Financial Aspects of Greenhouse Vegetables Production Systems in Jamaica and Trinidad & Tobago

TECHNICAL REPORT

By

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Acknowledgements

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Contents

1.0 Summary of Main Findings ..................................................................................................... 4
2.0 Introduction ............................................................................................................................ 4
3.0 Approaches to Ensuring Computation of Total Cost of Production ....................................... 5
4.0 Method of Data Collection and Analysis ................................................................................ 5
5.0 Results and Discussion ............................................................................................................ 6
5.1 Costs and Returns in Selected Greenhouse Crops – Tomato and Sweet pepper ................. 9
5.1.1 Introduction to the Concept of Value Chain Analysis and International Price Competitiveness ........................................................................................................................... 9
5.1.2 Costs of Production in Selected CARICOM Countries ....................................................... 10
5.2 Costs of Production and Market Prices ................................................................................ 11
5.3 International Price Competitiveness .................................................................................... 14
5.4 Cost of Production and International Price Benchmarking – Tomato ................................. 15
5.5 Cost of Production and International Price Benchmarking - Sweet pepper ....................... 16
5.6 Cost of Production and Domestic Market Prices – Tomato ................................................. 17
5.7 Cost of Production and Domestic Market Prices - Sweet pepper ........................................ 17
6.0 Socioeconomic Assessment (SEA) of Greenhouse Vegetables Producers ........................... 19
6.1 Farmer Situation ................................................................................................................... 19
6.2 Technology and Communication .......................................................................................... 21
6.3 Business Characteristics ....................................................................................................... 21
6.4 Contingency Plan .................................................................................................................. 22
1.0 Summary of Main Findings

This study examined tomato and sweet pepper greenhouse and open-field production models in Jamaica and Trinidad and Tobago. Following are the main findings:

1. Monitoring production costs and market prices were found to be critical for producers of greenhouse vegetable crops in order to ensure the economic feasibility of their operations.
2. The study found that greenhouse production costs were typically higher than those in open-field grown crops even when the initial capital costs for greenhouse construction were not included in the analysis.
3. Costs incurred in the production of greenhouse vegetable crops resulted in the need for higher market prices, typically requiring protective measures in order to be competitive.
4. Further, production costs for the greenhouse vegetable crops were typically higher than the wholesale market prices during the first and second quarters of the year.
5. Given that local producers are now entering the greenhouse vegetables production learning curve, time will be required to get the technology right and to be able to compete successfully with the international producers.
6. In both Jamaica and Trinidad, greenhouse vegetable producers indicated that in order to live a comfortable lifestyle, they needed to increase productivity in their greenhouses, obtain higher prices for their products and to operate at least 9,000sqft of greenhouse floor space.

2.0 Introduction

All agricultural production systems have costs, which affect financial returns and the owner’s decision to proceed or forego investments. Monitoring production costs and market prices are critical for greenhouse vegetable crops. In this regard, greenhouse vegetable growers should
take into consideration the intricacies of the market in terms of prices at different times of the year as well as the best time to enter the market as these can impact directly on returns to labour, investment and overall profitability.

Like any other business sector, records are important for computation of production costs. In this report, various greenhouse tomato and sweet pepper production sites were examined as part of the activities within the CFC-funded protected agriculture project being implemented by CARDI; the economic operating costs were computed and the returns were estimated. The costs in the greenhouse systems were also benchmarked to typical field-grown production systems, as well as those products which were sold in segmented markets based on size of the product and its origin e.g. ‘import vs local’ in order to delineate the imperatives of competitiveness. The data generated were then used to advise on the suitability and economic sustainability of the greenhouse systems.

3.0 Approaches to Ensuring Computation of Total Cost of Production

Given the technology necessary for the operation of a greenhouse vegetable production system, its costs are characterised by:

1. Higher initial investment - the system often requires growing crops that give either a higher return over the longer-term or those which give lower returns with rapid turnover.
2. Higher technical know-how of management and operating personnel – required to ensure success.

Fixed assets required for operation include: land, greenhouse structure, mesh/enclosure, pumps, fertigation system, water tanks and/or water reservoirs, pH meter and other monitoring devices. Variable costs include input supplies such as fertilizers, pesticides, growing media and labour.

