milestone 4.8 Market Analysis for validation of the potential for the farm to fork model in Trinidad (UWI)
This milestone has been achieved. The findings on this milestone are explained in detail in Annex 17. The results show that the more food insecure the household, the lower the expenditure on fruits, vegetables, food from animals and ‘other foods’ (e.g. fats and oils, spices and condiments, beverages). Households of non–African descent had a higher level of expenditure on food than households of African descent, and the older the head of the household, the lower the expenditure on the ‘other foods’ commodity group.

Milestone 4.9 Completed map of Food Value chain for local products in Trinidad (UWI)
This milestone has been achieved. The findings on this milestone are explained in detail in Annex 17. Mapping a ‘Farm to Fork’ food value chain for the School Meals programme reveals that the most popular point of purchase for caterers was import wholesalers (48.4%), indicating a strong link between the caterers and the wholesalers for locally produced goods. This point of purchase was the main source of several commodities for caterers (chicken, fish and fruit). It was also an important source of root crops and vegetables.

Current milestones (36-42 months)
Milestone 5.1 Agricultural interventions assessed in terms of increased year-round supply and diversity of locally produced vegetables in the region, and recommendations issued on appropriate agricultural technologies (McGill; UWI)
This milestone was achieved. Detailed results are provided in Annexes 6, 7, 8 and 9. As detailed in Annex 6 Thematic Report, farmers equipped with drip irrigation technology in St. Kitts and Guyana experienced increased year-round production of horticultural crops. Throughout the life of the project, crop yields progressively increased and performance values for some crops generally exceeded the average values for the Caribbean. The best responses were found with red beans and tomato in Guyana, and with pumpkin, string beans and honeydew melon in St. Kitts.

Due to differences in rainfall, climatic and soil conditions, drip irrigation had, in general, a much greater impact on crop yields in St. Kitts than in Guyana. In 2011, prior to the intervention in St. Kitts, the average national yield of pumpkin under local and rain fed agriculture was estimated at 815 kg/ha; in 2012, with the introduction of drip irrigation, the average yield of pumpkin at the irrigated project sites in St. Kitts was 6278 kg/ha, representing a 670% increase in the local productivity and annual output of pumpkin. We observed a similar, though less profound (1040 vs
1814 kg/ha) change (74% increase) in watermelon productivity in St. Kitts prior to and after the drip irrigation. However, not all crops tested responded to drip irrigation in St. Kitts.

In both St. Kitts and Guyana, an irrigation scheduling treatment of 80% at available water capacity (AWC) proved to be as effective as 100% AWC with the potential for 20% water savings during vegetable crop production. Annex 7 provides a detailed account of improvements in crop productivity and diversity under protected agriculture (green house) and open field conditions over the life of the project. Greenhouse trials conducted during dry and wet seasons showed that year-round supply of tomato and sweet pepper can be achieved. With improved management practices, open-field production of pumpkin can also be achieved. New varieties, local growth media and management information were completed.

Post-harvest studies (detailed in Annex 8 and 7) on a range of horticultural crops (including tomato, cucumber, eggplant, pumpkin, string beans) identified the magnitude of post-harvest losses along the supply chain in St. Kitts, Guyana and Trinidad. Post-harvest losses for tomato were as high as 30% at the farm level and about 40% at the street level of retail. Recommendations made to reduce post-harvest losses and increase year-round supply of crops include improved methods of crop handling, protection from sunlight, use of plastic wrapping, and proper curing methods for pumpkin.

Mulato grass, a drought tolerant forage, was introduced for the first time in St. Kitts, and conserved as silage for use in the dry season; this project intervention enhanced year-round availability of feed resources for small ruminants. Beyond the project site, there was a five-fold expansion (2 ha to 10 ha) in the area used for cultivating mulatto grass by local farmers. Detailed results are provided in Annex 9 Thematic report.

**Milestone 5.2 Improved consumer knowledge about nutrition and health (UWI)**

This milestone has been achieved. Detailed results and achievements for this milestone can be found in Annex 4 thematic report. A total of 134 parents received nutrition education on the following topics: Healthy eating and snacking, food safety, food budgeting and reading food labels. We found no effect of nutrition education on the change (difference between end point and baseline) in nutrition knowledge scores of children. There may have been a “ceiling effect” that prevented us from observing a difference in schools with nutrition education intervention alone. Out of a need identified by caregivers for information on planning healthy meals and buying safe and wholesome fruits and vegetables, a Guide for meal planning and purchasing local fruits and vegetables was developed. The Guide will help consumers to better understand some aspects of the food supply chain, including food safety as it relates to buying, handling, cooking and eating foods.

**Milestone 5.3 Nutrition interventions assessed, including documented changes in body mass index (BMI), diet, and vegetable and fruit intake (McGill, UWI)**

This milestone has been achieved. Detailed results can be found in Annex 4 Thematic report. Results regarding changes in BMI, diet, vegetable and fruit intake have been documented. Anthropometry and dietary measurements were assessed with the children and caregivers at both baseline and end point of the studies. The dietary improvements in the menu in both St. Kitts and Trinidad resulted in major increases in vegetable and fruit intake but the numbers daily servings were still below international standards. The nutrition interventions did not influence the rates of overweight or obesity among the children studied. Findings indicate that, independent of the nutrition interventions, some children continued to gain excess weight over the study period.
**Milestone 5.4** GAP (good agricultural practices) for food safety/quality report and recommendations produced (McGill, UWI);

This milestone has been achieved. The project undertook an extensive assessment of on-farm food safety practices in the four project countries (Guyana, St. Lucia, St. Kitts and Trinidad) as well food safety practices at facilities in Trinidad and St. Kitts that prepared school meals. The results, with recommendations for regional and national policy makers, can be found in Annex 12.

Although no food safety health risk was encountered in the food crops analyzed, there should still be some assessment of whether the combined amount of all pesticide residues presents an unacceptable health risk to students in the school meal program. In St. Kitts and Trinidad there should be an enforced system of record-keeping by farmers with respect to the use of chemicals for crop production. Lunch meals from the private caterers “school feeding kitchens” in Trinidad are, and should continue to be produced in accordance to the CODEX (CAC/RCP 1-1969) food hygienic guidelines. The caterers who prepare the school meals should be aware of the guidelines for pest control agents used in the kitchens, and produce should be sourced from vegetable and fruit farmers who adhere to GAP standards. Beyond the training and capacity building undertaken by the project, personnel engaged in school meals preparation and service should receive sustained training for awareness of chemical contamination of crops and water.

**Milestone 5.5 Completed End of Project Workshop for technology and knowledge transfer and outreach activities (UWI, McGill)**

This milestone has been achieved. Two Knowledge Sharing Workshops organized by McGill were conducted in St. Kitts and Nevis (10 and 16 June, 2014). About 150 stakeholders attended the workshops. The presentations and discussions dealt with agricultural technologies, the linkage between agriculture-health and education, and the role of the policy makers in undertaking collective efforts towards the reduction of NCD’s in the Caribbean. An additional Knowledge Sharing Forum organized by UWI, was conducted in Trinidad on August 21, 2014, at the Hyatt Regency Hotel. The Forum was attended by 82 persons representing various stakeholder organizations. The presentations focused on the Farm to Fork approach, technologies for enhancing agricultural productivity and diversity, and nutrition interventions in school feeding programmes to address obesity and NCD’s. The “farm to fork” model and its policy implications were discussed.

Project results and findings on the Farm to Fork model and other components of the project were also presented at the Food Security Dialogue 2014 (Alberta) and Sir Arthur Lewis Institute of Social and Economic Studies, SALISES 15th Annual Conference in Trinidad. Project results were also disseminated at other conferences in Canada (Canadian Association for Food Studies) and the Caribbean (Caribbean Food Crops Society 50th Meeting. in St. Thomas). The CARICOM Project final results were presented at the McGill Conference on Global Food Security held on October 28 and 29, 2014 in Montreal.

**Milestone 5.6 The potential of the farm to fork model to improve nutrition outcomes in St. Kitts and Trinidad has been assessed (McGill UWI)**

This milestone has been achieved. Detailed results can be found in Annex 4 and Annex 16 reports. Through dietary changes introduced by the project, consumption of vegetables and fruits by children offered the improved lunch meals in St. Kitts and Trinidad increased. Meal acceptance in St. Kitts acceptance varied by food item, with watermelon showing the greatest level of acceptance (85%) among children. In St. Kitts, the project established a mechanism for procurement of produce from local farmers by hiring an individual to source and coordinate the supply of local produce to the
School Meals Centre (SMC). Almost 20,000 kg of fruit and vegetables were delivered to the SMC in St. Kitts to enhance their offerings to the schoolchildren and replace imported foods. An economic assessment (Annex 16) based on simulation models, identified the potential economic impact on the health system in St. Kitts with a 5 to 30% reduction in NCDs.

In Trinidad, the overall mean acceptance was significantly different between fruits and vegetables consumption. Regression analysis predicted change in acceptance of fruits and vegetables over the period studied; results showed an average of 3.6% increase in the acceptance of vegetables for every 6 months, and an average of 5.8% increase in the consumption for fruit for the same time period.

**Milestone 5.7 Food and nutrition security recommendations issued, and implementation of a communication and policy incidence strategy to promote adoption of these recommendations by CARICOM Leaders (UWI, McGill).**

This milestone was achieved. A strategy was developed for communicating project results to all stakeholders, the general public, government officials and policymakers. This was implemented at the Caribbean Week of Agriculture (CWA) in Guyana in October 2013. Knowledge Sharing Workshops were conducted in June 2014 in St. Kitts and St. Lucia and in August 2014 in Trinidad; at these events, factsheets on project outcomes were distributed to participants.

Under the auspices of IDRC, and led by WRENmedia, a UK-based communications company, a communications workshop was held in St. Kitts in June 2014. Outcome stories and policy briefs were produced to inform CARICOM food security policy making. A “farm to fork” outcome story is included Annex 2, output 1. The outcome stories and policy briefs are expected to be presented to CARICOM policy makers.

**Milestone 5.8 Comparative evaluation of the cost-benefit analyses of the farm to fork models in St. Kitts and Trinidad (UWI, McGill)**

This milestone was achieved. In St. Kitts, an economic impact assessment of the farm to fork model was completed by an independent consultant (EconoTech Consulting Services). Results, detailed in Annex 16, show that in the long term, with an impact on childhood obesity, an improved school lunch program has the potential to significantly reduce the economic burden of NCDs in St. Kitts. However, the study notes that up-scaling of the farm to fork model to all primary schools could pose a financial burden on government, and thus the expansion of the model may require collecting a minimal student fee per meal. As part of the assessment of the farm to fork model, an economic analysis of the impact of drip irrigation (with plastic mulching) on crop yield and farm returns was undertaken. Results revealed net positive returns to farmers adopting the drip irrigation technology for most crops cultivated (details in Annex 15).

In Trinidad, a market analysis study for validation of the farm to fork model was completed (see Annex 17). Results show that farmers will benefit from an expansion of food flow through the model in terms of higher levels of revenue. In addition, caterers will also benefit by an expansion of their preferred source of supply for local foods. The school children will also benefit from fresher foods and a greater supply of fresh fruit and vegetables, for a higher standard of nutrition.

**Milestone 5.9 Pre-conditions for scaling up identified (McGill, UWI);**

This milestone has been achieved. Detailed findings are available in Annex 11 and Annex 16 reports. Fundamental preconditions for the functioning and up-scaling of the farm to fork model include regional and national commitment to innovation, technology adoption, knowledge sharing,
trust building, collaboration, partnership building and formation of the institutional linkages, all oriented towards collective action to improve CARICOM food security. The project conducted extensive social science research around these issues and identified some key conditions for upscaling the farm to fork model. The project identified the fact that harnessing social capital among agricultural actors, including farmers, scientists, national and regional policy actors, is central to the success of the Farm to Fork model in enabling more nutritious school meals to be served to over 1100 children in St. Kitts and Trinidad, and other CARICOM countries.

The project results also revealed that dissonance in policy directions and lack of trust about knowledge sharing threaten collective action to advance initiatives for CARICOM food security. Women were found to be more willing than men to adopt new technology. However, challenges related to access to land and financial resources by CARICOM women farmers could stymie upscaling of the farm to fork model, which relies on innovation in agricultural, nutritional and educational technologies.

**Milestone 5.10 Enhanced CARICOM human capacity in food and nutrition security (McGill, UWI)**

This milestone has been achieved. At the outset, the project devoted major efforts towards capacity building in different thematic areas of the project: agriculture technologies, post-harvest quality and food safety, nutrition and nutrition education, and social science research methodology. Details are provided in Section 4 of this report.

In brief, about 887 farmers and other “beneficiaries” (593 male, 294 female) participated in, and were trained in the project; of this number, over 680 field and farmer field personnel received direct skills and knowledge training through 33 workshops and field training events organized and delivered by researchers and other professionals in the project. Over 40 (about 80% female) highly qualified personnel (HQP), including graduate students, received skills, academic and professional training throughout the life of the project. Furthermore, 1165 children, parents, caterers and educators participated in the nutritional education programs and food hygienic training that were required to improve the school feeding programmes in St. Kitts and Trinidad.

