Optimizing the Use of Farm Waste and Non-Farm Waste to Increase Productivity and Food Security

Emerging Research and Opportunities

Leighton Naraine

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Dedicated to my family:
Gloria
Mark, Chris & Sean-Luc
Monique, Sasha & Ariana
for allowing me space and time to write
and to:
Julian Quarles
Kevin Meehan
& my late Father
for sharing knowledge in professional writing

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Preface

Traditional farming systems have dominated the agricultural sector for about as many as three centuries in most Caribbean countries. The main system of farming was the plantation structure of which its legacy continues and in a few cases still exists, having its primary purpose as cash crops, such as banana, sugar, tobacco, and rice for European markets under colonialism. That mode of production from that structure continued for several decades to supply the same markets and others to a lesser extent. Traditional systems continue to dominate, while governments, agriculturalists, economists, and policy analysts have argued vehemently that the plantation structure has been the main cause for the lack of local food production and the resultant dependency on more developed countries (MDCs) for local food supply at high costs and detriment to local economies. They have explored, planned, and implemented numerous programs as alternatives to boost local food production but without success, except for pockets of success stories. This book presents a historical perspective on the issues facing agriculture in the Caribbean.

Non-traditional farming systems in the most recent decade have been implemented among the alternatives with the potential for making a difference in the diminishing trend of local food production in lesser developed countries (LDCs) in the Caribbean and growing trend of imported foods from MDCs. This intervention has contributed to the success stories and remains with more potential to be realized. However, it is not a panacea for the magnitude of need for local food supply and range of requirements to meet production levels and range of food types. Naraine et al. (2015) have already made innovations in non-traditional agricultural systems in St. Kitts and Nevis, such as shadehouse-hydroponic, -organoponic, and -hybridponic demonstration models, that were scaled up and implemented in several other Caribbean countries. They were adopted from existing greenhouse hydroponic systems and open field organoponic systems to be relevant under tropical climatic

conditions to adapt to the changing climatic, environmental, and technological conditions, quite unlike greenhouse hydroponic systems that were introduced prior but without much success. Some imported greenhouse systems have been known to implode under hot and humid tropical conditions. The innovation in shadehouse technology allows for the free passage of air and simplified operation that is appropriate for the development status of the country and to the level of most novice farmer-operators. Similarly, the growing systems have been simplified but made more efficient for productivity and to accommodate a wider range of crop types. This innovation contributes to the model for enhanced food production, but the solution to the issues of low food production and food insecurity requires much further enhancements with a model to achieve agricultural diversification and food security. Nevertheless, none of these systems can accommodate the wide range of crop types needed and, inherently, does not address livestock needed to achieve national food security.

There are greater opportunities to be derived from the introduction of various technologies to enhance food production and food security that is much more comprehensive than what has already been introduced as systems of agricultural diversification to achieve food security. The approach is to optimize the beneficial aspects of existing systems and augment it with systems to fill the gaps where inefficiencies are occurring. Such an approach can learn from techniques used by MDCs with the caveat of utilizing what is applicable in the conditions in LDCs. MDCs have transformed their agricultural sector primarily by bringing more land into production, and introducing mechanization, technology, chemicalization, and marketing (Naraine & Meehan, 2016). These were supported by policy at the highest levels to gain competitive advantage in the global market to the extent that formerly agrarian societies in LDCs cannot compete and have become dependent on imported food from MDCs. Certainly, LDCs do not have all these options available to them in the same way and must rely upon adaptive strategies that are relevant to the prevailing conditions.

The farming model proposed in this book derives from about five decades of observing farming practices in the Caribbean emerging from a primarily plantation system of monoculture for export-oriented cash crops and attempting to transition to become self-sufficient in local food supply. This work follows from experimentation with non-traditional agricultural systems and now with a diversified integrated farming model that demonstrates how to enhance productivity, flexibility, competitiveness, and sustainability within an individual farming enterprise. It is common practice to produce food crops

and livestock to meet local food demand, while in such practice there is also waste production from farms that are not typically utilized.

The concept of this model is to utilize farm waste in a circular approach so that there is optimum utilization in the enterprise system to realize a zero waste scenario. There are also opportunities for utilization of non-farm waste contributions as sources of raw materials. In any event the waste production comes with an input cost to produce in the first instance, so redefining it as production of raw materials would add to productivity of the enterprise with marginally higher input cost attributed to processing. There will be flexibility with the use of crops and livestock particularly to minimize postharvest loss, competitiveness of market price, and long-term sustainability from the aspects of financial and environmental achievements. Ultimately, the enterprise will build resilience by having multiple income streams to minimize risk if any stream "dries up," and diversification will provide opportunities for integration of various output sources of the enterprise. It is important to consider this approach from an individual enterprise level in which success is critical to achieve sustainability.

However, achieving sustainability is not a straightforward process that can be realized with most of the definitions proposed over several decades of debate and logical recommendations. It is a process that requires strategic planning and systematic implementation over an average five-year duration with significant investment within the first few years of early developmental growth stages and then transitioning towards farm maturity. It is also a process with specific objectives and focus at the individual enterprise level, quite unlike national and sector strategic plans that have mission statements and objectives that are well intentioned but without focus on planning and objectives of the individual constituents, that is, the individual farm enterprise. This book has originated the Transitional Funnel Model of Farm Sustainability.

This model of farm sustainability is based on the assumption that individual farms will be sufficiently diversified and integrated to become successful and will cumulatively contribute to the attainment of national food security. This model is also based on actual experience of farmers and serves as a guide to those who wish to develop farms without trial and error but learning from success stories and contributing to innovations and become a part of the transformation process of agriculture that continues to face increasing challenges.

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Chapter 1
General Introduction

ABSTRACT

There are myriad issues facing traditional farming in the Caribbean region. Despite various policy interventions and implementation of concepts over the past five decades for agricultural diversification in the region to increase local food production, the region is still grappling with finding an appropriate model to solve major issues. The issues are now exacerbated by the impacts of climate change, and major shifts in the approach to solving the issues have not yet proved fruitful. Against the setback of issues, controversies, and problems of farming in the Caribbean and the St. Kitts-Nevis example of a small island developing state (SID), the justification will be made for a diversified-integrated model that can account for the setbacks by optimizing farm and non-farm waste to build productivity, competitiveness, flexibility, and sustainability which are categorically the factors of successful farming.

INTRODUCTION

Previous writings by the current author on Agricultural Diversification and Non-Traditional Farming Systems (Naraine, et al, 2015), and Sustainable Food Production Practices in Emerging Economies (Naraine and Meehan, 2016) showcased how non-traditional, technology-based systems, such as hydroponics, organoponics, and other forms of protected agriculture, as well as how smallholder farmers and backyard gardening, have contributed to the transition of agriculture from primarily traditional practices to more efficient practices of production towards achieving food security. While these

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interventions can make and have been making some strides in alleviating rural poverty and local food insecurity, there is a need for complementarity with more farms applying a similar approach on a larger scale to make more widespread and higher impact to the magnitude that matches the scale of national food demand. It is essential to project future needs when formulating solutions currently to the problem of food security, particularly in view of the changing climate and environment coupled with growing populations that impact on local food supply and resulting in high dependency on food imports.

While this Chapter gives a historical perspective of the issues, controversies, and problems of farming in the Caribbean and other small island developing states (SIDS), Chapters 2 and 3 present more contemporaneous models of agriculture that refute the dominant existing model of industrial and extensive agriculture. In progression, Chapter 4 will address the issue of farm waste and optimization of the use of waste, as well as non-farm waste, with examples of waste processing systems for the production of livestock feed and fertile soil. Chapter 5 showcases an example of the early developmental stage of a diversified integrated farm model (DIFM), and Chapter 6 proposes a theoretical model that gives meaning to the actual farm practice showcased in Chapter 5, before moving to the concluding chapter.

MAIN FOCUS OF THE CHAPTER

Issues, Controversies, and Problems of Farming in the Caribbean

This chapter begins with a historical view on the subject of agricultural diversification as a response to local food production and food security in the Caribbean at regional and local levels. The objectives, based on the issues, controversies, and problems of farming in small island developing states (SIDS) in the Caribbean, would then be stated. This chapter then turns to the research methodology that is guided by the stated objectives as well as the nature of the subject and its theoretical underpinnings based on the proposed Diversified Integrated Farm Model, as noted in Chapters 2 and 3. Note well, this chapter invokes the literature on methodology, while the remaining chapters review and apply the literature on agricultural diversification, integration, waste conversion to raw material, and the transitional model of farm sustainability.

Farming Model Types and Distribution in the Caribbean

All Caribbean countries prior to and for about 4 decades following their independence, have depended heavily on the monoculture of sugar or rice or banana, or combinations thereof, in a plantation economy and relied on it as their major export and earner of foreign exchange and major source of employment. Some countries continue to utilize this system of agriculture, while trying to make the transition to production of food for local consumption and niche market exports. Moreover, the plantation economy predominates the use of arable land, occupying the major portion and most productive soils on the islands, with the exception of Guyana on the continent of South America and Belize on Central America but they too continue to some extent with the plantation economy (the focus of this section is on small island developing states (SIDS) in the Caribbean). This leaves food crops and livestock production to peasant farmers on the fringes with small, scattered land holdings without integration in the mainstream of their agriculture sector. Over the decades, farmers toiled against the vagaries of weather on hillsides as they depended primarily on rain-fed systems, declining soil fertility on already marginal land, non-existent infrastructure, outmoded technology, lack of appropriate service support and expertise, and insufficient institutional support from either governmental entities, non-governmental organizations (NGOs), or community based organizations (CBOs).

This book will show how these problems are mitigated by intervention with the diversified integrated farm model (DIFM) and with citing an actual case study in the remaining chapters.

It is well known in the Caribbean that the plantation economy is on the downturn and on its way out of existence. The argument has already been made that land productivity, falling sugar, banana and other cash crop prices and competition with beet and substitutes – in the case of sugar, increasing unemployment, lower incomes, and the vulnerability of monoculture render the plantation cash crop industry incapable of being a major source of foreign exchange, employment, and general economic development (Codrington, 1994; Marie, 1979; Alleyne, 1994; Demas, 1987; Thomas, 1996).

To view the situation from a regional perspective, the OECS Economic Affairs Secretariat (OECS/EAS, 1994), in its annual performance review, indicated that among the countries of the OECS, the percentage contribution of agriculture to GDP in St. Kitts and Nevis for 1992 was 7.5 compared to 24.5 percent for Dominica, 14.7 percent for Grenada, 12.2 percent for St.

Lucia, and 16.0 percent for St. Vincent and the Grenadines. Only that of two countries in the OECS: 3.5 percent for Antigua and Barbuda, and 3.3 percent for Montserrat are lower (OECS/EAS, 1994). Note that Antigua has had severe droughts for several years causing a drastic decline in its agricultural sector and has depended on a growing tourism industry. Also, Montserrat has been hit with the disastrous volcanic eruption of Mt. Soufriere causing extensive damage to property, including agriculture, and has had to turn to international assistance in the form of disaster relief and is still in the state of reconstruction. The contribution of agriculture to GDP of 7.5 percent in 1992 (6.99) has gradually decreased over the decade to 4.52 percent for the year 2000 (St. Kitts and Nevis Annual Digest of Statistics, 2000). This sector in 1992, however, accounted for 33.3 percent of total employment in St. Kitts which is comparable to that of Dominica at 36 percent; Grenada at 29 percent; St. Lucia at 30 percent; and St. Vincent and the Grenadines at 30 percent. In 1999, the total employment of the agricultural sector in St. Kitts accounted for only 6.3 percent. All of these countries in the OECS and many in the wider Caribbean have been placing more emphasis on tourism as the main engine of growth in their economies, and to a lesser extent manufacturing. It leaves many opportunities untapped in the area of food production for local consumption and also for major potential linkages with manufacturing and tourism.

Whereas some Caribbean islands, such as St. Lucia and Dominica, have major problems with land tenure that require major land reform, this problem does not affect St. Kitts as most of the agricultural land is owned by the government. With the proposed dissolution of vast sugar lands, lies an opportunity for non-sugar agriculture. Most of all, there is a high and growing local and regional demand for food products. Ironically, St. Lucia and Dominica continue to be more self-sufficient with greater supply of locally produced food than St. Kitts-Nevis about one decade following the dissolution of "king sugar" in St. Kitts-Nevis.

The quest for agricultural diversification for select countries in the Caribbean, includes such countries as Barbados, St. Lucia, and Dominica, but also includes countries of the OECS in general where plantation systems predominated for most of their history, and with renewed interest by Trinidad and Tobago and Barbados in agriculture in the face of current downturn in their economies based on petroleum and tourism, respectively and effect of the "Dutch Disease" or mere neglect, complacency, and/or simply bad planning. There have been numerous studies on agricultural diversification in the Caribbean, although without significant success to

the extent of achieving local food demand and impactful success of farmers to the extent of competitive livelihoods and not extensively written about for academic publications. Beckford *et al*., (2017) found that small-scale farmers' experimental innovations have not been generally considered for on-farm research trials as those in the traditional sector have been perceived as recipients, rather than as originators of technical knowledge and sustainable and viable practices. Yet, there is abundant evidence throughout the tropics that small-scale farmers are adaptive and experimental problem solvers, and experts at devising innovative survival strategies. While literature on the topic is rich with accounts from Africa, Asia and Latin America, there is a general dearth of examples from the Caribbean. The Caribbean region has produced numerous scholars in the area of Agriculture such as: Agronomy, Agricultural Economists, Historians, and Public Policy. However, the results on the ground do not indicate formidable solutions as agriculture has continued to decline in performance and relative contribution to GDP. There has been much lamentation of the legacy and dominancy of the plantation system under colonialism, yet for about 50 decades following that precedent and with change in land tenure and markets under governments and local ownership of vast arable land, agricultural diversification continues to fail as a sector with almost the same litany of issues and now with climate change exacerbating the impacts.

The argument has been made (Barrow, 1992; Marie, 1979; Codrington, 1984) that the productivity of the land under sugar is less compared with that of domestic food production. According to Codrington (1984), employing cost-benefit analysis to the Barbados situation, non-sugar cane cultivation has a higher value per acre than sugar cane. Also, with regards to foreign exchange, he claims that, a characteristic of primary export-oriented economics is their dependence on imported food stuff and the allocation of a large part of their land resources to export production. Codrington concludes that it is possible to achieve net savings or net earnings of foreign exchange as a result of diverting arable land from sugar cane to food crop production. Also, with regards to employment, food crop production is more labor intensive than sugar cane cultivation, and changes in land allocation can be justified on the grounds of potential increase in employment. But the family land system typical of many Caribbean countries presents problems for development of agriculture outside of the plantation system. Barrow (1992) in the case for St. Lucia, condemns the family land system in the Caribbean as anachronistic, wasteful and as a barrier to agricultural modernization. These land arrangements pertain mainly to small land holdings, but in the context of St. Kitts-Nevis, the government

owns the large majority of over 80% (St. Kitts Department of Agriculture, 2005) of the agricultural land previously under sugar cultivation. The real challenge for St. Kitts lies with the distribution or redistribution mechanism when sugar land is reallocated to non-sugar agriculture. These lands are rapidly going into the private sector mainly for tourism and residential activities. It is common to find agricultural land currently, regardless of tenure, laying devoid of farming activities.

However, there is still the existence of small land-holdings that are currently under peasant farming for the most part. The issue of family land presents similar problems across much of the Caribbean. First, family land has implications with legal ownership or title due to multiple heirs (Barrow, 1992) and absentee owners living overseas. Secondly, the cultural heritage presents problems of land use with regards to production or economic activity. Barrow noted that emerging from a colonial past, land is tied vehemently to hard labor associated with slavery, while from an African heritage, land is valued more as security than as a resource for economic exploitation. Any distribution or redistribution plan in much of the Caribbean for resource development involving land may come in conflict with this historical and cultural perception of land and can have serious implications for social equity. Furthermore, diversification programs in some countries face potential challenges from an existing plantation structure. There are implications for employment, incomes, and foreign exchange. Marie (1979) justifies the need for diversification based on the Dominican experience with uncertainty faced by the economy due to external market forces facing the banana industry that is plantation-based, as well as export-based. Also highlighted in the Dominican experience, known among Caribbean SIDS as a top producer of local food products and consistently exporting to other countries in the Caribbean, until the hurricanes of 2017 devastated that country, still had the need to reduce the dependence on imports. In so far as the need to meet local demand, an import-substitution based system has its own set of implications for economic development. Marie argues that a small country like Dominica must also rely on exports that would play a crucial role in the pace and nature of a diversification plan. Moreover, St. Kitts-Nevis, like many other Caribbean nations, is competing with cheaper food imports.

With regards to employment and incomes, Beckford (in Alleyne, 1994) attributes low incomes and high unemployment in the non-plantation sector to peasantry or subsistence farming in most Caribbean countries. Beckford argues that it is the plantation system itself that has impeded the development of peasantry in areas of marketing and pricing. Although, in the present system

of production, plantations have a distinct advantage, using more advanced techniques of production resulting in higher labor productivity, and steadier employment, there needs to be more revolutionized land reforms that would transform peasantry on marginal land in rural areas to the mainstream of the economy. Alleyne (1994) raises concern for rural development in that the concern should extend beyond the growth of agricultural output and productivity, but should promote persistent improvement in the quality of life within rural communities. This concern, he emphasized, should be tackled through land reform to liberate food production and producers from marginal lands and peasantry. Alleyne (1994) cited the inappropriate policies carried out by Land Management Authorities in Dominica, Antigua, and Monsterrat, and the impact of tenure under this institutional setting that influence the efficiency of land resource. He contends that efficiency of land redistribution policies can only be assessed when placed within a total scenario and not serve political agendas.

From the longer historical perspective, the Caribbean economy became export-oriented during the period of seventeenth-century mercantilism (Grugel, 1995). The current economy continues to be led by export-orientation agriculture driven by the twin forces of colonialism and globalization and is shaped by the consumerism of external metropolises. Grugel asserted that, as contacts with Europe, the former colonial power, have declined, the USA has secured its position as the major investor and international broker in the region. It is no surprise, then, that the global recession of the 1980s had serious implications for the Caribbean. This crisis necessitated fundamental changes to the orientation in economic policy for the Caribbean. Yet, decades later, fundamental changes have not occurred to the extent that many Caribbean countries are far from achieving food security or at least significant increase in local food supply but depend heavily on food imports from more developed countries (MDCs).

Perhaps the most comprehensive perspective of agricultural diversification in the Caribbean is stated by Demas (1987), President of the Caribbean Development Bank at the Seventeenth Annual Meeting of the Board of Governors, maybe in large part due to scope of the Bank and its involvement in research and development in the agricultural sector in the Caribbean region. His perspective is consistent with those of the foregoing scholars on agricultural diversification. He outlines the full scope of issues and prescribes ways to combat the stark situation in Caribbean agriculture, which, although declared about 30 years ago, appears to have much relevance today. Demas points to the precarious situation of the sugar industry, because of stiff competition

from other natural and artificial sweeteners. It is also well known that cane sugar is produced much more efficiently and less costly in Australia, Brazil, and Mexico, presenting major competition for Caribbean sugar. When account is taken of the growing protectionism evident in industrialized countries (e.g. recent US sugar quota cuts) and, paradoxically, the growth in the food import bill of the essentially agriculture-based economies of the Caribbean, that there are structural deficits in the balance of payments which are likely to continue in the absence of remedial measures. A large portion of that deficit is made up of food imports from outside the Region. Many of the Caribbean countries, Demas notes, have embarked on structural adjustment programs aimed at correcting their weak balance-of-payments (and fiscal) situation and reducing the vulnerability of their highly open and undiversified economies to external shocks. But, with one or two exceptions, most still have a long way to go with such restructuring to achieve improved local food supply.

Demas questions the ability of Caribbean nationals to produce and willingness to consume more local and regional food. Studies undertaken at the Caribbean Community Secretariat, the Faculty of Agriculture of the UWI and the Caribbean Food and Nutrition Institute indicate both the technical and economic feasibility of substantially increased production of food in the countries of the region. These studies also indicate that increased local and regional food production can have a substantial impact in raising nutritional levels in the countries of the region. They make the assumption that the relevant unit for such higher levels of production of nutritious foods is the region rather than the individual country. It is also noted that most countries in the region have large amounts of unused and underutilized land in the hands of both the public and the private sectors coexisting with large volumes of unutilized manpower. The above-mentioned studies used this as a basic assumption in quantifying the scope for increased regional food production. In addition, it is quite possible to substitute other local fruit, juices and beverages for imported fruit and the juices and beverages derived from them. It is also possible for some Caribbean countries to grow local fruits and vegetables that are traditionally imported. Not only is import substitution (for example, growing strawberries or grapes at home instead of importing them) necessary but also import replacement, that is, the use of products indigenous to the region to replace imported products which cannot be grown at home. Thus, guava jelly could replace imported apricot jam and mangoes could replace apples or pears or peaches. The same could be applied to breakfast cereals and holiday snack foods. Demas also asserts that there is need for judicious restriction by governments of many foods, fruits, vegetables, animal feed and

confectionery imported from outside the region. It is also not unusual to find imported potting soil in hardware stores throughout most of the Caribbean countries, whereas this commodity may be feasibly produced with available technology and local materials.

Observation, based on tourism surveys, has shown that tourists adapt readily to locally produced rum and other alcoholic beverages, local fruit and fruit juices, meat, fish, vegetables, ground provisions, etc., provided that they are properly prepared and attractively presented. The same applies in the case of many local people in some countries of the region who are slowly but surely purchasing in supermarkets larger amounts of locally and regionally grown food, fruit, vegetables and drinks, once they are properly prepared and attractively presented.

IICA (1997) traces the traditions or models of development for agriculture since colonial times such as the import-substitution model and the outward-looking or development model. IICA argues for a new sustainable model of development in the agricultural sector. This model has come full circle with the comprehensive view, citing essentially the same traditional influential variables in the likes of Abbot (1990), and Norman (1985). Indeed, their argument for environmental sustainability is not a new one. However, the inclusion of environmentally sustainable practices alone does not render this new model sustainable.

According to IICA (1997), sustainability rests on three pillars:

- **Participation:** Producers and organizations are encouraged to play an active role in shaping public policies, in providing services, and in identifying shared actions;
- **Reconversion:** As production structures are overhauled, production becomes more efficient, and products can win a better market position, natural resources are conserved, and the degree of equity increases; and
- **Institutional Transformation:** The sector's institutions need to improve their ability to respond to the demands and needs of agricultural producers and to begin serving as facilitators, streamlining relations and integrating the sector in the framework of sustainable development. IICA also makes a strong case for hemispheric integration to boost the flow of capital and technology, exchange of knowledge and information, and shared needs and opportunities of groups of countries in the face of a global economy.

The core potential benefits of agricultural diversification, according to the foregoing debate, for the Caribbean Community economies to consider are as follows:

- *Food Security*
- *Foreign Exchange Savings and Earnings*
- *Employment Generation*
- *Creation of Economic Linkages*
- *Utilization of Underutilized Resources*

And the major limiting factors are:

- *Macro-Economic Policies*
- *Credit*
- *Technology*
- *Land Distribution and Land Tenure*
- *Marketing Systems and Methods*
- *Infrastructure.*

Globalization

The issues facing local food production in the Caribbean have been compounded by the issues of globalization as comes up often in the literature and political speeches on the issue of nation building. Globalization describes a complex phenomenon full of both promise and threat. It promises to bring millions of people into active participation in global economic life. Among other things, it promises to bring increasing food and goods production with less investment in resources. Yet it threatens to marginalize millions more in countries and situations unwilling or ill-equipped to adapt to its torrid pace. Neo-liberals argue that free trade and competition will lead to greater growth and prosperity (Wolf, 1997; Martin, 1997). They believe that a smaller role of government will make markets more efficient and enhance individual well-being. Others (Khor, 2000; Kregel, 1996) object to globalization's ethical implications; and Kregel (1996) argues against dominant corporations that favor markets over people. Globalization is therefore hailed by some as a panacea, and to others it is a dangerous trend to be feared.

Marsden (2000), for instance, identifies the difficulty of political economy models to assimilate non-conventional chains of food supply networks and the need for establishing a socially and ecologically informed approach to

agricultural-food developments. With the growing variations in the nature, complexity and spatial reach of globalized and regional food supply chains and networks there are quite asymmetrical constructions of power and value. Marsden argues that in most cases in the export and transfer of 'high-value' exotic fruits and vegetables from the South to the North, the social and natural properties of the food commodities themselves are given greater value by powerful retailing and importing interests than the natural and social values placed on either the local production or labor environment. Marsden continues to argue that local social and environmental costs are largely ignored in the race to reduce overall costs of supply to the northern consumer. Thus, in the globalized food sector the attribution of social and natural value is highly variable and unequal.

One caveat of globalization for lesser developed countries (LDCs) arises out of the Free Trade Area of the America's (FTAA) goal to impose the North American Free Trade Agreement's (NAFTA) model of increased privatization and deregulation throughout the hemisphere. According to Public Citizen's Global Trade Watch (2001), the NAFTAs model has failed, with poverty soaring more than ever in Mexico and Latin America. Furthermore, the use of pesticides and fertilizers has tripled and hazardous waste is disposed of improperly. The effects are lower wages and weaker labor standards, as well as environmental degradation and birth defects and other health related problems. Moreover, the Citizen's Global Trade Watch, referring to the FTAA as "the secret trade deal behind the summit of the Americas," claims that the FTAA working groups have been meeting secretly with only privileged corporate committees and representatives advising the US negotiations. It was noted that non-governmental civil society organizations demands for inclusion of working groups on democratic governance, labor and human rights, consumer safety, and the environment in the negotiations have been rejected. A director of the International Forum on Globalization (Global Citizen's Trade Watch, 2001) argues that it is time for a new international trading system based on the foundations of democracy, sustainability, diversity and development and that the world of international trade can no longer be the exclusive domain of sheltered elites, trade bureaucrats and corporate power brokers.

Another caveat for LDCs derives from liberalized trade in agricultural products through the 1994 Uruguay Round Agreement on Agriculture (URAA). Mullarkey *et al* (2001) identify how the URAA, in liberalizing trade, places enforceable limits, although with some non-trade concerns, on the agricultural policies and trade regimes of the World Trade Organization (WTO) members. Some countries contend that while Article 20 of the URAA recognizes the

importance of non-trade concerns, it does not create a loophole for protection and domestic support. These non-trade concerns are termed multifunctionality of agriculture. According to Mullarkey *et al.*, multifunctionality refers to the many secondary functions agriculture performs. Producing agricultural commodities for the market simultaneously produces many by-products. For instance, a primary function such as milk production often produces scenic pastures, and scenery then becomes one of the multifunctions of agriculture. They noted that multifunctionality can also refer to an attitude or policy position supporting domestic agricultural production as a means to a variety of non-trade ends. Its political use has led to vaguely specified non-trade concerns to include domestic policy objectives such as preserving family farms and rural landscapes or ensuring food safety, food security, and animal welfare. Mullarkey *et al* argue that these concerns reflect a fear that freer markets and globalization may undermine the provision of valued non-market amenities and cultural traditions associated with agriculture, and that these anxieties have coalesced and are often generalized using the term "multifunctionality." They asserted that the by-products of agriculture are externalities that are not fully accounted for in markets, and farmers do not bear all the costs associated with agricultural production. Examples include soil erosion, water depletion, surface and groundwater pollution, and loss of wildlife habitat. However, farmers also do not reap all the benefits of recreational amenities, open space, and flood control. Many of the externalities have the characteristics of public goods – no one can be excluded from enjoying them, and use by one individual does not preclude use by any other individual. Furthermore, some of these amenities, such as wildlife, open space, and sustaining a cultural heritage, may generate non-use values.

Therefore, countries may argue that various agricultural multifunctions are joint products of agricultural production; they can only be provided simultaneously. This claim is significant because countries may further argue that they need production subsidies to maintain the jointly produced desirable multifunctions. Mullarkey *et al* imply that policies targeting amenities and negative externalities are likely to be more effective in allocating resources and increasing social welfare, and less likely to violate WTO commitments. It is no surprise, therefore, that WTO member countries use multifunctionality as one of the new strategies in agricultural policy to achieve national objectives while remaining committed to reducing trade barriers, but there may be disproportionate advantages or disadvantages for MDCs and LDCs in this regard. One of the major challenges to this strategy is how to define and measure the multifunctions of agriculture. Mullarkey *et al* identify a long list

(stated in Box 1) of potential amenities and negative externalities, claiming that countries are likely not to agree on what should be added or omitted from it. Measuring the benefits requires putting a value on amenities and attributes that are not specifically valued in the market. Therefore, this area of analysis needs increased attention by policy analysts.

Policy Dimension

The policy literature suggests not only the tools or policy options available to government, but it also encompasses specific features of such tools. Of underlying importance, however, is the definition of the problems that would require systematic investigation. Understanding of the intrinsic nature of the problems with reference to the traditional market failures is what would determine the selection of policy options and their appropriate features. On the issue of agricultural development, the existing body of research falls short in applying this kind of analysis. Much of the existing research, in the form of case studies and policy traditions in agriculture, has a strong economic focus. The concept of development, if taken to mean betterment of the human condition, remains elusive when the predominant objective in development initiatives or programs appears to be economic growth. It fails to address the broader environmental and societal issues that are an integral part of any development initiative. It helps to make the case for a diversion away from extensive large-scale farming of a single or a few crops to a diversified integrated model at the farm enterprise level of small- to medium- to large-scale enterprises. Even those advocating government intervention often fail to provide a policy framework for use at the implementation level. This section explores the policy dimension of the issue of agricultural diversification where the existing body of research in the Caribbean falls short. It forms the first systematic investigation of policy at the implementation level with the

Box 1. Some Frequently Cited Multifunctions of Agriculture (Mularkey et al., 2001)

Environmental/Social	Rural Development/Food Security
Scenic vistas Traditional country life Wildlife habitat Small farm structure Flood control Cultural heritage.	Rural income and employment Elimination of hunger Viability of rural Rural income and communities Secure Food Supply

clear purpose of discerning the specific policy options for specific problems on the issue of agricultural diversification.