4.0 Method of Data Collection and Analysis

The Cost of Production model used in this assessment identified the major costs associated with greenhouse tomato and sweet pepper production under a typical/modified system technology. Other minor costs were lumped under “overheads” for ease of computation. Appendix 1 provides a typical proforma used for recording data as well as computation of the cost of production. The following steps were carried out:
1. Survey instruments for data collection were developed.

2. Data on primary production was collected through the use of field surveys conducted at eight greenhouses in Jamaica in the parishes of Clarendon, Manchester, St. Ann and St. Catherine (four under tomato and four under sweet pepper) and nine in the island of Trinidad in the towns of Arima, Cunupia, Mayaro and Santa Cruz (four under tomato and five under sweet pepper).

No survey was conducted in Tobago; reference in this report will, therefore, be made specifically to the island of Trinidad. In each country two tomato and two sweet pepper open-field farms (Manchester in Jamaica and Tabaquite in Trinidad) were examined for comparison with the greenhouse systems.

Farm records where not adequately kept in most instances and in some greenhouses only partial data were obtained. Where data were missing, estimates were made after farmer consultation. In the final analysis of the data, average values were obtained for all greenhouses or open-field systems examined in the countries.

3. The data were compiled for the different production models and analyses undertaken. Greenhouse design varied somewhat but the Split-Arch type was the most common.

4. In the calculation of the cost of production that was determined for tomato and sweet pepper, various components of the greenhouse had to be assigned different life spans for calculation of depreciation. For example, the steel structure was given a 15 year life span while the plastic was given 5 years.

5. **Results and Discussion**

The greenhouse vegetables production model was evaluated based on various systems being used by producers and also benchmarked against field grown tomato and sweet pepper. A number of different structural modifications were found. Various photographs (Figures 1 and 2) are presented below showing the systems found during the field visits.
Figure 1. Greenhouse vegetables production, Trinidad

a. Sweet pepper production with coir-based medium (exterior view) – Mayaro.

b. Tomato production with coir-based medium (internal view) – Cunupia.

c. Sweet pepper production with coir-based medium (close-up of crop) – Mayaro.

d. Tomato production with soil-based medium – (internal view) - Santa Cruz.

e. Tomato production with soil-based medium – (crop rows) - Santa Cruz.

f. Open-field grown tomato production – Tabaquite
**Figure 2.** Different types of greenhouse and open-field grown vegetable operations in Jamaica.

- Greenhouse with tomato, Manchester
- Greenhouse with sweet pepper, St. Ann
- Tomato being grown in greenhouse, Manchester
- Sweet pepper being grown in greenhouse, St. Ann.
- Sweet pepper being grown in greenhouse, Clarendon
- Open-field grown tomato production, Manchester
5.1 Costs and Returns in Selected Greenhouse Crops Tomato and Sweet Pepper

The approach undertaken employed the concept of the local value chain as an integral part of the global agribusiness value chain given the openness of markets to global competition. This methodology, therefore, assessed the local greenhouse industry relative to the global competitors as fresh produce importers are now an integral part of domestic competition along with open-field producers.

5.1.1 Tomato

The build-up of costs (US$) was computed for a typical tomato production system in Trinidad as detailed in Figure 3. Unit cost items per lb included building ($0.16), growth media ($0.08), seedlings ($0.05), chemical sprays ($0.08), fertigation ($0.16), weed control ($0.01), husbandry practices ($0.26), harvest and marketing ($0.11) and overheads ($0.07) for a total cost of production of $0.98/lb. The corresponding percentages of total cost of unit cost items were building (16%), growth media (8%), seedlings (5%), chemical sprays (8%), fertigation (16%), weed control (1%), husbandry practices (27%), harvest and marketing (12%) and overheads (7%).

The market price of tomato in Trinidad was US$1.08/lb thereby providing the producer with a gross margin of US$0.10/lb.