We conducted 28 knowledge sharing/dissemination activities involving over 1770 participants, and produced over 210 knowledge outputs (see Annex 1) for use by local and regional stakeholders and international audiences. The AFS questionnaire (Annex 2) documents additional details of capacity building achievements by the project.
3. SYNTHESIS OF RESEARCH ACTIVITIES

A. Preamble

The 42-month project was initiated in March 2011 with an overall goal to improve nutrition and health outcomes of CARICOM populations through an integrated, gender sensitive, and environmentally sustainable approach to food and nutrition security. Food and nutrition insecurity in the Caribbean Community (CARICOM) has shifted from under-nutrition to overweight and obesity, and the rising rate of childhood obesity is now a serious public concern. Among other factors, low consumption of vegetables and fruits among the region’s population contributes to obesity, a major risk factor in non-communicable diseases (NCDs).

The project responded to the regional problem of obesity by developing and implementing a multi-sectoral, integrated approach to generate new scientific evidence to inform CARICOM food and nutrition security policy. Research was conducted into community nutrition and appropriate agricultural technologies in support of local capacity and policy actions to address childhood obesity, through improvements in diet quality and diversity in school feeding programmes. The project was piloted in four CARICOM countries (St. Kitts-Nevis, Trinidad and Tobago, Guyana and St. Lucia), with a focus on school feeding and agricultural interventions in St. Kitts and Trinidad. Project interventions in Guyana and St. Lucia also involved applied (on-farm) research into agricultural technologies (drip irrigation, post-harvest quality) with small farmers. The strategy here was to broaden and strengthen the regional research knowledge on water resources management, crop productivity and diversity and post-harvest losses, and test regional replicability and applicability of knowledge gained from the project.

B. Achievement of Project Objectives in the context of the Farm to Fork Model

To achieve the overall project goal, we conducted research on a platform of activities based on the following 5 specific objectives:

1. Improve nutrition and health outcomes of vulnerable segments (children and women) of the populations, through availability of foods that would increase intake of vegetables and fruits, decrease caloric intake and increase micronutrient intake;

2. Develop food production systems based on agricultural diversification, conservation of water, and efficient use of land;

3. Increase the rate of technology adoption by small farmers experiencing common agricultural challenges;

4. Adapt international standards of food safety and quality for a healthy, market-oriented food supply chain in CARICOM countries;

5. Expand and build human and institutional capacity to solve problems of food and nutrition insecurity in CARICOM countries.
However, after the first year of project implementation, the project team identified an opportunity not only to achieve the five project objectives above but to go a step further to develop and test a functional ‘farm to fork’ model for CARICOM food and nutrition security (see Figure 1). The farm to fork approach entailed project interventions at all the essential segments of the value chain (from food production to consumption), implemented in a coordinated manner to supply school feeding programs with fresh fruits and vegetables produced by local smallholder farmers. The original five research objectives were consistent with this model and therefore, the five specific objectives were repositioned within three designated “pillars” and a “matrix” of this integrated farm to fork model: a) interventions in school feeding programs to improve diet quality and diversity, and nutrition outcomes of children; b) strengthening coordinating mechanisms for produce procurement from local smallholder farmers to meet the needs of school lunch programs, while enhancing domestic market opportunities for the farmers; c) equipping small holder farmers with agricultural technologies and capacity to sustainably enhance year-round productivity and diversity of local produce so that they can capture new markets, including the school feeding programmes; d) a social science matrix that serves as the “glue” holding the pillars together; without this matrix for collective action and innovation, the model cannot be sustained.

Therefore, the synthesis of results not only deals with the achievements and outcomes of each project objective but also discusses the findings in the context of building, for the first time in CARICOM, an integrated model for approaching and addressing the problems of food and nutrition insecurity by linking agriculture, health and education. This “synthesis section” draws on results and outcomes from 13 detailed thematic reports (Annexes 4 through 16) based on project activities implemented in the four project countries with enormous support from national regional partners, duly acknowledged in individual reports.

Figure 1: A Farm to Fork model for Food and Nutrition Security
**B1. Farm to Fork Model “Pillar” 1. School Feeding**

**Project Objective # 1.** Improve nutrition and health outcomes of vulnerable segments (children and women) of the populations, through availability of foods that would increase intake of vegetables and fruits, decrease caloric intake and increase micronutrient intake.

**Context:** Strengthening the nutritional quality of school feeding programmes (SFP) in CARICOM and linking the produce needs of SFP’s to domestic agricultural production would have the clear effects of improving nutritional outcomes of children while providing a market opportunity for small holder farmers. This model, labelled “home grown school feeding” by the World Food Programme (Espejo et al.), has never been investigated in the Caribbean; it is the central concept underlying the project activities for our “farm to fork model”. We show, in our discussion below, as a key model outcome, that we achieved the goal of enhancing vegetable and fruit intake by 5-12 y old children; however, the interventions did not influence the rates of overweight or obesity within the study period. Details of the results, outcomes and activities under this project objective are reported in Annex 4.

**Interventions in schools to improve nutrition outcomes:** A new 10- day cycle experimental menu with improved diet quality and diversity was implemented in the school lunch programmes in primary schools in both St. Kitts and Trinidad. The principal difference from control schools was enhanced portions of local fruits and vegetables (see Annexes 4, Tables 2 and 4). In Trinidad, we combined the improvement of lunch menus with nutrition education of the children (total of 291) to test the potential impact of an interaction between nutritional improvements in the menu and nutrition education of children. The content of the nutrition education lessons is shown in Annex 1. Details of the design of the 18-month (October 2012 through June 2014) studies with 643 children in 7 schools (3 controls) in St. Kitts and 8 schools (4 controls) in Trinidad are provided in Annex 4.

Prior to, and at the end of the school feeding interventions, we undertook baseline and endpoint community nutrition and health surveys (CHS) with the children and their caregivers, 90% of whom were female in both St. Kitts and Trinidad. We utilized the CHS tools to obtain baseline knowledge of dietary practices, nutritional status and food security of children and households in which they live, and to evaluate the impact of the interventions on outcome indicators. At baseline, interviews were conducted with 503 caregivers and measurements were taken on 643 children from 7 schools in St. Kitts and 8 schools in Trinidad. In St. Kitts, we supplemented the nutrition intervention study in schools with a *behavioural economics experiment* with the caregivers to better understand the non-market forces influencing their food consumption choices. This experiment involved 116 of the 188 caregivers who had responded to CHS survey questionnaire; details of this study are provided in (Annex 5)

**Baseline assessment of food security and nutritional status of children and the households:** The average age of the primary school children at baseline was 7.48 ± 1.03 y in both countries. Baseline levels of household food insecurity (Annex 4, Table 5) were 54% and 42% in St. Kitts and Trinidad, respectively. Based on the end point surveys, 11 % of the households in St. Kitts were severely food insecure; in Trinidad, the comparable figure was 12%. Estimates of childhood food insecurity were about 20 % in St. Kitts and 30% in Trinidad. In both countries, the level of household food insecurity was consistently higher than childhood food insecurity, suggesting that the children were “nutritionally protected” within the household.
The intake of protein, fibre and fat was higher among “food secure” than “food insecure” children (Table 1 below, Annex 4, Table 6) but in both groups the intake of these nutrients was within the range of recommended dietary intake (RDI) deemed acceptable for 4-18 year-old children (Institute of Medicine, 2005). There were no other differences in baseline dietary intake between food secure than food insecure groups of children.

Table 1: Daily nutrient intake by food security status at baseline in children aged 5-10 years in St. Kitts and Trinidad.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Food Secure (n= 256)</th>
<th>Food Insecure (n= 217)</th>
<th>Total (n= 473)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy, kilocalories</td>
<td>1977 ± 793</td>
<td>1869 ± 652</td>
<td>1927 ± 733</td>
<td>0.11</td>
</tr>
<tr>
<td>Carbohydrate, g</td>
<td>284 ± 126</td>
<td>276 ± 107</td>
<td>281 ± 118</td>
<td>0.45</td>
</tr>
<tr>
<td>Percent energy as carbohydrate, %</td>
<td>57.6 ± 11.3</td>
<td>59.3 ± 12.2</td>
<td>58.4 ± 11.7</td>
<td>0.12</td>
</tr>
<tr>
<td>Protein, g</td>
<td>67.3 ± 33.2</td>
<td>61.46 ± 28.9</td>
<td>64.7 ± 31.4</td>
<td>0.05</td>
</tr>
<tr>
<td>Percent energy as protein, %</td>
<td>13.8 ± 4.63</td>
<td>13.3 ± 4.81</td>
<td>13.6 ± 4.71</td>
<td>0.26</td>
</tr>
<tr>
<td>Fat, g</td>
<td>65.9 ± 34.4</td>
<td>59.7 ± 30.8</td>
<td>63.1 ± 32.9</td>
<td>0.04</td>
</tr>
<tr>
<td>Percent energy as fat, %</td>
<td>29.8 ± 8.83</td>
<td>28.5 ± 9.54</td>
<td>29.2 ± 9.18</td>
<td>0.12</td>
</tr>
<tr>
<td>Added Sugar, g</td>
<td>72.5 ± 56.2</td>
<td>73.8 ± 51.8</td>
<td>73.1 ± 54.2</td>
<td>0.79</td>
</tr>
<tr>
<td>Calcium, mg</td>
<td>682 ± 436</td>
<td>638 ± 364</td>
<td>662 ± 404</td>
<td>0.24</td>
</tr>
<tr>
<td>Iron, mg</td>
<td>15.0 ± 11.8</td>
<td>14.2 ± 8.10</td>
<td>14.6 ± 10.3</td>
<td>0.39</td>
</tr>
<tr>
<td>Zinc, mg</td>
<td>8.11 ± 4.59</td>
<td>7.94 ± 4.86</td>
<td>8.03 ± 4.71</td>
<td>0.70</td>
</tr>
<tr>
<td>Vitamin A, RAE</td>
<td>847 ± 791</td>
<td>860 ± 1018</td>
<td>853 ± 901</td>
<td>0.88</td>
</tr>
<tr>
<td>Vitamin C, mg</td>
<td>180 ± 246</td>
<td>167 ± 163</td>
<td>174 ± 212</td>
<td>0.50</td>
</tr>
<tr>
<td>Vitamin D, µg</td>
<td>6.97 ± 7.17</td>
<td>7.09 ± 7.46</td>
<td>7.03 ± 7.30</td>
<td>0.86</td>
</tr>
<tr>
<td>Fiber, g</td>
<td>15.6 ± 11.1</td>
<td>13.8 ± 7.25</td>
<td>14.8 ± 9.58</td>
<td>0.04</td>
</tr>
</tbody>
</table>

1 10 participants were missing food security information.
Values in cells are means ± SD. P values are based on t-tests.

The Z-score system expresses anthropometric values as standard deviations (SDs) below or above the reference mean or median value. For BMI for age and sex, overweight is defined as >+1 Z-score, for stunting, height for age and sex is <-2 Z and excessive thinness as BMI for age and sex as <-2 Z. Based on WHO standards, only 1% of children were stunted (height for age) and about 4% were underweight for height (>2 SD from median BMI by age and sex (Figure 2 below; Annex 4 Figure 1). These findings reinforce reports by (Simeon et al. 2003) that the prevalence of underweight and under-nutrition among children in CARICOM is declining. However, in both St. Kitts and Trinidad, about 10% (Figure 2, below) of children were obese (>+2 SD from median BMI by age and sex) and about 23% overweight or obese (>+1 SD), with no significant difference between those in food secure and food insecure households (26% vs 20%; p=0.07). It appears that food security, as measured in our study, may not be in synchrony with “nutrition security” of
children, since both food secure and food insecure children exhibited similar patterns of nutritional intake and weight status. This is an important study outcome, which suggests that different types of community interventions may be required when addressing issues of food security and nutrition security.

A 2011 Global Student Health Survey for St. Kitts and Nevis showed that about 33% of children (13-15 years old) were overweight and 14% were obese; only 3.5% were underweight. However, in that survey, no data were collected for children 5 to 12 year old. The prevalence of obesity among children and adolescents in Canada aged 2-17 years old has been estimated at 8% (Ogden et al. 2011). Clearly, obesity among children in St. Kitts-Nevis, as well as other CARICOM counties, should be a cause for concern. At baseline, 79% of the caregivers in St. Kitts were overweight or obese (BMI >25) and 46% were obese (BMI>30); in Trinidad, the corresponding values were 69% and 38%. A WHO study (WHO, 2007) conducted in St. Kitts revealed that 45% of the adult population (25-64 years old) was obese. The prevalence of obesity among caregivers in our study is consistent with the report by WHO. The high prevalence of obesity among the caregivers, predominantly women, in both St. Kitts and Trinidad, places CARICOM women at high risk for NCDs.