In order to determine the types of policies needed to solve the problems, it would be useful to cast the problem in market failure typologies. Without in-depth analysis at this stage, it still readily appears that there are problems of equity where employment and income are concerned, problems of capital good as well as equity where land tenure is concerned, problems of negative externalities where nuisances are concerned, problems of information asymmetry where farming practices are concerned, and problems of monopoly where infrastructure is concerned. However, the problem is compounded with failures of government as well, under the assumptions of the New Political Economy (NPE). Therefore, the institutional structure (s) with the responsibility of formulating agricultural diversification policy and filtering it into the socio-politico-economic environment must also be examined. These problems can be further explored and redefined and put into a framework to direct further development. Equally important, is the identification of the related interests for each problem or issue, the type of government intervention, and the institutions responsible for carrying out prescribed policies. It appears that primarily ministries and departments of agriculture are charged with the sole responsibility of carrying out all the policies to correct existing problems and develop the agricultural sector. It is important to explore the possibilities of collaboration with other organizations with policy expertise: governmental, NGOs, and CBOs.

One way to think about the Public Choice Paradigm (Mc Clennon in Dasgupta, 1991) in political economy is the Achimedean point of view in the classical model of 'homo economicus'. The basic tenet of this theory is that while under the constraints of a competitive market, homo economicus will act in a way that is Pareto-efficient, but under the constraints of political and/or bureaucratic interactions, he will act in a manner that is not. Pareto-efficient allocation of goods refers to the utility-maximizing behavior of persons and the profit maximization of firms that will, through the "invisible hand," distribute goods in such a way that one could be better-off without making anyone else worse-off (Weimer and Vining, 1989). Pareto-efficiency arises through voluntary actions and does not agree with government intervention or the need for public policy. Mc Clennon (in Dasgupta, 1991) argues, "When markets fail it does not follow that government should regulate: most market failures are due to property rights not being well-defined; government, then, should concern itself with defining the relevant property rights but only intervene to reduce transaction costs which can be achieved by assigning property to

those who would finally purchase them…" Unequivocally, according to this view, government should get out of the business of planning – and hence regulating – agricultural production and trade, both at the national and international levels, and let economic activity be organized on the principles of a competitive market (Mc Clennon, in Dasgupta, 1991). With a converse view, according to Weimer and Vining, economic reality never corresponds perfectly with the assumptions of the competitive model. Violations of the assumptions constitute market failures, that is, situations where individual behavior does not lead to Pareto-efficiency.

Societal relationships invoke the notion of altruism (Mansbridge, 1990; Wilson; 1990) based in large part on the dual-self describing the self-interested nature of humans but also the need to socialize. Indeed, human beings show moral obligations to others in social arrangements whether by nature or by design. For instance, Soderbaum (in Dasgupta, 1991) refutes Public Choice Theory on the basis of changes in today's agricultural sector with concern of increasing number of citizens and important actors on the public scene for the environmental and natural resource issues that were practically non-existent in previous traditions. He argues against the assumption of the self-interested nature of human behavior, but for one of relationships between the individual and various organizations or society as a whole, and that beliefs, values, and thinking habits thereof relate to economics. He attributes, for example, the degradation of the environment to a period when neoclassical economics had dominated the thinking habits of many important actors on the public scene. Soderbaum maintains that it is mainly through increased participation and democratic processes that the present trend of environmental degradation can be broken.

Dasgupta (2001) draws attention to the increasing power of multinational corporations, the growth of far-reaching and coercive trade agreements, and the imposition of structural adjustment policies on LDCs by the International Monetary Fund (IMF) and the World Bank. His perspective, espoused by traditional development thinking, is informed by recent structuralist analyses of the role of state activism in the development successes of Japan, Taiwan, and South Korea. His extension of structuralist analysis incorporates the Sub-Saharan Africa experience with structural adjustment as well as environmental issues, including recent international conventions on global warming. He shows how structural adjustment thinking, as a temporary response to adverse external shocks, has become a permanent overriding goal in LDCs. He identifies how the The Bretton Woods institutions, formerly designed with the objective of the core capitalist countries in mind (primarily the USA), continue to impose

structural adjustment in LDCs. However, such adjustments deepen inequalities in the world trade system with core-dominated international division of labor and reinforcement of protectionist trade regimes by the core countries. Dasgupta pinpoints the conflicts between first world and third world over international environmental regulations.

However, governmental intervention requires the application of public policy strategies, that is, 'tools' or policy options available to government. Problems associated with each tool or its advantages should be explored with the goal of how best to design a policy to achieve its desired objectives. On the premise that individual behavior does not lead to Pareto-efficiency, there are violations of the assumptions of the free market. Weimer and Vining (1989) describe four traditional market failures: public goods, externalities, natural monopoly, and information asymmetry. Given that free market failures can occur, the question is how to correct such failures. When the initiative is to redistribute, for instance in the case of land or providing subsidies, how should this be instituted? The argument for in-kind transfer stems from tangible costs to society (such as crime, disease, and delinquency) that can be avoided and be of less cost to society if the poor have better housing, medical care, and the like. Government uses regulatory programs as a device for transferring income from those with less political power to those with more, and with rules work to support the status quo. To satisfy this paramount political objective, policymakers may sacrifice efficiency. Rolph (1983) proposes a typology of programs: among them are programs to develop public resources and to control externalities.

Yet another problem with which government concerns itself is the issue of social equity. The basic argument against the economic approach to public policy is that economists are preoccupied with economic efficiency and neglectful of equity (Rhoads, 1985). Equity relates to distribution of income, justice, relative shares of national resources, and taxes. With regards to taxes, for instance, Mikesell (1999) contends that the willingness to pay depends on the ability to pay and addresses the issue of equity in taxation. Instead of 'command and control' methods instituted by the rule of law or bureaucratic regulations, an alternative method of collective intervention, according to Rhoads, is through market- like incentives such as taxes and subsidies that make private interests more congruent with public goals. Regulations create inefficiency, they are costly, they offer no incentive to do better, and the regulatory process itself is susceptible to regulatory capture. Meier (1993) noted that although the new political economy can provide insights into some instances of government failure, it is over-generalizing to

maintain that all policy-making can be explained in terms of rational choice self-interest models. He emphasizes that no single universal characterization of political behavior is possible. Instead of a unitary state, there is in reality an aggregation of preferences.

According to Grindle and Thomas (1991), the primacy of policy as the basis for encouraging and sustaining economic growth and social welfare has come to be widely accepted among those concerned about promoting development. They had the opportunity, as advisers and researchers, to see the process of policy making and implementation from inside several LDC governments and to work closely with a number of policy makers and managers who were actively seeking to bring about important changes. Grindle and Thomas found that, before the 1980s, national leaders, supported by international donors, assigned extensive responsibilities to governments for guiding economic development and bringing advances in conditions of social welfare to their populations. However, the 1980s brought a redefinition of these long-accepted goals and of the strategies considered appropriate for achieving them. In these new visions of how to achieve development, the state was no longer to be the principal force for achieving economic growth and welfare. It implied a shift in power away from central governments to the market and to more local levels of government. Thus, Grindle and Thomas focused their analysis on the role of decision makers and policy managers, the choices they make, and the factors that influence those choices. They found that dilemmas and choices are real and that policy elites were confronted by advisers, international agencies, development specialists, and others advocating a package of policy and institutional changes. They also had to consider the costs of altering existing practices. In this assessment, they were confronted with the fact that the ranks of opposition to change were filled with the beneficiaries of the status quo: economic elites supported by existing policies; ethnic and regional groups favored in allocative decision making; bureaucrats and bureaucratic agencies wielding regulatory power; and political elites sustained through patronage and clientele networks. They observed that in the name of efficiency and development, many changes implied a significant decentralization of decision making, a shrinking of the size of the public sector, and an important shift in the strongly interventionist role of the state in the economy.

If policy makers and public managers are conceptualized as self-interested and motivated only by the desire to remain in power, then little can be expected of them in terms of leadership or the management of change. Also, if all political action is assumed to emanate from a desire to capture the state for

personal benefit, then there is little basis for anticipating reasoned dialogue about the content of public policy. Grindle and Thomas found that policy elites often articulate goals for their societies and for the activities of the state and strategize about how change can be introduced. They are generally aware of the societal pressures and interests, historical contexts, and bureaucratic capacity that limit the options available to them, and they often seek to maneuver within these constraints and to craft policy solutions that will be politically and bureaucratically acceptable but that will also encapsulate serious efforts to address public problems. Many of the observed changes in the various countries cannot be explained without reference to the leadership and strategic management of policy makers and managers. Decision makers apply a series of criteria to the changes they consider, discuss, debate, and plan. They weigh decisions in response to their understanding of the technical aspects of the policy area under consideration, the probable impact of their choices on bureaucratic interactions, the meaning of change for political stability and political support, and the role that international actors have assumed in the reform process. The historical contexts, coalitions, conflicts, opposition and support, constraints, and opportunities that surround important public issues are vital ingredients in explaining issue formation, policy making, and implementation. Thus, reform implies authoritative choices about development that can only be fully understood by giving attention to the perceptions, motivations, values, skills, and opportunities of the decision makers and to the impact that characteristics of the decision-making process have on the choices that are made.

Balassa (1989) points to the experiences of developing countries with privatization. He notes that while at one time developing countries considered public enterprise as the mainstay of economic development, there has been an increasing disillusionment with public enterprise in recent years and proposals have been made for privatization in various areas. However, for privatization to succeed, certain policy conditions need to be met that necessitates the participation of government as a policy making body while private entities assume the role of enterprise operators. Indeed, there appears to be a growing trend in public-private partnerships in traditional government oriented services. In the quest to achieve food security and environmental and social objectives of agriculture, the farm model proposed needs to reconcile or make the case for multifunctions of farming for benefits to self-interest and society.

Methodological Considerations

A comprehensive, and ostensibly the most relevant, approach to assessing agricultural diversification in the Caribbean is that formulated and proposed by the University of the West Indies, Faculty of Agriculture and Natural Sciences – Continuing Education Program in Agricultural Technology (CEPAT) and presented in the "Proceedings of the Workshop on Models for Caribbean Agricultural Diversification (CAD)," in August 17-18, 1998. It takes into consideration the scope of issues in the various categories of literature and spans the history of agricultural diversification since the region became independent of colonial governance. Activities undertaken by the Faculty of Agriculture in support of agricultural diversification and development in the CARICOM Region commenced with:

- **1960's:** Shift in focus from traditional export crops to investigations on tropical tuber and legume species;
- **1970's:** Rockefeller and Ford Foundations-funded elite variety, yield improvement practices, detailed agro-economic survey of tuber crop production in Barbados, Jamaica, and St. Kitts, initiatives to develop new international niche markets, papers and workshops on agricultural diversification;
- **1966 to 1998:** culminating with the "Agricultural Diversification Policies and Strategies" conference in 1988 in St. Kitts, held by the biennial West Indies Agricultural Economics Conference series, initiated by the Department of Agricultural Economics and Farm Management;
- **1980's to early 1990's:** improve the performance of frontline extension workers as well as strengthen agricultural extension institutions, and research – extension linkages – in the OECS;
- **1979 to 1994:** USAID-funded Caribbean Agricultural Extension Project (CAEP) and the Agricultural Research Extension Project (AREP);
- **1990 to 1998:** CEPAT pursued intensive short course training of the CARICOM workforce in the food and agriculture sector in Agro-tourism and Agro-environmental linkages.

Essentially, the Workshops categorically addressed:

1. Policy on Agro-Ecological Issues
   a. Policy and Evaluation for CAD
   b. Policy Requirements for CAD
   c. Agro-ecological Considerations
   d. Evaluation for CAD.
2. Infrastructure and Services for CAD
   a. Production Infrastructure and Services
   b. Crop Production Infrastructure and Services
   c. Role of Livestock.
3. Processing, Business and Marketing Services
   a. Processing, Business and Marketing Services
   b. Processing Infrastructure and Services
   c. Business and Marketing Services.

It was noted that agricultural diversification had been attempted on many occasions in the history of Caribbean agriculture in response to crises in major export crops. However, although such attempts were almost always production-oriented with relatively little attention to marketing, examples of successfully implemented diversification programs were indicated. Moreover, it was concluded that the thrust in CAD since the 1980's adopted a more comprehensive approach to planning for agricultural diversification. It was also agreed that the general objectives for CAD were increased foreign exchange earnings through equitable agricultural transformation, involving value-added products for niche markets, with characteristics of productivity, sustainability, competitiveness and flexibility.

1. With respect to policy on agro-ecological issue, three questions arose: Are there sufficient areas of fertile soil on flat land, under suitable climatic conditions, with particular reference to adequate amount and distribution of rainfall? In the years and locations where rainfall is inadequate, is irrigation available so that the suitability of soils for a wider range of crops can be expanded? Can sloping soils be used productively and sustainably? These questions and related issues led to critical requirements for CAD, namely: A soil suitability inventory; land-use zoning to optimize the use of land; and better water storage and management.

In the perspective on horticultural diversification, it was emphasized that continuous selection and introduction of new species and varieties to meet consumer demand was a high priority for the industry. However, it was noted that a research/industry cooperative process for genetic, cultural and environmental evaluation of new plant material was critical for the successful introduction of new species and varieties, acceptable to consumers. In the perspective on evaluation, it was recommended that, notwithstanding the existence of alternative evaluation systems, Multi-Factor Productivity (MFP) could be adopted as a suitable parameter for evaluation of CAD, by virtue of its capacity to compare competitiveness and flexibility at national or at enterprise levels, as well as to evaluate input use aspects of sustainability. Moreover, other single factor indicators of diversification mentioned, e.g., increase or decrease in land area, number of farmers, employment and contribution to GDP could be assessed from MFP methodology. In addition, Domestic Resource Cost methodology was considered to be important for revealing underlying sources of competitiveness. However, the impact of agriculture on the environment must be subject to separate evaluation methodology.

2. Infrastructure and Services for CAD

Infrastructure and Services for CAD were addressed in background papers by Workshop participants, in two plenary panel discussions each, on production and on processing, business and marketing requirements. For Crop and Livestock Production, panel discussions emphasized the challenges and experiences of diversification of crop production in various countries, including those of the OECS. Discussions on experiences in livestock production came from other countries, including St. Kitts and Nevis. Some of the major problems in the infrastructure and services for crop production included:

- Concentration on production factors, leading to inadequate attention to marketing notwithstanding, inadequate provision of irrigation infrastructure
- Planning of enterprises in isolation, leading to lack of national focus
- Serious effects of praedial larceny as a production disincentive due to societal problems and inadequacy of security arrangements
- Land tenure and poor access roads
- High production costs due to high costs of labor and inputs

- Inadequate research and development and other support services for planting material, input supply, pest and disease control and specialist extension services.

It was also advocated that CAD initiatives might benefit from the experience of the support system in the banana industry, which engenders confidence in farmers to concentrate on the business of production, leaving marketing operations to Growers' Associations.

The major problem identified in livestock production was the negative impact of "cheap" subsidized imports of livestock products due to global trends in trade liberalization. In this regard, a number of challenges to livestock production were identified including:

- High costs of inputs of land, labor, credit, materials and supplies
- Production inefficiencies and inadequate product quality
- Provision of support services for breeding and genetics, feed and nutrition, health and fertility, extension and training
- Maximization of farmers' share of the consumer dollar
- Recognition of the place of livestock in national food and nutrition security and linkages with other sectors of the economy
- Improvement of milk production through use of in vitro maturation/ fertilization and embryo transfer technology to produce Bos Taurus x Bos Indicus F1 hybrids indefinitely.

Establishment and logistic support for small family farms, based on models of integrated livestock farming was proposed as a means of holistic community development. Livestock production was also accorded a crucial role in optimizing the farm product mix, in order to spread the risk in mixed crop/ livestock farming enterprises. However, in order to achieve this objective, it was recommended that livestock marketing systems must be better developed, if they are to increase their contribution to food and nutrition security.

3. Processing, Business and Marketing Services

Panel discussions on Processing Infrastructure and Services emphasized the need for support services for financing the modernization of processing plants and for product development. Alternatively, panelists on Business and Marketing Services identified a number of challenges in the improvement of these services including:

- Coordination of the financial support from several External Agencies
- Privatization of support services including research and development
- Infrastructural provision for roads and water, sea and airport facilities
- Market information, access and sustainability
- Development of Common Interest Groups including Production Marketing Teams and a joint Regional Marketing Program
- Development of a consumer-oriented approach to marketing.

The Workshop noted that mechanisms for improvement of the efficiency and competitiveness of traditional systems both for export commodities, e.g., sugar, banana, rice, coffee, cocoa, as well as for local food supply, e.g., tubers, vegetables, dairy and meat, were occurring simultaneously with those for accessing niche markets for non-traditional export crops, e.g., hot pepper, papaya, mango and tubers, in many Caribbean countries. Accordingly, they derived three models for CAD, based on the convergence between the requirements for traditional systems for both export commodities and local food supply, and non-traditional export crops to access niche markets. They proposed the Processing house-Based Model (PBD) for traditional and non-traditional commodities, the Farm-Based Model (FBD) for traditional food crops and livestock produce, and the Species Based Model (SBD) for new niche market products.

They noted that although each model has its specific priorities and driving forces, the sustainability of all three models will be determined by the competitiveness of their products in a dynamic, globalized market, both in the Caribbean and abroad. These specific driving forces were identified as follows:

- The PBD model is market driven, but dependent on strategic alliances or convergence with the FBD and SBD models and the critical mass of product necessary for competitiveness in international and regional markets.
- The FBD model is resource, information and management driven and directed mainly, but not exclusively, at national and regional markets.
- The SBD model is information, market and management driven and directed mainly, but not exclusively, at international markets.

The Working Groups at the Workshop adopted different approaches for identification of recommended species and products. Accordingly, the PBD group recommended selection of products to effect import substitution; the

FBD group advocated selection of those species shown to be successful by farmers in specific eco-systems; and the SBD group advised on experimental production and test marketing before selection of enterprises and products for niche markets. However, notwithstanding these differences in the overlapping of species in the PBD model, in the economic recovery strategy for sustainable agriculture in the FBD model, and particularly in the adoption of the SBD model as the policy for CAD, all Working Groups recognized elements of convergence between the three models. It was advocated that research in product development, training in food technology and post-harvest quality management and financial services for value-added processing and promotion, information and marketing services were common to these models. It was also advocated that, in view of the limited land area and high production costs in the Caribbean, CAD should increase the attention given to niche markets rather than to open mass market products. Alternatively, for the FBD model, provision of centralized marketing and processing in centrally-managed private sector organizations were considered to be a high priority.

Methods of Agricultural Policy Research

Ultimately, the design of this research and the design of policy to follow must consider the specific environment of agricultural research and policy. It is prudent to build upon the experience of others in similar circumstances. There is one caveat; what appears to work well elsewhere does not mean that it would in SIDS of the Caribbean. Nevertheless, certain features of models used elsewhere can be adopted or modified for application to the St. Kitts situation. The methods and design of the model proposed in this book adopts features from various contemporaneous agricultural research and policy development for LDCs undertaken by the Food and Agricultural Organization of the United Nations (FAO) Agricultural Policy Development Process, 1997; The Farming Systems Approach to Development and Appropriate Technology Generation, 1995; World Agriculture: Towards 2015/2030, An FAO Perspective, 2003). This section outlines a research methodology generally applied to farming systems (FAO, 1997). It also identifies the main components of a policy framework patterned from the Agricultural Policy Development Process for South Africa.

There are two main objectives:

1. A move from a document of broad principles to one that identifies implementable strategies and programs that would speed up delivery,

2. Coordination of ongoing activities into one process.

The policy framework identifies the following:

- Constraints on agricultural development
- Potential agricultural contribution to economic growth, employment and redistribution
- Roles and responsibilities of government and the private sector
- Institutional/organizational contributions towards achieving objectives
- Need for public participation.

The factors determining the methodology for the development of policy include:

- **Time Frames:** Synthesize existing knowledge and experience to set policies and interventions consistent with national policy goals
- **Existing Legislation:** Consider possible amendment or addition to legislation
- **Outline of Issues:** Identify working groups' position
- **Consultation Process:** Discussion among different working groups
- **Cooperation:** Between those inside and outside the Department of Agriculture to ensure that there are not parallel policy-making processes
- **Interactive Process of Policy Making and Implementation:** While policy is being developed, it is necessary to implement certain aspects of the policy.

The policy issues in farming requiring attention include:

- Food security
- Agricultural trade
- Co-operatives
- Land tenure
- Sustainable resource utilization
- Finance
- Farmer support services
- Marketing
- Livestock and animal health
- Agricultural employment
- Women's role in agriculture

- Budget allocations
- Subsidies and incentives
- Institutional reform
- Rural poverty alleviation
- Information systems.

This list is quite comprehensive and would require considerable time and resources for in-depth research on all of these issues. However, the model proposed in this book is limited to focus on rendering an individual farm successful to the extent that if it can, then farms can be potentially successful. When viewed collectively in a particular community or country, the range of issues identified will ultimately be addressed. It forms a standard for comprehensively examining agricultural development policy. According to Norman *et al* (1995, in FAO report for Botswana), collecting large amounts of accurate quantitative-type data over a long period of time is desirable, but this would be time consuming and costly. Norman *et al* agree that descriptive information would provide useful input into designing and testing ongoing development work in agriculture. With the view of setting priorities, research activities are described as high- and low-leverage interventions (Norman *et al*., 1995, in FAO report for Botswana). High-leverage interventions are considered as those activities that can be adopted readily by farmers, whereas low-leverage interventions are those that involve major changes in farming systems and are more difficult for the farmers to implement themselves. Additionally, priorities of farming activities require consideration. If researchers and farmers have different objectives, much research work may end up being wasted. It is important to find solutions to problems farmers feel are most important and those having high-level characteristics. This approach is more likely to boost positive attitudes of farmers as well as provide more immediate solutions that can be implemented readily at relatively least cost.

More significant than the strength of the state is the quality of policy decisions, their credibility, their transparency, and the administrative capacity to implement the policies. If policy elites are critical to the implementation, then the focus should be on making them equipped with knowledge and institutional or organizational capabilities to assist in policy implementation. However, the farmers themselves are also critical in implementing policy, as ultimate success would depend on the reaction or willingness of farmers to produce. Farmers are already equipped with a local knowledge base of science in their intimate and long-term exposure of their environment. Caribbean experiences reveal that the pervasive cooperative and parastatal

systems of agriculture as a recovery response to colonial dominance are not the solution to economic liberation. As mentioned earlier, in as much as there can be failures of the free-market, so too there can be government failures. Government failures can be addressed by specific features of policy design, for example, with particular attention to performance measures, and institutional framework and structure. Much has been written on bureaucracies and their functions, as well as on organizational culture or behavior of government employees – an area that needs further discussion but is beyond the scope of this book. Essentially, the trend in opportunities today seems to require private and public sectors to share responsibility for the agricultural sector development. The structure of this kind of arrangement needs to be explored further, not only from experience but also from theoretical considerations. These issues are a matter of policy design and implementation techniques under public stewardship as much as they are needed in a free-market environment. Even those advocating government intervention typically fail to provide a framework for use at the implementation level. For this reason, the farmer capacity and adoption of the appropriate model of farming is critical to the successful attainment of goals in agriculture.

Given the magnitude and complexity of the problem, it is critical to consider the far-reaching implications for many aspects of the society including political, social, economic, and environmental. These widely differing phenomena interrelate in complex ways that are often difficult to distinguish the relative influence or effect of each phenomenon on agriculture or vice versa. It is easy to assume that what works well elsewhere would work in various local contexts. However, the circumstances in St. Kitts are different from elsewhere. A deeper understanding of the social, political, economic, and environmental aspects of the communities in which the program is implemented can aid diversification. An initial normative view of how society should function leads policy analysts to advance ideas and policy proposals to politicians, entrepreneurs, and the general citizenry. While the actors in the policy process may be largely politically motivated, policy analysts are concerned with the world of analysis, employing a variety of analytical concepts, propositions, and techniques. This assertion is supported by Grover (1988) who writes, "Accountable policy makers confront problems which are situational and real, not abstract or philosophical. The reputable policy analyst presents the decision maker with an analysis of feasible decision options and their costs and benefits."

Therefore, the policy process and analysis are tightly bound together in practice and theory. The policy analyst is equipped with a range of analytical

tools of a mathematical/quantitative nature such as cost-benefit analysis, simulated models, and experiments. But pure quantification may not determine the effectiveness of a policy. While imports, for instance, may be reduced, what about the environment or the quality of life of the individuals affected by the policy? Does the policy reach the target population, that is, the population for which the policy was intended? Are farmers benefiting from the policy, or are they displaced by a new set of farmers? The policy analyst is concerned with who gets what. Based on these theoretical questions, the traditional cost-benefit technique employed by economists has been modified to the more contemporaneous technique of social cost-benefit analysis (Howard, 2001) taking into consideration social factors influencing policy. Policy analysts are not directly subject to the intensive political pressures, as do elected officials. However, values affect analysis and, in turn, policy decisions. But the analyst is far more likely to be neutral particularly if they are not directly attached to advocacy or owe allegiance to any political regime. Also, because the analyst tends to work on a specific issue for many years, they have longer time perspectives than elected officials who are relatively short-term. Additionally, they tend to be more knowledgeable regarding the intricacies of an issue and are therefore more likely to propose equitable solutions to ethical dilemmas.

Climate and Environmental Change

The factors of climate and environmental change on sustainable development will be first defined with reference to the literature in a time continuum of world views on the environment and attitudinal changes and responses to scientific revolutions and evolutionary changes in society. Impacts of climate change on sustainable development on society is a question for policy science that deals with input factors, decision-making, and outputs that are intertwined with feedback mechanisms to the policy process. As such, a model will be proposed to account for environmental, economic, social, and technological variables, and how decisions on adaptation and mitigation strategies can be designed for desired outcomes. In this framework, the ethical dimension will be introduced relating to vulnerabilities and a range of current questionable practices in our society. Responsibilities will also be examined, based on production and consumption of goods and services.

Approaches to environmental ethics utilize a hierarchy of priorities with prevention or reduction of loss of human life as the highest priority. Public health risk, particularly by infectious diseases, and conditions that can lead to loss of

human life are also high in the order. Other considerations in environmental objective are economics, loss of food security, habitat destruction and species extinction, biodiversity and ecosystem instability, social instability, safety and security, and cultural erosion of communities. Climate Change and associated adverse weather events of increasingly higher intensities, unhealthy air, tsunamis, and sea level rise are increasingly posing threats to small-island developing states (SIDS) and low-lying coastal communities (LLCC) where, historically, high concentrations of populations are located.

Trotz (2008) asserted that over the last 15 years (now about 25 years) climate change has emerged as a major concern for SIDS and LLCC of the Caribbean region. This assertion may be extended to SIDS and LLCC throughout the world. Other SIDS and LLCC in the South Pacific and Indian Ocean are equally vulnerable with respect to geographical characteristics. Outside of SIDS and LLCC, Bangladesh tops the list, largely due to population size, distribution and density. Others include Western Australia, the Sudan, and the Arctic and Antarctic regions. Now enjoined to the vagaries of climate change are China, Russia, Western Europe, the United States, and South America against the onslaught of severe floods and droughts. That is basically the entire world!

Trotz (Head Scientist for the Caribbean Community Climate Change Center(CCCCC), headquartered in Belize) emphasized that:

1. Greenhouse gas is a major concern
2. Economies and lives will be severely impacted
3. The poorest countries are most vulnerable
4. Adaptation and mitigation measures are essential
5. Collective intra-regional and inter-regional (or inter-governmental) actions are necessary
6. Immediate priority should be given to climate change response.

Some facts from research compiled by CARIBSAVE Partnership (Day, 2010):

Challenges (based on participation in CARIBSAVE National Consultation Workshop in St. Kitts-Nevis where the findings are similar to those of other Caribbean countries; and student-based research papers in the Caribbean Advanced Proficiency Examinations administered by the Caribbean Examinations Council) are:

1. Loss of human life

2. Loss of food security (have been dependent even before climate change coming to the fore, and with changes at the supplier side, prices are soaring)
3. Lack of freshwater, water contamination, and salt water intrusions
4. Higher health risks with increase in vectors within a wider temperature tolerance range, significantly on the plus side
5. Loss of livelihoods
6. Breakdown of law and order – loss of economic activities (mainly, agriculture, fishing, tourism, forestry, and trade)
7. Damage to homes and infrastructure
8. Impeded travel and communication
9. Loss of fuel supply
10. Loss of biodiversity
11. Environmental degradation.

Needs

Food security (agriculture with improved methods; less dependent on weather conditions – floods and drought, higher productivity on less land; more reliability of production, less impact on environment)

1. Water supply (rationing already in some places)
2. Medical supplies and facilities
3. Education and awareness (at all levels)
4. Food storage (for extended periods of time)
5. Water harvesting and storage and replenishment of aquifers (cisterns, reforestation, conservation)
6. Shelters and Institutional support (already some organizations, public services, and disaster management plans already in place)
7. Political will (not only from leaders but also from citizenry – building consensus – can draw political salience and influence public agenda)
8. Legislation enforcement (appears that legislation is already in place)
9. Reduced sedimentation by reforestation and from construction sites near the sea
10. Avoid building in high risk areas
11. Fuel storage and alternative sources of energy (solar, wind, geothermal)
12. Fish sanctuaries and fish farms.