Figure 3. Build-up of total cost of production (US$/lb) for tomato in Trinidad along the production chain from greenhouse start-up to market.
The costs of production of tomato for greenhouse and open-field systems in Jamaica and Trinidad are presented in Figure 4. The production costs under the greenhouse system were found to be higher in both countries when compared to open-field production. Greenhouse production costs were approximately two and a half to three times those of open-field in both countries. Actual costs of production in greenhouses were estimated at US$0.67/lb for Jamaica and US$0.94/lb for Trinidad compared to open-field costs of US$0.24/lb and US$0.38/lb for Jamaica and Trinidad, respectively.

**Figure 4.** Comparison of cost of production for tomato produced in greenhouses vs open-field in Jamaica and Trinidad.

5.1.2 Sweet pepper

The costs of production of sweet pepper for greenhouse and open-field systems in Jamaica and Trinidad are presented in Figure 5.

The production costs under the greenhouse system were found to be higher in both countries when compared to open-field production. Greenhouse production costs were approximately three to almost five times those of open-field in both countries. Actual costs of production in greenhouses were estimated at US$1.18/lb for Jamaica and US$1.31/lb for Trinidad compared to open-field costs of US$0.27/lb and US$0.48/lb for Jamaica and Trinidad, respectively. This difference in production costs was mainly due to the high costs for the greenhouse structures as well as the different levels of input used in the greenhouse production operations.
On one of the sweet pepper farms sampled in Jamaica where the producer had both greenhouse and open-field systems, the greenhouse production cost represented more than five times that of the open-field system. It was also found that one Trinidad producer’s greenhouse cost of production was as much as twice that estimated for the other producers sampled; this was accounted for partly by the use of a higher level of technology (especially the cooling system).

5.2 Costs of Production and Market Prices

Given the high cost of production experienced by producers using greenhouse systems, it is critical for these producers to closely monitor fluctuations in market prices. The cost of production can then be compared to the average quarterly market prices to aid in the decision as to which months of the year are best to produce and market. This is critical for greenhouse operations, given the higher cost of production compared to open-field production and also, the opportunities gained from greenhouse structures by the controlled environment which enables them to produce for targeted market periods.

Trinidad and Tobago

- Tomato: An examination of the average quarterly wholesale market prices for tomato sold in Trinidad is presented in Figure 6 for the 2009/11 period. On examination, there is an increasing trend in prices from Quarter 1 (Q1) to Quarter 4 (Q4). Using the price data, it is obvious that greenhouse producers will not be able to cover production costs in Q1.
In Q2 and Q3, they would receive only marginal returns. Thus, greenhouse producers in Trinidad should (i) endeavour to increase their productivity to lower costs and (ii) differentiate their products sufficiently to receive higher prices than those illustrated in Figure 6.

**Figure 6.** Average quarterly wholesale market prices for tomato in Trinidad & Tobago for the period 2009-2011 (Data source: NAMDEVCO)

- **Sweet Pepper:** Figure 7 shows average quarterly wholesale market prices (2009/2011) for a pound of sweet pepper sold in Trinidad. For greenhouse sweet pepper producers under the low input/low output system, they will not cover their cost of production in any of the four quarters while the high input: high output will provide marginal returns only in Q3.

Thus, as in the case for tomato, greenhouse sweet pepper producers in Trinidad should (i) endeavour to increase their productivity to lower costs and (ii) differentiate their products sufficiently to receive higher prices in all four quarters.
Figure 7. Average Quarterly Wholesale Market Prices for Sweet pepper in Trinidad & Tobago for the period 2009-2011 (Data source: NAMDEVCO)

Jamaica

- **Tomato**: Figure 8 illustrates the average quarterly farmgate price for tomato produced in Jamaica. In this case, producers cover their cost in Q4 and marginally cover costs in Q3. This demonstrates the need for (i) increased productivity as a means for reducing their cost of production and (ii) production differentiation should be pursued to receive higher prices.

Figure 8. Average quarterly farmgate prices (US$/lb) for tomato in Jamaica for the period 2009-2011 (Source: Ministry of Agriculture and Fisheries, Jamaica).
**Sweet Pepper:** Figure 9 illustrates the average quarterly farmgate price for sweet pepper produced in Jamaica. In this case, greenhouse producers will be unable to cover their cost in any of the quarters. This demonstrates the need for major technological innovations in the system which would drive productivity and lower costs substantially in order to compete. In the interim, product differentiation should be pursued to receive higher prices.