The dietary and anthropometric data collected in this project represent the most recent information in the Caribbean, and indicate that the problem of under-nutrition has given way to a growing problem of overweight and obesity among children and adults. The CARICOM region is clearly experiencing the global “nutrition transition” with a shift towards energy-dense diets that are low in fruits and vegetables and high in sugar and fat. Results of our food preference/food choice experiment in St. Kitts (detailed in Annex 5) reveal that children consumed vegetables and fruits less often than caregivers. A key observation, however, was that caregivers’ beliefs about nutrition, food preferences and food choices were more influenced by peers than by a nutrition expert. This scientific finding regarding peer influences on consumer food preferences is a novel “knowledge outcome” for the CARICOM region. Therefore, in tackling obesity, CARICOM policy makers should be concentrating on peer groups for behavioural and nutrition education programmes for shaping food choices of both caregivers and their children.
Impact of School feeding Interventions on Nutrition Outcomes of Children: At the end point of the study in St. Kitts, children’s intake of vegetables, vitamin A and protein from the school lunch (Table 2 below) and over the entire day (Annex 4, Table 13) was greater in the intervention schools than in control schools. This was true in analyzing data from children who reported eating the school lunch (76% of the children) on the interview day as well as all children interviewed, including those who did not eat the lunch meal on the day of the interview. Fruit consumption at endpoint was not influenced by the improvement in the lunch menu. The supply of fruits to the School Meals Centre (SMC) was low and inconsistent (Annex 4, Table 9), so it is possible that portions of fruits served for lunch were not sufficient to have the desired impact on fruit consumption by the children. Energy intake from the school lunch meal, or over the entire day (Annex 4, Tables 12 and 13) did not change.
Table 2: End point nutrient intake and food group portions at lunch meal for 6-12 year old children in St Kitts

<table>
<thead>
<tr>
<th>Nutrient/Food group</th>
<th>All Children in the school (n=163)</th>
<th>Children who consumed the school lunch meal (n=121)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control (n=73)</td>
<td>Menu improvement (n=90)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control (n=50)</td>
</tr>
<tr>
<td>Total energy, kilocalories</td>
<td>586±357</td>
<td>536±260</td>
</tr>
<tr>
<td>Energy as protein, %</td>
<td>14.1±5.99</td>
<td>18.8±9.70**</td>
</tr>
<tr>
<td>Energy as fat, %</td>
<td>22.5±13.2</td>
<td>23.7±10.3</td>
</tr>
<tr>
<td>Energy as carbohydrate, %</td>
<td>62.9±17.1</td>
<td>57.2±15.3</td>
</tr>
<tr>
<td>Calcium, mg</td>
<td>144±107</td>
<td>128±95.0</td>
</tr>
<tr>
<td>Iron, mg</td>
<td>2.84±2.30</td>
<td>2.58±1.41</td>
</tr>
<tr>
<td>Potassium, mg</td>
<td>404±348</td>
<td>493±327**</td>
</tr>
<tr>
<td>Vitamin A, RAE</td>
<td>104±253</td>
<td>184±229**</td>
</tr>
<tr>
<td>Vitamin C, mg</td>
<td>69.3±73.1</td>
<td>80.7±78.1</td>
</tr>
<tr>
<td>Fruits, portions</td>
<td>0.21±0.67</td>
<td>0.23±0.70</td>
</tr>
<tr>
<td>Vegetables, portions</td>
<td>0.09±0.23</td>
<td>0.23±0.31**</td>
</tr>
</tbody>
</table>

Mean±SD. * p<0.05  ** p<0.01.; T tests for normally distributed variables and non-parametric Wilcoxon test for those with non-normal distributions.

At the end point of the study in Trinidad, neither the improved menu nor nutrition education influenced vegetable consumption by the children (Annex 4, Tables 15 and 16). However, with the improved menu, in combination with nutrition education, the daily consumption of total vegetables and fruits by all children in the schools increased by 45% (from 1.80 to 2.61 portions per day). The greatest level of fruit consumption (2.14±1.98 portions per day) was observed with the combination of menu improvement and nutrition education, but the effect was not significantly different from that observed with menu improvement alone (1.40±1.15 portions per day). Based on the results of the 24 h recall interviews, the lunch meals could contribute up to 50% of the daily intake of fruits and vegetables by children. This finding reinforces the notion that intervening in the lunch programs is a meaningful strategy to influence nutrition outcomes of children.

Although lunch menu improvements enhanced intake of vegetables and fruit by children, even the maximum combined portions of vegetables and fruits (2.86 servings per day) consumed met only 57% of the minimum (5 servings per day) international recommendations (e.g. Canada’s Food Guide). Fruit and vegetable consumption is reported to have positive effects in preventing obesity
(Shields, 2006) and therefore, it is beneficial for CARICOM children to consume the recommended levels of fruits and vegetables as one of the elements of healthy living.

A very important finding from the studies in both St. Kitts and Trinidad is that, independent of the project intervention, the number of overweight or obese children increased over time (Annex 4, Tables 17 and 18). In St Kitts, the rates of overweight or obesity among children (across control and intervention schools) increased from 20% at baseline to 26% at endpoint; similarly in Trinidad, the rates increased from 25% at baseline to 32% at endpoint. Introducing nutrition education as part of the project interventions did not significantly influence change in nutrition knowledge, intake of vegetables and fruits, nor prevalence of overweight or obesity among children studied in Trinidad (Annex 4, Table 19). While urgent steps are required to strengthen and improve the nutritional quality of school meals, the project results underscore the urgent need for additional national and regional intervention strategies to reverse the weight trajectories among children in CARICOM populations.

**B2. Farm to Fork Model “Pillar” 2-: Procurement of local produce**

**Project Objective # 1-** Improve nutrition and health outcomes of vulnerable segments (children and women) of the populations, through availability of foods that would increase intake of vegetables and fruits, decrease caloric intake and increase micronutrient intake.

The introduction of large quantities of vegetables and fruits into the St. Kitts school feeding programme led to increased dietary diversity and nutritional quality of the school lunch meals. This coordinated procurement of local produce for school feeding programmes is the second “pillar” of the farm to fork model (Figure 1). The intervention schools in Trinidad added local fruits such as watermelon, tangerines and bananas to the improved menu. However, a survey of 37 caterers servicing the School Meals programme in Trinidad showed that private caterers purchased less than 7% of their food products directly from farmers (Annex 4, Figure 5). The most popular point of purchase (48%) for produced used in the Trinidad school meals programme was import wholesalers; the next most important point of purchase by caterers was farmer’s markets (26%) but it is not clear the extent to which such produce was locally farmed.

It is interesting to note that in Trinidad 33% of farmers surveyed preferred selling their produce to wholesalers; relative to other options, farmers perceived this option to yield a fair market price and to be less time consuming. The school meals programme in Trinidad seems, therefore, to be severely hamstrung in procuring produce from local farmers. Given the privatized nature of the school meals catering service in Trinidad, the challenge to policy makers of utilizing the school feeding programme both as a market outlet for farmers as well as a vehicle to improve nutrition outcome of children seems to be greater in Trinidad and Tobago than in St. Kitts-Nevis. Farm to fork model building was clearly made easier due to the centralized and publically-operated school feeding programme in St. Kitts.

For the first time in St. Kitts-Nevis and perhaps in the Caribbean, and with full collaboration of local ministries of agriculture, health and education, and cooperation from 28 local small-holder farmers (10 “project farmers” and 18 non-project farmers), a coordinated project effort was initiated to treat the local school feeding programme as a new and enhanced market outlet for small holder farmers, while serving as a vehicle for improving child nutrition and health. Prior to the project, negligible quantities and range of local produce (only pumpkin) were supplied to the SMC in St. Kitts for use in the school lunch programme. Over the course of the study (January 2013 to March 2014) the SMC procured 11 different fruits and vegetables (including tomatoes, sweet potatoes,
carrots, string beans, cabbage, cucumber and watermelon) from the local farmers (Annex 4, Table 9) and these products were added to the lunch menu as part of the nutrition intervention.

Over the period of 15 months, the farmers supplied the SMC with nearly 20,000 kg (Annex 4, Figure 3) of local produce which were used to improve the nutritional quality and diversity lunch meals served to 800 children in the intervention schools in St. Kitts. This new inflow of produce to the SMC provided new market opportunities for the local farmers, most of whom were equipped by the project with technologies to increase diversity and productivity of produce (to be discussed below) to meet market needs. The enhanced quantity and diversity of local produce took place over time (Figures 3 and 4, Annex 4) with important increases over the life of the project. However, less than 20% of the SMC’s needs for fruits were not by local farmers. Constraints to the provision of adequate quantities of fruit and vegetables for the lunch menu include, seasonality in crop production, water scarcity and technical capacity. We discuss, below, agricultural interventions undertaken by the project to address some of the constraints to local production and availability of produce for school lunch programmes and other markets.

As the new food items were introduced into the lunch menus in both St. Kitts and Trinidad, there were progressive increases in children’s acceptance of the new meals over time. In St. Kitts, the proportion of children accepting vegetables and fruits ranged from 51% for cooked carrots to 85% for watermelon (Annex 4). After the menu change in Trinidad, meal acceptance increased from 69% to 86%. Acceptance rates for individual foods varied, with vegetables being less popular than fruits (62% vs 79% mean acceptance rates; Annex 4). As new and diverse locally-produced vegetables and fruits are introduced into school lunch menus in CARICOM, there is a need for a strong national and regional emphasis on recipe development to entice children to consume meals with enhanced potions of local vegetables and fruits.

The cost of improving the lunch menu in St. Kitts increased from $0.96 EC ($USD 0.36) for control schools up to $2.46 EC ($USD 0.91) for intervention schools (Annex 4, Table 10). The cost increases were due to the fact that offerings of vegetables were substantially enhanced and fruit was placed on the menu for the first time; another factor was the addition of more animal source products (meat, fish) to increase diet diversity. In Trinidad, the meal cost increased from TT$8.15 ($USD 1.30) for control schools to TT$12.65 ($USD 2.02) for intervention schools. However, improving the lunch menus in both St. Kitts and Trinidad had the desired effect of significantly enhancing the intake of fruit and vegetables by over 1000 children. Policy trade-offs must be made between minimizing menu cost and improving the diet quality of the school meals to improve nutrition outcomes of children in CARICOM. During the course of the studies in both countries, we encountered the use of sweetened drinks at lunch meals plus the sale of sugary drinks and high-fat snacks within and in the vicinity of the schools. These factors militate against the project’s goal of having children consume healthy lunch meals. Limiting children’s access to unhealthy snacks and drinks at school, and a focus on food procurement and recipe development policies to increase the children’s acceptance of healthy lunch meals could strengthen the food procurement and food acceptance pillar of the farm to fork model for improved nutrition outcome for CARICOM children.

B3. Farm to Fork Model “Pillar” 3- Technologies for Agricultural Productivity and diversity

Project Objective #2. Develop food production systems based on agricultural diversification, conservation of water, and efficient use of land

Context: Since an adequate and steady supply of locally grown fruits and vegetables is central to the functioning of the farm to fork model, our second objective, embedded in the third pillar of the
model, was to boost the productivity and diversity of locally grown commodities. We investigated, technologies dealing with drip irrigation, protected and open field agriculture, post-harvest quality, and forage production and conservation (as silage) for small ruminants (sheep and goats). We show, in the ensuing discussion, that this second project objective was fully achieved; there were major outcomes and innovations related to forage and horticultural crop productivity and diversity, irrigation water management, and year-round supply of vegetables and fruits to meet the needs of local school feeding programmes.

Drip irrigation is a water saving technology since small amounts of water are applied directly to the crop root zone. This technology is highly relevant to the Eastern Caribbean (Madramootoo and Jutras, 1984), especially in St. Kitts-Nevis where water is scarce during the dry season and water conservation techniques ought to be implemented. With drip irrigation, it is possible to achieve year-round production of fruits and vegetables to supply the school meals programme, thereby increasing small farmer income. Protected agriculture (greenhouse systems) represents another underutilized technology to enhance year-round productivity and diversity of crops in CARICOM; low farmer uptake of protected agriculture technology (PA) is due to the limited regional research into appropriate crop varieties, growth media and greenhouse systems designed for the climatic conditions of CARICOM. There is also a lack of information regarding best practices for producing vegetables (such as tomato and sweet pepper) under PA structures. The project launched extensive research into drip irrigation and protected agriculture to increase year-round output of horticultural crops by small-holder farmers. The crops targeted for investigation, amongst others, were tomato, melons, string beans, cabbage, egg-plant, cucumbers, carrots and pumpkin, all of which were utilized in the school feeding programmes under the farm to fork model. Four of these crops (tomato, pumpkin, carrots and cabbage) are typically grown by most horticultural farmers in St. Kitts and other CARICOM countries.