The above findings, by their very nature of transcending regional and international boundaries, present a serious geopolitical problem and, therefore, any solution to combat climate change and its effects would require compromise, dispute resolutions, significant costs, incentives, disincentives, diffusion of information and acceptance by widely differing social and cultural backgrounds, management practices, and shared responsibilities at various levels, including individual and executive governance, at local, regional and international levels. Problems of a similar nature, for example fresh water, fuel, and other natural resources of wider environmental nature that cause environmental degradation, often lead to wars and other forms of tragedy, not unlike the proverbial "Tragedy of The Commons." The most important characteristic of Caribbean communities is their small economies; a little goes a far way such as the input of a major development project, but the flipside of the coin is that destruction of one major development can send a shock wave throughout the economy. This is compounded by the fact of low economic diversification and heavy reliance on tourism. It is well known from economic perspectives that tourism is fickle and vulnerable to external shocks, stigma of crime, devastation, and simply a change in preference by tourists themselves. It is also dependent on climate and weather, and general environmental conditions.

Issues, Controversies and Problems of Farming in St. Kitts and Nevis

This book uses the example of a model farm being developed in St. Kitts, and inference is made upon other island nations within the Caribbean, particularly those of the Organization of Eastern Caribbean States (OECS) that have similar issues and environments, as the model would have relevance to the similar conditions in those other Caribbean SIDS. It follows that much of the background information in the foregoing section on the Caribbean context bears similarities to the St. Kitts and Nevis situation and confirms that for the three and a half decades following its independence, St. Kitts and Nevis continued to embrace the plantation model of development typical of the Caribbean countries with a colonial past. Despite declining productivity, it held on to this industry to meet the status quo of being the major source of employment. Additionally, in the face of price competition and sugar substitutes in overseas markets, St. Kitts and Nevis sought to maintain its trade relations with its overseas trading partners through the export of sugar.

A survey of crop and livestock farmers in St. Kitts, conducted by Naraine in 2005, with the target population of persons actively involved in agricultural diversification in St. Kitts, revealed a myriad of issues in farming. It is assumed that these crop and livestock farmers who were actively involved in farming were directly exposed to the overall operating conditions in farming and were perhaps most aware of the issues affecting their farming activities. The reasons why non-farmers have not become actively involved in farming or their perceptions of farming in St. Kitts may provide some insight to the issues, but that was beyond the scope and feasibility of the survey, and given the constraints of time and cost to undertake a larger study that may provide only marginally increased insight to the issues.

The target population of farmers was constructed from the 2000 Census of Agriculture and Fisheries in St. Kitts (St. Kitts Ministry of Agriculture *et al.,* 2001), and from partial listings of farmers who have requested assistance from the St. Kitts Department of Agriculture for such things as land provision, flea and tick control, and disease control. In particular, the St. Kitts and Nevis 2000 Agriculture and Fisheries Census identifies an agricultural holding as, "… an economic unit of agricultural production under single management comprising all livestock kept and all land used wholly or partly for agricultural production purposes, without regard to title, legal form, or size." Accordingly, those who manage such holdings are referred to as "holders." The person who makes the day-to-day, on-the-spot decisions is the "farmer." Note that, in some cases, the farmer is also the "holder." In other cases, there is a "hired manager" who makes the day-to-day, on-the-spot decisions and is responsible for the required work. In some instances, where the holder or farmer is not available, the point of contact is the hired manager. The criteria for defining the target population are based mainly on the extent or level of involvement in farming activities, which includes the holder, farmer, or hired manager. Therefore, the survey referred to holders and hired managers as farmers, as they too are directly involved in farming and are perhaps most aware and are exposed to the overall operating conditions in farming.

According to the 2000 Agriculture Census, there were 1,795 holdings in St. Kitts. Of these, 684 (22.2%) were "landless" farmers. Of the 1,795 holdings, there were numerous "landless" farmers who were involved in rearing of livestock that roam freely in the community, and "back yard" farmers who cultivated small patches of land in residential communities for their own consumption or for minor sale in the local community to supplement their income. This category of farmers was referred to in the survey as "subsistence" farmers. The survey targeted all farmers, regardless

of tenure. In addition, the target population constituted those who operated a farm on a commercial or semi-commercial scale, as well as subsistence farmers. Note that there was no clear distinction between commercial and semi-commercial farmers with regards to listing or record-keeping. There were subtle variations in these two types of farmers, and the distinction may change from time to time, depending on the level of activity and the amount of land put under production. Therefore, the survey placed all farmers into two categories: commercial/semi-commercial farmers, and subsistence farmers.

The St. Kitts Department of Agriculture estimated that there were 234 crop farms and 62 livestock farms meeting the stated criteria of commercial or semi-commercial farming, as shown in Table 1.

Table 2, shows the distribution of farms by the threshold farm size criterion for the farms shown in Table 1. Threshold levels of farm size have been determined by the St. Kitts Department of Agriculture and were used to distinguish between commercial and subsistence farmers.

It should be noted, however, that about 60 farms practiced both crop and livestock farming or more than one livestock type. Therefore, the target population constitutes one holder, or farmer, or manager from each location from the universe of farms, but more than one person per farm location was targeted if the different farming activities were managed separately. With regards to subsistence farmers, the St. Kitts Department of Agriculture estimated that there were 1499 subsistence farmers in St. Kitts, without

Table 1. Showing the distribution of commercial/semi-commercial crop and livestock farms by parish in St. Kitts

PARISHES	# CROP FARMS	# LIVESTOCK FARMS	TOTAL # OF FARMS
St. George	27	24	51
St. Paul	36	2	38
St. Anne	16	5	21
St. Thomas	24	5	29
Trinity	9	2	11
Christ Church	14	9	23
St. John	74	3	77
St. Mary	17	4	21
St. Peter	16	9	25
TOTAL	**233**	**63**	**296**

Table 2. Showing the distribution of commercial/semi-commercial crop and livestock farms by farm size in St. Kitts

FARM SIZE	# FARMS	FARMING TYPE
1 to 3 acres	152	Crop
> 3 acres	81	Crop
= or > 20 Sows	7	Pigs
60 to <100 Sheep & Goats	9	Sheep & Goats
= or > 100 Sheep & Goats	11	Sheep & Goats
20 to < 30 Cattle	15	Cattle
= or > 20 Cattle	18	Cattle
= or > 500 Poultry	3	Poultry
TOTAL	**296**	

distinction of farm size or farming type – whether crop or livestock, distributed in the various parishes, as shown in Table 3.

The real problem lies with the fact that St. Kitts-Nevis needs an alternative use for the relatively vast sugar lands and a comparable source of labor that the sugar industry offered. Ironically, the sugar industry employed relatively large amounts of seasonal workers, mainly cane cutters, from overseas (Guyana, St. Vincent and the Grenadines, and the Dominican Republic). This form of labor is viewed as undignified, low-paying, and plain hard work in a global economy. The St. Kitts-Nevis sugar industry workers, in large part, held the more skilled jobs such as machine operators, factory technicians, as

Table 3. Showing the distribution of subsistence farms by parish in St. Kitts

PARISHES	TOTAL # OF CROP & LIVESTOCK FARMS
St. George	284
St. Paul	98
St. Anne	164
St. Thomas	102
Trinity	67
Christ Church	128
St. John	210
St. Mary	244
St. Peter	202
TOTAL	**1499**

well as office positions. With the dissolution of the sugar industry in 2005, such workers from St. Kitts and Nevis were not skilled or experienced in agriculture for the production of food crops and livestock, and had preferences for manufacturing and tourism and other service oriented jobs, as well as entrepreneurship in small businesses, instead of farming which continued to be perceived and practiced as a substance activity.

Agricultural development is also affected by inaccessibility to credit, low prices for their produce with oversupply in some periods but quickly followed by scarcity in off-season periods, lack of marketing systems, nuisances of dog attacks on livestock, nuisances of monkeys and livestock feeding on and damaging food crops, and, not infrequently, environmental disasters attributed to severe storms, hurricanes, and in more recent years with drought conditions. It appears that many of these issues can be mitigated with the use of modern and innovative techniques in policy design, planning and implementation, agri-science and agro-technology, and agri-business to enhance the productivity of individual farms.

The myriad of issues facing the agricultural sector indicates the magnitude and complexity of the problem. It is no surprise, therefore, that interest in agriculture as a viable economic activity has diminished to a point of rejection by the general citizenry and even by the absolute 'die-hards' – the farmers – who complain about the hardships and frustrations they face but still persist in the face of adversity. These problems manifest themselves further into problems to society at large such as the incidences of poverty, deforestation and soil erosion, inconsistent and unreliable food supply, contamination of ground water by pollution due to the use of fertilizers, insecticides and pesticides and animal waste, and the perception of farming as undignified work. According to the literature and interaction with farmers, it appears that farming is not an economic activity of choice. The public, in large part, has lost interest in agriculture as a reliable source of income. Farming is viewed as a subsistence activity and does not afford a life style or standard of living worthy of pursuing. It appears to give neither social mobility nor economic progress to farmers.

This survey also yielded information to assess the level of agricultural diversification which was a primary objective of agricultural policy and plans shortly before and after (until the present time) the dissolution of the sugar industry in 2005. Agricultural Diversification in St. Kitts will be dealt with in Chapter 2.

Justification for a New Approach to Farming

Vis-à-vis the current shortfalls in the agricultural sector and growing dependency on imported food from more developed economies, numerous Caribbean SIDS have been seeking to initiate development in agriculture to meet the growing needs of their population. Policy initiatives have been made in the past, for example in St. Kitts-Nevis, to encourage the growth of non-sugar agriculture, but with growing challenges of climate variability, as well as the complex dynamics of the food supply and distribution chain. Some farmers claim that agricultural diversification has entered their vocabulary since the 1970s but have not achieved stated goals of production to meet local food demand. Document reviews indicate that such initiatives have not been effectively designed and implemented, given the problems that still exist today in the agricultural sector. Often thoughtful policy initiatives are made and good plans are formulated, but they fail to be implemented due to lack of a clear policy design that takes into account the needed resources such as policy science, financial and business, marketing, monitoring soil and water conservation practices, environmental protection, and relevant education and training. Development of agriculture in the Caribbean region continues to experience an apparent low rate of success. Broad policy recommendations and initiatives are usually made in the political arena, but technical personnel are usually faced with the challenges of implementing them without further substantial policy design, planning, and implementation support. It is not unusual that well intentioned policies and equally good plans end up in fiascoes for lack of good policy design and implementation and monitoring strategies.

This book is timely, given the exacerbated impacts of climate and environmental change coupled with diminishing fresh water supply, rising food costs, rising rate of imported foods from MDCs, food shortages following more intense natural disasters, and sectoral shifts to manufacturing and tourism without a strong "take off" base in the agricultural sector.

Collectively, agricultural diversification may be achieved at the national level as a primary sector with supply contributed from individual farmers having a single or few crops and livestock at a given period under seasonal variations. There may also be gluts on the market followed by scarcity without proper coordination of farming activities among farmers. However, individual farms may not be diversified sufficiently to reduce risk for farmers to benefit from the overall success at a national level. For farmers to be successful and sustainable on small- to medium-scale enterprises, they need to be more

internally efficient to benefit from the value chain, otherwise they remain generally at the subsistence level and largely as a part-time activity, with more exits than entries to the sector. It is critical to give attention and importance to the success of individual farming enterprises which, when aggregated, translates into greater national agricultural diversification and success.

Therefore, the main unit of analysis for this model is agricultural diversification and integration at the individual farm enterprise level and on the assumption that optimum utilization of waste can enhance the productivity of farms to contribute to food security. The various chapters will identify and examine the background issues of agriculture to be followed by opportunities for such enhancements on a proposed model farm in its currently early stage of development to projected maturity. Sustainability of a farm may be perceived as a funnel, having a wide crown and a narrow base, in which there is considerable input in the beginning with relatively low output. In time, the original funnel shape will progressively change its configuration to a columnar shape and then to an upside down funnel with relatively lesser input and greater output as the farm matures.

CONCLUSION

There are far-reaching implications for many aspects of the society including political, social, economic, and environmental. These widely differing phenomena interrelate in complex ways that it is often difficult to distinguish the relative influence or effect of each phenomenon on agriculture or vice versa. This is the first asserted model to diversify the St. Kitts agricultural sector and it proposes a market-oriented approach. It is easy to assume that what works well elsewhere would work in St. Kitts. However, the circumstances in St. Kitts-Nevis and SIDS in the Caribbean and other regions are different from each other. Nevertheless, there are some similarities and one can draw from models elsewhere and adopt and modify to apply to local contexts at the advent of new ventures. A deeper understanding of the social, political, economic, and environmental aspects of the communities in which the proposed model is implemented can aid diversification. Given the relatively short timeframe of the implementation of the Diversified Integrated Model of the demonstration farm, which this book uses as its main example, some projections are made to account for the components to be added and for the farm to reach maturity over a 4- to 5-year period.

This research would provide policy support to the implementation plan and development process in St. Kitts with regards to diversifying the agricultural sector of its economy. The various interests, such as elected officials, technical personnel, administrators, creditors, planners, and entrepreneurs/farmers, can use the feedback mechanism and the final research product as a guide to making informed decisions. It would be challenging to influence decision makers and program directors in a direction that is unprecedented in the context of St. Kitts. The expertise in the Department of Agriculture appears to be predominantly in the specialty of agricultural science but not policy science. Policy documents show evidence of broad policy initiatives. The current researcher observes, anecdotally, that there is minimal evidence of policy design and implementation strategies from the perspective of policy analysis. There is no agricultural diversification model that can be observed in the immediate environment of St. Kitts. Usually, programs are implemented with ideas from what is observed to be successful elsewhere, but this does not mean that it would be successful in St. Kitts. Consideration would have to be given to the peculiarities of St. Kitts, and any successful examples elsewhere would have to be customized to meet the needs of this particular environment with its own set of circumstances.

There is reliance on previous success and experience with empirical, exploratory and action oriented research in community development programs, as well as experience interacting with decision makers in government institutions, NGOs, and CBOs. This work attempts to provide methods of investigation and analyses from scientific principles of policy and planning that could be relied upon by those charged with the implementation of agricultural diversification and national development.

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Chapter 2
Concept and Metrics of Agricultural Diversification

ABSTRACT

This chapter presents some comparative analysis on agricultural diversification at the national and individual enterprise levels illustrating that although a country or region may have optimum diversification it may not translate into optimum diversification at the enterprise level to the disadvantage of farmers causing the national diversification to be unsustainable. This finding may strengthen the justification for an expanded model at the enterprise level to include integration of various aspects of production, such as crops, livestock, aquaculture, and soil and livestock feed production. The remaining chapters will identify and describe the various aspects and characteristics of the farm model from a practical perspective of an individual farm enterprise utilizing the model and demonstrating how to optimize farm waste to approach a zero waste scenario so that it can be instructive for various levels of uptake, including the individual farm enterprise level.

INTRODUCTION

The issues presented in Chapter 1 show that despite all the policy solutions and farming models introduced over the past 5 decades, achieving agricultural diversification to meet local food demand and food security have essentially failed. While the solutions are formulated and implemented, the conditions change with the new dimension of climate change that has exacerbated the

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effects of the factors influencing farming. The current circumstances are in a state of complexity with no clear strategic direction, except latching on to the "mantra" of adaption to climate change to which all the past issues in agricultural diversification are now pinned. One thing that is clear is the major source of funds coming from the climate change initiatives on adaptation and mitigation is followed by policy and decision makers at the levels of governance of the agriculture sectors in the region.

It is here proposed that although there is complexity, the problem of food supply can be simplified and viewed from the perspective of the individual farming enterprise. Focusing on the success of individual farms will cumulatively and positively impact regional or national production and diversification but not necessarily the opposite, i.e. the regional or national would not necessarily result in individual success. There is evidence to be presented that indicate farmers enter and exit the sector with high turnover, except for older farmers who continue mainly at a subsistence level.

This chapter now turns to an analysis of agricultural diversification at the national level for the small island nation of St. Kitts, also considered as a small island developing state.

NATIONAL AGRICULTURAL DIVERSIFICATION IN ST. KITTS

This section gives an insight of the general economic environment and the role that agriculture plays in the economy. First is the GDP trend from 1986 to 2003. Second is the absolute contribution of the agricultural sector in general to the Gross National Product (GDP) of St. Kitts. Third, and finally, is the relative contribution of agriculture to GDP, expressed as a percentage of Agriculture to GDP. These visual impressions of the macro-environment form the backdrop for presenting the index of agricultural diversification in St. Kitts. This chapter then examines the factors that may influence agricultural diversification at the national level in St. Kitts. Please note that the data are provided by the St. Kitts Planning Unit – Statistics for the years 1986-2003. The data to compute the diversification index go back only to 1986, and therefore the data selected by this research for the other variables, although available for earlier years, are limited to those years only to facilitate analysis. The first set of objectives relates to the macro-economic factors influencing agricultural diversification of the island, St. Kitts, generally.

- To examine the influence of per capita income, government expenditures in agriculture, and shift in the various economic sectors on agricultural diversification
- To examine the characteristics of the institutional framework responsible for executing the plan and providing support to farmers
- To examine the stated criteria for performance and determine their appropriateness.

More specifically, the second set of objectives relates to the micro-economic environment and its influence on agricultural diversification at the individual enterprise level.

- To examine the characteristics of the target population of farmers, i.e. farm and farmer characteristics, and the attitude of farmers towards diversification
- To develop a policy framework and formulate implementation strategies with feedback mechanisms for agricultural diversification, with the consideration of what goes on "on the ground."

The additional step to complement the growing trends of technology-based systems is transformation of extensive farming systems to integrated farming systems. Intensive farming systems can be transformed into integrated sectoral systems with inherent advantages of transitioning from primary sector economic activities to secondary and tertiary sectors to derive greater value of outputs that typically occurs at each higher sector. However, integrated systems require some level of diversification from which the diverse raw materials form the scope of the system from which all components are linked to derive internal efficiencies with the transfer of energy to achieve a zero waste scenario.

A diversified integrated farming model is being demonstrated by Plum Tree Farms in St. Kitts, commencing in 2016, on a semi-commercial scale (4.5 acres), with crops and livestock, with some production of feeding stuff for livestock that needs further development with more capital input for equipment. This model includes direct marketing by which more income accrues to the enterprise. Greater realization of this concept requires the implementation of technology to produce livestock feed which is about 75% of the cost of input for livestock. More technology for energy and irrigation is also required for greater utilization of livestock waste to nutrient recycling in soil and from offal for protein concentrates, and also waste to energy. This

demonstration project, having been implemented partially for about 2 years has led to a successful farm that is ripe for expansion, upscaling, and replication.

A diversified system, according to Bernardo, D, et al. (2015), consists of components such as crops and livestock that coexist independently from each other. In this case, the emphasis is not to integrate crops and livestock to minimize the risk of dependency on a single or few commodities, and there is no emphasis to recycle resources. In an integrated system, crops and livestock interact to create a synergy with recycling, allowing the maximum use of available resources. Crop residues can be used for animal feed, while livestock and livestock by-product production and processing can enhance agricultural productivity by intensifying nutrients that improve soil fertility, and reducing the use of chemical fertilizers.

Viaux (1995) posit that integrated arable farming systems take into account all natural and agronomic environment of the farm to reduce the level of external inputs. Those systems require a holistic approach of the crop production with regard to rotation, varieties selection according to their disease sensibility and quality, sowing dates and densities, crop protection adjusted to diseases populations and crop stages, fertilization adapted to soil potentials and plant needs. At the individual farming enterprise level, there is the advantage of agricultural diversification which also achieves integration at the enterprise level, and which is the main tenet of this farming model that is being demonstrated by Plum Tree Farms, so that elements of flexibility, productivity, competitiveness, and sustainability can be achieved. When this is individually or collectively practiced, the cumulative impact is agricultural diversification at the national level. Conversion of a farm to become integrated is an "evolutionary" process, primarily due to relatively high initial capital input requirement, stages of production to facilitate other stages towards maturity in a cyclical pattern. Small farmers, in particular, need to have sufficient access to knowledge, assets and inputs to manage this system in a way that is economically and environmentally sustainable over the long term. One essential consideration is to generate cash flow at every stage of the cycle for feasibility to implement other stages.

Wilson and Bekele (1998) have derived quantitative techniques to assess whether or not diversification has taken place. Otherwise, claims of agricultural diversification are only arbitrary and subjective. With a descriptive backdrop of the current trends in Caribbean agriculture, they first present a more up-to-date definition of agricultural diversification than that of Demas (1987), presented earlier in this review. In its widest sense, according to Wilson and Bekele, agricultural diversification refers to increasing the range of agricultural

output at farm, sectoral or regional levels either through expanding the number of crop or livestock species produced or by vertical integration of one or more species into a diversified product mix, through processing. Diversification could also be achieved by internationally sourcing raw material e.g., fresh fruit to achieve all year manufacture of products for an export mass market. International franchising of the processing technology will also achieve the same result. These examples of diversification include both agro-ecological and agro-economic dimensions. Wilson and Bekele incorporate agro-ecological as well as agro-economic considerations into their model, as outlined below:

Agro-Ecological Dimension

Following concerns raised on the sustainability of the genetic-chemical technology of the Green Revolution, because of its higher levels of energy use and environmental pollution, attention has been directed to the *Farming Systems* approach to agricultural development. Resulting agronomic and agro-ecological investigations of experimental multiple cropping and traditional agro-ecosystems suggested that species-based crop diversity could provide alternatives to the crop specialization in Green Revolution monoculture systems. Accordingly, it has been shown that *spatial diversity* of crop species could lead to better use of available nutrients, water and light. Inclusion of tree crops in the spatial arrangements e.g., in alley cropping and multi-storey canopies, improved light interception and increased the availability of nutrients, by facilitating upward movement from deeper soil horizons. Also, temporal diversity of species, e.g., in rotation and relay cropping extended the growing season and increased land productivity, while genetic diversity, both within and among crop species, often provided natural biological control of pests and diseases and restricted weed invasion. Moreover, the intensive operations involved in multiple cropping systems and the resulting increases in land productivity, often led to increased labor productivity. Wilson and Bekele draw attention to the work of Conway (1985) and Dover and Talbot (1987) who contended that carefully engineered farm-based agro-ecosystems, including species diversity could increase agro-ecological characteristics of productivity, stability, sustainability, compatibility, energy efficiency, and equity, as well as ecological and economic risk distribution. In the final analysis, these authors suggest that the real value of farm-based species diversity, as presented in traditional farming systems, is increased productivity of biomass and plant and animal food, without excessive use of energy intensive inputs of fertilizer, pesticides and farm machinery.

Agro-Economic Dimension

If the demonstrable agro-ecological advantages of species diversity in traditional and experimental multi-cropping systems are to be applied to management of agricultural diversification as a national policy, then diversification must be defined in economic terms with more precise parameters of evaluation of such systems at national levels. To this end, they draw attention to the work of Davis (1990) and Langham, *et al* (1998) who adopted the Shannon Index of entropy (SIE), which will be applied in Chapter 2 of this book, to analyze diversification at the national level for St. Kitts and also, for the first time, will be applied at the individual enterprise level.

Much of the existing literature, in the form of case studies and policy traditions in agriculture, has a strong economic focus. The concept of development, if taken to mean betterment of the human condition, remains elusive when the predominant objective in development initiatives or programs appears to be economic growth. It fails to address the broader societal issues that are an integral part of any developmental initiative. The literature on agricultural policy identifies a multiplicity of variables ranging from financial performance statistics that are easily quantifiable to microeconomic models that utilize mathematical concepts to development models and systems of production that conform to core beliefs or paradigms, and to policy issues dealing with social equity, land reform, environment, institutions and services, community development, and natural resources. As such, governmental intervention is critical in addressing agricultural diversification. Given the constraints outlined in the above sections, with particular attention to restrictions of international trade organizations, and failures of the free market, have emerged stronger nationalistic approaches to the issue of agriculture.

It should be noted that the data to calculate the diversification index, i.e. the production value of each crop and livestock type, are for St. Kitts only, while the other data are available for the Federation of St. Kitts and Nevis. It is here assumed that the change in amounts for St. Kitts and Nevis independently would vary proportionately over the selected years and, therefore, would not affect the trend that is underlying significance to the analysis.

Gross National Product of St. Kitts-Nevis

Figure 1, shows the GDP for St. Kitts-Nevis for the years 1986 to 2003. It is readily noticed that there has been a steady growing trend over the years. This suggests an increasingly greater production of goods and services of which agriculture is a part.

Contribution of Agriculture to GDP

Figure 2, shows the contribution of the agricultural sector in St. Kitts-Nevis to the GDP of the federation of which non-sugar agriculture is a part. Figure 2 also shows the contribution of non-sugar agriculture (crops and livestock) and sugarcane to the GDP. Note that these figures do not include the contribution of fisheries.

It shows a decreasing trend, in large part due to the decline in sugarcane; note in the trend lines that as sugarcane contribution to GDP decreases so does the contribution of agriculture in general to GDP. The contribution on non-sugar agriculture shows a slightly increasing trend over the years and helps the agricultural sector from declining to steeply, despite the rapid decline in sugarcane.

Figure 1. Showing the trend in GDP for St. Kitts-Nevis

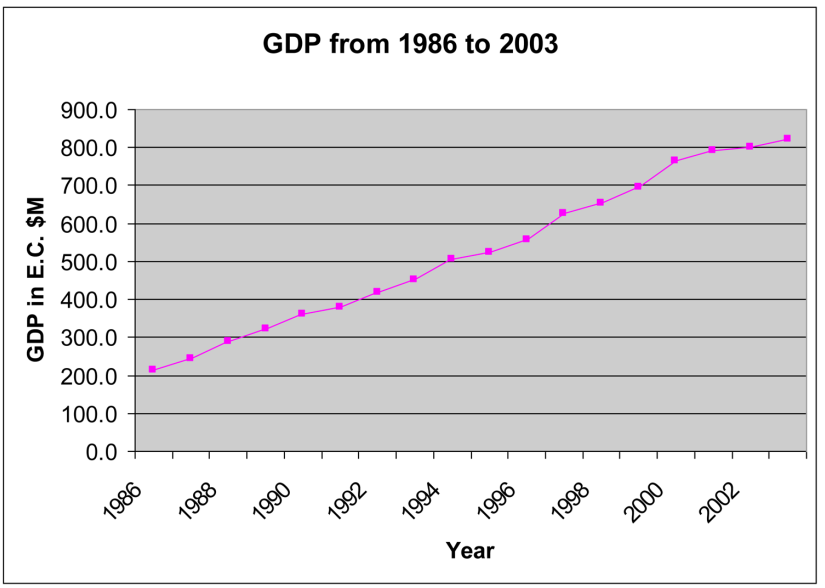
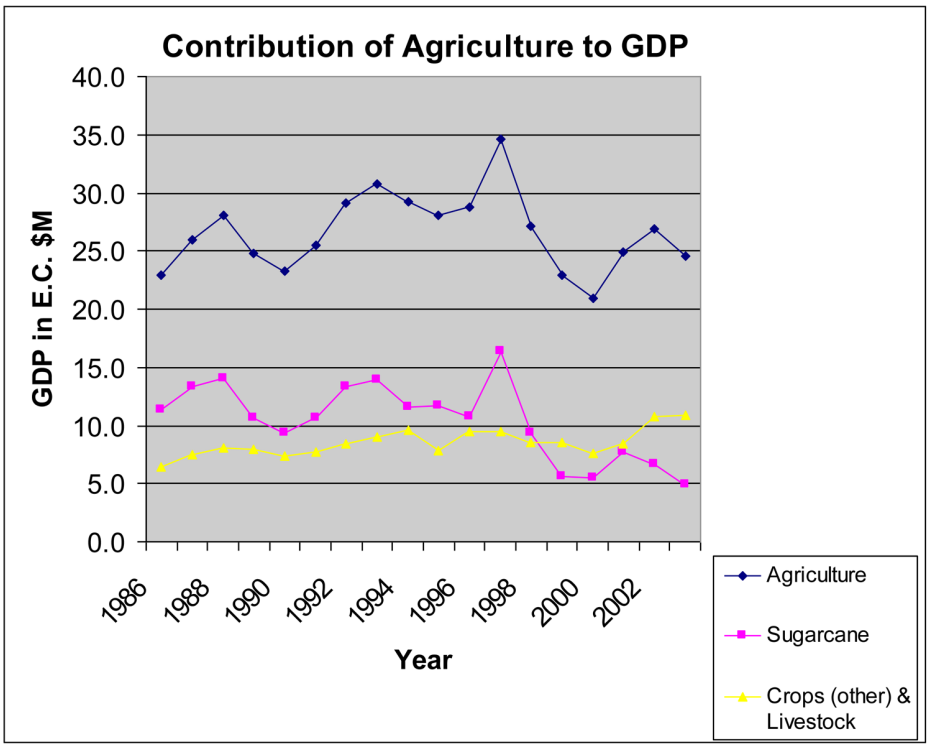


Figure 2. Showing contribution of agriculture to GDP



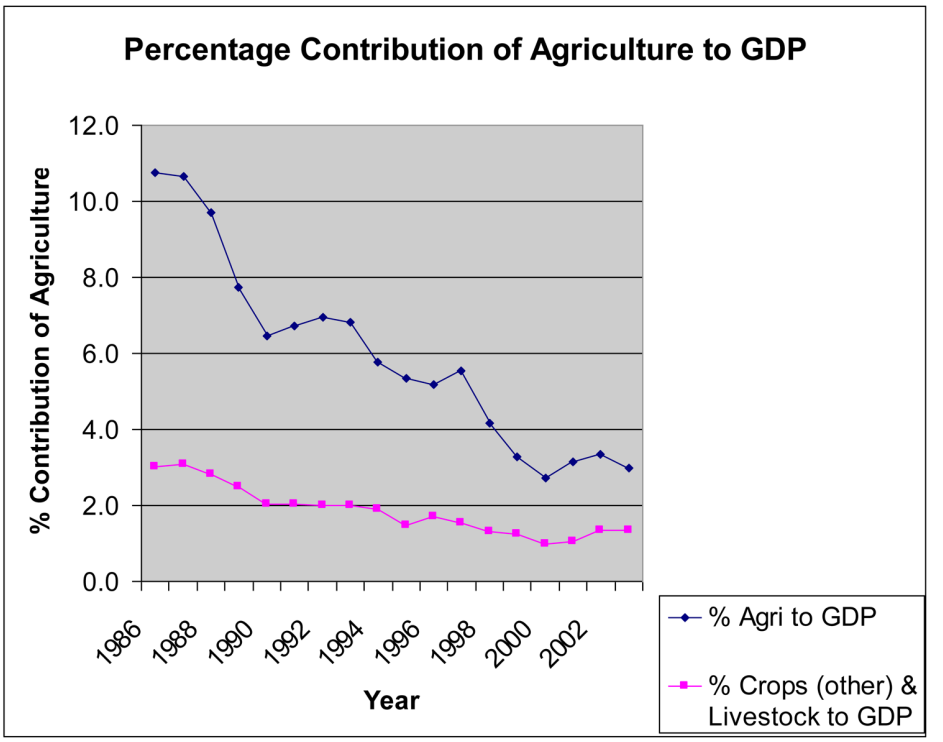
Percentage Contribution of Agriculture to GDP

Although the absolute contribution of agriculture shown in Figure 2 does not show a rapidly declining trend, when its contribution is viewed relative to GDP, there is a stark difference. This is due to the fact that the GDP has been on a steady increase, while agriculture has been experiencing a decline – although large for sugarcane but small for non-sugar agriculture. Figure 3, shows the percentage contribution to GDP showing the relative contribution of crops and livestock.