**Figure 9.** Average quarterly farmgate prices (US$/lb) for sweet pepper in Jamaica for the period 2009-2011 (Source: Ministry of Agriculture and Fisheries, Jamaica).

### 5.3 International Price Competitiveness

The fresh produce market from a greenhouse operation perspective, involves competition from major USA producers. Figure 10 illustrates cost build up for the importation of tomato from Miami Terminal Market to Kingston, Jamaica with a 15% importer’s mark-up.

The typical cost transmission for tomato from the Miami Terminal market to Kingston was computed to determine the addition of value to imported tomato. Actual expenses and industry mark-up were used for the average annual USA Terminal market price, freight, custom broker’s charges, port charges, importer and other services along with the supply chain from Miami to Jamaica.

It was found that mature green tomato was sold at prices ranging from US$0.24–0.60/lb (average of US$0.42/lb) in Miami in 2011. At this average price of US$0.42/lb with freight costs of US$0.14/lb plus border tariffs/taxes, the product was landed at US$2.02/lb (duties and taxes represents an increase of 262% of the CIF value). Fees for brokerage, importer’s warehouse and importer’s mark-up carried the imported product cost to US$2.39/lb. The duties afford
domestic producers – whether highly efficient or not, a temporary significant level of protection.

**Figure 10.** Cost build-up (US$/lb) for importation of tomato from Miami into Jamaica.

<table>
<thead>
<tr>
<th>Terminal Market Price</th>
<th>Freight</th>
<th>CIF</th>
<th>Custom Duties (262%)</th>
<th>Landed cost</th>
<th>Port charges + Broker fees</th>
<th>Importer’s Warehouse</th>
<th>Importer’s Markup (15%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.14</td>
<td>2.02</td>
<td>0.05</td>
<td>2.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.56</td>
<td>1.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.42</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the case of sweet pepper, the annual average Miami Terminal Market price for 2011 was US$0.46/lb, landing (Cost, Insurance and Freight or CIF = US$0.60/lb) and ready to sell at the importer's warehouse at US$2.07/lb. Duties and taxes amounted to 92%. Using a similar transmission model as done for tomato, the high level of duties and taxes employed in Jamaica again afford greenhouse producers a significant level of protection.

### 5.4 Cost of Production and International Price Benchmarking – Tomato

Given the prevailing prices for tomato at the Miami Terminal Market, the greenhouse operations evaluated in Jamaica and Trinidad will not be able to compete with the respective average imported product. The tariffs are required to offer the greenhouse producers temporary market space (protection) until their efficiency levels are enhanced sufficiently for them to compete globally (Figure 11).

Open-field production systems in Jamaica will enjoy a more comfortable position, given the duties being used to protect the local industry from the highly efficient extra-regional sources.
Figure 11. Cost of production of tomato produced under greenhouse and open-field production systems in Jamaica and Trinidad (2012/2013).

5.5 Cost of Production and International Price Benchmarking - Sweet pepper

Similarly, given the prevailing prices for sweet pepper at the Miami Terminal Market, the greenhouse farms evaluated will not be able to compete with the average imported price for sweet pepper plus freight. The tariffs are also required to protect the greenhouse producers from the imported products. As illustrated in Figure 12, open-field producers will enjoy some degree of comfort because of their much lower cost of production.

Figure 12. Cost of production of sweet pepper produced under greenhouse and open-field production systems in Jamaica and Trinidad (2012/2013).
5.6 Cost of Production and Domestic Market Prices – Tomato

In the case of domestic prices, greenhouse producers will not be able to compete with open-field. In this regard, producers will need to target production for delivery in the market during the third and fourth quarters when prices are higher (Figure 13). In the case of Trinidad, production can be targeted for Q2, Q3 and Q4 when wholesale market prices are higher.

This recommendation is, however, made with reservations as there is also the need to maintain production and revenues throughout the year to optimise returns to investments.

Figure 13. Cost of production of tomato produced under greenhouse and open-field production systems in Jamaica and Trinidad (2012/2013). Included in the diagram are the seasonal high and low prices for the two countries.