**Drip Irrigation outcomes:** The drip irrigation studies were conducted on small holder farms in St. Kitts (two sites) and Guyana (two sites) over a 2 year period (May 2012 to March 2014), covering both dry and wet seasons. Details of the drip irrigation studies and results are provided in Annex 6. A total of 26 farmers (16 in St. Kitts; 10 in Guyana) participated in the studies with 16 vegetable and fruit crops (8 in St. Kitts; 8 in Guyana). The drip irrigation technology and capacity building packages led to progressive increases in crop productivity over the life of the project; farmers achieved crop yields up to three times FAO average values for the Caribbean (Annex 6). The best yield results were observed with pumpkin and string beans in St. Kitts, and with red beans and tomato in Guyana. For example, In St. Kitts, pumpkin yields were 6,278 Kg/ha and 24,883 Kg/ha for the first and second crop season, respectively; for string beans, the yield production was 2,378 Kg/ha, 5,872 Kg/ha and 9,840 Kg/ha for first, second and third seasons. In Guyana, tomato yield production was 18,460 Kg/ha, 46,652 Kg/ha and 52,727 kg/ha for the first, second and third seasons, respectively; for red beans the yield production was 1,106 Kg/ha and 2,672 Kg/ha for the first and third seasons, respectively.

In general, drip irrigation had a much greater impact on crop yields in St. Kitts than in Guyana. In 2011, prior to the intervention in St. Kitts, the average national yield of pumpkin under local and rain-fed agriculture was estimated at 815 kg/ha (Annex 6, Figure 8); in 2012 by contrast, the average yield of pumpkin at the irrigated project sites in St. Kitts was 6278 kg/ha, representing a major improvement (670% increase) in the local productivity and annual output of pumpkin. We observed a similar, though less profound (1040 vs 1814 kg/ha), increase (74%) in watermelon yield in St. Kitts prior to, and after introduction of drip irrigation (Annex 6, Figure 8).
We found no statistically significant effect of drip irrigation technology on yields of watermelon and tomato in Guyana. In St. Kitts, however, drip irrigation led to 73% increase in tomato yield, and 48% and 250% increases in yields of pumpkin and string beans, respectively (Figure 3 below; Annex 6, Figure 10). Irrigated yields of honey dew melon in St. Kitts (Annex 6, Figure 9) also increased (44%) but drip irrigation decreased yield of watermelon (Figure 3 below; Annex 6, Figure 10). Farmers in St. Kitts clearly benefited from drip irrigation, especially during the dry season.

Despite variations in the percent sand, silt and clay at the 4 pilot sites in St Kitts and Guyana, the soil water holding capacity at the four sites was about the same (Table 3, below; Annex 6 Table 1). Thus, the amounts and timing of rainfall at the four sites were much more influential than soil properties in determining irrigation amounts. Consequently, the computer simulation model, McGill-IRRIMOD©, was used to calculate the daily irrigation requirements for vegetables in St. Kitts and Guyana (Annex 6, Table 7). Results from the model showed crop water deficits and the need for supplemental water, particularly in the dry months (Annex 6, Figures 11, 12, 13). Model results also demonstrated that, although supplemental irrigation is generally necessary in St Kitts and Guyana during wet and dry seasons, there are important seasonal and site-specific differences not only in the irrigation amounts but also frequency to sustain year-round vegetable production. In humid regions, the application of irrigation water at regular intervals results in over-irrigation and waste of water and energy. The use of the water balance model in CARICOM countries overcomes this problem, and irrigation scheduling introduced by the project can now be used to prevent over application of water, while minimizing crop yield loss due to drought stress.

Project results highlighting the dynamics in rainfall variability between CARICOM countries, and the impact on crop productivity, clearly illustrate why country-specific irrigation modelling studies
should be conducted. Studies about the effects of climate patterns on vegetable production in Caribbean are scarce, and the project was innovative in providing such information.

Table 3: Soil properties of Experimental Sites in Guyana and St. Kitts

<table>
<thead>
<tr>
<th>Project sites</th>
<th>Soil Classification</th>
<th>Particle distribution</th>
<th>Size</th>
<th>Field Capacity</th>
<th>Permanent Wilting Point</th>
<th>Available Water Content</th>
<th>Trigger Value 60% of AWC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sand</td>
<td>Silt</td>
<td>Clay</td>
<td>% VWC</td>
<td>% VWC</td>
<td>% VWC</td>
</tr>
<tr>
<td>guyana</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>parika</td>
<td>Silty clay (Mara series 21)</td>
<td>1.04</td>
<td>53.39</td>
<td>45.57</td>
<td>54.5</td>
<td>40.4</td>
<td>14.1</td>
</tr>
<tr>
<td>black bush polder</td>
<td>Clay (Corentyne Clay 11d)</td>
<td>2.29</td>
<td>33.78</td>
<td>63.93</td>
<td>50.1</td>
<td>33.9</td>
<td>16.2</td>
</tr>
<tr>
<td>st. kitts and nevis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>stapleton</td>
<td>Sandy Loam (Golden Rock series)</td>
<td>71.55</td>
<td>24.22</td>
<td>4.23</td>
<td>23.2</td>
<td>9</td>
<td>14.2</td>
</tr>
<tr>
<td>mansion</td>
<td>Sandy Loam (Sandy Bay loamy sand series)</td>
<td>69,68</td>
<td>23,49</td>
<td>6,83</td>
<td>33.7</td>
<td>18</td>
<td>15.7</td>
</tr>
</tbody>
</table>

We also observed no statistically significant differences in crop response between the two levels of irrigation treatments (100% and 80% of available water content, AWC) applied at the experimental sites in both Guyana and St. Kitts (Annex 6, Tables 4 and 6). The results suggest that by using an irrigation scheduling treatment of 80% of AWC, a 20% increase in water use efficiency could be achieved. In Guyana, we recommend the use of rice paddy straw as the mulching treatment, since it is easily found along the coastal rice growing regions; for St. Kitts, the plastic mulch seems to be favoured by farmers. There was significant spread and uptake of the drip irrigation technology in the region, principally in St. Kitts where farmers expanded, on their own land (not part of the project), the cropping area under drip irrigation by 32% (from 1.84 ha to 2.43 ha).

**Crop productivity and diversity in greenhouse and open-field environments:** Open-field cultivation of fruits and vegetables is the normal practice of farmers in CARICOM but protected agriculture (green house) systems can address the limitations (for example, heat and soil moisture stress during the dry season, flood damage during the wet season) of open field cultivation of vegetables. However, for full uptake of protected agriculture technology, farmers require knowledge of the crop varieties and growing media that are appropriate for green house production under local climatic conditions. In Trinidad and St Kitts, we investigated greenhouse production of seven
cultivars of tomato and five cultivars sweet pepper varieties, cultivated with more than 7 types of growing media. Detailed results and outcomes are provided in (Annex 7).

Two of the seven cultivars of tomato (IT 71 and Versatile) tested under greenhouse conditions produced the best crop yield (number of fruits per plant) when cultivated with coconut coir, a local by-product was used as a growing medium (Figure 4, below). For greenhouse production of either cultivar of tomato, coconut coir proved to be a better growing medium than “sharp sand”, another local product. Results with sweet pepper (Figure 5, below) show that local composted products (grass or mushroom compost), used in combination with perlite (a permeable volcanic mineral imported product) performed better than coconut coir and substantially better than perlite alone. These findings indicate that enhanced productivity of tomato and sweet pepper could be achieved through the adoption of improved crop varieties and the use of local waste products as growing media for greenhouse production in CARICOM.

Under open field cultivation, four varieties of pumpkin (Bodles Globe, Future NP-999, and Crapaud back, and CEstarz) were tested for their suitability in the school feeding (Annex 7). Two pumpkin lines (CEStarz and Bodles Globe) developed in the Caribbean exhibited greater yields (2,675 kg/ha and 2,500 kg/ha, respectively) and superior taste qualities than imported variety Future NP-999 (yield 2,450 kg/ha). The shelf life of the Bodles Globe variety was the longest. Further local initiatives are underway to enhance the taste of CEstarz and to encourage wide use of local varieties of pumpkin among CARICOM farmers.

**Figure 4. Comparison of total yield of tomato in sharp sand and coconut coir**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Total Fruit Weight/g Sharp Sand</th>
<th>Total Fruit Weight/g Coconut Coir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caribe</td>
<td>2970.6</td>
<td>3465.51</td>
</tr>
<tr>
<td>Hybrid 61</td>
<td>3110.4</td>
<td>3463.2</td>
</tr>
<tr>
<td>IT 71</td>
<td>1618.8</td>
<td>5523.9</td>
</tr>
<tr>
<td>Rhapsody</td>
<td>2370.1</td>
<td>2890.7</td>
</tr>
<tr>
<td>Striker</td>
<td>3068.2</td>
<td>3431.2</td>
</tr>
<tr>
<td>Summer Star</td>
<td>2022.2</td>
<td>3471.2</td>
</tr>
<tr>
<td>Versatile</td>
<td>3142.4</td>
<td>4977.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variety</th>
<th>Total Fruit Count/ Weight(g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caribe</td>
<td>3570.6</td>
</tr>
<tr>
<td>Hybrid 61</td>
<td>3710.4</td>
</tr>
<tr>
<td>IT 71</td>
<td>2022.2</td>
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</tr>
<tr>
<td>Versatile</td>
<td>3142.4</td>
</tr>
</tbody>
</table>

*Note: The chart shows the comparison of total fruit count and weight between sharp sand and coconut coir for different tomato cultivars.*
The findings above indicate that year-round production of several horticultural crops could be substantially improved under open field and greenhouse conditions when appropriate selection of crop varieties, growing media, and drip irrigation technologies are optimized by local farmers. These crops investigated with these technologies play an important role in the improved menus of school feeding programmes. Consequently, every effort should be made by small farmers and policy makers to facilitate the use of these technologies to ensure a steady flow of these products to local school feeding programs and other local markets.

Reducing Post Harvest Losses: Post-harvest crop losses represent a major constraint to food availability in CARICOM countries. The main causes of post-harvest loss of fresh produce in the region are inappropriate handling and exposure to undesirable environmental conditions. Due to the absence of reliable and accurate data on post-harvest losses in CARICOM, we studied post-harvest crop losses using surveys of over 600 small-holder farmer households in all four project countries. We also undertook, in St. Kitts, Guyana and Trinidad, direct measurements of post-harvest losses along segments of the value chain for seven regionally important horticultural crops (tomato, string beans, eggplant, okra and cucumber, sweet pepper, and pumpkin). Four of these crops (tomato, string beans, cucumber, and pumpkin) were cultivated by “project farmers” for use in the school feeding programmes. We further strengthened our knowledge base on post-harvest quality with laboratory-based research that simulated environmental conditions (temperature, relative humidity, light) that obtain in the Caribbean during the post-harvest handling process. This approach allowed us to test methods to reduce post- harvest losses of crops cultivated as part of the
agricultural interventions of the project, and our efforts to generate research data for farm to fork model building.

Survey results indicate that most farmers in St. Kitts and Trinidad stored their produce on farm before selling (Annex 8 Figure 2) while in Guyana and St. Lucia, the majority of farmers reported selling their crops at harvest. Farmers in St. Kitts and Trinidad reported between 15% and 18% post-harvest losses of crops due to spoilage (Annex 8 Figure 2) but those in St. Lucia and Guyana reported considerably less post-harvest losses (3% and 10%). Regional differences among farmers in marketing practices seem to influence on-farm post-harvest losses.

Direct measurements with specific crops from the farmer to the consumer in St. Kitts revealed post-harvest losses of about 60% for tomato when the product is sold by local street vendor; the corresponding value for string beans was about 55% (Figure 6 below), with losses at the street vendor being twice as great as on the farm. In Guyana, major postharvest losses also occur at the street market due to inappropriate handling, and exposure to undesirable environmental conditions. Results from Trinidad revealed that on farm post-harvest losses of tomato was substantially less (6%) under greenhouse production than under the open field cultivation (25%). Bruising and physical defects resulted in 13%–22% postharvest losses for pumpkin (Annex 8).

Simple interventions, such as the use of umbrellas to protect the produce from direct sunlight and high temperature, could reduce post-harvest loss along the supply chain. Based on laboratory work (Figure 7 below), the use of food grade polyethylene wrapping film to protect eggplant was shown to prevent weight loss and further loss of firmness, and inhibit discoloration.

![Diagram](image_url)

**Figure 6.** Post-harvest map showing percent loss of string beans (left number) and tomato (right number) in St. Kitts.
Animal-source product for diet diversity and quality: Animal source products are an integral part of a diverse diet. Results from our baseline nutrition studies revealed a high prevalence of anaemia among school children in St. Kitts and Trinidad, despite adequate intake of total dietary iron. In addition to total intake of iron, the source dietary iron influences iron status; consequently, offering the more bioavailable haeme-iron from animal products could alleviate dietary-induced anemia. Therefore, we considered the inclusion of mutton (sheep and goat meat), a source of haeme iron and a source of high quality protein, to be a useful nutritional strategy to enhance the quality of school meals in St. Kitts. Mutton is a popular food item in St. Kitts and Nevis but the local supply falls far short (supply is 12% of demand) of consumer demand due, in part, to low productivity of the small ruminant sector. In the dry months, natural pastures are unable to provide sufficient energy and protein, severely limiting year-round productivity of sheep and goats and the availability of mutton.