Agricultural Diversification for St. Kitts

Diversifying the agricultural sector away from sugarcane has been the thrust in St. Kitts for over 20 years. However, this thrust has not been consistent as may be reflected in the fluctuation in production in this sub-category of farming. It is therefore important to examine how the performance of crops

Figure 3. Showing percentage contribution of agriculture to GDP



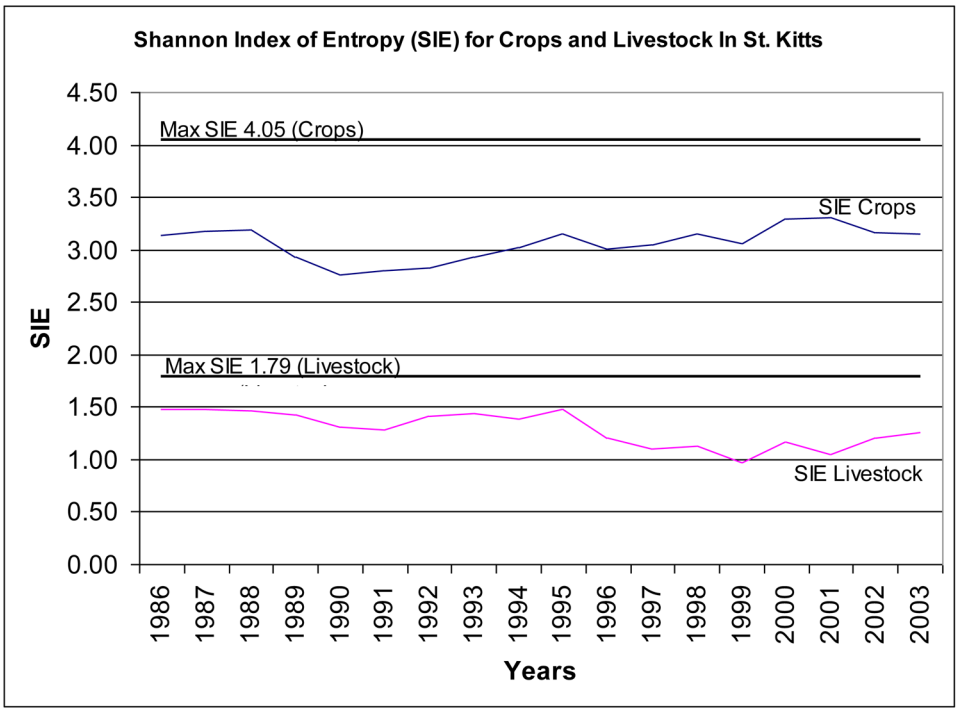
and livestock vary over the years. It is assumed that a diversified sector would be more robust and not suffer the same fate as sugarcane if there were to be only a small number of crops and livestock types. It is for this purpose that the Shannon Index of Entropy (SIE) is used to calculate a diversification index at the national level.

Figure 4 shows the SIE for St. Kitts from 1986 to 2003. The trend line for crops shows a small increase, while the trend line for livestock shows a small decrease.

These trends may be attributed to three main factors:

1. Government expenditure in agriculture as a percentage of total expenditures;
2. Gross National Income Per Capita (GNI per capita); and
3. Changes in policy on agricultural diversification. It may be assumed that whenever a policy strategy is in place, there would be more enthusiasm and motivation to diversify. This potential dummy variable, however, is not

Figure 4. Showing the SIE for crops and livestock in St. Kitts



modeled due to the fact that there are only two documented agricultural diversification plans in St. Kitts (the 1995 Strategic Plan for Agricultural Diversification; and the 2002-2005 Agricultural Diversification Plan). These data points would not be sufficient to make a valid analysis.

Percentage Expenditure in Agriculture to Total Government Expenditures

The data for this variable is available only in combined fashion for agriculture, fisheries, co-ops, lands, and housing. Furthermore, agriculture also includes sugarcane. Therefore, it would be difficult to decipher what percentage is spent on agricultural diversification or non-sugar agriculture, and therefore this variable may not prove meaningful. Nevertheless, this variable is used to explore any potential relationship between government expenditures and diversification.

It is may be assumed that as government expenditure in this sector increases so does the SIE, as it would relate to the emphasis placed on this sector that may result in more incentive to diversify.

Figure 5 showing the percentage expenditure in the agricultural sector to total government expenditures, displays a highly fluctuating trend.

Gross National Income Per Capita

There has been a steady increase in the GNI per capita over the years (see Figure 6). This trend coincides with the trend in GDP growth. However, this statistic is used as it relates more closely to the spending power or disposable income of Kittitians.

It may be assumed that as GNI per capita increases so does SIE, as people would have more disposable income to spend on food items. Therefore, any change in GNI per capita may effect a change in diversification.

Figure 5. Showing percentage expenditure in agriculture to total expenditures

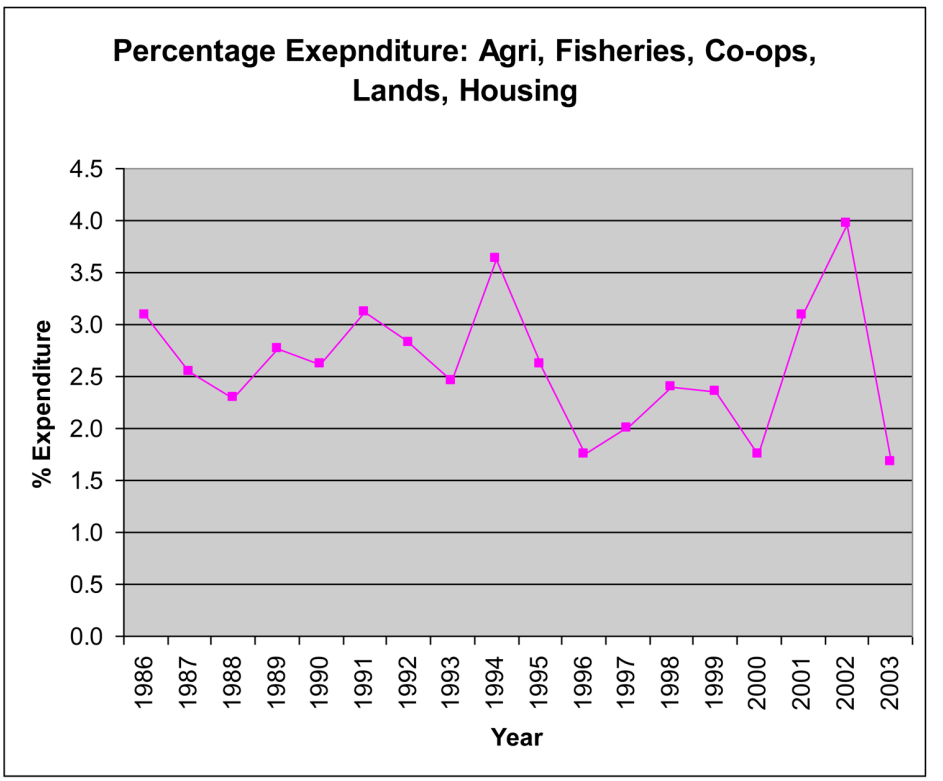
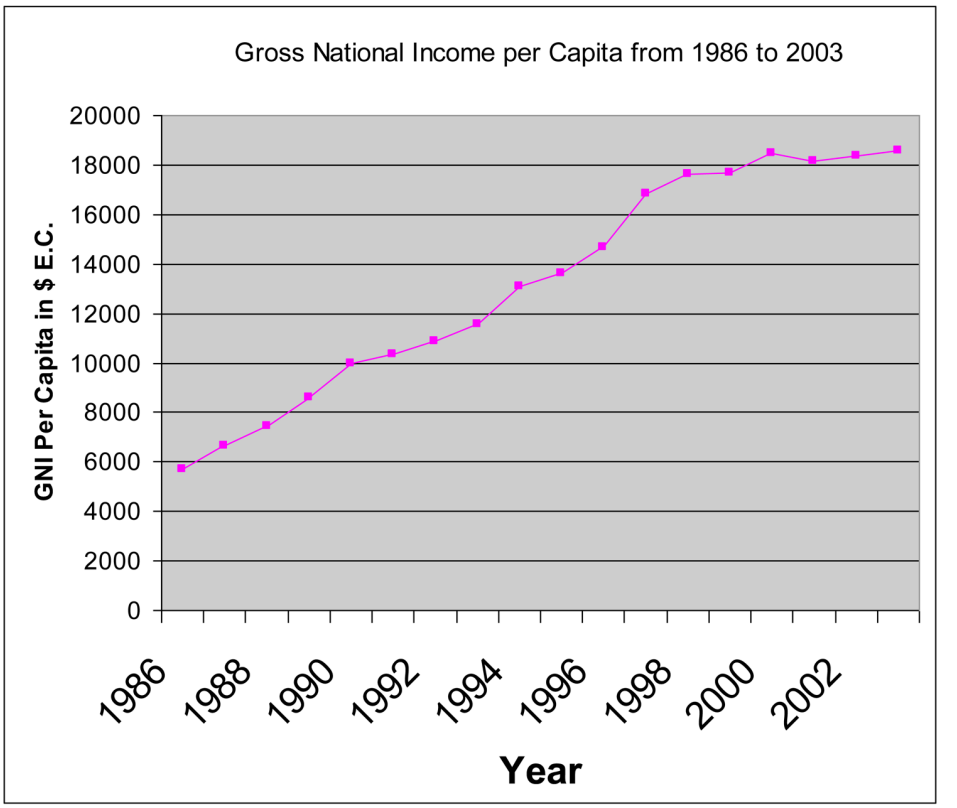


Figure 6. Showing gross national income per capita



Correlation Between SIE, Government Expenditure, and GNI per Capita

Table 1 shows the correlation coefficients derived from the above mentioned data sets. The coefficients between SIE for crops and livestock and percentage expenditure on agriculture do not indicate any significance between these two variables, perhaps due to the fact that the data for agriculture combine with other elements.

The coefficient between SIE for crops and GNI per capita shows a positive relationship, although not necessarily strong, with an index of 0.5. This indicates that as consumers have more disposable income they tend to have a greater demand for agricultural products and therefore a greater demand results in higher production and/or value of agricultural products. There is a strong relationship between SIE and GNI per capita. However, this is a

negative relationship, with a coefficient of – 0.8. Even though it is expected to have a positive relationship, the negative relationship is perhaps due to the fact that consumers demand more imported livestock products while livestock farmers tend to decrease production. This may be supported by the evidence in Figure 4, above, where the SIE for livestock decreased over the years.

This scenario leads to further exploration of factors influencing diversification, and therefore food imports are factored into the equation. As shown in Table 1, the correlation coefficients between SIE and food imports (0.5 and – 0.7, respectively) are almost parallel to those between SIE and GNI per capita for crops and livestock. It appears that there is some degree of multicollinearity among the variables; note the strong correlation (0.9) between GNI per capita and food imports (Table 1).

The foregoing analysis shows that agricultural diversification can be explained by GNI per capita. The policy implication here is that consumers demand more food products and they turn to imports. However, there are opportunities for agricultural diversification with increasing demand for food items, but the opportunities are not realized.

The next chapter, therefore, examines the issues related to agricultural diversification to find out what is happening with the diversification in the food crop and livestock sub-sector of agriculture at the implementation level.

INDIVIDUAL ENTERPRISE DIVERSIFICATION

Agricultural diversification at the national level is not the same as diversification at the individual enterprise level. While the range of crops at the national level varies from 46 to 53, reflecting the cumulative number of crop types cultivated by all farmers, the range of crops at the individual enterprise

Table 1. Showing the correlation between diversification, percentage expenditure on agriculture, gross national income per capita, and food imports

	SIE Crops	**SIE Livestock**	**% Expend Agri, etc.**	**Income Per Capita**
SIE Crops	1.0			
SIE Livestock	-0.3	1.0		
% Expend: Agri, Fisheries, Lands, Housing	-0.2	0.1	1.0	
Income Per Capita	**0.5**	**-0.8**	-0.1	1.0
Food Imports	**0.5**	**-0.7**	-0.2	**0.9**

level would naturally be smaller. However, the range of livestock at the national level is relatively small (4 to 6 types), and it is feasible for individual enterprises to rear the full range of livestock as the national level. But it does not necessarily follow that a majority of livestock farms would consist of the full range of livestock as the national level. Therefore, it is important to compute the diversification index (SIE) at the individual enterprise level in this Chapter in order to know the variation and to examine separately what factors influence diversification. As such, this Chapter would also examine the farm and farmer characteristics.

The data set to compute the SIE and for the farm and farmer characteristics is derived from a survey questionnaire administered in 2005.

Representativeness of Questionnaire Survey Results

Table 2 shows the target population of 296 farms, i.e. the number of enterprises, the sample (168) size in relation to the target population and the number of acceptable responses (154). It should be noted that some of the responses were not complete enough to contribute to meaningful analysis, but the number of acceptable responses constitute an actual sample size of 52 percent of the target population. Thus the actual sample size is sufficient to achieve representativeness of the target population.

Among the 154 responses are 14 percent retired farmers and 6 percent of farmers that quitted farming (see Table 2). These categories were also target to find out the experiences of those that stopped farming and the reasons thereof.

The stratified random sampling technique applied to the survey yielded a distribution of responses representative of each of the 9 parishes in St.

Table 2. Showing number of survey responses in relation to target population

SURVEY RESPONSES AND FARMER IDENTIFICATION	# Crop Farms	# Live-stock Farms	# Mixed Farms	Total Farms
# of Enterprises/Target Population	233	81		296
Sample Size				168
% Sample Size to Target Population				**57**
# Acceptable Responses	**94**	**29**	**31**	**154**
% Responses to Target Population	40	36		**52**
Activity Status of Farmers	**Current**	**Retired**	**Quitted**	
# of Farms	124	21	9	154
% Total Responses	81	**14**	6	100

Kitts. Figure 7 shows the number of responses in each parish compared to the number of farms in each parish. It should be noted that all parishes are represented proportionately, with some small variations.

These variations result from the fact that the database for selecting the sample constituted farmers' residences, but not all farmers live in the same parish where the farms are actually located. Figure 8 shows that some parishes yielded more survey responses than there are farms in particular parishes. St. Peter, e.g., yielded more responses than the sample size reflects, while St. George yielded fewer samples. St. Peter is well known as an established farming area, while St. George is essentially more urban, having the Capital City of Basseterre. It is found that some farmers live in St. George but practice farming in St. Peter. This is true for some other parishes, as indicated in Figure 8. Nevertheless, each parish is adequately represented in the sample/responses.

Table 3 summarizes the distribution of survey responses by residence parish and by farm parish location in relation to the target population. Note that it is necessary to survey both crop and livestock farmers, but this issue

Figure 7. Showing representativeness of survey questionnaire responses

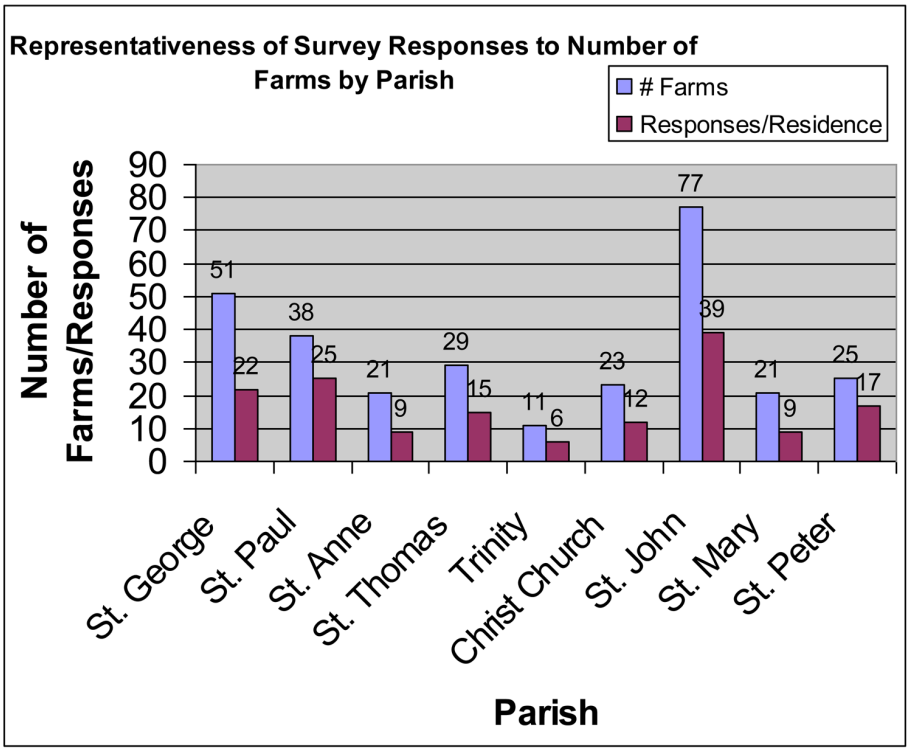
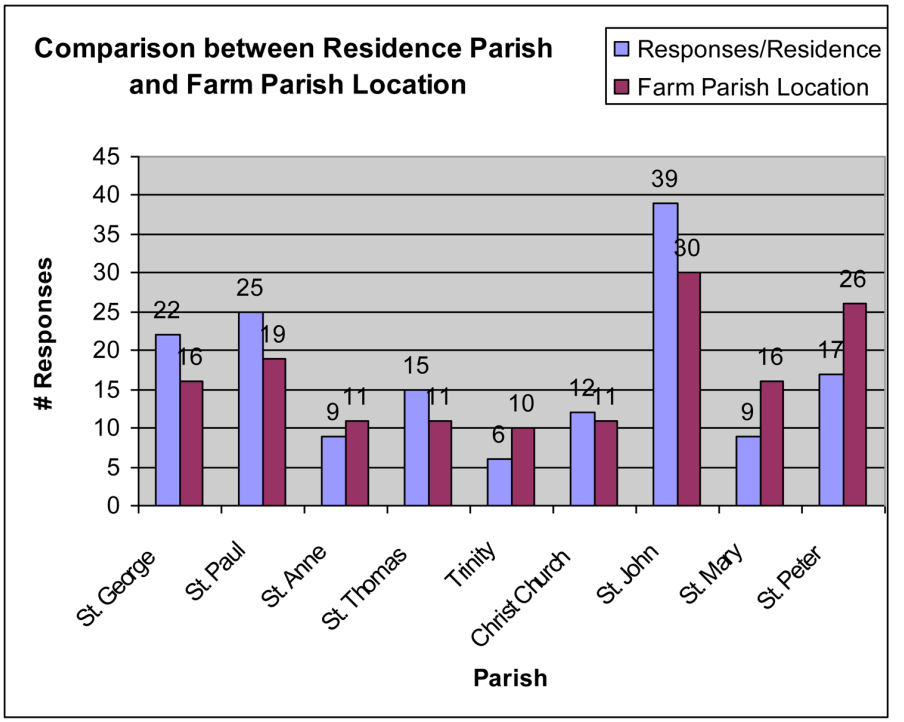


Figure 8. Showing how farmers' residences vary from actual farm locations



is addressed later in this chapter when the actual farm characteristics are examined. While the database of target population showed crop farmers and livestock farmers separately, the survey finds a substantial number of mixed enterprises practicing both crop and livestock farming.

Farmers are also identified by the extent or level of their involvement in farming. Table 3 shows that 60 percent of all farms operate on a part-time or seasonal basis. This indicates that the majority of farmers is not fully involved in farming and therefore is not likely to depend on farming alone as a source of income. Indeed, as much as 30 percent of all farmers have other occupations, as also shown in Table 3. While it is generally expected that a large percentage of subsistence farmers may have other occupations, it is significant to note that a substantial number of commercial farmers too have other occupations. This is perhaps reflective of the relatively small scale at which the commercial farmers operate in the context of St. Kitts. The majority of responses are from the farmers or farm holders themselves that are more fully aware than laborers or hired managers of the wide range

Table 3. Showing a summary of survey responses for representativeness

Representativeness of Responses by Parish	Target Population/ Residence	# Responses by Residence	# Responses by Farm Location	% Responses by Farm Location
St. George	51	22	9	**18**
St. Paul	38	10	14	**37**
St. Anne	21	24	21	100
St. Thomas	29	15	15	52
Trinity	11	11	10	91
Christ Church	23	7	6	**26**
St. John	77	18	18	**23**
St. Mary	21	20	19	90
St. Peter	25	27	38	**152**
TOTAL	296	154	150	

of issues relating to farming activities. But this representation is perhaps reflective of the low number of enterprises with hired managers or laborers, seen in Table 4.

Demographics

It is also necessary to examine the demographic characteristics of farmers at this stage. Apart from having potential policy implications, it provides background information on the social and cultural environment for understanding the nature of the issue of farming, as it involves to a great extent the everyday life and involvement of farmers and their households. Any policy for agricultural

Table 4. Showing type of farming level of involvement in farming

How Often Involved in Farming	Full-time	Part-time/Seasonal	Occasional	Total
# of Farms	59	92	3	154
% of Farms	38	**60**	2	100
Work Status	**Farm Holder**	**Farmer**	**Manager**	**Laborer**
# of Farms	51	100	1	2
% of Total Farms	33	65	1	1
0.9: Other Occupation	**Yes**	**No**	**No Answer**	**Total**
# of Farms	46	103	5	154
% of Total Farms	**30**	67	3	100

must take into consideration the livelihood of farmers. Table 5 shows the distribution of age groups, sex of farmer, level of educational attainment, and household size of farmers.

Table 5. Showing the demographic characteristics of farmers

DEMOGRAPHIC CHARACTERISTICS	**# Responses**	**% Responses**		
Age: Under 18 yrs	0	0		
18 - 34 yrs	11	7		
35 - 44 yrs	29	19		
45 - 54 yrs	80	**52**		
55 - 64 yrs	19	12		
65 + yrs	15	10		
TOTAL	154	100		
Sex	**Females**	**% Females**	**Males**	**% Males**
# of Farmers	41	**27**	113	73
Educational Attainment	**# Farmers**	**% Farmers**		
No Schooling	7	5		
Elementary School	17	11		
All-Age School	31	20		
High School	78	**51**	87	
Vocational/Technical College	15	10		
Bachelor's Degree	3	2		
Master's Degree and/or higher	1	1		
	152	100		
Household Size	**# Persons**	**% Total Popn**		
Under 18 yrs	203	**31**		
18 - 34 yrs	186	**29**	60	
35 - 44 yrs	100	15		
45 - 54 yrs	110	17		
55 - 64 yrs	25	4		
65 + yrs	24	4		
TOTAL	648	100		
# Persons in Each Household	**1-2 Persons**	**3-4 Persons**	**5 - 6 Persons**	**> 6 Persons**
# of Farms	31	54	41	23
% of Farms	21	**36**	28	15
# Responses (149)				

Notable in Table 5 is that the largest percentage (52%), by far, is in the age group 45 – 54 years old, followed by 19 percent in the younger age group 35 – 44 years old. This is quite contrary to the literature that most farmers in St. Kitts are old, retired people and that young people are not interested in farming. This assertion, however, contributes to the fact that there is not an overall great involvement of the general citizenry of St. Kitts in farming.

Table 5 also shows that as much as 27 percent of all farmers are females, although the literature on farming suggests that farmers are predominantly males. It is difficult to distinguish whether or not the female respondents are part of a household with males also involved in farming but were not available or did not choose to participate in the survey. Nevertheless, there is a growing trend of single, female head of households in St. Kitts, and it appears that females are turning to farming as they are to other occupations to become the sole breadwinner of their households.

With regards to educational attainment, the greatest percentage (51%) of farmers, by farm, indicated that they have attained high school education (see Table 5). It is not clear whether they have actually graduated from high school or only attended a few years of high school. When combined with those attaining lower than high school education, it amounts to 87 percent. Although this is not an unusual finding, it is important to note that higher educational training, particularly vocational and/or technical in agriculture and related specialties, is crucial to compete in a technologically oriented global arena.

Also in Table 5 is the distribution of household members by age group. The majority of household members are below 35 years old (31% under 18 years; 29% between 18-34 years old). This conforms to the wide base of the St. Kitts population structure, as is typical of lesser developed countries of the world. What is unusual, however, is that he majority of households (36%) has a household size of 3-4 persons. While this is atypical of lesser developed countries that tend to have large household sizes, it conforms to the relatively small average household size of 3 persons in St. Kitts computed by the St. Kitts Planning Unit. There is, however, a tendency of larger households in farming, with 28 percent of households having 5-6 persons (Table 5), thus translating to combined 64 percent for the wider age group of 3-6 persons. This would have implications for the labor source for farm work, to be discussed later in this chapter.

Farm Characteristics

Naturally, this is the largest group of data collected in the survey, as it encompasses such elements as ownership, tenure, physical farm characteristics, farming practices, crop and livestock types, production, marketing, problems experienced, farms assets, farm input credit, governmental assistance, and employment issues. It is also the component of the data set from which the agricultural diversification index (SIE) at the enterprise level is derived. It is the data collected from this section of the survey instrument that inform the research of what actually goes on on-the-ground and are sure to have implications for policy design and implementation strategies.

Ownership Status and Land Tenure

Most notable is the very high percentage (61%) of farms that are individually owned (see Table 6). Combined with household ownership (16%), about 75 percent of all farms have no third-party ownership. This indicates that farmers have a preference of operating on an individual or family basis and may have implications for the scale of farming enterprises and business orientation; these aspects would be discussed the sections to follow.

With regards to land tenure, the majority (46%), by far, of all lands for farming are government owned and where farmers squat. Other government owned farm lands (leased, rented, or free to operate) constitute 27 percent. Therefore, about 75 percent of lands occupied by farmers are owned by government. Several issues may be associated with such arrangements:

- Farmers may not be willing to develop infrastructure on lands that they do not own;
- Farmers may not be motivated to operate as intensively as if they were privately owned;
- The real value of the land may not be factored into the profit or loss of the enterprise;
- Farmers may occupy farm lands as a means of abode rather than for serious farming.

It is typical that issues of land are sensitive and have major implications for distributive or redistributive type policies.

Table 6. Showing ownership status and land tenure of farming enterprises

Ownership Status	# Farms	% Farms
Individual	**93**	**61**
Household	25	16
Government	25	16
Partnership - Farmer as Principal	10	7
Partnership - Farmer NOT Principal		0
Corporation		0
TOTAL	153	100
Type of Land Tenure	**# Farms**	**% Farms**
Squatting on Government Land	**69**	**46**
Self-owned	**22**	**15**
Lease from Government	**17**	**11**
Rent from Government	13	9
Operate Free from Government	10	**7**
Operate Free from Private	10	7
Squatting on Private Land	4	3
Rent from Others	3	2
Lease from Others	3	2
	151	100

Crop Farm Size

Table 7 shows that the highest percentage (51%), by far, of crop farms is less than one acre in size. When added to those that are less than 5 acres (26%), it amounts to about 75 percent of all farms being less than 5 acres. With further computation, there are actually about 70 percent of all farms that are less than 3 acres. Note, in earlier findings, there are about 65 percent of farms that are less than 3 acres, according to the St. Kitts Department of Agriculture. Therefore, the sample closely corresponds with the statistics gathered by the government.

It should be further noted that this pattern is consistent with the literature finding that the great majority of non-sugar crop farms in St. Kitts and the wider Caribbean are generally restricted to small sizes (less than 5 acres). The literature also finds that these small size farms are usually on marginal

Table 7. Showing number of crop farms by size of land

2.3: Farm Size (Crops)	# Farms	% Farms
< 1 acre	74	51
1 < 5 acres	38	26
5 < 10 acres	19	13
10 + acres	13	9
TOTAL	144	100

land and are generally fragmented. Observations in St. Kitts reveal the same pattern. This pattern would certainly have policy implications with regards to infrastructure development with regards to fragmentation, and scale of production with regards to farm size.