5.7 Cost of Production and Domestic Market Prices - Sweet pepper

In the case of sweet pepper, greenhouse producers in both countries will not be able to compete with the low and high farmgate prices for the vegetable. In this regard, producers will need to target delivery to end users in the market (Figure 14) who afford a higher negotiated price.
Figure 14. Cost of production of sweet pepper produced under greenhouse and open-field production systems in Jamaica and Trinidad (2012/2013). Included in the diagram are the seasonal high and low prices for the two countries.

Table 1 illustrates a comparison of cost of production and yield between greenhouse and open-field sweet pepper production in Jamaica and Trinidad. On examination of the yield/sq ft/month in both countries, the greenhouse system performed better (three times as much) than the open-field in Jamaica but was the same in both systems in Trinidad. However, unit cost of production was greater for greenhouse operations, being US$1.50 for greenhouses in Jamaica versus US$0.27 in open-field and US$1.68 for greenhouses in Trinidad versus US$0.48 in open-field.

The open-field system examined in Trinidad used a much higher level of technology (greater plant density, advanced drip irrigation system, higher fertiliser rates and field mechanisation) compared to the one in Jamaica, resulting in a higher cost of production. However, this resulted in a much higher yield over space (1.15lb/sqft in Trinidad versus 0.28lb/sqft in Jamaica) and time (0.29lb/sqft/month in Trinidad versus 0.07lb/sqft/month in Jamaica).
Table 1: Comparison of Cost of Production (US$) and Yield/sq ft/month for Sweet pepper grown under greenhouse and open-field production systems in Jamaica and Trinidad.

<table>
<thead>
<tr>
<th>Item of cost</th>
<th>Jamaica greenhouse (average for two units)</th>
<th>Jamaica open-field</th>
<th>Trinidad greenhouse (average for two units)</th>
<th>Trinidad open-field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of building/Field plot size (sqft)</td>
<td>6,000</td>
<td>43,560</td>
<td>3,000</td>
<td>43,560</td>
</tr>
<tr>
<td>Building &amp;/or Irrigation infrastructure</td>
<td>5,520</td>
<td>244</td>
<td>3,775</td>
<td>1,978</td>
</tr>
<tr>
<td>Operations</td>
<td>12,426</td>
<td>2,639</td>
<td>6,185</td>
<td>20,475</td>
</tr>
<tr>
<td>Overheads</td>
<td>1,188</td>
<td>370</td>
<td>684</td>
<td>1,737</td>
</tr>
<tr>
<td>Total cost</td>
<td>19,134</td>
<td>3,254</td>
<td>10,644</td>
<td>24,190</td>
</tr>
<tr>
<td>Yield (lb)/crop</td>
<td>12,000/10mth</td>
<td>12,000/4mth</td>
<td>7,486/10mth</td>
<td>50,000/4mth</td>
</tr>
<tr>
<td>Unit cost/lb</td>
<td>1.50</td>
<td>0.27</td>
<td>1.68</td>
<td>0.48</td>
</tr>
<tr>
<td>Yield (lb)/sqft</td>
<td>2.00</td>
<td>0.28</td>
<td>2.50</td>
<td>1.15</td>
</tr>
<tr>
<td>Yield (lb)/sqft/mth</td>
<td>0.20</td>
<td>0.07</td>
<td>0.25</td>
<td>0.29</td>
</tr>
</tbody>
</table>

6.0 Socioeconomic Assessment (SEA) of Greenhouse Vegetables Producers

This section of the report gives a brief description of the socioeconomic situation of the two producers in south-east Trinidad who participated in the study. The primary objective of the SEA is to examine the contribution that greenhouses are making to the livelihoods of producers.

6.1 Farmer Situation

The major characteristics of the greenhouse producers are presented below.

Case Study – Greenhouse Vegetables Producers in Trinidad:

1. Both farmers were operated 30ft x 100ft greenhouse structures as a fulltime activity and as such, it is assumed that 95%-100% of the operators’ incomes came from this source.
2. Sweet pepper farmer Taylor attained secondary school education while Sweet pepper farmer Rambarose attained secondary school level and also pursued technical schooling.

3. Both farmers benefitted from a donor greenhouse grant.

4. Both farmers are new to greenhouse operations, having less than 5 years’ experience in the business. They have been in the open-field system of farming previously.