For the above reasons, we conducted research with local sheep and goats (small ruminants) to promote a forage-based, sustainable production system to improve the productivity of the small ruminant sector. Under the project, and for the first time in St. Kitts-Nevis, Mulato II grass (Brachiaria hybrid CIAT 36087) and sorghum forage (Sorghum bicolor), both drought-tolerant forages, were established and evaluated for their ability to provide better year-round nutrition to sheep and goats. A detailed report of the research and the outcome is provided in Annex 9. We utilized two animal feeding trials to test the ability of Mulato II grass and sorghum to enhance animal performance. The first trial (beginning October 2012) was an “on-farm study” conducted (with both Mulato II grass and sorghum silages) over a 5 month period with 75 young sheep and goats (average initial body weight 17 kg) on 5 local small holder farms. The second trial (with Mulato II grass silage) was undertaken in partnership with Ross University School of Veterinary Medicine in St. Kitts; the study was conducted over a 5 month period (beginning December 201)
with 36 young sheep (average initial weight 18 kg) under controlled research conditions at the University’s research facilities.

The results show that, for the first time in St Kitts and Nevis, Mulato II grass was successfully established for livestock feeding. Despite being seeded in the dry season, this newly established pasture forage covered 98% of the soil surface within 6-7 months of establishment. The annual biomass yield from Mulato II grass (Figure 8 below; Annex 9, Figures a, b, c) was approximately 30,000 kg DM/ha. This annual yield of Mulato II grass was 36% greater than that reported for Mulato II during the first year (2010) of establishment in Trinidad (Hosein et al. 2011) and 10-20% greater than values reported for other common grasses (Tifton 85 and Pangola) grown in the Eastern Caribbean (John and Hosein, 2008). The crude protein content was comparable to values reported in the literature. However, with improved crop management the protein content of Mulato II grass could be increased, thereby enhancing the nutritive value of the forage. Silage produced from Mulato II grass maintained good quality for the first 3 months, though pH values were not optimal; spoilage occurred after 3 months of storage. The project experienced less success with sorghum forage (Annex 9, Figures 5, 6 and 7) due mainly to limited experience of local field staff with forage and soil management, and to crop damage by monkeys that found the crop palatable. Consequently, the annual biomass yield of the sorghum forage was less than 25% of its potential yield (26,697 kg of DM/ha) as observed under optimal conditions of irrigation and crop management in Texas, USA (Bean et al. 2010).

From an initial project establishment of 5 ha of Mulato II grass, farmers established, on their own land, an additional 20 ha, leading to five-fold expansion of the area currently under cultivation in St. Kitts. Based on the fact that a one hectare area of Mulato II grass can feed more than 70 adult sheep and goats for 6 months in the dry season, the increased acreage of Mulato II grass could substantially enhance year-round availability of mutton in St. Kitts.

Figure 8: Biomass production (kg dry matter DM/ha) of Mulato II from February 2012 to July 2013 in St. Kitts

Wet brewer’s grains (WBG), a freely available local brewery by-product, was added as a supplement to Mulato II silage or Napier grass under more controlled research conditions at Ross University School of Veterinary Medicine. With supplementation of WBG, young sheep grew at a
rate of up to 150 g/d, three time faster than observed under on-farm conditions where supplemented Mulato II grass silage was tested. Supplemental feeding of WBG resulted in weaned lambs being marketed at a desirable body weight (35 -40 kg) with substantially less “days on feed” compared to Mulato II grass silage alone. This means that lambs weaned at 8 weeks of age, with an average body weight of 18 kg, could be marketed within 7 months rather than over 12 months, as is the currently accepted norm in St. Kitts. Gastrointestinal parasite burden was demonstrated to be a serious constraint to sheep production (Annex 9, Table 10). Our findings reveal that an undersupply of dietary protein and parasite burden are proving to be major factors constraining productivity of small ruminants under conditions of natural pastures or “cut and carry” systems in St. Kitts-Nevis.

Another major outcome from the project was the establishment, for the first time in St. Kitts-Nevis and through partnership with CARDI and Ross University, of a Small Ruminant Farmers’ Association; this Association was created to facilitate access to markets and enhance technology adoption amongst farmers. Institutional and policy support to address constraints on the small ruminant sector would improve availability of mutton for domestic markets, including the school feeding programme, leading to increased household income for small holder farmers.

**B4. Farm to Fork Model “Matrix”: Social Capital and Governance**

**Project Objective #3.** Increase the rate of technology adoption by small farmers experiencing common agricultural challenges;

**Project Objective #5.** Expand and build human and institutional capacity to solve problems of food and nutrition insecurity in CARICOM countries

**Context:** In undertaking research activities to achieve objectives 3 and 5, we considered the fact that these two objectives are interconnected; they deal with mobilizing and building human and institutional capital for successful uptake of the farm to fork technologies introduced by the project in objectives 1 and 2. The common theme linking these two objectives is the need to put in place and strengthen supportive mechanisms and relationships that allow stakeholders (actors) in the farm to fork model (e.g. farmers, caterers, teachers, policy makers) to work together and innovate towards CARICOM’s food security goals. Therefore, the two objective above are presented together under the heading, “Social Capital and Governance”.

In the ensuing discussion, we treat “technology adoption” (objective 3) and “capacity building” (objective 5) as components of the broader concepts of innovation and collective action; they represent the social science matrix that contribute to the functioning and sustainability of the farm to fork model (Figure 1 above). We provide evidence that harnessing social capital (i.e. shared values and links among community members) is a critical means of fostering the innovation and collective action (i.e. governance) needed to support, at both institutional and community levels, problem solving and progress towards CARICOM food and nutrition security.

**Project Objective #3.** Increase the rate of technology adoption by small farmers experiencing common agricultural challenges;

**Technology Adoption and Innovation among farmers:** One of the major challenges in bringing about change in farming practices, especially among small-scale or subsistence farmers, is the lack of understanding around the perceived unwillingness of farmers to undertake these changes; this is particularly evident in CARICOM countries where the level of agricultural productivity and profitability is low.
Results of our baseline surveys (full details in previous IDRC Joint Technical Reports to IDRC) of about 600 farmers in Guyana, St. Lucia, St. Kitts and Trinidad show that, although there was variation among countries, less than 7% of farmers, on average, adopted new technologies. More revealing was the finding that less than 2% (on average) of the farmers surveyed kept records (Table 4 below; Annex 10, Table 2). The survey also identified important market-based barriers to technology adoption, including limited access to technical assistance, weak access to markets and financing, and gender and education. Women and more educated farmers were more likely to adopt new technologies (Annex 10).

### Table 4: Use and Adoption (%) of New Technology by Farmers Surveyed in Guyana, St. Lucia, St. Kitts and Trinidad

<table>
<thead>
<tr>
<th>Country</th>
<th>Crop</th>
<th>Tool or Equipment</th>
<th>Irrigation Technique</th>
<th>Fertilizer</th>
<th>Pesticide</th>
<th>Record-keeping Technique</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guyana</td>
<td>2.7</td>
<td>1.0</td>
<td>0.7</td>
<td>28.2</td>
<td>47.6</td>
<td>0.3</td>
<td>298</td>
</tr>
<tr>
<td>St. Lucia</td>
<td>13.0</td>
<td>0.9</td>
<td>3.4</td>
<td>0.9</td>
<td>14.7</td>
<td>0.0</td>
<td>116</td>
</tr>
<tr>
<td>St. Kitts</td>
<td>17.5</td>
<td>14.8</td>
<td>1.6</td>
<td>3.2</td>
<td>3.2</td>
<td>1.9</td>
<td>63</td>
</tr>
<tr>
<td>Trinidad</td>
<td>10.8</td>
<td>10.5</td>
<td>3.9</td>
<td>19.2</td>
<td>11.4</td>
<td>3.9</td>
<td>78</td>
</tr>
<tr>
<td>Total</td>
<td>7.62</td>
<td>3.68</td>
<td>1.81</td>
<td>18.38</td>
<td>30.36</td>
<td>0.92</td>
<td>555</td>
</tr>
<tr>
<td>N</td>
<td>551</td>
<td>543</td>
<td>554</td>
<td>555</td>
<td>550</td>
<td>542</td>
<td></td>
</tr>
</tbody>
</table>

Source: PHS Baseline 2012. Table reproduced from Laszlo et al. (2013), Table 12

A behavioral economics experiment conducted in Guyana, combined with collaborative studies in Peru (Annex 10), also explored the influence of attitudes towards, and perceptions about uncertainty with technology adoption behaviour by farmers. The results showed that farmers’ beliefs about technologies and the probability distribution of the benefits they generate can be influenced by open group discussions of these beliefs. In both Guyana and Peru, women tended to have stronger beliefs than men about probability distribution of benefits, and were more likely to take up an ambiguous option as a result of new information. Our project findings suggest that in providing technical assistance to farmers, policy-makers might consider targeting their information to groups of farmers, allowing these farmers to openly discuss this information and facilitating the dissemination of information within the social networks of participating farmers. The technical assistance might be particularly effective if targeted to women, and allowing the diffusion process to take place within their social networks.

**Harnessing Farmer and Institutional Social Capital for Innovation and Collection Action:**

Research on social networks and social capital in CARICOM is new, and the project made a significant contribution by providing research evidence on the importance of social capital in supporting innovation towards food security goals. A large body of literature has linked social capital to the capacity to act collectively and innovate (Adger, 2010; Subramaniam and Youndt, 2005). Here, innovation can be defined as an idea, practice, or process perceived as novel by a social actor (Rogers, 1983). As indicated above, from the inception, the project clearly identified low levels of farmer innovation, including technology adoption, as a constraint to progress towards regional food security.
During the course of the project, research data dealing with social capital were collected in all four project countries (see Annex 11). In St. Lucia, challenges with uptake and implementation of technologies introduced by the project presented an opportunity to explore in greater depth the role of farmer social capital for innovation and progress towards regional food security. The study measured different forms of social capital (Groteart et al. 2004): (1) “bonding” social capital (strong ties, within group ties—kinship; friendship); “bridging” social capital (bridging distinct and different groups); and “linking” social capital (vertical ties to power, finance through shared tasks toward the common good). Data were collected through 112 surveys of farmer households in two communities (Marquis and Black Bay), eight farmer focus groups, and 55 discussion points with community leaders, and analyzed using quantitative and qualitative data network analysis tools (UCINET software; NetDraw software). The results were used to map knowledge flows among members of each community.

This analysis of farmer networks identified structural constraints to knowledge flow that may limit innovation in rural communities. Two key findings emerged from the study: 1) Most of the farmers obtained their knowledge from other farmers; extension workers from government institutions were less of a source of knowledge to farmers; 2) There were differences between the two farming communities regarding the nature of the knowledge flow. In Black Bay, the farmer knowledge network (Annex 11, Figure 1) appeared to be based on “weak ties” (bridging capital) providing sources of new information within the community. In Marquis, the knowledge network appears to be based on “strong ties” (bonding capital). According to the literature (Granovetter 1973; Sabatini 2009; Scott and Carrington 2011), diffusion of innovation is facilitated in communities with bridging social capital (weak ties); communities characterized as having bonding capital foster group identity and cohesiveness but are less responsive to innovation and change (Coleman 1994; Burt 1984).

The results of project findings in St. Lucia, combined with studies in Peru and Guyana, suggest that initiatives to disseminate knowledge and information for technology adoption and innovation among farmers should take into account not only the importance of social/peer learning and “gender targeting,” but also differences in the nature of the social networks and the social capital that exists within rural and other communities. These are novel “knowledge outcomes” from the project and should be used to redesign regional and national institutional strategies and policies to increase innovation and technology-uptake by farmers and other food security actors in CARICOM.

In addition mobilizing social capital at the farmer-level, social capital is important in fostering innovation among institutions in support of food security aims. Results of a policy analysis completed by the project revealed that national and regional policies are not coordinated, and institutions are often working separately, and even at cross-purposes, limiting their ability to address the common goal of food security (see Annex 11). As a result of the project, new forms of “linking social capital” were generated among diverse actors, including farmers, scientists, and policymakers, and institutional capacity to collaborate on food security goals was enhanced. This contributed to the success and outcomes of the farm to fork model initiated in St. Kitts-Nevis. For example, a senior policymaker in St. Kitts remarked: “[Since the project] our relationship with other Ministries is improved, we depended on each other for it to be successful. The more you work with other Ministries the better the outcome. Often there are cross-cutting issues. This is one of them. It’s a wonderful thing when you can work with other Ministries to reach a goal of benefit to the country.”

Focus group research was also undertaken with project actors in St. Kitts-Nevis and in Trinidad and Tobago to identify some of the conditions important for fostering collaboration across different
countries, organizations and institutions on complex policy problems, such as food security. Participants identified building trust, having clear communication, and engaging in co-learning and knowledge sharing, amongst other factors, as being critical for working together.

Collectively, these findings point to an urgent need for food security policy to focus on building social capital among farmers, and other key actors in the agro-food system, in order to foster collaboration, collection action and innovation, including technology adoption. Building social capital among farmers and institutions proved key in facilitating technology adoption, collective action and innovative outcomes achieved by the farm to fork model for CARICOM food security (see Outcome Story, Annex 2, and Output 1).