Crop Types

Of the 47 crop types reported in this survey, 16 are considered major based on their highest percentage dollar value of all crops produced. For the most part, these crops also coincide with the highest number of farms on which these crops are cultivated, with the exception of corn which has a significantly low number of farms producing it but ranks among the 16 highest in percentage value.

However, a closer look at the statistics in Table 8 reveals that only 4 crop types (peanut, tomato, pumpkin, and water melon) have individually large percentage contribution to total crop values, with another 2 crops (sweet pepper, and carrot) to a lesser extent. Nevertheless, 15 crop types are cultivated on a large percentage of total farms. It should be noted that the information derived from the survey for size of farms for crops is deficient due to incomplete information, mixed farming occupying the same space. However, information of the overall size of the farm is adequately reported, as described earlier in this chapter.

It is specifically from the number of crops cultivated on each farm and the percentage dollar value for each crop to the total value of all crops on the same farm that the diversification index (SIE) is calculated. The SIE is presented later in this chapter after the characteristics of livestock farms are described. In this way, it would display a comparative view of the SIE for crop and livestock farms.

Table 8. Showing major crop types and values on all farms in the sample

Crop Types	# Farms	% Farms	$ Value of Produce	% Value of Total
Peanut	**17**	**3**	**459550**	**23**
Tomato	**19**	**3**	**278933**	**14**
Pumpkin	**69**	**10**	**199625**	**10**
Water Melon	**44**	**7**	**195053**	**10**
Sweet Pepper	**60**	**9**	**143220**	**7**
Carrot	**38**	**6**	**123474**	**6**
Sweet Potato	36	5	84245	4
White Potato	32	5	77645	4
Dasheen	21	3	63475	3
Herbs	**50**	**7**	**51750**	**3**
Corn	**4**	**1**	**39600**	**2**
Cucumber	37	6	36480	2
Yam	24	4	34938	2
Cabbage	**55**	**8**	**30051**	**2**
Lettuce	32	5	18918	1
Thyme	31	5	15803	1
Other Crop Types (31)	**99**	**15**	**137925**	**7**
TOTALS	**668**	100	1990685	100
Crop Types and Production Values	**# Crop Types**	**% Crop Types**	**$ Value**	**% Value**
# Major Crop Types	16	34	1852760	**93**
# Other Crop Types	31	**66**	137925	7
TOTALS	47	100	1990685	100

Marketing and Profitability (or Loss) of Crop Produce

Farm produce is readily market at various outlets in St. Kitts, with supermarkets and the Central Marketing Corporation (government operated) as almost equally major outlets (see Table 9).

The Public Market or Farmer's Market is another major outlet (used by 19% of all farmers), and housed in a government, partly enclosed facility in the downtown, Capital City of Basseterre, is usually known for its Saturday event when farmers from across the island trade or sell what they reap during that week. It should be noted that Mondays are designated to produce from Dominica and St. Vincent and from where a marine vessel arrives in St. Kitts on a weekly basis. However that produce source(s) markets mainly

Table 9. Showing outlets used by crop farmers and levels of profitability/loss

Outlets (Crop Produce)	**# Farms**	**% Farms**		
Supermarket	58	**22**		
CEMACO (Gov't)	56	**21**		
Public Market	51	**19**		
Traders	39	15		
Restaurant (and hotels)	29	11		
Roadside	18	7		
Door-to-door	14	5		
Export	1	0		
# Responses (126)	266	100		
% Household Use/Giveaways	**Average %**	**# Hslds**		
	6	126		
Profitability/Loss (Crops)	**< $25K**	**$25-45K**	**> $45K**	**Loss**
# Farms	89	22	14	1
% Farms (126 responses)	**71**	17	11	**1**

green bananas, ground provisions, and citrus, items that are generally low in production in St. Kitts.

Observations at the marketplace on a frequent basis confirm that produce of sorts are almost always in high demand, and it not unusual to experience shortages in supply of oranges, tomatoes, and other fresh fruits and vegetables. A case in point, noted as recent as January 2005: tomatoes were scarce and demanding a price of more than the usual four to five dollars ($4 to $5) per pound.

For this reason, of high demand and low supply, the assumption can be made that the value of food crops (and livestock) sold equals the production resulting from of all farming activities in St. Kitts. It is also therefore assumed that there is no problem of finding markets and storage. Nevertheless, short-term waves of oversupply are noticeable at times but not to any significant extent to create a major glut on the market. Due to the fairly consistent high demand, farmers are not exposed to issues of storage in a major way, but this issue may need to be addressed in future policy if the country is moving towards greater production of food crops for the domestic and export markets.

This relatively high demand and low supply scenario partly explains the high food import bill compared to food exports. Although constituting an infinitesimally small percentage of outlets for crop produce, it is significant

to note that only one farm reports that it directly exports its produce (see Table 9). This, however, does not mean that exports are not done by traders (showing 15% outlet for produce). Also, partly for this reason, of high demand and low supply, some members of the general St. Kitts public question the apparent non-profitability of CEMACO. More information about CEMACO is currently sought by this ongoing research in an effort to examine the policy implications for agricultural diversification. This research also seeks to explore the implications of the newly emerging Caribbean Single Market and Economy as it relates to import and export of agricultural commodities. Currently, the "Monday" market supplied by Dominica and St. Vincent benefits from CARICOM and OECS terms on tariffs. However, the major portion of food imports are currently from the United States, and prices constitute a pressing issue for local consumers.

Problems Experienced on Crop Farms

Among the problems expressed by farmers in relation to their farming activities, pest and diseases (19%), monkeys (17%), and theft or praedial larceny (16%) are the most significant ones, with the highest percentages of farms experiencing such problems (see Table 10). Note that locating markets does not show up as a particularly significant problem and also that storage

Table 10. Showing the relative extent of the various problems on crop farms

Problems on Crop Farms	# Farms	% Farms
Diseases/Pests	81	**19**
Monkeys	69	**17**
Theft/Praedial Larceny	65	**16**
Transportation	45	11
Obtaining Labour	39	9
Stray Roaming Livestock	34	8
Locating Markets	27	6
Weather	27	6
Donkeys	14	3
Obtaining Credit	11	3
Obtaining Farm Inputs	5	1
Storage	1	**0**
# Responses (127)	418	100

is not an issue, confirming the assumptions in the previous section that value of crops equals production.

Many of the expressed problems are perhaps excusable to some extent, given that they require major capital input. However, the issue of monkeys appears to persist. There was a practice of shooting monkeys in St. Kitts to combat the problem, but this practice was outlawed due to concerns by tourists. When added to the problem with other animals (stray, roaming livestock, and donkeys), it is difficult to accept that these are tolerated to such extent. Apart from the issue of pests and diseases, the issue of monkeys and theft need high priority intervention so that farmers can seriously move forward with the business of farming.

Crop Farming Practices

In the above section, diseases/pests were the most significant problem experienced by farmers, while, as shown in Table 11 control of these problems is practiced on most (22%) farms. The high extent of crop rotation (21%) indicates some attention to environmentally sustainable practice. The significant use of inorganic fertilizers as well as disease/pest control, although normal practice, should not be overlooked, as overuse can pose a problem for the environment. Considering that the chemicals are subsidized, the real costs may not be realized, leading to the propensity of overuse, less desire to seek out alternatives, e.g. biological control mechanisms.

Although the use of protective clothing occurs on 56 percent of all farms (see Table 11), it is significant to note that its non-use (46%) is still high due to the inherent toxicity problems, both to the environment and human health, associated with the use of chemicals. What is even more significant is the fact that about 75 percent of farmers have not had formal training for disease/pest control. The St. Kitts Department of Agriculture is the main source of training for the relatively small percentage of farmers that are formally trained (Table 11).

Livestock Types, Date Started, and Farm Size

Naturally, there is not as much variability in livestock types as do crop types, as the traditional livestock types are cattle, goats, sheep, pigs and poultry. In Table 12 shows that most farms (30%) have cattle, followed by goats (21%), pigs (21%), and sheep (19%). It is significant to note that poultry production

Table 11. Showing the extent of farming practices used on crop farms

Crop Farming Practices	# Farms	% Farms	
Disease/Pest Control	**120**	**22**	
Crop Rotation	**113**	**21**	
Inorganic Fertilizers	**106**	**19**	
Farmyard Manure, Crop Residue, Filter Press Mud	84	15	
Mechanized Equipment	65	12	
Hybridized Seeds	41	7	
Open Pollinated Seeds	19	3	
TOTALS (126 Responses)	548	100	
Protective Clothing Use for Disease/Pest Control	**Yes**	**No**	**# Responses**
# of Farms	69	55	124
% of Farms	56	44	100
Formal Training for Disease/Pest Control	**Yes**	**No**	**# Responses**
# of Farms	30	94	124
% of Farms	24	**76**	100
Training Source	**# Persons Trained**	**% Persons Trained**	**Average Duration (months)**
Dept. of Agriculture	**17**	**68**	**1**
Sugar Industry	3	12	
UWI	2	8	25
Other	3	12	13
	25	100	

is quite low (only 7%). With no particularly large scale of poultry production anywhere on the island, the import of chicken is very high.

Table 12 also shows that the majority of livestock farmers (45%) first started farming before 1990, with still a significant number (40%) between 1990 and 1999. However, only a small percentage began in 2000, and none since 2000, despite the launching of the new 2002-2007 Agricultural Diversification Program in St. Kitts. Note that this statistic was sketchy for crop farmers due to either misinterpretation of the question or unwillingness – or uncertainty – of farmers to give such information.

The majority of livestock farms (67%), consistent with the literature, are less than 5 acres, with those less than one acre constitution 47 percent (see Table 12). In St. Kitts, there is the phenomenon of stray roaming livestock, and, as mentioned earlier in this chapter, they are a menace to crop farmers.

Table 12. Showing types, date started, and size of livestock farming

Livestock Types	# Farms	% Farms	$ Value of Products	% Value of Total
Cattle	30	30		
Goats	21	21		
Sheep	19	19		
Pigs	21	21		
Poultry	7	7		
Donkey	1	1		
Rabbits	2	2		
TOTALS	101	100		
First Started in Livestock Type	**# Farms**	**% Farms**		
Before 1980	10	12		
1980 - 1989	27	33		
1990 - 1999	33	40		
2000 - 2000	12	15		
TOTALS	82	100		
Livestock Farm Size	**# Farms**	**% Farms**		
< 1 Acre	23	47		
1 < 5 Acres	10	20		
5 < 10 Acres	6	12		
10 + 10 Acres	10	20		
	49	100		

Marketing and Profitability (or Loss) of Livestock Products

Like in the case of crop produce, CEMACO is one of the major outlets for livestock products, particularly beef (see Table 13). However, in the case of livestock, traders and the abattoir are also major outlets. This is perhaps due to the special processing and handling that livestock requires.

The majority of farms (65%) indicate a profitability of less than $25,000 (see Table 13), a situation quite similar to that of crop farms (Table 7).

Table 13. Showing outlets used by livestock farmers, and profitability/loss

Outlets (Livestock Products)	**Cattle**	**Goats**	**Pigs**	**Sheep**
Restaurant	3	3	4	3
Supermarket	**9**	1	3	3
CEMACO	**10**	**6**	**6**	4
Traders	7	**10**	**7**	**7**
NELFA	1			
Abattoir	**11**	**6**	**6**	3
# Livestock Farms (97)				
Profitability/Loss (Livestock)	**< $25K**	**$25-45K**	**>$45K**	**Loss**
Cattle	14	8	1	0
Poultry	2	1	1	0
Goats	7	0	0	0
Pigs	5	3	1	1
Sheep	9	3	0	1
# Farms/responses (57)	37	15	3	2
% Farms	**65**	26	5	4
% Household Use (avg)	**# responses**	% Use		
	52	11		

Problems Experienced on Livestock Farms

As seen in Table 14, among the various problems reported by farmers, dog attacks on livestock stand out as the most menacing, followed by theft or praedial larceny. This is a similar scenario as that occurring on crop farms, further illustrating the pervasiveness of such problems. Diseases and pests also pose a problem for livestock farms.

Livestock Farming Practices

Disease/pest control is practiced to a great extent (23%) as in the case of crop farming. Securing animals also ranks high among practices. This indicates that effort is made to mitigate the problems of stray roaming livestock and theft/larceny. Rotational grazing is also practiced to a great extent (18%), a parallel to crop rotation in the case of crop farms. Similarly, there is a

Table 14. Showing problems on livestock farms

Problems on Livestock Farms	Cattle	Goats	Pigs	Sheep
Obtaining Labour	2	1	2	1
Obtaining Credit	1		1	2
Locating Markets	5	4	2	2
Transportation	**7**	7	7	5
Obtaining Farm Inputs	1		1	2
Theft/Praedial Larceny	6	**11**	6	6
Pests & Diseases	**12**	7	4	4
Dogs	**11**	**14**	3	**12**
Adverse Weather	2	2		2
# Farms/responses (86)	47	46	26	36

significant percentage (56%) of farmers that do not use protective clothing when applying disease/pest control. Also, for the small percentage of farmers with formal training in applying disease/pest control, the main source of training is the St. Kitts Department of Agriculture.

Farm Inspection by St. Kitts Department of Agriculture/Extension Officers

For both crop and livestock farms, the largest percentage (37%) have never been inspected or monitored by the Department of Agriculture (see Table 16). Institutional support to complement the effort of farmers is essential for successful attainment of any diversification program objectives. It is also an important mechanism to help policy makers, planners and technicians know what is actually going on on-the-ground.

Farm Irrigation

Table 17 shows that about 60 percent of all farms are irrigated, with a great portion (about 70%) of the entire farm being irrigated. Additionally, about 70 percent use overhead sprinklers. It is also noted that water supply is available to most (about 75%) farms. However, a closer examination of farm irrigation reveals that the supply is mainly (about 60%) from catchment supply. this conforms that farms in St. Kitts are mostly rain-fed. This would have implications for reliability of water source for farming. The central

Table 15. Showing the extent of practices used on livestock farms

Farming Practices (Livestock)	# Farms	% Farms	
Supplemental Feed	33	15	
Disease/Pest Control	52	**23**	
Breeding/Selection	31	14	
Securing Animals	49	**22**	
Pasture Development	16	7	
Fodder Bank Development	5	2	
Rotational Grazing	40	**18**	
TOTALS (60 Responses)	226	100	
Protective Clothing for Disease/Pest Control	**Yes**	**No**	**# Responses**
# of Farms	25	32	57
% of Farms	44	56	100
Formal Training for Disease/Pest Control	**Yes**	**No**	**# Responses**
# of Farms	12	36	48
% of Farms	25	75	100
Training Source	**# Persons Trained**	**% Persons Trained**	**Duration (avg. mths)**
Dept. of Agriculture	7	78	1
Sugar Industry	1	11	
UWI	1	11	48
TOTALS	9	100	

Table 16. Showing frequency of farm inspection by St. Kitts department of agriculture

Inspected/Monitored by DOA	# Farms	% Farms
Once/Year	22	14
Once/6 months	23	15
Once/3 months	30	20
Once/month	22	14
Never	56	**37**
TOTALS	153	100

mountain ranges in St. Kitts, rising to about 3,700 feet, provides the condition for considerable amounts of orographic rainfall, but the steep slopes and lack of irrigation infrastructure do not allow much of it to be harnessed. Productivity of particular crops, e.g. tomatoes, may be increased multiple times with proper irrigation systems, according to officers at the St. Kitts Department of Agriculture.

Table 17. Showing extent and methods of farm irrigation

Farm Irrigation	**Yes**	**No**	**Total**	
# of Farms	92	55	147	
% of Farms	63	37	100	
Area of Farm Irrigated	**< 50%**	**50 < 100%**	**Entire (100%)**	**Total**
# of Farms	4	16	49	69
% of Farms	6	23	71	100
Irrigation Method	**Hand**	**Overhead Sprinkler**	**Drip Irrigation**	**Total**
# of Farms	11	69	11	91
% of Farms	12	76	12	100
(5 farms with > 1 Irrigation Method)				
Water Supply Availability	**Yes**	**No**	**Total**	**(No), but within 1/2 mile**
# of Farms	90	28	118	18
% of Farms	**76**	24	100	64
Source of Water Supply	**Public, Piped**	**Catchment**	**Dam, Piped**	**Total**
# of Farms	34	68	16	118
% of Farms	29	**58**	14	100

Source of Information to Farmers

The majority of farmers, by far, received their information about farming from the radio and other farmers; all the major institutional sources trail far behind (see Table 18). However, it cannot be ascertained from the survey data whether or not any of the radio information that farmers use is facilitated by any of the agricultural institutions. Perhaps it is easier for more information to be disseminated more effectively and reach farmers more readily. However, it is important that agricultural institutions take the lead in information provision for farmers not only to realize the commitment of those institutions but also to ensure the quality and application/use of such information.

Also revealed in Table 18, is that more than 90 percent of farmers do not have any membership or affiliation with agricultural based organizations. This can potentially be a great mechanism for information provision. Moreover, organizations can be a vital mechanism for helping farmers to benefit from collaborative efforts for many aspects of farming operations, including marketing of products.

Table 18. Showing source of farm-related information to farmers

Source of Information	First (main)	Second	Third	Total
Extension Service	21	6	4	31
Radio	**69**	**33**	**6**	**108**
Other Farmers	**26**	**66**	**20**	**112**
Almanac	1	3	2	6
Newsletter	5	4	11	20
CARDI	2	7	4	13
IICA	0	0	1	1
ROC	2	2	2	6
Agri Diversification Program	11	6	6	**23**
Others (Canada, reading)	5	1	2	8
Membership/Affiliation	**Yes**	**No**	**Total**	
# of Farmers	10	129	139	
% of Farmers	7	**93**	100	
Organizations	**# Farmers**			
Small Farmers Peanut Growers Association	2			
St. Kitts Farmers Co-op	6			
Progressive Pig Farmers Association	1			
St. Kitts Pineapple Association	1			
TOTAL	10			

Farm Input Credit

Of all farmers, 37 percent indicated that they required farm input credit (or cash) for use on the farm, but it is significant to note that only 12 percent of all farmers (18 farmers) received farm input credit (see Table 19). Moreover, 56 percent of those who indicated that they received credit obtained it from a commercial or private bank (FND), with interest rate of as much as 13 percent. The St. Kitts Development Bank was also a notable lending source with a lower (11%) interest rate. Information about loan fees and grace period appear incomplete, but in most cases there was a grace period before the loans went into repayment.

Table 19. Showing the use and terms of farm input credit

Required Cash or Credit During Past 3 Years	**Yes**	**No**	**Total**	
# of Farmers	53	92	145	
% of Farmers	**37**	63	100	
Received Cash or Credit	**Yes**	**No**	**Total**	
# of Farmers	18	125	143	
% of Farmers	**12**	88	100	
Credit Source	**# Farmers**	**% Farmers**		
Commercial Bank	5	**28**		
Development Bank	5	28		
Credit Unions	1	6		
FND	5	**28**		
Dept. of Agriculture	0	0		
Family/Friends	2	11		
	18	100		
> 1 Credit Source	2			
Credit Sources	**$Borrowed ($ Owing)**	**% Int**	**Fees**	**(Duration) (Grace)**
Credit Union, FND	5 figure (0)			
Credit Union	50000	**13**	2700	Grace (3)
FND	12500 (16000)	**13**		(200)(3)
FND	3000 (400)	7		(18)(3)
Commercial Bank	2000	7		
Commercial Bank				
Development Bank, CU, FND	5400 (0)	**11**	115	(30)(3)
Development Bank	8000			
Development Bank	5000	8	250	Grace (12)
Development Bank				

Keeping Farm Records and Business Plan

Keeping records is an essential part of any business operation, as much as 80 percent (see Table 20) of all farmers do not keep business records. Additionally, as also seen in Table 20), over 90 percent of farmers do not have a business plan. Perhaps this is reflective of the non-business approach to farming, but it can also be due to a lack of business training. This is a sensitive question for tax purposes, but the question was answered to a great extent; there were

only two non-responses to this question. A business orientation or approach to farming, especially for these commercial farmers, is vital with regards to competitiveness, profitability, obtaining credit, and overall development of their farming enterprise. Table 20 also shows that very little training takes place. However, the St. Kitts Department of Agriculture is a main source of training.

Household Members Working on the Farm

Contrary to the general perception of the St. Kitts public that mostly old people are involved in farming, this survey shows that the majority of household farm workers are young people (26% below 18 years of age, and 36% in the age group 18-34 years old (see Table 21). This is consistent with the finding on age of farmers, mentioned earlier in this chapter, that many young people

Table 20. Showing the keeping of farm records, business plan, and related training

Keep Farm Records	**Yes**	**No**	**Total**
# of Farmers	30	122	152
% of Farmers	20	**80**	100
Received Credit and Keep Records	12		
Farm Business Plan	**Yes**	**No**	**Total**
# of Farmers	9	141	150
% of Farmers	6	**94**	100
Received Credit and have Business Plan	7		
Training in Farm Management/Keeping Farm Records	**Yes**	**No**	**Total**
# of Farmers	17	130	147
% of Farmers	12	88	100
Received Training and have Business Plan	4		
Received Training and Credit	8		
Training Sources	**# Persons Trained**	**Avg Duration**	
Dept. of Agriculture	7	10 days	
Development Bank	1	4 days	
GSA	1	2 years	
Guyana	1	5 days	
UWI, DOA	1	4 years	
IICA, DOA	1	1 year	

Table 21. Showing distribution of household farm workers

Household Farm Workers	# Persons	% Persons
Under 18 yrs old	79	26
18 - 34 yrs	110	36
35 - 44 yrs	50	17
45 - 54 yrs	46	15
55 - 64 yrs	8	3
65 + yrs	9	3
TOTALS	**302**	100
# Household Workers per Farm	**# Farms**	**% Farms**
1 to 2 persons	44	44
3 to 4 persons	42	42
5 to 6 persons	10	10
> 6 persons	4	4
TOTALS	100	100

are involved in farming in St. Kitts. There is also consistency with regards to household size; 44 percent of farmers have households of less than 2 persons, and another 42 percent have households with 3-4 persons (see Table 21).

Types of Farm Employees and Conditions of Employment

Among 154 farms, only 52 persons are employed on 29 farms. Table 22 shows the distribution of the number of employees on these farms. Note that the great majority of farms (about 90%) with employees have between 1-2 employees, and also the majority of employees are males working on a full-time basis. However, there is an almost even distribution of male and female employees hired on an occasional basis. There are 11 overseas employees; 7 from Guyana, and 4 others for whom the country of origin is not stated. The average number of hours worked per day and per week, and the hourly wages are consistent with general employment conditions in the context of St. Kitts. However, it is significant to note that 15 workers, with 10 of the 11 overseas workers, are unpaid. It is not certain of the type of arrangements in these circumstances, but it is indicated that they work for food or farm produce.

Table 22. Showing types of farm employees and conditions of employment

# of Employees on Farms	# Farms	% Farms	# Workers	
1 person	14	**48**	14	
2 persons	12	**41**	24	
3 persons	1	3	3	
4 persons	1	3	4	
7 persons	1	3	7	
	29	100	**52**	
Employee Types	**Full-time**	**Part-time**	**Occasional**	**Totals**
# of Males	23	6	10	39
# of Females	3	3	8	14
Total # of Employees	26	9	18	53
# of Local/St. Kitts	18	6	18	42
# of Overseas	8 (6 from Guyana; 2 unnamed country)	3 (1 from Guyana; 2 unnamed country)	0	11
# of Farms	15	7	11	33
Average Hours/day	8	6	4	
Average Hours/week	47	30	18	
Average Hourly Wages	17	23	17	
Range of Hourly Wages/Benefits	$6 to $35	1 person gets $50/hr @ 1hr/wk	1 Farms pays Soc. Sec. Benefits	
Unpaid/work for food or produce (OS = Overseas)	8 (OS)	4 (2 OS)	3	15

Farm Assets

The majority of farms have vehicles (mostly pick-up trucks) and light equipment (see Table 23). The average value per vehicle is $33,695, indicating that farmers have relatively high to medium cost vehicles, with some to a lesser extent having old vehicles. Perhaps this is an indication that farmers are doing generally well to be equipped to this extent with vehicles. However, it may also be that this is their sole vehicle that is used for other (non-business) purposes. It is also important to note that the average cost of vehicles is greater than the average cost of heavy equipment ($24,316). The low investment in heavy equipment is indicative of the scale of farming, as well as the fairly low level of mechanization. As asserted earlier in this chapter, farmers may not be willing or have the incentive to invest in building infrastructure (averaging 12,419 per farm). Also, land asset is not necessarily of high value, as the land is predominantly government owned.

Table 23. Showing the types and average value of farm assets

# Farms with Assets	Building, Land, etc.	Vehicles	Heavy Equip	Light Equip
# Farms	69	**125**	**28**	125
Average Value of Assets per Farm	12419	**33695**	**24316**	2759
# of Responses with Value	62	56	25	115

Awareness and Influence of Agricultural Diversification Plan (2002-2007)

Table 24 shows that 55 percent of farmers are aware of the current 5-year Agricultural Diversification Plan, launched in October, 2002. Although this percentage is higher than the percentage of those who are not aware of the plan, any diversification plan should seek to sensitize the great majority of people about its mission and objectives, particularly commercial farmers who are most directly involved in farming activities and can contribute to its failure or success. Moreover, the majority of farmers declare that the plan has not influenced their farming activity, although the majority overall thinks that the plan would help to improve agriculture in St. Kitts.

Table 24. Showing awareness and influence of agricultural diversification plan

Awareness of Agricultural Diversification Plan (2002)	Yes	No	Total
# of Farmers	83	67	150
% of Farmers	55	**45**	100
Awareness/Influence	**Extent of Awareness**	**Think It would help Agri**	**Influence Your Farming Activity**
1 = Little/Not at all	5	4	22
2	9	8	13
3	3	8	12
4	21	**18**	12
5	15	**16**	1
6	13	**8**	9
7 = Great	17	**19**	13
# of Responses	83	81	82

Annual Household Income and Farm Income

Over 80 percent of farmers reported annual household income (from all sources) of less than $35,000 (see Table 25). This is consistent with the national median income of about $20,000 per person (according to the St. Kitts Department of Social Security for the year 2003), and considering that the average household size is 3 and potentially 1-2 persons working in each household.

Further noted in Table 25 is that the majority (about 70%) indicated that less than 25 percent of their household income is attributed to farming activities, with most in the lower income categories. This illustrates that, even for commercial farmers, the income or dependence on income from agricultural is secondary too other sources of income – a pattern consistent with the high percentage of farmers involved in other occupations, discussed earlier in this chapter.

Table 25. Showing annual household income and % from agricultural activities

Annual Household Income of Farmers (from all sources)	**# Households**	**% Households**		
Under $15K	26	**19**		
$15 - 24,999	52	**38**		
$25 - 34,999	38	**28**	**84**	
$35 - 44,999	9	7		
$45 - 54,999	6	4		
$55K +	7	5		
TOTALS	138	100		
% of Household Income from Agricultural Activities	**< 25%**	**25 - 49%**	**50 - 74%**	**75% +**
Under $15K	**15**	4	2	5
$15 - 24,999	**39**	10	3	0
$25 - 34,999	**12**	11	7	8
$35 - 44,999	3	1	4	1
$45 - 54,999	2	2	0	1
$55K +	1	1	2	3
TOTALS (137 Responses)	**72**	29	18	18

Agricultural Diversification Index for Individual Enterprises

The foregoing farmer and farm characteristics have set the backdrop for understanding the nature of agricultural diversification and its influential factors. The Agricultural diversification index can now be presented.

As alluded to earlier in this chapter, the Shannon Index of Entropy (SIE) is calculated by using the range of crop or livestock types on individual enterprises and their percentage value to the total value of production on that particular enterprise. In the case of the SIE at the national level, it was calculated for crop and livestock farms separately. However, in this instance of individual enterprises, the SIE is also calculated for mixed farms, i.e. for enterprises that practice crop and livestock farming concurrently.

Figure 9 shows the SIE for crop, livestock, and combined crop and livestock farms (mixed enterprises) at the individual enterprise level. The number of livestock only farms (94) far exceeds the number of crop only farms (29). There is an additional 31 farms practicing both crop and livestock farming. The SIE for all livestock farms fall generally between 1-2, whereas, all livestock farms fall below one, with many at zero – having only one livestock type. Some mixed enterprises exceed an SIE of 2, indicating a potentially higher level of diversification than for crop only or livestock only farms.

Overall, individual farms show a generally low level of diversification compared to an optimum SIE of 1.61 for crop and mixed enterprises. The optimum SIE is derived when the average number of crop types is 5, with each contributing equally to the total value of production on that particular enterprise. The optimum number of 5 crops is taken from the average number of crops planted by each farmer (677crops/154 farmers = 4.4; or mode = 5). Note that the average number of crops and livestock on mixed enterprises has the same mode as crop only enterprises; the overwhelming majority of mixed enterprises has only one livestock type. It is possible to have an SIE higher than 1.61, for instance, if the number of crops exceeds 5 and with equal value of production in each crop type. However, it would be more practical to produce about 5 crops (including or not including one livestock type) to achieve optimum diversification rather than maximum diversification, taking into consideration such issues as the relatively small average in farm size, manageability, number of employees, growing season, and farm inputs.