5. Both farmers were growing sweet pepper at the time of the survey.


Other General Industry Observations (Trinidad and Jamaica)

Given that the sweet pepper greenhouse operators receive most of their income from the farm, the income represents returns to their labour and investment. This supports the argument that these greenhouse operators will not be able to fully support a subsistence-plus lifestyle and asset-accessible status. As suggested from discussions with respondents, at the current level of output, a minimum of three greenhouse structures (total of approximately 9,000sqft) will be required to provide the scale of operation that would allow a comfortable lifestyle and an adequate credit-rating.

Using information gathered from the survey of greenhouse producers in Jamaica and Trinidad, the main issues confronting them can be summarised as follows:

1. Given that the farm is an extension of the household with intrinsic linkages therein (labour, finances, etc), the farmer very often has to prioritise purchases between personal/household requirements and that of the greenhouse. This can translate into reduction of fertiliser applications, labour and pesticide input and thus lower yields. The plants may be sustained alive until the cash flow situation improves.

2. A lack of financial security and confidence to face the financial institutions for credit. Given the low desire displayed by financial institutions to facilitate credit to the agricultural sector, and the high up-front costs required by greenhouse production systems, many producers will not obtain assistance easily.

3. Assessments of the financial institutions indicated that they were not well equipped to assess greenhouse-type investments and, therefore, they deflect from these agribusiness applications. Staff from agri-lending institutions should be given specialist greenhouse agribusiness training.
4. There appears to be a tendency by operators to be willing to explore the probability of grant funding for expansion rather than loans. This exists despite the ready market that exists for their farm output.

5. In both countries of the survey, greenhouse vegetables producers indicated that in order to live a comfortable lifestyle, operators will need to:
   a. Increase productivity levels in the greenhouses.
   b. Expand operations to two or three greenhouse structures so as to operate approximately 9,000 sq ft of greenhouse space.

6. For the sector to develop, there is need for greater understanding of:
   a. Market intelligence.
   b. Business assessment skills.
   c. Business negotiation skills.
   d. Greenhouse crop agronomy.
   e. Financial and human capital development.

7. Given that greenhouse vegetable operations require higher technical competences, investments in training for both greenhouse operators and employed labour are recommended.

6.2 Technology and Communication

Farmers preferred to receive technical information through newsletters and eventually, Internet. Attending seminars may be difficult, given the workload and demands on the farm. Technology information required includes:

(i) Fertiliser technology
(ii) Pesticide technology
(iii) Crop varieties for use in greenhouse system
(iv) Cooling/ventilation technology

6.3 Business Characteristics

Some of the positive comments expressed include:
(i) Greenhouse produce is easier to sell because of its visibly higher quality than open-field produce.
(ii) Low vulnerability to market price fluctuations when there is a long-term buyer arrangement in place.
(iii) Can supply vegetables to the market year-round.
(iv) Income from the farm has been improving.
(v) Business is more profitable under greenhouse vegetable production systems.

Areas of concern with respect to the greenhouse operations include:

(i) Operators are likely to remain and expand the greenhouse vegetables business only if profitable over the very short term.
(ii) Exposure to pesticides in an enclosed environment.
(iii) Timely technical support from scientists and extension workers is critical for technological adoption. Many farmers expressed disdain being left to experiment with greenhouse operating systems without the requisite technical support.

6.4 Contingency Plan

The review found that the farmers didn’t have any contingency plan for the greenhouse structures in place in case of any occurrence of natural disaster/risk. From a risk mitigation perspective, this area needs to be addressed particularly since countries such as Jamaica and Haiti are in the hurricane belt.

Notwithstanding, many farmers developed a portfolio of other cash crops to grow in the greenhouse to increase the total on-farm income. These include lettuce, sweet potato, Irish potato, and a range of herbs and spices.

As earlier indicated, the adoption of indeterminate sweet pepper and tomato together with some determinate varieties can increase the whole farm output and allow for a continuous cash flow through an on-going presence in the marketplace.