**Project Objective #5. Expand and build human and institutional capacity to solve problems of food and nutrition insecurity in CARICOM countries**

The sustainability of the farm to fork model is critically dependent on human and institutional capacity building to sustain the technologies introduced by the project, capitalize on its outcomes, and adapt the farm to fork model to evolving conditions beyond the life of the project. Consequently, strengthening institutions and skills and knowledge training of farmers, field personnel, and other stakeholders, providing policy makers with a strong evidence base for decision-making, and contributing to “enabling conditions” within CARICOM were key elements of the project’s capacity building objective. We outline, below, important project outcomes that contribute to the achievement of this objective.

Throughout the life of the project, over 2,000 participants benefited from the project’s interventions and/or gained skills and knowledge in protected agriculture, drip irrigation, forage conservation, environmental quality assessment, nutritional status assessment, food service and food safety, and methods for social science, including survey and focus groups instruments.

Approximately 1200 children, parents, caterers and educators benefitted and participated in the nutritional education programs and hygienic practices training required for improving the school feeding programmes in St. Kitts and Trinidad. About 890 farmers and other beneficiaries (593 male, 294 female) participated in the project. As part of the project’s strong emphasis on human capacity building (See Table 5 below), skills and knowledge training was provided directly to over 680 field and farmer field personnel through 33 workshops and field training events, organized and delivered by researchers and other professionals in the project. Over 40 (about 80% female) highly qualified personnel (HQP), including graduate students and research associates, received skills, academic and professional training throughout the life of the project.

Skills training and the adoption of technologies introduced by the project led to farmers in St. Kitts, increasing, on their own initiative (and outside the project sites) the cropping area under drip irrigation by 32% and expanding five-fold the area under cultivation of Mulato II grass for small ruminant production. As indicated previously, a major project outcome, as a results of the capacity building initiatives of the project, was the establishment of the Small Ruminant Farmers’ Association to facilitate access to markets and enhance technology adoption among farmers.

At the School Meal Centre (SMC) in St. Kitts, skills training was conducted in food service and safety, and best practices were developed for hygiene and sanitation. Significant project investment was made in improving the equipment and infrastructure at the SMC to improve efficiency and safety of lunch meal service for over 3000 children each day and about 30 food service staff. In Trinidad, all three caterers involved in the project were trained in post-harvest handling and food
safety. In Guyana, there was an initiative to adopt the on-farm check list for food safety monitoring, based on CODEX international standards.

The project conducted or participated in 28 knowledge sharing/dissemination conference and workshop events that reached over 1770 participants from the Caribbean, Canada, and elsewhere in the world. We produced over 210 (see list in Annex 1) knowledge and communication outputs (including policy briefs outcome stories, scientific manuscripts under peer review, nutrition education manuals and videos, training manuals, magazine articles, technical reports and numerous conference and workshop presentations, and factsheets) for use by local and regional stakeholders and international audiences.

In October 2013, the project presented its integrated package of research evidence to leading CARICOM policy makers at the annual meeting of Council of Trade and Economic Development (COTED) held during the Caribbean Week of Agriculture in Guyana. Project findings and emerging outcomes were well received by COTED, with formal acknowledgement of the project’s contribution to evidence-based decision making to improve regional food security. In addition, a project exhibition booth and extensive national and regional media coverage (13 events—radio and TV interviews, newspaper articles) during the CWA resulted in enhanced public awareness of the project’s role in responding to CARICOM food security challenges.

The project’s top 20 outputs are provided in Annex 2, Output 1, and a table listing over 210 project outputs is provided in Annex 1. The project’s web site (www.mcgill.ca/globalfoodsecurity/research-initiatives/caricom-project) provides access to project outputs, and the AFS questionnaire (Annex 2) documents specific other specific details of capacity building achievements by the project.

### Table 5. Project Capacity Building and Outreach Activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Number of Participants</th>
<th>Total number of events</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Male</td>
</tr>
<tr>
<td>Knowledge Sharing and Dissemination activities</td>
<td>1773</td>
<td>1438</td>
</tr>
<tr>
<td>Beneficiaries and Stakeholder involvement</td>
<td>1203</td>
<td>n/a</td>
</tr>
<tr>
<td>Farmer-beneficiaries involvement in project</td>
<td>887</td>
<td>593</td>
</tr>
<tr>
<td>Farmers and field personnel Training</td>
<td>683</td>
<td>346</td>
</tr>
<tr>
<td>Academic (HQP) training at UWI and McGill (graduate students, postdoctoral fellows and research associates, research assistants and undergraduate students)</td>
<td>41</td>
<td>7</td>
</tr>
<tr>
<td>Undergraduate student training (at UWI &amp; McGill)</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Graduate student training on project (UWI)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Graduate student training on project (McGill)</td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>
C. Model testing for Food Safety and Environmental Sustainability:

**Project Objective #4.** Adapt international standards of food safety and quality for a healthy, market-oriented food supply chain in CARICOM countries

**Context:** Food safety and environmental sustainability/quality are intimately linked objectives and are addressed together under the above project objective (#4). Prior to the project, there was relatively little objective information on the prevalence of food safety hazards (biological, chemical and physical hazards) in food crops produced in Caribbean countries. In assessing food safety and environmental quality, we adopted a “value chain” approach, consistent with the farm to fork model. Across the four project countries, we undertook extensive evaluation of farming practices of project and non-project farmers, analyzed food items for chemical and microbial contamination, and conducted extensive soil and water quality analyses at the project sites. In St. Kitts, we also conducted a study of insect bio-biodiversity to determine whether the introduction of new forage species (sorghum and Mulato II grass) for ruminants would have an untoward environmental impact.

Four research approaches resulted in collection of a large body of scientific evidence on food safety and environmental quality: 1) A “checklist monitoring” system (on 57 farms and in school meals facilities of two caterers in Trinidad), based on CODEX Alimentarius food safety standards (see Annex 12); 2) a series of “knowledge, attitude and practice” (KAP) surveys of pesticide usage among 737 farmers in 15 targeted communities in Guyana, St. Kitts, St. Lucia and Trinidad (see Annex 13); 3) Laboratory analyses of pesticide residues, heavy metals (lead and cadmium) and microbial hazards (fecal coliforms, Salmonella and Staphylococcus aureus) in selected farm produce (tomatoes, pepper, cassava) and prepared school meals; 4) extensive laboratory analyses of soil and water samples (about 290 samples) from project sites in St. Kitts, St. Lucia and Guyana for objective assessment of environmental quality (see Annex 14). We discuss, below, the key results and outcomes of these interlocking areas of project activities, and utilize the outcome findings as a test of the food safety and environmental implications for the farm to fork approach to CARICOM food security.

**Food Safety:** Results of the check list monitoring revealed that on-farm practices posed no unacceptable health risk related to food safety hazards or sanitation. With regards to food safety in food service, one of the two kitchens monitored in Trinidad did not keep records of some of the food safety practices. The results of the complementary cross sectional KAP survey (Annex 13) revealed that 94% of the farmers experienced problems with pests on farms. Farmers’ knowledge, attitudes and practices varied within and across countries but 97% of those farmers reporting problems with pests applied inorganic pesticides to crops.

Pesticide residues were analysed on samples of select crops, particularly tomato. Results revealed that, among the 30 farms in St. Lucia and Guyana from which samples of tomato were collected and analysed, five pesticide residues were detected in 33% of the samples; CODEX maximum residue limits (MRL) were exceeded in 10% of the samples; Cypermethrin was the most frequently detected pesticide residue. No organochlorine pesticide residues were detected in tomato samples from Guyana and St. Lucia, and no pesticides were detected in samples of tomato from farms in St. Kitts. This study was the first to attempt to quantify pesticide contamination of tomatoes cultivated in Guyana, where farmers’ knowledge of pesticides was found to be relatively low.

In Trinidad, the pesticide, Ethion, was detected in tomato cultivated under open-field conditions but not under greenhouse production. Several other pesticides were detected in tomato cultivated under
both open field and greenhouse conditions in Trinidad but the individual levels of pesticide did not exceed the CODEX MRLs. Cadmium and lead concentrations in samples of tomato from greenhouse production in Trinidad were below MRLs but when tested under open field conditions, the lead content of tomato exceeded MRL. In St. Kitts, cadmium content of tomato from open field cultivation exceeded MRL. The levels of heavy metals in some crops would be of concern and could be influenced by soil content. The cadmium and lead content of soil samples from project sites in St. Kitts is discussed below.

Analyses of samples of individual food items (tomato, pepper, cassava), as well as prepared meals for school lunch service in Trinidad and St. Kitts, revealed no unacceptable health risk associated with microbial hazards. The school meal facilities and the operation of the meal service in Trinidad were found to be in accordance with HACCP-based protocol and Good Manufacturing Practices; in St. Kitts, the project undertook major initiatives to improve the facilities and operations at the School Meals Centre and to assist with the institution’s goal of achieving HACCP-based standards.

Overall, the food safety practices of farmers and private school meal caterers were found to be acceptable. However, farmers and caterers can still benefit from more formal training to improve record keeping and safe use of agricultural chemicals to ensure best practices and food safety across the value chain. It appears from the project results that greenhouse production has the potential to reduce the levels of pesticides and heavy metals in crops. The research conducted in this project, though based on limited quantity and diversity of crop samples, should prompt CARICOM leaders towards action aimed at adopting international standards of food safety.

**Environmental Quality:** A total of 74 soil samples and 12 water samples were collected from the project sites in St. Kitts at baseline and at the end of the interventions; 24 soil samples and 12 water samples were collected (at baseline only) from the Black Bay project site in St. Lucia. A total of 135 soil samples and 34 water samples were collected from the two project sites in Guyana (Parika and Black Bush). Irrigation water and soil samples from all sites in the three countries were analyzed for indicators of water and soil quality (Annex 14).

In both St. Kitts and St. Lucia, the soil parameters tested prior to, and after project interventions were generally within the normal ranges for the types of soils; the concentrations of cadmium in soil samples from St. Kitts were < 0.5 mg/kg; for lead, the values ranged from 11 to 42 mg/kg at both sites, with Stapleton presenting lower values than Mansion. As indicated above, high levels of cadmium were found in a limited number of samples of tomato grown on project sites in St. Kitts but the concentration of soil cadmium in samples from St. Kitts was less than the average value (1 mg/kg) for the world’s soils.

Soil samples from the plots on which Mulato grass and sorghum forages were established were moderately to strongly acidic at baseline but by the end of the project this acidity appeared to decline. Introduction of these forages had no deleterious impact on soil particle size or bulk density; in fact, the organic matter content of the plot with Mulato grass increased from 5.7 % at the beginning of the project to 6.7% to the end, indicating a beneficial effect on soil fertility. There was no adverse impact on insect biodiversity due to the introduction of Mulato grass and sorghum forages to St. Kitts-Nevis (Annex 13). Overall, the results suggest that the introduction of the new forage species had a beneficial rather than any deleterious impact on soil quality, with no deleterious effects on measured indicators of biodiversity.

In Guyana, results of baseline analyses revealed high levels of nitrogen in soils at both project sites. In Parika, the principal vegetable growing region, the low- pH soils (46% clay) presented higher
values for K while the soils in Black Bush (64% clay) had higher content of P. High values for N, P and K in soils suggest a high level of fertilizer application; this could be a cause for concern related to the costs of farm inputs and water pollution due to soil leaching of nitrogen and phosphorus.

Analyses of water samples from St. Kitts revealed concentrations of total N and P that exceeded the maximum allowable limit for discharge to marine waters; this was also true for P content of water samples from St. Lucia. These findings have implications for environmental quality and marine life because N and P can have eutrophication effects if surface water reaches rivers and coastal waters. All water samples taken from St. Kitts and St. Lucia had organo-chlorine pesticides levels below the method detection limits but in Saint Lucia, microbial contamination was a concern due to high counts of *E. coli* in the river water used for irrigation. The quality of the river water used for irrigation at both sites in Guyana was excellent and posed no environmental risk. Depending on the country under consideration, the source irrigation water and potential overuse of fertilizer have been identified as issues to be addressed to ensure safety of farm produce and quality of the environment.

As is the case with food safety, local farmers and technical and extension staff can also benefit from further training in agricultural management to ensure acceptable standards of soil and water quality; this will strengthen the CARICOM farm to fork model, whose viability and sustainability require continual monitoring of both environmental quality and food safety. However, the results of this project indicate that the farm to fork model, as currently developed and based principally on value chain research in St. Kitts, has no serious limitations regarding food safety and environmental quality that would constrain its utility and upscaling to other CARICOM countries.

**D. Economic Assessment, Functioning and Upscaling the Farm to Fork Model**

Based mainly on studies in St. Kitts, we undertook economic assessment of the farm to fork model for CARICOM food security; these studies were supplemented with a value chain analysis of the supply of local produce to the school feeding programme in Trinidad and a study of household expenditure on locally produced foods. Details are provided in Annex 17.

We conducted (March 2014) a cost-benefit analysis of the drip irrigation technology introduced by the project in St. Kitts. Drip irrigation was the technology utilized by most farmers (total of 34 in the four countries) participating in the project. Details of the cost benefit of drip irrigation are provided in Annex 15. We also recruited an independent consultant to undertake a broader economic assessment of the costs, benefits, viability and sustainability of the farm to fork model, and its potential for upscaling nationally and regionally. This study focused on the research activities in St. Kitts; details are provided in Annex 16.