The optimum SIE of 0.69 for livestock only enterprises based on 2 livestock types per farm. The average number of livestock per farm is 1.3

(38 livestock types/29 farmers = 1.3; mode = 1, with 21 of 29 farms having only one livestock type). Note that one livestock type per farm translates to an SIE of zero. The optimum SIE is calculated based on two livestock types to achieve risk spreading.

Figure 9 illustrates that the majority of enterprises falls below an SIE of 1.61. This scenario is representative of the few number of crop types with high levels of production values, while the great majority of other crop types contribute a small percentage to total value, despite the average number of crops per farm being 5. Also in Figure 9, the majority of livestock enterprises, by far, fall below the optimum SIE of 0.69. Also, the majority of mixed enterprises fall below the optimum SIE of 1.61, but this type of enterprise has the greatest potential to achieve a high degree of diversification.

A low SIE can result in potentially high vulnerability to losses in the event of such things as a shift in market forces, higher incidence of diseases and pests, and adverse weather conditions. Risk spreading is therefore key in achieving diversification and, ultimately, greater potential for long-term profitability.

Table 26 illustrates, in another way, the distribution of enterprises relative to the optimum SIE of 1.61 for crop and mixed enterprises, and to the optimum SIE of 0.69 for livestock enterprises. While there is an even distribution

Figure 9. Showing diversification index for crop, livestock, and mixed enterprises

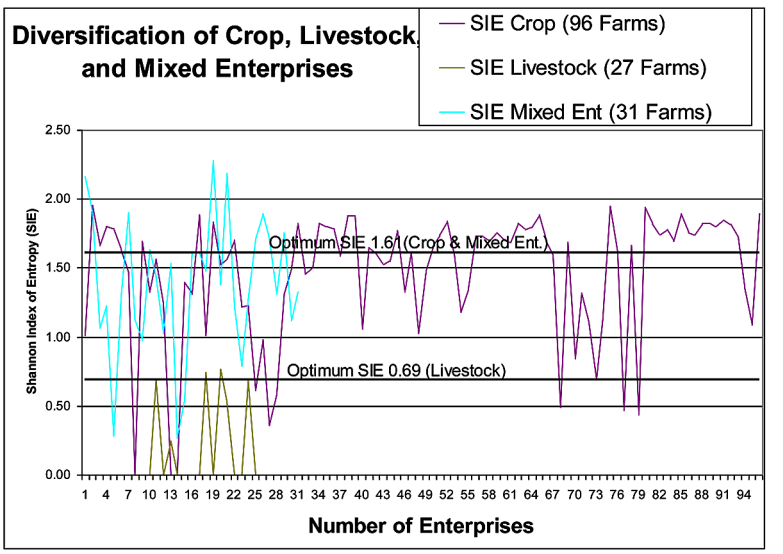


Table 26. Showing distribution of enterprises relative to optimum SIE

Enterprise Type	# Farms with SIE < 1.61	% Farms with SIE < 1.61	# Farms with SIE = > 1.61	% Farms with SIE = > 1.61
Crop Farms (94)	45	49	49	51
Mixed Enterprises (31)	19	61	12	39
	# Farms with SIE < 0.69	**% Farms with SIE < 0.69**	**# Farms with SIE = > 0.69**	**% Farms with SIE = > 0.69**
Livestock Farms (29)	23	79	9	21

of crop farm enterprises in relation to the optimum SIE, the majority of livestock farms (over 90%) fall below the optimum SIE. The majority of mixed enterprises (about 60%) also fall below the optimum SIE.

Correlation Between Diversification and Variables Related to Farming Activities

The issues identified in the foregoing sections are very likely to be influential upon the SIE. The following correlation coefficients (represented by R^2 or R-Square) would illuminate such influence, with R^2 values that can range from 0 to 1 or -1, where 0 indicates no relationship, and 1 or -1 indicating the strongest positive or negative relationships, respectively.

Among the 58 data points (variables) derived from the questionnaire survey, only 2 variables show particularly significant relationships with agricultural diversification (SIE), as can be seen in Table 27.

As expected, the relationship is strongest between with the SIE and the enterprises that practice both crop and livestock farming and progressively

Table 27. Showing correlation between SIE and independent variables

Independent Variables with Highest Significance	R^2
Combined Crop & Livestock Enterprises	**0.92**
Crop only Enterprises	**0.82**
Livestock only Enterprises	**0.51**
Dept. of Agriculture Assistance Received	**0.35**
Water Available within ½ Mile of Farm (if farm is not irrigated)	**-0.39**
Irrigation on Farm	**-0.43**

weaker relationships between enterprises that practice only crops and only livestock. The varying strengths of these relationships confirm the graphic indicators in Figure 9 where combined crop and livestock enterprises show the highest level of diversification over crop only enterprises and livestock only enterprises. Note in this analysis that again livestock only enterprises show a significantly weaker level of diversification than the other enterprises.

Although the other independent variables in Table 27 are not necessarily strongly related to agricultural diversification, they are the only other factors among the 58 that were examined that show any noteworthy significance. It is important to note that even the variables that show the most significant relationships, i.e. enterprise types earlier referred to in Table 26, are essentially measures of how diversified those enterprises are and not necessarily factors influencing diversification.

Therefore, the most significant factors influencing agricultural diversification are actually farm irrigation or availability of water within ½ mile of those farms that do not have irrigation, and Department of Agriculture assistance to farmers.

Irrigation on the farm is the most influential factor of agricultural diversification (note that the questionnaire item required a Yes/No response and, therefore, the negative relationship relates only to the numeric allocation to "Yes" and "No" and is does not mean that farms with greater diversification are less irrigated; similarly, questionnaire item also required a Yes/No response). For farms that are not irrigated, availability of water within ½ mile of the farm is of importance to agricultural diversification. Therefore, the overall availability of water is of primary importance among physical farm characteristics to promote agricultural diversification.

Assistance to farmers from the Department of Agriculture is also an influential factor on diversification. The number of farmers that indicated in the survey questionnaire having received some form of such assistance is 43 (about 30%) among the 154 survey respondents (see Appendix 4, in digital format, also showing the types and nature of assistance).

Although these influential factors are not statistically significant, they are of most significance among the influential variables. But more noteworthy, is the policy implications of these factors. Any diversification policy should perhaps focus on these issues with high emphasis.

Cross-Cutting Analysis of Independent Variables

This category of analysis illuminates the dynamics among other activities related to farming, but they may ultimately influence agricultural diversification. It should be noted that this section presents only the variables that show some level of significance among the 3,364 possible associations (58 by 58 matrix) that may be derived from the multiple-correlation analysis. As in the case of influential variables on agricultural diversification, there are very few with statistical significance (with R^2 above 0.5). Therefore, those with R^2 of approximately 0.4 are also considered, as they are among the highest category in the possible 3,364 associations.

As expected, there is a significant relationship between availability of water and farm irrigation (see Table 28), and where water supply is available, there is some relation to assistance from the Department of Agriculture. This relationship further establishes the important role that the Department of Agriculture may play in agricultural diversification. Additionally, where irrigation is used, but water supply is available within ½ mile of the farm, there is some relationship to the water source, i.e. a water source is available

Table 28. Showing correlation of independent variables

Variables	*2.12 Irrigation on Farm*
Water Supply Available	**0.58**
	2.13 Water Supply Available
Dept. of Agriculture Assistance Received	**-0.37**
	2.13.1 Water Source
Water available within ½ mile of Farm	**-0.50**
Dept. of Agriculture Assistance Received	**0.40**
	2.3 Farm Size
Pest Control Training for Crops	**-0.43**
Dept. of Agriculture Assistance Received	**-0.42**
Tenure	**-0.36**
Irrigation on Farm	**0.39**
Water available within ½ mile of Farm	**0.40**
Total Dollar Value of Farm Production	**0.42**
	2.4 Tenure
Profitability of Crop Farms	**-0.44**
Percentage Household Income from Agriculture	**-0.38**

as well. Noteworthy again is the role of the Department of Agriculture. Also significant is the relationship between Department of Agriculture assistance and farm size. There is a tendency towards assistance for larger size farms.

Larger size farms (also in Table 28) tend to have more likelihood of farmers with training for pest/disease control for crops, irrigation or availability of water within ½ mile of the farm, and greater dollar value of crop and/or livestock production. Additionally, there is an association between tenure type and farm size; government owned lands, whether leased or occupied by squatters, tend to be larger than privately owned plots. However, on lands that are government owned, there is a tendency for less profitability and, likewise, a smaller percentage of household income from farming. As suggested earlier in this chapter, there is perhaps less motivation to produce to the optimum potential of the land when it is not owned by the farmer.

Ultimately, it is hoped that greater diversification would lead to greater profitability to individual farmers, but it does not mean that more diversified farms have greater profitability. Table 29 shows another set of significant relationships, i.e. the factors most significant on profitability. Most significant is the relationship between profitability on crop farms and livestock farms. This indicates that crop farms are more likely to be profitable when associated with livestock farms; note also in Table 29 that there is a strong relationship between number of crops per farm and the number of crops and livestock per

Table 29. Showing factors influencing profitability of crop and livestock farms

	Profitability of Crop Farms
Keep Farm Records	**-0.35**
Training in Farm Management/Record Keeping	**-0.33**
Would Recommend Farming as a Business	**0.36**
Would Recommend Farming as Employment	**0.37**
Preference to Consume Local Farm Produce	**0.40**
Percentage Household Income from Agriculture	**0.47**
Profitability of Livestock Farms	**0.53**
	Profitability of Livestock Farms
Pest/Disease Control Training for Livestock	**-0.36**
Number of Household Workers	**0.35**
Annual Household Income	**0.37**
	Number of Crops
Number of Crops and Livestock	**0.87**

farm. As noted earlier in Figure 2.9, mixed enterprises also have a greater degree of diversification. A greater number of agricultural types does not necessarily mean that there is greater diversification but is a precondition for greater diversification, as diversification has to do with how the revenue is distributed among the various crop and livestock types.

Also, crop farmers with greater profitability have a greater percentage of their household income from agriculture. Profitability of crop farms is also associated with those that keep farm records or have some kind of training in farm management or record keeping. Additionally, farmers with greater profitability are more likely to recommend farming as a business or employment to others. Profitability of livestock farming is also influenced to some extent by the practice of pest and/or disease control, as well as number of household workers on the farm. Table 29 also shows some association between profitability and household income, but note that household income may be attributed to other types of income than from livestock farming.

There is a strong relationship between training for pest and/or disease training for crops and such training for livestock (see Table 30). This is perhaps due to the fact that some farmers practice both crop and livestock farming and the training may be transferable. Such farmers are also more likely to be trained in farm management and/or record keeping, with the issue of training derived from the same source as pest/disease control training and the same importance placed on training, and with the Department of Agriculture playing a significant role for those who have been trained. However, only

Table 30. Showing factors influencing pest/disease control for crops/livestock

	Pest/Disease Control Training for Crops
Number of Employees	**-0.42**
Total Dollar Value of Farm Production	**-0.37**
Keep Farm Records	**0.36**
Affiliation/Membership	**0.36**
Department of Agriculture Assistance Received	**0.42**
Training in Farm Management/Record Keeping	**0.49**
Training for Pest/Disease Control for Livestock	**0.67**
	Pest/Disease Control Training for Livestock
Would Recommend Farming as a Business	**-0.36**
Has a Farm Business Plan	**0.38**
Training in Farm Management/Record Keeping	**0.39**

about 20 percent of all farmers have received training. Likewise, those who have received training are more likely to have a business plan, although only about 5 percent of all farmers have a business plan. Also, there is an association between training and affiliation or membership with a farming organization. Such affiliation can perhaps have an influence on the value farmers place in training. Additionally, value of production tends to be higher for farmers who have received training in pest/disease control.

Table 31 shows interrelationships among a number of organizational or institutional related factors. There is a relationship between those with affiliation or membership to organizations and percentage household income from agriculture; note that less than 10 percent of all farmers such affiliation or membership. There is also a relationship between those who required cash or farm input credit and those who received them; note again that only about 10 percent of all farmers received cash or farm input credit. Those who received cash or farm input credit are more likely to keep farm records, to have a farm business plan, to take training, as well as to receive assistance from the Department of Agriculture. The other indicators in Table 31 further illustrate the interrelationships among these variables. Moreover, there is a

Table 31. Showing relationship between organizational/institutional factors

Variables	*Affiliation/Membership*
Percentage Household Income from Agriculture	**-0.39**
	Required Cash/Credit
Received Cash/Credit	**0.46**
	Received Cash/Credit
Keep Farm Records	**0.47**
Have Farm Business Plan	**0.57**
Training in Management/Record Keeping	**0.40**
Department of Agriculture Assistance Received	**0.39**
	Keep Farm Records
Agri Div Plan Influenced Farming Activity	**-0.42**
Extent of Awareness of Agri Div Plan	**-0.36**
Have Farm Business Plan	**0.36**
Considering Changes on Farm	**0.39**
Training in Management/Record Keeping	**0.40**
	Farm Business Plan
Training in Management/Record Keeping	**0.35**

relationship between those who keep farm records and the influence of the agricultural diversification plan and extent of awareness of the plan.

The category of variables in Table 32 illustrates the attitudes of farmers towards agricultural diversification and how it may have influenced their farming activities. There is a relationship between farmers' awareness of the agricultural diversification plan and their feeling that it has influenced their farming activities, specifically, and more generally that it would help improve agriculture in St. Kitts. Moreover, the notion that agricultural diversification would help improve agriculture in St. Kitts helps to influence their farming activities with some feeling of optimism about agricultural diversification. Also in Table 32 is illustrated the likelihood to continue farming is related to the desire to consider changes to the farm. In this instance, the farmers who are more likely to continue farming are less likely to consider changes to their farm. This is perhaps reflective of farmers' receptivity to changes. Any diversification plan would require the receptiveness to transformation of traditional methods, in instances where they may not be successful, to innovative ones. Those farmers who are likely to continue farming are also likely to recommend farming to others both as a business activity or as employment; a reflection of positive attitude towards farming. There is also indication that there is consistency between the extent to which farmers consume local produce and their preference or desire for this type of produce.

Table 32. Showing interrelationships between attitudinal variables

Variables	Extent of Awareness of Agri Div Plan
Agri Div Would Help Improve Agriculture	**0.40**
Agri Div Plan Influenced Farming Activity	**0.57**
	Agri Div Would Help Improve Agri
Agri Div Plan Influenced Farming Activity	**0.65**
Feeling about Agricultural Diversification	**0.43**
	Agri Div Plan Influenced Farming
Feeling about Agricultural Diversification	**0.39**
Percentage Household Income from Agri	**0.46**
	Likely to Continue Farming
Considering Changes on Farm	**-0.36**
Would Recommend Agri as Employment	**0.42**
Would Recommend Agri as a Business	**0.43**
	Extent of Consuming Local Produce
Preference to Consume Local Produce	**0.68**

Farmers' Recommendations and Comments

This chapter cannot end without consideration of what farmers have to say about agricultural diversification and their overall experiences. This is perhaps best communicated by displaying a list of the actual comments (see Table 33) made by farmers (with some minor editing) so that a good insight of concerns and issues may be derived to complement the statistical renderings. Note that there is some grouping of recommendations in the first 2 rows in Table 33.

Table 33. Showing farmers' actual recommendations and comments

	What do you recommend to improve the attitude of Kittitians towards farming in St. Kitts?
1	(36 farmers) Farming education/agriculture college, school or university
2	(8 farmers) Be patient
3	Adopt positive attitude, be focused, consider benefits
4	Agriculture forums
5	Be patient and work hard
6	Be patient, it has good rewards
7	Be patient, it takes time but rewards are great
8	Be successful and let it be seen
9	Before anyone go into the farming business, get suitable training first
10	Can be self employed
11	Can earn living; good self-employment
12	Crops are better than manufactured goods
13	Develop a positive feeling; love for farming as a means of survival
14	Diversify
15	Encouragement
16	Encouragement because it pays
17	Farmers need to form marketing groups. Too much competition, and same product being produced by all farmers at the same time
18	Farming is good because it brings income when other things may fail
19	Farming is likely to become the more ready source of income particularly when imports are restricted
20	Farming school, more farming facilities
21	Farming workshops
22	Get financial assistance
23	Go in farming as it would be profitable

continued on following page

Table 33. Continued

	What do you recommend to improve the attitude of Kittitians towards farming in St. Kitts?
24	Government incentives
25	Gov't and agri dept should reach out to those who are ignorant towards farming in St. Kitts
26	If you do farming you must like or you won't be for long
27	In order for country to cut back on import bill
28	Inform public about farming and its importance
29	Intensive activity in agri education, provision of a food security plan
30	It's a good business to make money from
31	It's better to farm and earn something rather than stealing
32	It's helpful and it's a good job
33	Land ; gained other resources; started and what benefits gained from farming
34	Money takes time
35	More agri awareness programs
36	More educational and interesting training programs
37	More gov't support in terms of marketing and incentives
38	More incentives from gov't
39	More interesting training seminars
40	More mechanization
41	Need a good marketing facility
42	Need to come together
43	Need to come together to influence policies
44	Need to have groups to make representation on behalf of farmers
45	Need to work better together (co-operatives)
46	Need to work together
47	One can make a living from farming but must take it seriously
48	Opportunities take time
49	Own a piece of land
50	Pay attention to the benefits and rewards of farming
51	People too lazy
52	Programs for people to better appreciate agriculture
53	Programs on agri div and its benefits
54	Programs that get the people involved in farming so they can appreciate and accept the benefits of farming.
55	Promote farming as a business
56	Provide programs for people to understand farming
57	Public needs to see agri in more positive light

continued on following page

Table 33. Continued

	What do you recommend to improve the attitude of Kittitians towards farming in St. Kitts?
58	Put in more time and take it seriously
59	Show them the benefits one can achieve by providing for their family
60	Show them the great benefits and profits from farming
61	Start farming young
62	Stop characterizing farming as poor people work
63	Stop impart curtain food would be forced to grow own
64	Stop importation of some foods; then local people would appreciate local produce/farming more
65	Take care of crops and plant crops that are needed
66	Take farming seriously if all things are available
67	Teach it in school; provide startup capital and access to land
68	The attitude of locals to local grown produce as opposed to imports
69	They must educate themselves to benefit fully from agri, e.g. Learn how to count money; also guard land from monkeys
70	They need to be a dedicated and hard working to get success
71	To recognize making it a livelihood
72	Training programs
73	Try and get interested because it is good and you can make money and not deal with a boss
74	Try to get some help
75	Try to understand and grow to appreciate the benefits of farming
76	Use land for right things and not to plant illegal things
77	Use of workshops and the media by the agri dept; educate and enlighten people of the positives; improve availability of markets
78	Work hard and you will get good returns
79	Work hard, it something good
80	Young people want office jobs
	Comments/Questions
1	Marketing; financial assistance; need land and water; technical assistance (also cultivates sugar cane)
2	A new approach has to be taken, new policies and support and water is needed
3	Enough is not being done to help peasant farmers by the relevant authorities.
4	Farmers need to form groups and policies need reviewing with farmers' input.
5	Farming no longer profitable in St. Kitts
6	Farming should be taught from primary to college
7	Fed up with how farmers are treated
8	Government don't give poor people good land
9	Government giving foreigners the best land

continued on following page

Table 33. Continued

	What do you recommend to improve the attitude of Kittitians towards farming in St. Kitts?
10	Government needs to assist farmers more in order for farmers to be more competitive with foreign imports; Mr. Naraine should meet with the persons who have been interviewed.
11	Government should work with farmers
12	Gov't needs to reduce prices on seeds and fertilizers, needs to start exporting food, needs to help farmers more
13	Gov't should encourage supermarkets and hotels to buy more local pork
14	I believe in providing quality; only problem is labor shortage
15	I think more people should go into farming
16	I wish to upgrade my farm in the future
17	Kittitians need to appreciate their roots and culture, starting from primary schools. Tie agri with modern technology, put local produce first and not imports. Mothers should be encouraged to buy local and be educated of advantages. Introduce local dishes in homes and not just hotels. Need for redevelopment of local taste from homes.
18	More awareness of the meaning of agricultural diversification particularly to agri producers; be sure to bring to these people in a simple form the implications of agri div.
19	Need gov't assistance
20	Need to help poor people; start food effort; need cheaper prices
21	Requests a copy of findings of survey
22	Requests a copy of results of survey
23	Stop importing agri produce that can be grown here, particularly all year round.
24	The need for more lands to become available for farming
25	The questionnaire has inspired me to do more; improve on my farm but if I can get some assistance especially in transportation, water, and finance.
26	To have non-sugar agri has its advantages and disadvantages. It's just the right perception of the people that might not make it strive.
27	We can do better, we need to have better policies to protect farmers
28	Why is this being done; what is it really about; confidentiality of survey
29	Why the gov't is using up all the sugar lands

CONCLUSION

The foregoing presentation and analysis of data at the individual enterprise level show that the circumstances at the farm or micro level are much more complex than at the national or macro level. It is here suggested that the distinction is between abstract and real-world phenomena. While the macro analysis is abstract, it is driven by what takes place "on-the-ground." There is much complexity and interrelationships of real-phenomena such as the activities or actual experiences of farmers. What is important to note is that although most of the interrelationships among the factors influencing agricultural diversification are not so statistically significant, there is all indication that

there is the potential that such factors may have policy implications and, if pursued, may derive great benefits towards diversification.

Generally, a low level of diversification is achieved at the individual enterprise level, particularly on livestock farm enterprises. What is most interesting in this chapter is there is poignant internal consistency in the findings. It can be inferred that many of the other variables can be influenced by input from the Department of Agriculture. Therefore, the Department of Agriculture has a potentially significant role to play in agricultural diversification.

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Chapter 3
Diversified Integrated Farm Model:
Case Study – Plum Tree Farms, St. Kitts

ABSTRACT

There is a worldwide issue in emerging economies with food security and increasing dependence on imported food from more developed countries. St. Kitts-Nevis and numerous Caribbean countries face similar circumstances. St. Kitts-Nevis is positioned to change this trend in its national economy and contribute to export with its Caribbean partners and perhaps further afield. Climate change, particularly pervasive drought conditions, present serious challenges but also opportunities to mitigate and adapt such adversities and accrue benefits to local farmers and related entrepreneurs if a model integrated farm is established with key contributing factors in its design such as productivity, flexibility, efficiency, and sustainability. An integrated farming system would compensate for low economies of scale in a value chain model, and linkages would sustain long-term stability and growth at the enterprise, sectoral, and inter-sectoral levels.

INTRODUCTION

This chapter begins with a review of the nature, trends, and characteristics of the diversified integrated farm model and similar models. We saw in Chapter 1 how the paradigmatic shift has been made from the industrial

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model of monoculture or extensive farming of a single or few crop types and livestock types independently, although there were industries to utilize by products of one as raw material for the other. That industrial model has led to environmental degradation and negative impacts on climate, ineffective processing and utilization of waste, marginalization of smallholder farmers in rural communities particularly in lesser developed countries (LDCs) in favor of more developed countries (MDCs), and ineffective in reaching the vast majority of the world's population that is undernourished. Although that scenario is complex in nature it may be simplified or categorized into three dimensions: 1. profitability of the majority of individual farmers and their livelihoods; 2. lack of social equity and status in society of smallholder farmers; and 3. detrimental environmental impacts to the extent of climate change and the loss of biodiversity and overall health and living conditions.

The more contemporaneous literature cites examples of farm models that promote adaptive capacity of communities to cope with the three dimensions (stated above) by addressing productivity, flexibility, efficiency, and sustainability, and their advantage over the industrial model.

THE DIVERSIFIED INTEGRATED FARM MODEL (DIFM): NATURE, TRENDS, AND CHARACTERISTICS

Howard-Hassmann (2015, in The Human Rights Quarterly) investigates the right to food in Venezuela for the period 1999 to 2013. She found that the state failed to protect this fundamental right. The state-run stores endured that food was sold cheaply and imposed price controls but the food supply was reduced and became extremely severe. Baptiste and Nordenstam (2017) relate the perceptions and action of villagers in the wetlands of rural Trinidad where drilling for oil and gas occurred. They show, contrary to general perception of mainstream researchers on environmental ethics in more developed economies, that villagers in rural wetland communities place high value and respond appropriately to the extent that they are capable with concern for the environment. They found that those whose livelihoods depended on the wetlands were more likely than others to perceive oil and gas drilling as dangerous to the environment and their livelihoods. They asserted that environmental concern was traditionally considered among the highly educated and wealthy people in most affluent countries. Their investigation

referred to the finding of scholars who found that people residing in LDCs also have high levels of perception of environmental problems and express concern for the environment.

Blazy, et al (2017), investigating farm diversity with prototyping as useful for designing alternative crop management systems (CMS). They view prototyping methods inadequate to take into account farm diversity in terms of economic, social, and natural constraints. Instead, they propose a two-step methodological framework. Looking at Banana Crop Management systems in Guadeloupe (French Caribbean), the first step is designing a farm typology based on their technical nature, context, and performance, and the second step is prototyping different modalities of intercropping, patterns of pesticide use, choices of hybrid cultivars, and rotations with cover or cash crops. They made the justification for new decision rules for pest control by replacing systematic pest control treatments with new biological components to realize better performances.

Beckford, et al (2017) draw attention to survival strategies of small-scale farmers in Jamaica as an adaptation strategy and innovation for domestic food production. They asserted that such adaptation and innovation have not generally been considered for on-farm research because they have been perceived as recipients, instead of originators, of technical knowledge and sustainable and viable practices. They point to abundant evidence in the tropics of small-scale farmers as adaptive and experimental problem solvers, and experts at devising innovative survival strategies. They argued that, "While literature on the topic is rich with accounts from Africa, Asia and Latin America, there is a general dearth of examples from the Caribbean." They highlighted some examples from Jamaica among small-scale domestic producers functioning with village-level problem solving and survival practices in the challenging agroecological environment. They noted that one reason given for the perception of village-level farmers by researchers is that researchers are unfamiliar with the rationale of traditional agricultural practices and compounded by lack of historical records. They also noted that there is potential of traditional small-scale farming systems to adapt to changing local socioeconomic realities and environmental conditions that can respond to specific environmental contexts in ways that are not only sustainable but also critical in maintaining food and social security. The identified the characteristic deep-rooted structural dualism of agriculture in Jamaica, i.e. of large-scale, commercial or privileged traditional export sector and the small-scale traditional farming sector that produces mainly for

the domestic market sector, and with how dualism pervades and influences agricultural policy and funding, resulting in unequal competition between the two agricultural sectors. They made the case for recognizing local knowledge of small-scale farmers as model innovators, efficient resource manager and reservoirs of valuable traditional knowledge and that there is room for greater collaboration between scientists and farmers.

Gamble, et al (2010) agree with Beckford, et al, on the value of local knowledge of Jamaican farmers to be adaptive to drought that has become increasingly prevalent even the former traditional wet seasons as a result of climate change. Using satellite data from remote sensing of precipitation and vegetation with perception local farmers, they show that farmers are concerned about an increase in drought occurrence that are becoming more frequent. They further show that the perception of drought are not driven by magnitude and frequency along but also by the difference between growing seasons. They propose that development of drought adaptation and mitigation plans must not only focus on drought but also compare moisture conditions between months and seasons to be effective.

Saint Ville, et al (2015) addressed food and nutrition insecurity in the Caribbean and highlighted that domestic smallholder farmers are key actors vis-à-vis the challenges facing the Caribbean Community (CARICOM), while also minimizing the ecological footprint of food production systems. They lamented that fifty years since their independence, CARICOM SIDS continue to grapple with food and nutrition security challenges that resulted from plantation legacies. They recommended that smallholder farming systems will require more decentralized, adaptive, and heterogeneous institutional structures and approached than presently exist. As such, they (Saint Ville, et al, 2016) argue for a different approach to agricultural development in SIDS of CARICOM that draws from socioecological resilience and agricultural innovation systems frameworks, and the need to better understand the social capital of smallholder farmers in influencing knowledge flows and innovation that can facilitate adaptive capacity in diverse farming contexts and for collaboration, co-learning, and collective action among farmers and institutions. Variations in context include specific challenges such as small size, insularity, remoteness, geographic isolation, proneness to natural disasters, as well as climatic variability and intensification of extreme weather. They identified how two farming communities in Saint Lucia, despite structural differences, reported using their social networks to access new agricultural knowledge to innovate, noting that such knowledge was more important than state-run agricultural extension knowledge.

Utilizing a framework coupling farm typology and biophysical modelling, Sierra, et al (2018), described the typology of farm practices and assessed the impact of vegetable in diversified and monoculture crop-based systems compared to traditional monoculture export agriculture on soil carbon stocks in Guadaloupe (French Caribbean). They found that characteristics of agroecological systems of vegetable crop-based system had less impact. This finding emphasizes that the management of vegetable crop systems can be improved in order to maintain or increase SOC despite the environmental conditions.

Teelucksingh, et al (2013) examined Caribbean SIDS fisheries and tourism diverse development metrics and found that they are uniformly vulnerable to macroeconomic shocks and changes in biodiversity. Although the topic of this book does not include fisheries and marine ecosystems, it should be noted that agriculture impacts marine and fluvio-marine ecosystems, while fish waste is a highly valuable source of raw material for livestock feed, having high protein and calcium contents and also Omega 3 fatty acids. Therefore, there is scope for integrating fisheries in the diversified integrated farm model which can also include aquaculture at the farm enterprise level. They identified the challenge for SIDS as the need increases to implement an integrated, sustainable resource management strategy that allows biological resources to be allocated to their highest valued uses. As SIDS become more severely affected by natural disasters, competitive land use, marine pollution, over-exploitation and destructive fishing, and shore-derived sediment and nutrients, as well as the volume and pattern of tourism, they render SIDS are susceptible to such impacts. However, they also identified evidence for increasing value of resource conservation since tourist willingness to pay to access biodiversity-rich ecosystems is increasing. Accordingly, they propose that SIDS have the challenge of implementing an integrated, sustainable resource management strategy.