7.0 Conclusions

From the study, the following broad conclusions were drawn:

1. From the data collection exercise, three costs were often overlooked by producers: (i) the cost of the greenhouse structure, (ii) cost of working capital and (iii) overhead costs. These costs are critical for computation of profitability and replacement of fixed costs items and thus every attempt should be taken to collect the required data for analysis of their agribusiness operations.
2. The high level of the up-front cost, that is, the fixed cost – building and equipment, impacts heavily on cost competitiveness. Once the fixed asset cost is taken into consideration, it makes the greenhouse production model unsustainable in the present undifferentiated market condition (greenhouse vs open-field grown). This is an area that needs to be addressed.

8.0 Recommendations

Key areas of management to ensure viability of protected agriculture crops: tomato and sweet pepper.

1. Data on all aspects of the greenhouse operations should be documented and made available for analysis. These costs are critical for computation of profitability and replacement of fixed costs items and should thus be taken into consideration. The high level of up-front cost, that is, the fixed assets – building and equipment impacts heavily on cost price competitiveness.

   Greenhouse structural costs should be amortised, that is, the up-front cost components (steel, plastic, equipment etc.) of the greenhouse should be accordingly spread over the life of the items and the real cost of production be used when negotiating supply contracts. All effort should be made at reducing cost while maximising outputs.

2. Given that greenhouse-produced indeterminate varieties of tomato grow and bear for as much as 9-10 months, the production schedule should ideally be done to avoid peak production during the months of lowest market price (Q1/Q2). However, consideration must be given to the buyers’ requirement for year-round supply. This will serve to reduce competition from field production on the one hand and also afford output that will help to cover recurrent costs during the months when the prices are typically higher.

3. There is no doubt that the locally produced vegetables (Figure 15) either match or are superior to the imported products in taste and appearance. In this regard, greenhouse producers should negotiate premium prices for their products and occupy prime shelf-space (Figure 16). However, greenhouse producers should identify attributes clearly desired by consumers so that they can better satisfy their needs and wants.
Figure 15. Locally-produced greenhouse tomato and sweet pepper on display at a supermarket in Jamaica.

Vine-ripened tomato  Roma tomato  Sweet pepper colour combinations

4. The price to be concerned about is the CIF price for the vegetables of interest, landed in the local port, before application of duties and taxes. Given the openness of markets and limitations with respect to application of border control measures, domestic producers will need to benchmark their production costs to the imported products and develop methods to lower their cost of production, and also to capture and retain market share. Aggressive initiatives including strategic alliances are important in this regard.

5. Given that local producers are now entering the learning curve, time will be required to get the technology right and to be able to compete successfully with the international producers. Policy makers should create room (as the case of Jamaica) for local expertise to develop. Food security and rural development arguments can justify imposition of tariffs and other measures.

Figure 16. Different types of display of greenhouse-produced tomato and sweet pepper in a supermarket in Trinidad.

Premium shelf space  Scattered display  Sorted–prepacked
9.0 Lessons Learned

1. There is the need for further evaluation of greenhouse structures and the development of sustainable designs for warmer areas of the region.
2. As a cost-reduction option, use of soil as the growing medium should be further exploited. Care should be taken regarding introduction of weed seeds, nematodes and other pests and diseases.
3. Use of determinate as well as indeterminate varieties and the introduction of varieties that set fruit quickly can all enhance production output.
4. Provision of technical support in the early post-construction and grow-out phase is critical for adoption of the technology and sustainability.

10.0 Future Work - Reduction of Costs across Production Systems – Cost Reduction Initiatives

Review of the cost structures between greenhouse operations and open-field systems shows higher costs for the former ranging between 30%-40% of production costs due to building infrastructure. Additionally, preparation of greenhouses for planting (growth media, fertigation, etc.) incurs costs within the range of 30%-40%. In comparison, field-grown land preparation operations are within the 10% range. In this regard, future work should target cost reduction in the greenhouse production model and thus seek to address the following:

1. The parts of the greenhouse structure which are absolutely essential and what elements can be excluded. Focus research on the design of greenhouse structures; the use of perimeter nets, etc, with respect to pest control and cooling.
2. Research and development for cheaper sources of growing media such as soil, sharp sand and saw dust. Fibre coir from Guyana should also be examined as a replacement for the imported stock from extra-regional sources.
3. Whether exclusion of the perimeter nets will also reduce the demand on hand pollination activities.
4. To what extent can the bearing phase be decoupled from the grow-out phase? For example, can grow-out of plants take place in pots elsewhere and introduced in the greenhouse just about 1 week before flower initiation. Should this be possible, harvest can move from 32 weeks per year to about 50 weeks per year.
5. Should determinate varieties be used, given the shorter time concentration of yields? Can replacement plants be cultivated in pots and brought into the greenhouse just before flower initiation to reduce breaks in production cycles? Would the use of determinate varieties also facilitate higher density planting? Would the use of determinate varieties yield comparably higher yields per unit area and per unit time?