Farmers participating in the drip irrigation interventions received production inputs (example: drip irrigation equipment, agricultural chemicals, and seeds, harvesting material, irrigation water and occasional labor) at no cost. However, for the cost-benefit analysis, using a partial farm budget approach, estimates of input costs were computed, and farm income was calculated based on market price for produce and estimates of quantities sold. Sixteen “project” farmers at both project sites in St. Kitts (12 farmers at Mansion; total of 3.3 acres under irrigation; 4 farmers at Stapleton; total 1.2 acres under irrigation) participated in the cost benefit analysis study.

All seven crops studied (tomato, pumpkin, string beans, carrot, cabbage, cucumber, watermelon) were cultivated under irrigation at both project sites and supplied the local school feeding programme (SFP). The SFP accounted for about 10% of the market outlet for the farmers’ produce which met 0 to 100% of the produce needs of the SFP, depending on the crop and the month of the year (see Annex 4, Table 9). During the study, we encountered some challenges with record keeping.
by farmers which influenced the robustness of the results; however, important conclusions could be drawn.

A key finding from the study is that the SFP in St. Kitts paid the same price for produce as that received by the farmers on the open retail market; the SFP did not seem to use the reliability and volume of its market and government procurement mechanisms as leverage in purchasing of local produce from farmers. Clearly, an opportunity exists for the SFP in St. Kitts to enter into contractual arrangements with local farmers to reduce produce price in return for a secure year-round school meals market. This would have the effect of reducing the cost of school lunch meals while potentially stimulating domestic production of horticultural products.

Another key finding is that, overall, there were positive economic benefits for adopting drip irrigation technology as part of the farm to fork model. When combined over the two project sites, the Net Present Value or NPV (a measure of the difference between cash inflows and outflows across time periods) from investing in the drip irrigation technology ranged from $USD $261,801 to $USD $1,444,410 when discounted over rates ranging from 15% to 5%, and over 3 to 20 years (Table 6 below; Annex 15, Table 9). The Mansion site (Annex 15, Table 10) had higher NPVs than the Stapleton site (Annex 15, Table 11).

Table 6: Net Present Values (NPV) of Mansion and Stapleton sites combined

<table>
<thead>
<tr>
<th>NPV/Discount Rate</th>
<th>r=5%</th>
<th>r=10%</th>
<th>r=15%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NPV EC $</strong></td>
<td>$3,899,906</td>
<td>$2,664,958</td>
<td>$1,959,386</td>
</tr>
<tr>
<td><strong>NPV USD</strong></td>
<td>$1,444,410</td>
<td>$987,021</td>
<td>$725,699</td>
</tr>
<tr>
<td><strong>n=20</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NPV EC $</strong></td>
<td>$2,412,510</td>
<td>$1,920,644</td>
<td>$1,569,118</td>
</tr>
<tr>
<td><strong>NPV USD</strong></td>
<td>$893,522</td>
<td>$711,350</td>
<td>$581,155</td>
</tr>
<tr>
<td><strong>n=10</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NPV EC $</strong></td>
<td>$842,511</td>
<td>$769,676</td>
<td>$706,862</td>
</tr>
<tr>
<td><strong>NPV USD</strong></td>
<td>$312,041</td>
<td>$285,056</td>
<td>$261,801</td>
</tr>
<tr>
<td><strong>n=3</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n=number of years; r= discount rate

The broader economic assessment of the farm to fork model included an evaluation of the technology package introduced by the project plus the school feeding interventions undertaken in St. Kitts. Assumptions were made regarding the long-term impact of adopting the agricultural and school feeding interventions advocated by the model, with nutrition outcomes in children resulting in a 5 to 30% reduction in prevalence of NCDs into adulthood in St. Kitts.
The evaluation of the agricultural technology interventions on small holder farms revealed that adoption of drip irrigation and associated farming practices (such as plastic mulching) increases the returns to farming for seven out of the eight crops considered. As a result of adopting project technologies supplied, farmer productivity increased and prices remained competitive.

The broader economic evaluation finds that under reasonable assumptions of reduction of NCDs arising from improved childhood nutrition, the reduction in direct economic burden as a result of intervention in the project schools in St. Kitts is estimated to range from USD 7,323 to $43,940 per annum. If we assume a linear scale up of the interventions to include all primary schools (about 3000 children) in St. Kitts, then it is estimated that the NCD economic burden would be reduced by US$58,306 to US$349,836 per annum. The food cost for providing the improved school lunches in St. Kitts is estimated to have increased from USD $0.35 to $0.91; if we estimate that the benefit could be up to US$349,836 per annum, it would still be greater than the maximum cost (US 317,520 per annum) of the improved lunch meal under a range of outcomes. There is clearly a trade-off between increased cost of enhancing the nutritional quality of school meals to combat childhood obesity and the long term reduction in the economic burden of NCD in adulthood. Of course, as discussed above, the increase in vegetable intake due to the improved school lunch menu in St. Kitts did not influence obesity rate, and even the enhanced intake of vegetables and fruits was still below recommendations for the whole day.

To reverse the rising trend in childhood obesity, investment in school programmes, including substantially enhancing intake of vegetables and fruit and reducing the offerings of extra non-nutritious foods in schools are important. While fruit and vegetable consumption was clearly demonstrated to have increased without offering a meal with a higher energy content, there is a strong potential to decrease the energy intake from each meal, as well as the meal cost; this could be achieved by providing vegetarian meals on some days and not offering sugar drinks as part of the meal. These changes could only be made slowly since there is considerable resistance to such suggestions as being culturally inappropriate and not easy to implement. Changing dietary patterns is known to be a slow process but increased fruit and vegetable intake is an important step which has the potential to change food habits and reduce the NCD burden (Shields 2006, World Bank, 2012). This increased access to healthy foods is essential to removing barriers to healthy eating and addressing the rising rate of obesity among children.

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1 An increase in the cost of providing daily school lunches from US 0.35 to 0.91 represents an annual increase in the school budget for the lunch program of US 317,520 (assuming feeding 3,000 pupils across St. Kitts and 189 school lunch days). There are likely to be efficiency gains from the upscaling of the school lunch programs such that an increase in providing daily school lunches to be around US 0.37 which amounts to an annual increase of the school budget going towards school lunches at US 209,790. Given that we estimate that benefits can be as high as US 350,000 these costs are lower than then expected benefits.
5. **SYNTHESIS OF RESULTS TOWARDS AFS OUTCOMES**

5.1 **New technologies and/or farming systems and practices:**

These outcomes were generated from activities linked to project objective # 2 that deals with developing food production systems based on agricultural diversification, conservation of water and efficient use of land.

*The NVAC greenhouse* (natural ventilation augmenting cooling) was developed as a new protected agriculture structure design that would increase the natural ventilation and address the critical challenges of humidity and high temperatures faced by Caribbean farmers. The project designed and tested this structure under Canadian summer conditions, but for logistic reasons it could not be tested in the Caribbean.

*Adapted cultivars* were identified for tomato (IT 71, Hybrid 61, Versatile and Striker) and sweet pepper (Crusader, Palladin and Bipode) under Gable roof greenhouse conditions in Trinidad and St. Kitts. Coconut coir media produced higher yields for total yield and marketable tomatoes in Trinidad and St. Kitts. Furthermore, local growth media: coconut coir, compost, (Trinidad) and sharp sand (St. Kitts) proved to be successful substitutes for imported products from Germany. Open field varieties were also identified for pumpkin (Future NP999 and Bodles Globe in Trinidad), carrots (Abaco, Kuroda and Juliana in St. Kitts) and 8 sweet potato varieties: two yellow fleshed (Cabey, Black Vine) two orange fleshed (Clarke, Lover’s Name), two white fleshed (Never Miss Black Vine SVG) and two introduced varieties (Viola, AVRDC). Food crops were evaluated in terms of yield, market quality, storage endurance and nutritional value.

*Drip irrigation technology* has not been widely used in the Caribbean due to lack appropriate knowledge and training. The project introduced this technology with training and technical support, and this enabled farmers to produce crops year-round, with efficient use of water, and to increase farm income. Participant countries were equipped with agro-meteorological stations and soil moisture sensors to have a better understanding of the irrigation requirements of their crops at the various project sites. A major technology output is the application of the computer simulation model, McGill-IRRIMOD®, that calculates the irrigation requirements for vegetables grown in Guyana and St. Kitts.

*The “silage bag” technique* was developed as a new technology for conserving forage, overproduced during the rainy season, as silage using polyethylene bags. The forage was conserved for 6 months in St. Kitts and was available for feeding during the dry season. This technique proved to be successful only when 8 mil thickness bags were available. The forage sorghum proved to reach better pH levels compared to Mulato grass. However, the Mulato grass proved to be a well-adapted good quality forage with promising use in grazing systems for small ruminants in St. Kitts.

*Postharvest handling management* in St. Kitts and Guyana has demonstrated the potential to reduce post-harvest loss of fresh fruits and vegetables along supply chain segments. This included (1) the development of consistent and reliable approaches to map and quantify those losses and (2) the recommendation of the use of simple interventions such as umbrellas and bright colour textiles to protect the produce from direct sunlight and high temperature. The use of food grade polyethylene wrapping film to protect vegetables such as eggplant was shown to prevent weight loss and further loss of firmness as well as inhibiting discoloration. The good quality of the wrapped produce was well maintained even after 10 days of storage at 30°C.
The continuous utilization of the above technologies will lead to increase food availability for local households within the next 3 years. Moreover, adopting those technologies will positively affect livelihood by alleviating food insecurity and generating income for farmers.

5.2 Dietary diversity and nutrition

These outcomes were generated from activities linked to project objective # 1-improve nutrition and health outcomes of vulnerable segments of the populations, through introduction of foods that would decrease caloric intake and increase micronutrient intake.

The project developed new school lunch menus to improve the nutritional quality of school meals for about 1000 primary school children in St. Kitts-Nevis and Trinidad and Tobago. The project also developed a number of nutrition education outputs. To enhance nutritional education among primary school aged children and their households, eight instructional videos were developed on the six Caribbean Food groups, food labels, and school gardening. These videos are outputs from the lessons presented face to face to children in the following classes or grades: 2nd year to standard 4 or grades 1 to 5. The use of this technology will not only enhance student learning but will be a valuable resource for educators.

A Manual of Sample Lesson Plans has also been complied to accompany the videos. The lessons presented build on the nutrition component of the Health and Family Life Education (HFLE) curriculum which was implemented by the Ministry of Education, Trinidad in 2006. For the academic year September, 2014, the Ministry of Education, Trinidad and Tobago has mandated all schools, both primary and secondary to implement the curriculum. Similarly, in St. Kitts the Ministry of Education has implemented the Health and Family Life Education curriculum. Presently, discussions are ongoing with the Curriculum Officers at the Ministries of Education, St. Kitts and Nevis and Trinidad and Tobago for the adoption of the project outputs to be utilized in the classroom to enhance the nutrition component of the HFLE curriculum.

In addition to these educational activities for children, a Meal Planning and Purchasing Guide has been developed at UWI as a tool designed to improve consumer awareness when selecting and purchasing local fruits and vegetables, and to plan and prepare healthy meals to help reduce the incidence of chronic diseases in the Caribbean. The guide contains tips on menu planning, purchasing, preparing, storage and service of safe and wholesome meals and will assist consumers when selecting local produce. The guide is a major component of the caregiver/parent nutrition education outreach activities.

5.3 Engagement of Canadian researchers with Southern researcher organizations

These outcomes were generated from activities linked to objective # 5- to expand and build human and institutional capacity to solve problems of food and nutrition insecurity in CARICOM countries.

The computer simulation model, McGill-IRRIMOD©, represents Canadian (McGill) technology and expertise and this technology has been instrumental in developing the irrigation water requirements for crops grown in CARICOM. Canadian researchers at McGill have been increasingly and intensely involved in all aspects of the project and have been especially helpful in research capacity building and field training of personnel at UWI, and partner organization in CARICOM and Peru. Since the beginning of the project, McGill’s contribution to capacity building in the CARICOM project countries has been substantial. The new technologies introduced to the project are led mainly by researchers from McGill (NVAC; drip irrigation; silage bag technique and postharvest...
management). Nine senior researchers, 4 research associates and 9 graduate students from McGill are directly involved in the project and have actively trained personnel, organized workshops and presented abstracts, posters and oral presentations of project results to audiences in the Caribbean and at the international level (CHRC-CARPHA, CWA, CWN, CAES/CFCS/ISHS Meetings and ISPC CGIAR Science Forum 2013). McGill has a proud tradition of working with partners around the world, and utilizing its knowledge and resources to enhance human capacity to solve problems of food insecurity. It has developed more than 40 IDRC projects and 23 DFATD (CIDA) projects since the year 2000 to address food security, water scarcity and nutrition issues around the world.

A long-term commitment was the launch of the McGill Institute for Global Food Security (October 2010), with the mission to address food insecurity and alleviate hunger and malnutrition in the world in an environmentally sustainable manner. The CARICOM Project is rooted in the Institute, and represents direct collaboration with UWI, a leading Caribbean University, to address constraints to CARICOM food and nutrition security.