According to Alfaro and Mille (2017) in their case study of farming Liberia, West Africa, they noted that industrial symbiosis (IS) has largely focused on exchange of energy and materials in the process to increase value, reduce environmental impact, and benefit to agricultural systems. They noted that whereas IS has traditionally focused on industrialized systems in develop countries, such agricultural systems have potential benefits of integrated material and energy flows in smallholder farming. They proposed that smallholder farmers can optimize the techniques of IS to maximize farm output while minimizing waste, and their research links IS to integrated farming

research (IFR) and found that IFR benefits from established IS tools to create pathways for increased output from symbiotic relationships with the potential for positively impacting sustainable development. Alfaro and Miller found that by exchanging of materials and energy streams among industries there is improved performance from symbiotic relationship, which can be measured environmentally, economically, and socially. Such exchanges allow wastes to be used as inputs for other processes. It appears, however, that IS would be inefficient in Caribbean SIDS at an industrial level which would likely render costs of collecting waste in relatively small quantities, processing at relatively low combined quantities, and redistributing them to small farms. Collectively as a Caribbean region it would be even more inefficient, given the overseas fragmentation. There is scope for IS to be done collectively for a cluster of farms in individual territories, but this would require major transformation of practices to the extent that operationalization is like to be protracted into yet a longer timeframe. Integration within a specific farm site would not require the logistics and machinery for IS, and would therefore be more feasible to some extent to begin making the transformation and accruing benefits to the farmer.

Various research have shown the comparisons between monocultures and polycultures, with the latter being more productive, utilizing natural resources and photosynthetically active radiation more efficiently, resisting pests epidemics better, producing more varied and nutritious foods, contributing more to economic stability and social equity, and providing farmers' direct participation in decision making (Bernardo, et al, 2005). They drew attention to the challenges of small-scale tropical farmers who have generally been confined to farming in low quality, marginal and fragile soils with little institutional support, their systems provide valuable information for the development of sustainable agricultural production systems.

Diversified farming systems (DFS) as an agroecological system and alternative to modern industrial agriculture is designed according to whole systems with principles that contribute to creating a more suitable, socially just, and secure global food system (Kremen, et al, 2012). They define DFS as "farming practices and landscapes that are intentionally functional biodiversity at multiple spatial and/or temporal scales in order to maintain ecosystem services that provide critical inputs to agriculture, such as soil fertility, pest and disease control, water use efficiency, and pollination." They contrasted that with, industrialized agriculture that is heavily impacting surrounding environments, polluting waterways, creating dead zones in the oceans, destroying biodiverse habitats, releasing toxins into food chains, endangering

public health via disease outbreaks and pesticide exposures, and contributing to climate warming. They asserted that although industrial systems simplify ecosystems and utilize highly specialized, technical information with the goal of maximizing the profitability of a commodity crop or livestock on any given farm, industrial systems do not necessarily maximize the total yield per land area or energy use as in the case of DFS.

A definition of integrated farming, in the International Research Journal of Engineering, IT and Scientific Research (IRJEISR, 2016) is presented as, "an agricultural system that integrates the various agriculture components in a whole unified system. It had a positive impact and meets the criteria for the development of sustainable agricultural by optimizing the user of local resources." The nature of this system of agriculture gives advantage to the farmer by increasing income, and for example in Bali farmers' incomes were doubled. It presents the opportunity for the farm to have income streams from multiple activities throughout the year, quite unlike monoculture or animal husbandry or horticulture or aquaculture. It also promotes environmental integrity with the processing and utilization of waste to improve soil fertility, weed and pest control, and efficiency of water. There is less dependence on relatively costly fuel and chemical fertilizer, resulting in less environmental degradation. In this system, there can be optimum utilization of farm waste to enhance productivity. Marias (2017) noted that the integrated diversified farming, which is essentially the same as a whole unified system or integrated farming, is strategically structured so that distinct components are designed to maximize one another. Rana and Chopra (2013) also noted that the integrated farming system brings prosperity to farmers, compared to monoculture approaches. They found worldwide that farmers work hard but do not make money, with little left after they pay for all inputs, and the integrated approach will help to lift the economy of agriculture and standard of living of farmers. Such contrast between the two systems, i.e. diversified integrated and monoculture are synonymous with the contrast between specialized farming system and integrated farming system as defined by Rana and Chopra (2013), and they identified the benefits or advantages of integrated farming as:

1. Productivity
2. Profitability
3. Potentiality or Sustainability
4. Environmental Safety
5. Recycling

6. Income around the year
7. Saving Energy
8. Employment Generation
9. Agro-industries
10. Increasing Input Efficiency.

In principle, Walia and Kaur (2013), also agrees with the advantages, noted by the other researchers aforementioned in this section, of the integrated farming system and further referring to it as an ecofriendly approach for sustainable agricultural environment, over monoculture or specialized farming. In addition, they point specifically to the role of improving soil health by increasing nitrogen, phosphorous, organic carbon and microbial count. They analyzed the value of nutrient from livestock litter with dry broiler litter than other poultry and livestock, having the highest percentage of nitrogen. This is an important consideration when choosing the type of livestock and crops, depending on the objectives or needs of the particular farm enterprise. The Taranaki Regional Council Land Management in New Zealand also supports these values of the integrated farming system where it is noted that farmers and ranchers apply innovative strategies to produce and distribute food, fuel and fiber sustainably and what they refer to as the 3 pillars of sustainability: 1. profit over the long term; 2. stewardship of the nation's land, air, and water, and 3. quality of life for farmers, ranchers and their communities.

The Union of Concerned Scientists (in the USA), Gold (2007 for the USDA (2007), Stauber, et al (1995 for Iowa State University), and Archer, et al (2017 for University of California – Davis) espoused the foregoing definitions, characteristics, and nature of sustainable agriculture and recognized the transformation taking place on farms across the United States. The Union of Concerned Scientists noted that, "For decades, we've produced the bulk of our food through industrial agriculture—a system dominated by large farms growing the same crops year after year, using enormous amounts of chemical pesticides and fertilizers that damage soils, water, air, and climate. This system is not built to last, because it squanders and degrades the resources that it depends on." They argued that sustainable agriculture includes the economic, social, and environmental dimensions towards development of a robust economy with a mutually beneficial relationship the surrounding community, and that environmental sustainability means good stewardship of natural systems and resources that farms rely on, and posited the following as attributes of sustainable agriculture:

- Building and maintaining healthier soils
- Managing water wisely
- Minimizing air, water, and climate pollution
- Promoting biodiversity

Does Sustainable = Organic?

"Organic" and "sustainable" aren't quite synonyms: current organic standards leave room for some practices that are not optimal from a sustainability point of view, and not all farmers who use sustainable practices qualify for USDA certification or choose to pursue it.

Sustainable agriculture practices

Over decades of science and practice, several key sustainable farming practices have emerged—for example:

- *Rotating crops and embracing diversity.* Planting a variety of crops can have many benefits, including healthier soils and improved pest control. Crop diversity practices include intercropping (growing a mix of crops in the same area) and complex multi-year crop rotations.
- *Planting cover crops.* These crops protect and build soil health at Plum Tree Farms by preventing erosion, replenishing soil nutrients, and keeping weeds in check, reducing the need for herbicides.
- *Reducing or eliminating tillage.* Traditional plowing (tillage) prepares fields for planting and prevents weed problems, but can cause a lot of soil loss. No-till or reduced till methods, which involve inserting seeds directly into undisturbed soil, can reduce erosion and improve soil health at Plum Tree Farm.
- *Applying integrated pest management (IPM).* A range of methods, including mechanical and biological controls, can be applied systematically to keep pest populations under control while minimizing use of chemical pesticides.
- *Integrating livestock and crops.* Industrial agriculture tends to keep plant and animal production separate, with animals living far from the areas where their feed is produced, and crops growing far away from abundant manure fertilizers. A growing body of evidence shows that

a smart integration of crop and animal production can be a recipe for more efficient, profitable farms.

- *Adopting agroforestry practices.* By mixing trees or shrubs into their operations, farmers can provide shade and shelter to protect plants, animals, and water resources, while also potentially offering additional income.
- *Managing whole systems and landscapes.* Sustainable farms treat uncultivated or less intensively cultivated areas as integral to the farm—valued for their role in controlling erosion, reducing nutrient runoff, and supporting pollinators and other biodiversity.

There is general agreement among all the proponents of the diversified integrated farming model which is the focus of this book, optimizing the use of farm (and non-farm waste) to enhance productivity and food security. They agree that the type of farming model rests on the three pillars: greater productivity or profitability for farmers, improvement of their social status, and environmental integrity.

DIVERSIFIED INTEGRATED FARM: CASE STUDY – PLUM TREE FARMS, ST. KITTS

Concept

Plum Tree Farms was conceptualized with the primary purpose of developing a diversified-integrated farming model to produce crops and livestock in a manner and a commercial scale that would achieve efficiency in primary production of fruits, vegetables, meat, and farmed-fish, and the secondary of production of meat products, livestock feeding materials, organic fertilizers, and soil. A corollary purpose is to form linkages with local farmers and enterprises for the production and marketing of their produce to target the local and export markets.

The stated objectives were to:

1. Strengthen Food Security
2. Create Employment
3. **Support Entrepreneurship** (Local Farmers and related enterprises)
4. **Training and Research** (Capacity Building and Internships for Students)

5. **Building Environmental Sustainability** (recycling of farm and non-farm waste to energy and nutrient recycling).

With tourism as the main thrust in the economy of St. Kitts and Nevis, the national demand for food virtually multiplies with the presence of tourists in any given year, including foreign students who consume like tourists and are present almost year-round. There is also increasing demand for agricultural food products and livestock feed in neighboring countries and trading partners. Unlike many of its counterparts in the OECS, St. Kitts-Nevis has considerable resource endowments suitable for agricultural activities. It has exceptionally fertile soils due to its volcanic origin, and impoverished soils can be enhanced with nutrient recycling, e.g. by composting. The relatively high mountain ranges forming the central spine of the island provide a mechanism for an almost daily cycle of orographic rainfall. If properly harnessed with wells, strategic drainage (restricting loss to the sea) and water catchment, the agricultural sector can benefit from adequate supplies of fresh water for farming. However, soil and water conservation are highly essential, given the porous loamy soils that are vulnerable to leaching and water infiltration that are readily translocated to lower depths. With changing climatic conditions, the effects are exacerbated and require technical input and strategic management to yield optimum or favorable outputs.

The government of St. Kitts-Nevis has an enabling policy environment having consistently expressed a strong interest since 2002 in diversifying its agricultural sector, primarily of sugarcane cultivation and sugar manufacturing for export, to achieve food security. It's plan from since 2002 consists of five main components: to promote agricultural development; to develop marketing support; to monitor soil and conservation/environmental protection activities; to strengthen the Department of Agriculture and the Water Services Department; and to provide support to private sector development (St. Kitts Ministry of Agriculture, Fisheries, Cooperatives, Lands and Housing, 2002).

With such an enabling policy environment, coupled with private sector innovative systems that can be made available through this proposed farming model for Plum Tree Farms, already being partially implemented, and collaboration with related local enterprises, the conditions are ripe for rapid development. Plum Tree Farms has already tested its model for poultry, pig, and livestock feed raw material and feed processing. It is strategically positioned for upscaling and replication and is already in its early expansion phase in pig ranching with great success. Feed manufacturing has the potential

of opening up the sector multiple-fold, with direct benefits to other livestock and crop farmers.

If this model were to be scaled up and replicated on a 1,000 acre contiguous farmland or a farming zone with relatively large parcels, this commercial-scale diversified-integrated model will put St. Kitts-Nevis in a commanding position on food security, while generating a multiplier effect in a value chain system, as well as enabling entrepreneurs to partner with the enterprise through incubation or with horizontal linkages. Such an integrated system will achieve all the hallmarks of sustainability, such as diversification, flexibility, productivity, competitiveness, and with environmental integrity to produce high quality products that are hormone free and without genetic modification.

Contiguity or a farming zone is essential so that infrastructure cost can be minimized, while it can be segmented or parceled so that multiple farmers can operate individually at a lower input cost per enterprise. A farming zone in the context of St. Kitts-Nevis will require the following to mitigate major concerns:

1. Fencing for protection from the pervasive nuisance of monkeys, wild pigs, stray roaming livestock, and praedial larceny
2. Water supply from abandoned wells and catchment, as well as water harvesting from rooftops from storage and manufacturing buildings, and to replace the predominantly rain-fed systems
3. Fertilizer from aquaculture ponds for crop irrigation
4. Potting soil production from composting that will be amplified with a larger source of waste- raw-material and which is more effective on a larger scale with regards to machinery for processing, and, similarly, mulch production for ground cover to enhance soil water retention capacity while adding nutrients from decomposition of mulch
5. Energy production with biogas produced from livestock waste to power agro-processing plant, cold storage, chillers, pumps, pumps, lights, and crop drying
6. Passive solar drying with the use of solar collector system that will facilitate the storage of raw materials for livestock feed to be milled and formulated as needed to reduce decomposition
7. Farm machinery for land preparation (low tillage and point tillage where possible) and harvesting that are capable of more work than a small farm
8. Transportation with vehicles of various sizes and accessories
9. Agro-processing that is feasible on relatively large scale

10. Collective bargaining for purchases and marketing so that more profitability will accrue directly to individual farmers
11. Coordination of production that is demand led to avoid gluts and scarcity so that reliability and consistency is assured to markets
12. Sharing of expertise, transfer of knowledge, and promotion of innovation.

A system of this nature will have continuous presence on the farm to increase production time in any given day. Such a scale and system will reduce the input cost of production per unit space to achieve higher productivity, competitiveness, sustainability, and flexibility. With such a scale and intensified system, the national demand for a wide range of essential foods and beverages will be met and ultimately food security will be achieved.

Plum Tree Farms Description

In the face of increasing food prices worldwide and a great need for food security in small island states (SIDS), St. Kitts-Nevis is actively initiating development in agriculture to meet the growing needs of its population. Climate change in recent decades has posed increasing vulnerabilities to which adaptation and mitigation require non-traditional and innovative systems of agricultural production. St. Kitts-Nevis has experienced over the past four or so decades, increasing food imports but decreasing food exports. SIDS, in general, are impacted by exogenous variables when world financial markets become unstable. Perhaps the best way to combat vulnerabilities, whether induced by anthropogenic or natural factors, is to improve livelihoods of the general citizenry. A key mechanism to improve livelihood, is through skills- and competency-based education that would enable persons to find employment or create employment that would empower them to participate positively in economic activities and build resilience in the face of vulnerabilities. It is also essential to formulate and develop adaptive mechanisms and capacities to sustain environmental integrity, while promoting economic development, so that the environment remains a resource for development to meet the needs of current population demand but without compromising the benefit to future generations. Promoting local production will also contribute to the creation of Plum Tree Farms attributed to the multiplier effect of local enterprise. Plum Tree Farms is proposing the type of business that would respond appropriately by mitigation and adaptive mechanisms by modern and innovative techniques in policy design, planning and implementation, and improved education in

agricultural science, agri-business and agro-technology, and ultimately to building a sector with linkages to other sectors. It will transform the agriculture sector from a primary economic activity to secondary, tertiary, and quaternary sectors that will further enhance the benefits in the value chain, i.e. with increasing percentage profit as it progresses through the various sectors from primary to quaternary.

With tourism as the main thrust in the economy, the demand for food virtually multiplies, with the presence of tourists, including foreign students, in any given year. There is also increasing demand for agricultural food products and animal feed in neighboring countries that can be fulfilled by St. Kitts-Nevis with the implementation of this plan by Plum Tree Farms. Unlike many of its counterparts in the OECS, St. Kitts has considerable resource endowments suitable for agricultural activities. It has exceptionally fertile soils due to its volcanic origin. Despite its mountainous landscape, good soils extend up to about 1,500 feet above sea level, above which there are rain forests protecting the higher and steeper slopes. The relatively high mountain ranges (about 3,600 ft. altitude) in the center of the island provide a mechanism for an almost daily cycle of orographic rainfall. The resultant rainforest at higher elevations, in turn, further perpetuates the hydrological cycle. If properly harnessed, the agricultural sector can benefit from adequate supplies of fresh water for farming.

The government of St. Kitts has expressed a strong interest in diversifying its agricultural sector beyond sugar. The plan (actually launched in October 2002 as projected in anticipation of the closure of the Sugar Industry) consists of five main components: to promote agricultural development; to develop marketing support; to monitor soil and conservation/environmental protection activities; to strengthen the Department of Agriculture and the Water Services Department; and to provide support to private sector development (St. Kitts Ministry of Agriculture, Fisheries, Cooperatives, Lands and Housing, 2002). With such an enabling policy environment, coupled with innovative systems that can be made available to the industry by Plum Tree Farms, the prevailing conditions present opportunities for non-traditional systems of agriculture to build resilience and foster development.

Perhaps the greatest impact yet to be made is in the area of animal feed manufacturing. St. Kitts-Nevis has never had a feed manufacturing plant, the main reason for not producing poultry and pork locally to any significant extent. While all poultry is imported, pork imports account for more than 80% of local demand. Imported feed is price prohibitive. Plum Tree Farms, although it is a high risk venture due to dependence on imported ingredients,

particularly grain, has experimented on technologies to produce soy beans and corn in hydroponic and organoponic systems to produce these main ingredients on a commercial, reliable, and competitive scale. Plum Tree Farms also has the technology to produce other forms of protein content from locally grown plants with about 22% protein content that have multifunctions. Plum Tree Farms key personnel have had experience with manufacturing feed from "broken rice" in Guyana and producing broilers at competitive prices. While rice forms the bulk of fiber and some protein, Plum Tree Farms will enhance feed quality with locally grown concentrated protein sources mentioned above. Additionally, there is arrangement to utilize spent grain from the local brewery that otherwise goes to waste. Accelerated drying of grain of all sorts, spent or produced locally, to avoid biological degradation/decomposition, will be accomplished by a passive solar dryer. The current imported feed generally decomposes before reaching farmers and has become an ineffective means of supply. The Government of St. Kitts-Nevis expressed strong interest in the proposed livestock feed enterprise at Plum Tree Farms as an alternative to feed imports.

Feed manufacturing has the potential of opening up the sector multiple-fold, with direct benefit to livestock and crop farmers. An integrated system will inherently possess efficiencies in linkages from one aspect of production to others, so that by-products from one aspect are utilized as raw materials in another aspect. Such efficiencies will lead to value added benefits at each processing stage of the system, as well as multiplier effect immediate and adjacent local communities and export markets. Naturally, jobs will be created at various levels, and development at the macro- and micro-economic levels will be realized. Moreover, the linkages among the various aspects of production will have inherent environmental sustainability. For example, natural biological pest control mechanisms will be introduced through ecological systems, natural herbs will be formulated for some pest control, animal and poultry waste will be intercepted by mulch and further processed in composting or vermiculture cells before utilization for crops, etc. In this way, all waste will be recycled and/or reused.

Affordable livestock feed availability is the major determinant of meat of various kinds, e.g. chicken, pork, lamb, and beef; egg production and aquaculture are also impacted significantly by livestock feed. The livestock feed production aspect of the enterprise is ripe for development in St. Kitts-Nevis. Affordable livestock feed is also the single-most important factor of competitive livestock production in St. Kitts-Nevis and SIDS, primarily because of fierce competition from industrialized countries, inter alia, with

larger economies of scale, industry linkages, land availability for extensive agriculture and raw materials for livestock feed, and capital.

Feed manufacturing has the potential of opening up the sector multiple-fold, with direct benefit to livestock and crop farmers. An integrated system will inherently possess efficiencies in linkages from one aspect of production to others, so that by-products from one aspect are utilized as raw materials in another aspect. Preston (1996) writes, on the "specialized feed conversion" as the major role of animals in natural resource management, and proposes that, the animal provides the most efficient pre-treatment of high-moisture biomass to convert it to a substrate suitable for biodigestion. Equally the "animal-bio-digester" sub-system is a more efficient way of preparing organic matter for return to the soil than aerobic composting. Thus, as emphasis has shifted from "adapting the resource to the system" to "adapting the animal to the resource, the economic traits required of livestock will also change.

Such efficiencies will lead to value added benefits at each processing stage of the system, as well as multiplier effect immediate and adjacent local communities and export markets. Naturally, jobs will be created at various levels, and development at the macro- and micro-economic levels will be realized. Moreover, the linkages among the various aspects of production will have inherent environmental sustainability. For example, natural biological pest control mechanisms will be introduced through ecological systems, natural herbs will be formulated for some pest control, animal and bird waste will be intercepted by mulch and further processed in vermiculture or composting cells before utilization for crops, etc. In this way, all waste will be recycled and/or reused.

The system of production, here proposed, is unique in its technology and science that can be competitive in the larger scheme of conditions, with efficient utilization of waste protein and waste fuel in a value chain model that has proven to be sustainable and effective from economic and environmental perspectives. Moreover, it has the capacity of a multiplier effect with farmers, wholesalers and retailers, and other enterprises in a community development context.

According to Viaux (1995), Integrated production is defined as a farming system which integrates natural resources and regulation mechanisms into farming activities to achieve maximum replacement of off-farm inputs, secures sustainable production of high quality food and other products through ecologically preferred technologies, sustains farm incomes, eliminates or reduces sources of present environmental pollution generated by agriculture, sustains the multiple functions of agriculture. There are many opportunities

to implement an integrated farming system with multi-functionality and environmental integrity, and also derive benefits.

A diversified systems consist of components such as crops and livestock that coexist independently from each other. In this case, the emphasis is not to integrate crops and livestock to minimize the risk of dependency on a single or few commodities, and there is no emphasis to recycle resources. In an integrated system, crops and livestock interact to create a synergy with recycling, allowing the maximum use of available resources. Crop residues can be used for animal feed, while livestock and livestock by-product production and processing can enhance agricultural productivity by intensifying nutrients that improve soil fertility, and reducing the use of chemical fertilizers.

Viaux (1995) posit that, Integrated Arable Farming Systems take into account all natural and agronomic environment of the farm to reduce the level of external inputs. Those systems require a holistic approach of the crop production with regard to rotation, varieties selection according to their disease sensibility and quality, sowing dates and densities, crop protection adjusted to diseases populations and crop stages, fertilization adapted to soil potentials and plant needs. At the individual farming enterprise level, there is the advantage of agricultural diversification which also achieves integration at the enterprise level, and which is the main tenet of this farming model that is being demonstrated by Plum Tree Farms, so that elements of flexibility, productivity, competitiveness, and sustainability can be achieved. When this is individually or collectively practiced, the cumulative impact is agricultural diversification at the national level. Conversion of a farm to become integrated is an "evolutionary" process, primarily due to relatively high initial capital input requirement, stages of production to facilitate other stages towards maturity in a cyclical pattern. Small farmers, in particular, need to have sufficient access to knowledge, assets and inputs to manage this system in a way that is economically and environmentally sustainable over the long term. One essential consideration is to generate cash flow at every stage of the cycle for feasibility to implement other stages.

An index of diversification at the enterprise level, analyzed in Chapter 2, is essential to the success of farmers by spreading risk with cultivation of at least 5 crop types or mixed crop and livestock farming so that there is internal efficiency, inter alia, from the recycling of nutrients, utilization of farm workers, profitability from combined income from multiple revenue streams, and reduced dependency on a single commodity (Naraine, 2015). In such a farming system, there is control (and resultant advantages) for economic, human, market, technological-scientific, and sustainability factors.

The key design features of the system of production for the livestock feed factory are the utilization of:

1. Waste motor oil to produce energy for a boiler
2. Biogas from livestock waste
3. Cooker for rendering organic waste and other biomass with steam under high pressure
4. Animal Protein from Offal (fish and poultry) to be cooked in Bio-digester
5. Vegetable Protein (from Moringa, Leucaena, Gliricidia; also excellent for composting for enhancement of nitrogen in soil)
6. Brewery Spent Grain (BSG)
7. Used Cooking Oil (from Kentucky, Church's, homes)
8. Passive Solar + Biogas Dryer for fruits and vegetables, e.g. breadfruit, cassava, vegetables
9. Organic Fertilizer from Factory Residual
10. Pet Food Production from Offal (Pig waste).

Significant waste fuel and waste raw materials are available locally, and with internal efficiencies of recycling of nutrients in an integrated farming system and appropriate technologies the production of livestock feed can be self-propelled to larger scales. Naraine collaborated with an engineering innovator, James Aronson, for the required engineering design to customize a factory system that will be appropriate in the context of St. Kitts-Nevis, with similar characteristics to a system in Grenada that he developed and was supported in part by funding through the Organization of American States (OAS) under the theme, "Sustainable Cities in the Caribbean and Latin America," and presented in La Antigua, Guatemala and Antigua (West Indies/Caribbean) were Naraine and Aronson presented separate papers.

The most significant input of livestock production is feed (about 75% of total cost), and the most significant input of livestock feed is protein (about 60% of total cost). Imported Livestock Feed to St. Kitts-Nevis for several years has been averaging US$15 per 50 pound bag (33 US cents per pound), even with governmental support, while storage and decomposition also posed problems for imported feed. The feed is imported from various Caribbean countries from time-to-time through the Department of Agriculture as a non-profit activity to make it available to livestock farmers. Those suppliers utilize some imported raw materials or byproducts from other industries using imported raw materials to manufacture livestock feed. Even so, the protein

content of imported feed ranged from only 18% to 21%. A higher percentage (about 24%) is required for competitive production.

Despite such support to livestock farmers with imported feed, St. Kitts-Nevis farmers cannot produce poultry meat at competitive prices with imported chicken and is therefore practically non-existent. Poultry eggs are produced but at a relatively high cost to consumers. Pork production suffers from similar effects, and Plum Tree Farms, although there has been significant improvement in pig ranching in recent years there has been a significant stagnation over the past few years due to precipitous fall in prices of imported pork, mainly from Brazil, with the quality in question, compared to local pork with very high meat quality from pure bred cross between Duroc and Yorkshire White. The major determining factor for local producers in St. Kitts-Nevis is the high cost of imported feed. Plum Tree Farms, although the competition can be buffered by a policy solution to protect local farmers, there is the competing interest of supermarkets, restaurants, and the general population of consumers with whom the disparities have to be reconciled.

The solution is to reduce the cost of livestock feed, which is a major objective of the integrated farming concept, here presented. It sits at the intersection of crops and livestock and is at the core of determining the success of crops and livestock productivity.

Crops Diversification

In order to develop consistency and reliability, key concerns of supermarket and restaurant clients, the crop cycles have to be precisely timed so that when one crop is harvested there are at least two other crops in their early and mid-growth stages. Ideally, it is better to develop cycles for individual crops so that harvesting is done from two crops at the same time, with one that is about to go out and the other just coming in; in this way, there is less risk of missing the timing and also as a contingency in case of intervening circumstances, e.g. water shortage, pest and disease, unseasonal weather which has been the trend in rapidly changing climate, and if there is an occasional large order. Any excess produce from post-harvest can be fed to the perennially hungry pigs!

Time Scales and Crop Types

Short-Term Crops: 2- to 3-Month Cycle

These include crops, such as cucumber, lettuce, sweet pepper, and tomato, which are best cultivated in hydroponics or organoponics controlled conditions – as protected agricultural conditions, and with eggplant, ochre, and seasoning pepper as field crops with drip irrigation and with carrot with sprinkler system. They consist of relatively high water content and therefore also require significant water. They are also vulnerable to pests and diseases, as well as Plum Tree Farms alternating drought and wet conditions within the same climatic season. Plum Tree Farms utilizes both hydroponics and organoponics for such crops. There is preference for such crops for local residents and tourists alike, demanding these on a regular basis from daily to weekly either from supermarkets or from farmers' market vending that require consistent and reliable supplies. Plum Tree Farms is capable of producing about 25 lbs. of each of these eight (8) vegetable types per day (about 200 lbs. per day) according to average demand and sales per day with current clientele. Excess production may result in more competition for market share and may result in loss if not sold timely. Recall the optimum diversification of 5 crop types (see Chapter 2) for a single farming enterprise. Plum Tree Farms started with 5 crop types and became consistent at it within one year of start-up. However, with the incidence of 2 hurricanes in 2017, it was setback for about 6 months but has since been reset. From the lessons learned, including psychological impact on employees, it has also reset with resiliency to rebound within 2 to 3 months with these short term crops. The latter Chapter on sustainability addresses the issue of resiliency.

As the farm matures, there is a plan to add broccoli, cauliflower, cabbage, and micro leafy lettuce and other leafy salad vegetables. Higher diversification does not necessarily mean a better scenario, as it can introduce greater risk in some ways with regards to higher capital input and more precise management techniques. The strategy is to become efficient and consistent of producing the 5 crop types consistently before adding diversifying further to a total of about 10 crop types to double the output and remaining demand led. Each crop type added ought to be introduced when it is feasible to produce it consistently.

Maybe the response is to produce higher quantities and increase marketing, but this may be practical with time and reputation, as well as with more intensive cultivation to optimum levels of land use, but considering the

carrying capacity and other activities on the 4.5 acre parcel. The existing quantity of 300 lbs. per week and potential to double this quantity translates into cost of input and profitability without significant increase of input that will yield disproportionately higher output so that productivity increases for this category of crops. Five (5) crop types are sufficient to pay recurring expenses for this activity and make about 5 percent profit. With 10 to 14 crop types in this category, profits can increase to about 8 to 12 percent. These are important cash flow considerations to remain as a viable business.