6. Research and development to improve the level of output per unit area by (i) increasing plant density and (ii) maximising the use of all available space in the greenhouse structure (e.g. cultivating additional leafy crops around building perimeters).

7. Given that many consumers are becoming more health conscious, nutritional analysis to identify attributes where the greenhouse and open-field systems can be differentiated should be established so that promotional campaigns can be developed to help capture premium prices.
Appendix 1. An example of a greenhouse cost of production data template.

<table>
<thead>
<tr>
<th>ITEMS IN THE COST OF PRODUCTION</th>
<th>MATERIALS, MACHINERY AND EQUIPMENT COST</th>
<th>LABOUR COST</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Building/Infrastructure</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30ft x 100ft structural frame (annualised)</td>
<td></td>
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<tr>
<td>100ft plastic (annualised)</td>
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</tr>
<tr>
<td>Shade cloth (annualised)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set up cost (annualised)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertigation equipment (annualised)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total building/Infrastructure cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Plants &amp; transplanting</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual greenhouse preparation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nursery purchases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transplanting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spraying, fertilising &amp; establishment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total plants and transplanting cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pests and diseases control</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All chemicals before, during and after production</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Insecticide</td>
<td></td>
<td></td>
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<tr>
<td>Fungicide</td>
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<td></td>
<td></td>
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<tr>
<td>Total pests and diseases control cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fertiliser application</strong></td>
<td></td>
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<tr>
<td>Fertiliser 1</td>
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<tr>
<td>Fertiliser 2</td>
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<tr>
<td>Total fertiliser application cost</td>
<td></td>
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<tr>
<td><strong>Weed control (in and around building)</strong></td>
<td></td>
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<tr>
<td>Chemical weed control</td>
<td></td>
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<tr>
<td>Manual weed control (including ridging-up)</td>
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<tr>
<td>Total weed control cost</td>
<td></td>
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</tr>
<tr>
<td><strong>Husbandry activities</strong></td>
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<tr>
<td>Pruning</td>
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<tr>
<td>Pollination</td>
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<tr>
<td>Leaf sanitation</td>
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<tr>
<td>Other (specify)</td>
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<tr>
<td>Total husbandry cost</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Harvesting and marketing</strong></td>
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</tr>
<tr>
<td>Harvesting</td>
<td></td>
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<tr>
<td>Bags</td>
<td>Crates</td>
<td>Post-harvest handling/Farmgate transport</td>
<td>Marketing (arrangements)</td>
</tr>
<tr>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Total operational cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead costs:</td>
</tr>
<tr>
<td>Land cost (annualised)</td>
</tr>
<tr>
<td>Cost of working capital (%)</td>
</tr>
<tr>
<td>Farmers’ Association fees</td>
</tr>
<tr>
<td>Other overheads (%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total overhead cost</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>TOTAL COST OF PRODUCTION</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>RETURNS ON THE GREENHOUSE OPERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Total marketable yield (lb)</td>
</tr>
<tr>
<td>(2) Farmgate price or market price ($/lb)</td>
</tr>
<tr>
<td>Total revenue ($) = (1) x (2)</td>
</tr>
<tr>
<td>Gross margin ($) = total revenue – total cost of production</td>
</tr>
<tr>
<td>Gross margin/lb ($/lb) = gross margin ($) / total marketable yield (lb)</td>
</tr>
<tr>
<td>Break-even yield (lb) = total cost of production ($) / market price ($/lb)</td>
</tr>
<tr>
<td>Break-even price ($/lb) = total cost of production ($) / yield required to recapture total production costs (lb)</td>
</tr>
</tbody>
</table>