The UWI is the largest and most long-standing higher education provider in the English-speaking Caribbean. It is 1 of only 2 regional universities in the world, and serves 15 territories. The UWI is an institution rich in history, achievement and impact on the societies in which it operate. The St. Augustine Campus has always had an emphasis on agriculture as it grew out of the Imperial College of Tropical Agriculture (ICTA). The institution’s proud tradition in agriculture is still strong and continues to play a key role in agricultural development and food security at the national and regional levels in CARICOM.

As an icon of Caribbean integration and culture, UWI remains committed to enhancing every aspect of Caribbean development and improving the well-being of the people of the Caribbean, and as such was able to respond through its regional and national networks – CARDI, IICA, FAO, CARPHA, Ministries of Education, Agriculture, Health and other institutions to the successful achievement and completion of the project. A key technology that led to the success of the project was introduced by UWI in Trinidad and St. Kitts, in conjunction with McGill University: through the community nutrition and health research subtheme: nutrition education and menu modification. This technology in conjunction with all the other technologies introduced by McGill provided a platform for testing and modelling a “farm to fork” initiative for the region. Through the partnership with McGill, the UWI researchers gained insights on research ethics, measurement of food security and data handling and archival options and strategies.

In addition to President Jagdeo’s CARICOM food security initiative providing a platform for the project, the linkages between UWI and McGill networks, resulted in opportunities for the two universities to further develop and strengthen their networks and partnerships in CARICOM. The partnership with McGill University provided an opportunity for UWI to network and build capacity in areas of project execution and management.

5.4 Research groups

This outcome was generated through project objective # 5, and deals with collaboration among UWI, NAREI, CARDI, UG, CARPHA and McGill.

The project research teams were formed with McGill researchers and counterpart researchers at the University of West Indies in Trinidad (UWI), and collaborating research partners in regional institutions including, the National Agricultural Research and Extension Institute (NAREI) in
Guyana, the University of Guyana (UG), the Caribbean like the Caribbean Agricultural Research and Development Institute (CARDI) and the Caribbean Public Health Agency (CARPHA). All the partners demonstrated strong collaborative efforts in the preparation of joint publications and posters for a two-day Workshop and an Exhibition booth at Caribbean Week of Agriculture in October 2013 in Guyana. The Ministers of Agriculture from all Caribbean countries present at 2013 Forum of the Council for Trade and Economic Development (COTED) were briefed on the project results and emerging outcomes during the Caribbean Week of Agriculture (CWA) in Guyana. The project was presented at a Minister’s policy making platform and a folder with all project contributions to food security policies was handed to each of the Ministers during this event. In addition, a write shop entitled “Communicating Research for Policy Influence: Agriculture and Food Security in the Caribbean” was facilitated by WrenMedia in St. Kitts in order to develop communication products for policy makers and the public.

5.5 Food distribution
The project focused more on the issue of food availability and food utilisation and did not address the food accessibility and equity in the distribution.

5.6 Food processing and storage
This outcome was generated from activities in objective # 2 through a better understanding and management of efficient handling and storage of fresh fruits and vegetables aimed at reducing significantly reducing postharvest losses along the supply chain segments.

The project mapped and quantified postharvest losses along the value chain for selected crops (tomato, string beans, cucumber, eggplant and pumpkin) grown by smallholder farmers in St. Kitts, Guyana and Trinidad. This has allowed project researchers to identify predict the outcome of different storage and distribution conditions, and to provide recommendations to reduce loss of quantity and quality along supply chain segments.

Potential uptake of the technology is likely to occur within the next 3 years, since the information generated from the project should enable farmers and retailers to reduce postharvest quality loss of fresh produce and increase income. Training programs in both safety and quality during pre and postharvest were conducted to raise food safety standards in CARICOM towards international standards.

5.7 Risk-mitigation
No specific objective was set to deliver this outcome. However, the project addressed the need to build more resilient and sustainable food security within the CARICOM region in three ways. The first involved research that recommended changes to build more resilient food security policies by addressing the low levels of adaptive capacity that currently exists among national and regional agriculture-food institutions. Second, the project interventions (agro meteorological stations, soil sensors) enhanced national capacity to monitor how weather conditions and conserve water in agricultural production (drip irrigation). Third, food safety and environmental quality risks have been identified through extensive monitoring of water and soil contamination, and monitoring of pesticide residues on crops.

5.8 Access to resources
This outcome was generated from activities under objective # 2- develop food production systems based on agricultural diversification, conservation of water, and efficient use of land.
Novel research conducted by the project in the Caribbean generated insights about how to improve knowledge transfer among smallholder farmers by harnessing social capital. This research has resulted in enhanced awareness among extensionists, researchers, and policy-makers about the untapped resources embedded in farmer social networks that can be used to improve access of extension services to farmers. Extensionists working in the project communities and other areas can use these insights and tools – including social network analysis – to develop interventions better adapted to local communities, and to build make use of social relationships, including peer to peer learning and trust building, to enhance knowledge exchange and innovation.

The project also improved market access for farmers by linking them directly to school feeding programs in St Kitts. The amount of locally farmed vegetables fruits supplied to the School Meals Centre in St. Kitts substantially increased to 20 tonnes over the course of the project. Prior to the project, the SMC procured negligible amounts of local produce for school meals. The SMC has become a new market outlet for local farmers in St. Kitts.

5.9 Income generation
This outcome was generated from objectives # 1 and 2.

Cost benefit analysis conducted by the project in St. Kitts showed that drip irrigation interventions by the project (in St-Kitts) resulted in net financial returns to small farmers involved in drip irrigating technology which enabled dry season cropping, and increased crop productivity and year-round supply of vegetables for consumers. In Trinidad, a market validation survey was undertaken to examine factors determining the level of household expenditure on food commodity groups for households of the children involved in this project and to explore the school feeding programme as a market outlet for farmers. Results are being used to expand markets for farmers. Lastly, as a result of project interventions in Trinidad, nutrition education is encouraging more healthy purchasing by households.

5.10 Policy options
This outcome was generated from objective # 5 in order to expand and build human and institutional capacity to solve problems of food and nutrition insecurity in CARICOM countries.

The project undertook a policy analysis of food security instruments and documents in the region (10 regional organizations and the 13 English speaking national governments) and found different understandings and approaches to food security operating in the region. The results of this study, communicated at a regional conference in Trinidad and end of project knowledge sharing forums, have raised awareness about the need for CARICOM policy forums, such as COTED (Council on Trade and Economic Development), to foster coordination among policy actors and institutions at regional and national levels in support of more integrated food security policy and programming. The results of this policy analysis can be used by policy leaders in CARICOM as strong evidence in support of the need for food security policy reforms.

5.11 Information Communications Technologies (ICTs)
No specific objective was set to deliver this outcome. However, the project developed a website as a key ICT tool for knowledge dissemination of the project results among project stakeholders and to regional and international communities. It is a key reference for team members of the project (McGill and UWI) and institutional partners (third party institutions) and serves for external and internal promotion of the project. The website is being updated with the latest outputs and knowledge dissemination activities.
5.12 Gender

This outcome was generated from objective # 5 in order to expand and build human and institutional capacity to solve problems of food and nutrition insecurity in CARICOM countries.

Women are vital to agriculture and food security. The project sensitized staff, researchers and institutional partners on gender considerations and the need and designed interventions to meet the specific needs of women. The project designed interventions to directly account for women’s agricultural roles by introducing technologies that saved time, reduced physical labour on farms, enhanced access to training and capacity building, and monitored women’s farming issues and food security status. Further, as a result of the project 325 women received training in areas of food and nutrition safety, conducting surveys, post-harvest management and labour-saving technologies. This training has helped improved women’s capacities and skills to improve their livelihoods beyond the project. At the same time, greater awareness of gender considerations among project staff, partners and researchers may contribute to more gender-sensitive interventions in the project countries and beyond to the regional level.

5.13 Environment

This outcome was generated from activities under objective #2 and 4-Develop food production systems based on agricultural diversification, conservation of water, and efficient use of land.

Three of the agricultural technology interventions (drip irrigation, protected agriculture, forage production and conservation) undertaken by the project supported more environmentally sustainable agriculture. The introduction of drip irrigation to project farmers resulting in a 20% decrease in water use; protected agriculture research identified the potential for the use of waste by-products as growing media in green house production; promotion of the use of protected under controlled environmental conditions to reduce use of agrochemicals by farmers arising from weed, pest and disease infestations under “open field” agriculture; forage introduction/production supported soil conservation by limiting soil loss from erosion.

The project conducted extensive soil and water monitoring to generate data on environmental impacts of the interventions and ensure environmental protection throughout the study. This research knowledge provides important baseline data for local governments in agricultural planning land use and development.

6. PROBLEMS AND CHALLENGES

A number of challenges were encountered during the course of the project. Most significant among these were delays in finalizing partnership agreements, challenges with full participation of farmers in the on-farm research initiatives, and coordination and communications with field staff, stakeholders and operations management.

Partnership arrangements

Over the course of the project, one of the main challenges encountered involved administrative delays in negotiating and finalizing partnership agreements. These delays arose because of differences in administrative capacity and efficiency among project partners, or budget expectations of third party organizations. Such challenges led to delays in disbursement of project funds for some partners. These challenges were overcome by strengthening the staff within the project management
office at McGill and UWI, and identifying local and institutional champions to facilitate completion of contracts, and put in place mechanisms for transfer and accountability of funds.

**Stakeholder engagement**

Challenges were encountered in Trinidad in obtaining cooperation from farmers to provide information about produce sales to school lunch programmes, and with parents in completing end of project survey questionnaires. This slowed progress with the mapping of the food value chain and the completion of the end of project survey. These problems were addressed by introducing incentives such, as phone cards and food vouchers, to increase participation in the project by farmers and parents.

In St Kitts, low levels of farmer participation influenced the quantity of data collected for the on-farm experiment with small ruminants. Challenges in St. Kitts with farmer participation and field operations were addressed by the project’s hiring of a local full time Field Operations Manager, increasing the frequency of monitoring local field project activities through CARDI (a regional project partner), and establishing a new partnership with Ross University School of Medicine in St. Kitts to strengthen the implementation of project activities dealing with small ruminants.

In Trinidad, very few farmers participated in the protected agriculture trials. This was mainly due to farmers’ perception of a high cost of this type of involvement in on-farm research; also, for biosecurity reasons, many greenhouse producers were reluctant to allow UWI researchers to enter their structures. To stimulate interest and build capacity among farmers, 18 new farmers were trained in greenhouse technology and management. Due to time constraint, no further work was undertaken with the farmers.

**Coordination and communications**

A final challenge encountered related to less than optimal communication among project researchers, project and local agricultural extension staff and farmers. This resulted in challenges with timely sharing of knowledge with farmers and other stakeholders. For example, the results of technologies undertaken by the project on farmers’ plots did not always reach farmers in a timely manner. Farmers believed, therefore, that they were not able to swiftly improve their practices in light of new results. Of course, research protocols could not be altered mid-stream, even in light of promising results; this may not have been fully communicated to, and appreciated by farmers, thereby leading to communication gaps within the project. To ensure farmers and other stakeholders were fully informed about the research findings generated by the project, several “end of project knowledge sharing workshops” were held in St Kitts, Trinidad, and St Lucia between June and August 2014. Many farmers and other stakeholders attended the workshops, and expressed great interest in the research and technology findings, with the aims changing practices based on “lessons learnt”.

7. **RECOMMENDATIONS**

A research project of this scope and complexity, combined with the administrative and reporting demands of the granting agency, would have benefited from more time for partnership building and administration prior to actual project implementation of project field activities. A five-year timeline would be a recommendation, with the first year focused on partnership building and planning.
Another key recommendation is to include a communications coordinator from the project proposal development stage. This would facilitate ongoing communication amongst all researchers and regional stakeholders to establish and maintain a common purpose, transparency and shared understanding. This will also help gain the commitment, trust and support of all stakeholders and ensure that outreach communication is efficient.

In response to challenges encountered with partnership building, identifying proven partnerships and working with applicant researchers that have established and proven working relationships, prior to the start of the project, would be a recommendation. We make no other recommendations beyond those documented in previous reports to IDRC.

The support of IDRC and its project officers has been outstanding, and the CIFSRF programme provided an excellent model for funding, facilitating and translating food security research into international development.

References


Ogden, Cynthia L et al. 2011. The Epidemiology of Childhood Obesity in Canada, Mexico and the United States. 2011, pp 69-93


Hosein, Ansari, Janet Lawrence and Norman Gibson. 2011. The livestock programme of the Trinidad and Tobago unit a review 2007-2010.


John, Michelle and Ansari Hosein. January 2008. Comparing the yield and quality of two improved forage species with tanner (Brachiaria arrecta) and pangola (Digitaria ecumbens) Caribbean Agricultural Research and Development Institute; Final Report


Global School-based Student Health Survey: Saint Kitts & Nevis 2011 Fact Global School-based Student Health Survey Saint Kitts & Nevis 2011 Fact