Medium-Term Crops: 4- to 6-Month Cycle

Crop types in this category currently cultivated are eggplant, okra, pumpkin, seasoning pepper, and watermelon as field crops with drip irrigation. Plum Tree Farms, although the case has been made for 5 to 14 short-term crop types, this medium-term category acts as if it were a separate farm. This is an expansion strategy to grow the enterprise commercially and adding employees and profitability.

The medium-term crops are more resilient to pests and diseases and climate variability. Some harvesting followed immediately after the hurricanes but reestablishment obviously took a longer time than the short-term crops. However, these crop types have a higher demand for land space and preparation, and maintenance than for short-term crops. The higher quantities of production but lower per unit price at the market is roughly proportionate to the input factors and, therefore, the profitability is about the same as short-term crops. With about 5 percent profitability added to the short-term crops, there is now profitability on a larger volume of production. These crop types are also demand led, as the same clientele for short-term crop types has a consistent appetite for such medium-term crop produce. Plum Tree Farms has mastered the crop types in this category with consistency, Plum Tree Farms, although it had to hit the reset button after the major hurricanes in 2017 and took a longer time to reestablish this category of crops, having given priority attention to short-term crops for faster cash flow.

Any excess pumpkin, e.g. is excellent at the fattening stage of pigs. After the hurricanes, immature fruits that the battered leaves could not support were fed to the pigs that contributed to the resilience of the farm.

Medium- to Long-Term Crops: More Than 6-Month Cycle

Crop types in this category are cassava, and banana and plantain. Cassava can be sold to the farm clientele at about 10 lbs per day with variability. However, it is excellent for pig feed and contributed to resilience and sustainability. This root crop and its stems and leaves served as food for the pigs when livestock feed was scarce from delayed shipment and also while cash flow diminished due to the hurricanes. It is not easily affected by diseases and pests, low maintenance, and is cultivate on peripheral areas without much impact on land use. Going forward, it remains a good option for pig feed to reduce dependency on imported feed and cost of production.

Banana and plantain are high demand crop types and require large acreage. The main reason for integrating this crop type at Plum Tree Farms is to contribute to livestock feed and generate additional cash flow from sale of produce in the first instance and secondly to bring down the cost of feed. It is cultivated on peripheral land and provides shade for some other crops, contributes to soil water retention and also acts as a buffering zone for waste water, without requiring irrigation. This crop type is easily susceptible to wind damage but rebounds on its own after hurricanes. The setback is that it takes about 9 months to produce to its original capacity. Crops that are destroyed by hurricanes can be utilized as livestock feed. The trunks are also good for feeding in small quantities to pigs. They are not susceptible to diseases and pests and can withstand climate variability but with corresponding variability in production. The farm has about 200 trees at various growth stages interspersed throughout.

There are plans for adding about 4 breadfruit trees on the farm to contribute to livestock feed. Fruit crops such as guava and papaya in their early growth stage. The strategy here is to introduce long term crops on a limited basis in peripheral areas so that as the farm matures over a 3- to 5-year period, it will achieve sustainable levels.

Demonstration Ranches for Plum Tree Farms

Pig Ranch

The feed formulation has already been tested in Grenada on poultry with excellent results: Protein Supplement that is 30% but the protein % is too high to feed directly to animals. Farmers mix 15 lbs of that with a 50lb bag

of broiler finisher feed @ 18% to get 21.7% for a grower and 10 lbs of that with a 50 lb bag to get 20% for an enhanced finisher. Farmers in the Grenada test averaged 11.4% more meat by using Protein Supplement as per above.

Plum Tree Farms already has a demonstration pig ranch (of 12 sows, 2 boars, and about 120 piglets) that has been utilizing its own formulation of feed from BSG and other plant-based materials mixed with a small proportion of imported feed; the results are also excellent. However, a full substitute for the imported feed would be more sustainable and competitive. Plum Tree farms has also tested its feed formulation on 24 broilers with satisfactory results. Plum Tree Farms will test the feed from the proposed feed factory on its pig ranch and proposes to develop a demonstration ranch for broilers and layers on a small scale that can be replicated by other farmers, the analysis for which is shown in Table 1.

Proposed Aquaculture Component for Plum Tree Farms

Marine resources and fisheries have been negatively affected by the increase of coastal development as a result of tourism development, urbanization and other anthropogenic activities in the Caribbean. Beekhius (1981) described the Caribbean as "free of the widespread environmental degradation that has plagued such areas as the Mediterranean," (p.1). Seventeen years after, Suman (1998) said, "Caribbean ecosystems, coral reefs, and numerous estuaries, are under threat from marine based and land based pollution, uncontrolled coastal development, and overexploitation of natural resources", (p.33). In a research done by (Foster, Lake, Watkinson and Gill, 2011), it revealed that coastal development is currently the leading threat on the marine environment in United Kingdom Caribbean territories. Today coastal habitats such as coral reefs, sea grass beds and mangroves, which support the coastal fisheries, are under serious degradation. The only regulating instrument have been building control mechanism, which regulate how the structures are built and it is hardly enforced (Lewsey, 2003), and with hardly any spatial planning done prior.

Sand mining in the Eastern Caribbean has caused negative impacts on the marine resources and fisheries. Sand is being removed from beaches for the manufacturing of cement, construction of settlements and mass tourism resorts. The Eastern Caribbean has seen the disappearance of sand dunes in Josiah's Bay (British Virgin Islands), Diamond Bay (St. Vincent) and Grande Anse beach (Grenada), (Fitzpatrick, 2010). Large sand mining activities can

Table 1a. Proposed poultry ranch for Plum Tree Farms: Cost analysis of poultry demonstration ranch with locally produced feed

Item #	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL USD
1	Processing & Cold Storage	1		$ 16,000.00	$ 16,000
2	Facilities	1		$ 50,000.00	$ 50,000
3	Wages	36	Mth	$ 600.00	$ 21,600
4	Temporary workers	24	Mth	$ 400.00	$ 9,600
5	Broilers (1000/wk@52 wks/yr)	52000	each	$ 1.00	$ 26,000
6	Broilers Feed (2:1 feed ratio; 5 Lb bird)	52000	10	$ 0.22	$ 114,400
7	Processing & Packaging	52000	Each	$ 0.10	$ 5,200
8	Layers (2000/year)	2000	Each	$ 1.00	$ 2,000
9	Layers Feed (2:1 ratio 6 Lb bird)	2000	12	$ 0.22	$ 5,280
10	Packaging/Dozen	364000	12	$ 0.20	$ 6,067
11	Overhead	12	Mth	$ 3,000.00	$ 36,000
	TOTAL COST				**$ 292,147**
	TOTAL REVENUE	**Quantity**	**Lbs/each**	**Unit Price**	**TOTAL**
	Y1 Broilers	**52000**	**5**	$ 1.00	$ 260,000
	Y1 Eggs	364000	**1**	$ 0.25	$ 91,000
	Y1 Revenue				$ 351,000
	Y1 Expenses				$ 292,147
	Y1 Income				**$ 58,853**
	Y2 Broilers	**52000**	**5**	$ 1.00	$ 260,000
	Y2 Eggs	730000	**1**	$ 0.25	$ 182,500
	Y2 Revenue				$ 442,500
	Y2 Expenses				$ 226,147
	Y2 Income				**$ 256,053**

disrupt and exacerbate erosion of coastlines, which increases the effect of sedimentation on marine resources.

Sedimentation negatively impact coral reefs and sea grass beds, which are important fish habitats. Sedimentation deprives coral reefs and sea grass beds of light that is important to their survival. Sediments quite often smother them and cause detrimental habitat damage (Islam and Tanaka, 2003). Sedimentation is also associated with pollution, where the particles are contaminated with metals and phosphorous, which causes instant deterioration of the seagrass bed and corals reefs, fish kills, bioaccumulation in the fish stocks and eutrophication as a result of increase nutrients from sediments.

Table 1b. Proposed poultry ranch for Plum Tree Farms: Start-up cost for poultry demonstration ranch

Item #	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL USD
1	Processing & Cold Storage	1		$ 16,000.00	$ 16,000
2	Facilities	1		$ 50,000.00	$ 50,000
3	Wages	6	Mth	$ 600.00	$ 3,600
4	Temporary workers	12	Mth	$ 400.00	$ 4,800
5	Broilers (1000/wk@52 wks/yr)	6000	each	$ 1.00	$ 6,000
6	Broilers Feed (2:1 feed ratio; 5 Lb bird)	6000	10	$ 0.22	$ 13,200
7	Processing & Packaging	6000	Each	$ 0.10	$ 600
8	Layers (2000/year)	500	Each	$ 1.00	$ 500
9	Layers Feed (2:1 ratio 6 Lb bird)	500	12	$ 0.22	$ 1,320
10	Packaging/Dozen	15000	12	$ 0.20	$ 250
11	Overhead	6	Mth	$ 3,000.00	$ 18,000
	TOTAL COST				**$ 114,270**

Sedimentation stresses the coral reefs as well and makes them more vulnerable to coral diseases.

As more farmers move into aquaculture, there is a high probability for the increased production of fish, which can help to reduce fish importation. Aquaculture, the farming of fish species is one of the fastest growing good production sectors worldwide. It is contributing tremendously to food security, as it is able to support the growing demand for fresh fish and fish products. Nearly 50% of the world's food fish is produced by aquaculture and 23 million people are employed by the industry (CRFM, 2014). With regards to the Caribbean, the aquaculture industry has been deemed an avenue for economic growth, job creation and food security. Currently the top countries in commercial production in the region are in order of quantities are Belize, Jamaica, the Dominican Republic, Guyana, Haiti and Suriname. In the Eastern Caribbean, smaller scale production has been established in Dominica, the Bahamas, St. Lucia, Barbados, Grenada and St. Kitts and Nevis (CRFM, 2014). The story of TT-Tilapia in Trinidad is a good example of the challenges overcome by smallholder fish farming in order to build scale to the verge of commercial operations, according to contributor, Ryan Mohammed, UWI St. Augustine Ph.D. student in 2016.

From the 1930s to the 1990s, aquaculture in Trinidad witnessed series of startups that all failed due to issues ranging from poor adaptation of imported

Table 2a. Proposed beef cattle ranch for Plum Tree Farms: beef cattle ranching analysis

MAJOR REQUIREMENTS	DEFINITION	INTERPRETATION
Angus	**A recognized breed for quality beef cattle known for high meat quality**	**Not adaptable to tropical conditions but can be achieved over time with adaptation and breeding strategy**
Marbling	**Texture with distributed fat content based on breed, grass + feed supplements, & animal care**	**Feeding and care that contribute to animal health at Plum Tree Farms are as important as the breed**
Taste	**Primarily depends on variety of grass or foliage, which are also a function of climate**	**If they eat mostly broccoli, then the meat would taste like broccoli**
Logistics	Sourcing and shipment with inherent risks of weight loss and mortality	**It is best to ship cattle that are just weaned or no older than 1 year old as they would be better at adaptation. This is particularly important for this analysis, given that Angus is not readily adaptable to tropical climates**
Feed	Types of feeding stuff, e.g. grass, grain, vitamins & Supplements	
Climatic Adaptability	For animal adaptation: primarily humidity & heat combination which can lead to poor meat quality, weight loss, and mortality during reproduction	**Strategy: Start with cross breeding of most adaptable and compatible and the % of Angus required will increase over time**
Reproduction	Fertility, frequency, and mortality	
Ranching-Feeding	Space requirement for grazing and feedlot	
Facilities	Waste disposal from feedlot, slaughtering, and storage	
Feasibility	Least-cost may not be best option; quality is essential	**Equally important to investor and producer**

species, insufficient security, invasion of predators, pollution, poor water quality, and lack of acceptance by consumers based on taste, coloration, and other factors. In the new millennium, more concerted efforts by government, non-government, and private entities eventually resulted in the founding of the Tilapia Task Force in 2012 and an Aquaculture Unit in the Ministry of Food Production in 2014. Combining entrepreneurial inputs from private sector stakeholders with advanced knowledge of species characteristics from ministry specialists, the task force identified key issues such as feed supply security, hatchery management, fingerling security, aquaculture legislation, post-harvest handling of fish, additional processing, and marketing. From just under 2000 lbs. per month or 11 tons annually in 2014, production nearly quadrupled to 40 tons in 2015 and is projected to more than double again

Table 2b. Proposed beef cattle ranch for Plum Tree Farms

		OPTIONS - based on quality and cost, which are functions of major controlling factors				
ITEM #	**FACTORS**	Will remain constant in production because each year they have to be imported with close to Modest Marbling	Will increase in number with the Brahman adaptability to drought conditions with Small Marbling	Will increase in number with the Senepol adaptability to general tropical conditions with Small to Modest Marbling	New strain developed for optimum adapatbility with Small to Modest Marbling; figures are extrapolated from AA; AB; AS	**COMMENTS**
1	**Breed**	**Angus x Angus (AA)**	**Angus x Brahaman (AB)**	**Angus x Senepol (AS)**	**Angus x Brahman x Senepol (ABS)**	
2	**Marbling**	**486**	**395**	**424**	**435**	**Slight = 300; Small = 400; Modest = 500**
3	**Carcass Finished Kg**	**497**	**515**	**538**	**517**	**AA Lowest Weigh conversion**
4	Carcass Days to Finish	128	126	126	127	No significant difference
5	Total Days to Maturity (Life Cycle)					**To be computed but assumed as insignificant**
6	Climatic Adaptability	Low	High	Moderate	High	AB and New Strain have highest adaptability, while AA has the lowest adaptability that is highest risk
7	Logistical Risk	High	Moderate	Moderate	Low	AA is highest risk, while new strain is lowest risk
8	**CONCLUSIONS**	**Angus x Angus (AA**	**Angus x Brahaman (AB) - Brangus**	**Angus x Senepol (AS)**	**Angus x Brahman x Senepol (ABS)**	
	The analysis goes up to 5 year. It will take 6 years for this concept to become sustainable.		This is the least-cost, least-quality option that is not recommended Plum Tree Farms, although it is better than the Angus x Angus option.	This is the 2nd best option with respect to cost satisfactory marbling quality, and sustainability. Has a lower level of adaptability and meat quality than Angus x Brahaman x Senepol. Has highest weight conversion.	**This is the best option with optimum marbling quality, most adaptable (Angus x Brahaman x Senepol), and has higher marbling, Plum Tree Farms, although it has lower weight than Angus x Senepol.** **It is also essential to have Brahman in the mix because of its larger size than Senepol, which is an important consideration for birthing of the relatively large sized Angus.**	

Table 3. Showing potential benefits of proposed aquaculture in St. Kitts-Nevis context

Aquaculture Benefits	
Fishing Operation	• Reduce fuel consumption by fishing vessels • Higher probability of catching fish • Less effort and returns for fishing in comparison to reef fishing
Environmental Benefits	• Reduce coastal Pressure from overfishing • Replenishing of fish stocks • Fish and species interaction improve resilience of coral reef and sea grasses
Economic Benefits	• Development of fishing industry • Development of economic linkages in the fisheries sector • Satisfy local market, and tourism demands • Reduce import bill for fish products

in 2016 with an expected yield of 100 tons. With that increase, one of the pivotal challenges was meeting consumer preference for tilapia that are filleted and drawn (meaning the entrails, gills, scales and fins have been removed). Just as agro-processing with crops becomes a challenge and opportunity as production scale increases, fisheries too require processing facilities and attention to packaging, distribution, and pricing issues. The multi-sector resources and capacities of the Tilapia Task Force have so far proven up to the task of addressing these issues and the TT-Tilapia brand appears to be well-established and paving the way for the development of new aquaculture product lines such as TT-Cascadura, TT-Conch, TT-Crayfish, TT-Prawn, and a series of value-added products to accompany these projected brands.

1. Proposed Species for Aquaculture at Plum Tree Farms
    a. **Tilapia (*Oreochromis niloticus*):** Tilapia are a good fish for warm-water aquaculture. They are more tolerant than most commonly farmed freshwater fish to a range of salinities, high water temperature, low dissolved oxygen, and high ammonia concentrations. They are easily spawned, use a wide variety of natural foods as well as artificial feeds, tolerate poor water quality, and grow rapidly at warm temperatures. Currently, tilapia is second only to carp in global finfish production with a total of over 2 million MT. It is grown in over 100 countries in a wide array of environments. The production of *Oreochromis niloticus* alone, the species proposed in this project, amounted to about 1 million MT, with a value of about US$1 billion.
    b. **Tambaqui (*Colossoma macropomum*):** The Tambaqui is a fish native to the Amazonian River system, and can also be found in

Brazil, Venezuela and Paraguay. The Tambaqui is a good fish for freshwater warm water aquaculture. They are very tolerant to poor water conditions, and can withstand poor handling. They have an excellent growth rate, grow very well on low protein feeds, and can utilize crop residues, left-over food products and natural fruits and seeds, making them suitable for rearing in situations where feed supply is restricted.

c. **Giant Malaysian Freshwater Prawn (*Macrobrachium rosenbergii*):** The Giant Malaysian Freshwater Prawn is native to Southeast Asia, and has been introduced to many parts of the world for aquaculture purposes. It is a freshwater species, which grows to adulthood in freshwater. However, reproduction must take place in brackish water (a mixture of fresh and Plum Tree Farms water), for the resulting small shrimp to survive and grow. It is useful for aquaculture due to its' rapid growth rate, ability to be grown under a variety of culture systems, and adaptability to various food sources.

d. **Australian Red Claw Crayfish (*Cherax quadricarinatus*):** The red claw crayfish a tropical species native to the rivers of north-west Queensland and the Northern Territory in Australia. It is suited to aquaculture, due to its physical robustness, simple life cycle, and ability to perform well on a low protein diet. Its texture and flavor compares very favorably with commonly eaten marine crustaceans and, having the appearance of a lobster, is positioned at the premium end of the crustacean market spectrum.

2. **Parameters of Aquaculture Components:** The aquaculture components will comprise approximately two (2) acre in total, which will also include reservoirs for irrigation to form a network of narrow canals within the existing crop farming acreage.
3. Individual Aspects
   a. Tilapia (*Oreochromis niloticus* strains)
      i. **Purpose:** The purpose of Tilapia culture will be to generate fish for human consumption, and to generate nutrient-rich water for crop irrigation activities.
      ii. **Potential Annual Yield:** 6,000 pounds
      iii. **Target Markets:** Local fish and meat markets for the food fish and on-farm crops, to be irrigated using the nutrient-rich water. These are Banana, Corn, Sorghum and Soybean that will be used for livestock feed, including fish feed.

iv. **Rearing System:** *T*he fish will be reared in freshwater, in a green-water, plankton rich system.
v. **Traceability:** Traceability will be built into the rearing system, with each batch being tracked individually.
vi. **Inputs:** Feed, fertilizer and freshwater will be the main inputs.
vii. **Feed Sources to be Used:** Farm-grown Corn, Soybean, Cassava; farm produced recovered protein, from slaughter waste of chickens, pigs and cattle; and imported micro-nutrients.
viii. **Purging:** In the event that off-flavor occurs, the Tilapia will be purged using brackish water.
ix. **Training and Sensitization:** Seminars, Field Schools, and Attachments.
x. **Technical Support:** On farm and Long distance.
xi. **Underpinning and Cross Cutting Principles:** Environmental integrity, Sustainability, Health, Quality, Certification, and Taste.
xii. **Benefits to the Country:** Development and Support of Local Entrepreneurs, Import Substitution, Foreign Exchange Savings, Value Added Tourism, and Traceability and Personal Involvement.

b. Giant Malaysian Freshwater Prawn (*Macrobrachium rosenbergii*)
i. **Purpose:** The purpose of Prawn culture will be to generate shrimp for human consumption, and to generate nutrient-rich water for crop irrigation activities.
ii. **Potential Annual Yield:** 250 pounds.
iii. **Target Markets:** Local fish and meat markets for the food fish, and on-farm crops, to be irrigated using the nutrient-rich water. These are Banana, Corn, Sorghum and Soybean.
iv. **Rearing System:** The shrimp will be reared in freshwater, in a green-water, plankton rich system.
v. **Traceability:** Traceability will be built into the rearing system, with each batch being tracked individually.
vi. **Inputs:** Feed, fertilizer and freshwater will be the main inputs.
vii. **Feed Sources to Be Used:** Farm-grown Corn, Soybean, Cassava; farm produced recovered protein, from slaughter waste of chickens, pigs and cattle, and imported micro-nutrients.
viii. **Training and Sensitization:** Seminars, Field Schools, and Attachments.
ix. **Technical Support:** On farm and Long distance.

x. **Underpinning and Cross Cutting Principles:** Environmental integrity, Sustainability, Health, Quality, Certification, and Taste.

xi. **Benefits to the Country:** Development and Support of Local Entrepreneurs, Import Substitution, Foreign Exchange Savings, Value Added Tourism, and Traceability and Personal Involvement

c. Australian Red Claw Crayfish (*Cherax quadricarinatus)*

i. **Purpose:** The purpose of Crayfish culture will be to generate crayfish for human consumption, and to generate nutrient-rich water for crop irrigation activities.

ii. **Potential Annual Yields:** 250 pounds

iii. **Target Markets:** Local fish and meat markets for the food fish, and on-farm crops, to be irrigated using the nutrient-rich water. These are Banana, Corn, Sorghum and Soybean.

iv. **Rearing System:** The crayfish will be reared in freshwater, in a green-water, plankton rich system.

v. **Traceability:** Traceability will be built into the rearing system, with each batch being tracked individually.

vi. **Inputs:** Feed, fertilizer and freshwater will be the main inputs.

vii. **Feed Sources to Be Used:** Farm-grown Corn, Soybean, Cassava; farm produced recovered protein, from slaughter waste of chickens, pigs and cattle; and imported micro-nutrients.

viii. **Training and Sensitization:** Seminars, Field Schools, and Attachments.

ix. **Technical Support:** On farm and Long distance.

x. **Underpinning and Cross Cutting Principles:** Environmental integrity, Sustainability, Health, Quality, Certification, and Taste.

xi. **Benefits to the Country:** Development and Support of Local Entrepreneurs; Import Substitution; Foreign Exchange Savings; Value Added Tourism; and Traceability and Personal Involvement.

d. Tambaqui *(Colossoma macropomum)*

i. **Purpose:** The purpose of Tambaqui culture will be to generate fish for human consumption, and to generate nutrient-rich water for crop irrigation activities.

ii. **Potential Annual Yields:** 6,000 pounds.

iii. **Target Markets:** Local fish and meat markets for the food fish, and on-farm crops, to be irrigated using the nutrient-rich water. These are Banana, Corn, Sorghum and Soybean.
iv. **Rearing System:** The fish will be reared in freshwater, in a green-water, plankton rich system.
v. **Traceability:** Traceability will be built into the rearing system, with each batch being tracked individually.
vi. **Inputs:** Feed, fertilizer and freshwater will be the main inputs.
vii. **Feed Sources to Be Used:** Farm-grown Corn, Soybean, Cassava; farm produced recovered protein, from slaughter waste of chickens, pigs and cattle; and imported micro-nutrients.
viii. **Training and Sensitization:** Seminars, Field Schools, and Attachments.
ix. **Technical Support:** On farm and long distance.
x. **Underpinning and Cross Cutting Principles:** Environmental integrity, Sustainability, Health, Quality, Certification, and Taste.
xi. **Benefits to the Country:** Development and Support of Local Entrepreneurs; Import Substitution; Foreign Exchange Savings; Value Added Tourism; Traceability and Personal Involvement.

CONCLUSION

Once this source is utilized from the current availability, it will contribute to a thriving and evolving livestock industry that, in turn, will expand to higher production of offal and crop production (with nutrient recycling for soil production) and perpetuate a manufacturing plant that can fully meet local demand with the potential of exporting on a number of fronts. The integrated farm in St. Kitts-Nevis can meet the objectives of exporting meat and produce from various crops to other Caribbean countries.

The factory has the capacity to produce approximately 80 tons of livestock feed per month to meet the current needs of St. Kitts-Nevis so that it can replace the quantities of imported feed. Once the system is established in the integrated farm, it will self-propel to larger scales to meet optimum demand of future growth in the near- to medium-term. The central purpose of the concept of integration is to build internal efficiencies to counter low economies of scale. If practiced at an enterprise level higher productivity can be achieved, while it can form the initial basis for larger economies of scale

to be developed by vertical and horizontal linkages with other industries and similar or related enterprises.

For this development of proposed livestock enterprises within Plum Tree Farms, it would require capital injection and approximately 10 additional acres of contiguous land (in addition to the existing 4.5 acres) for the integrated concept to be fully demonstrated. The income potential would enable Plum Tree Farms to reach a breakeven point of about 5 years, that is, to reach a point of mature sustainability. At this scale, the enterprise can be classified as semi-commercial. With assumptions and projections, the concept can be scaled up and replicated in St. Kitts-Nevis, other Caribbean countries, and SIDS in general.

The incidence of hurricane in any given year remains a high probability. Building resilience is an imperative and depends precisely on the ability to replant as quickly as possible with short-term crops to generate cash flow to cover recurring expenses. The question of sustainability deserves special attention as a model (referred to in this book as the "Transitional Funnel Model of Farm Sustainability") in a separate chapter which would include the issue of catastrophic failures and building resilience thereof.

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Chapter 4
Crop Waste to Livestock Feed and Livestock Waste to Soil

ABSTRACT

Significant waste but edible biomass and fuel that can be utilized as raw materials are available locally. With internal efficiencies of recycling of nutrients in an integrated farming system and appropriate technologies, such waste can be optimized for the production of livestock feed and potting soil. These items are pivotal to the productivity and efficiency of sustainable farming. Once the initial set up cost can be laid out, the operation can be self-propelled to larger scales with economic benefits at the farm level as well as at the national level. There has been the argument that livestock feed requires large acreages under grain production which is not feasible in small economies of scale and in the context of small island developing states. The paradox is that there is high cost to produce waste which is not utilized and is a loss to the enterprise.

INTRODUCTION

The most significant input of livestock production is feed (about 75% of total cost), and the most significant input of livestock feed is protein (about 60% of total cost). Imported Livestock Feed to St. Kitts-Nevis for several years has been averaging US$15 per 50 pound bag (33 US cents per pound), even with governmental support, while storage and decomposition also posed problems for imported feed. The feed is imported from various Caribbean countries from time to time through the Department of Agriculture as a non-profit

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activity to make it available to livestock farmers. Those suppliers utilize some imported raw materials or byproducts from other industries using imported raw materials to manufacture livestock feed. Even so, the protein content of imported feed ranged from only 18% to 21%. A higher percentage (about 24%) is required for competitive production.

Despite such support to livestock farmers with imported feed, St. Kitts-Nevis farmers cannot produce poultry meat at competitive prices with imported chicken and is therefore practically non-existent. Poultry eggs are produced but at a relatively high cost to consumers. Pork production suffers from similar effects, and although there has been significant improvement in pig ranching in recent years there has been a significant stagnation over the past year due to lower prices of imported pork. The major determining factor for local producers in St. Kitts-Nevis is the high cost of imported feed. Although the competition can be buffered by a policy solution to protect local farmers, there is the competing interest of supermarkets, restaurants, and the general population of consumers with whom the disparities have to be reconciled. The solution is to reduce the cost of livestock feed, which is a primary objective of the integrated farming concept, here presented.

Various economic uses can be obtained from organic wastes and prevent pollution, including organic fertilizer by composting. Non-farm waste, e.g. Sargassum Seaweed that is now prevalent and a menace on Caribbean seashores that can also be used to produce organic fertilizer. Gliricidia, Leucaena, and Moringa that are high in nitrogen and protein can also be used as organic fertilizer and livestock feed, respectively. Similarly, fish waste and some types of garbage can be processed and used for similar purposes. In most cases on the farm, waste is left in the field or cleared and dumped or burned, but they can be processed and returned to the farm so that there would be less cost in buying chemical fertilizers and other economic and environmental benefits already discussed in Chapter 3. Moreover, it can be processed and sold to generate an additional income stream for the farmer.

ISSUES AND OPPORTUNITIES OF FARM WASTE

Alexander, et al (2017), noted that there are losses at every stage in the food system which can otherwise by used to meet nutritional requirements of a growing global population, but that is beyond the scope of this book. However, such waste can be otherwise returned to the farm to enhance productivity. They estimated the magnitude of such waste as to the following extent:

- The proportion of global agricultural dry biomass consumed as food is just 6% (9.0% for energy and 7.6% for protein), and 24.8% of harvest biomass (31.9% for energy and 27.8% for protein)
- The highest rates of loss are associated with livestock production
- Losses of harvested crops at 44.0% of crop dry matter (36.9% of energy and 50.1% of protein) lost prior to human consumption
- If human overconsumption, defined as food consumption in excess of nutritional requirements, is included as an additional inefficiency, 48.4% of harvested crops were found to be lost (53.2% of energy and 42.3% of protein).

Evans and Negele (2018), Buzby, et al (2017, for USDA ERS), Segrè A (2014, for FAO), Gustavssonl, et al (2011, for FAO), Pink (2016), and Munesue, et al (2014) with observations in various regions of the world agree on the staggering proportion of food waste. In the United States, e.g. in 2014 it was estimated that about 31 percent of the food grown, produced, and transported was wasted annually. That translated into 96 billion pounds of food and USD 165 billion in lost economic value. Similarly, the FAO estimates that in 2011, the world loses or wastes was about 30% of the food produced for human consumption, which is about 1.3 billion tons annually or USD 1 trillion annually. Such losses have a negative impact on the environment since they represent a waste of production factors and energy resources, and contribute to greenhouse gasses emissions. It is also estimated by the FAO that 870 million people are still suffering from hunger and malnutrition. Therefore, policies and strategies to reduce food waste and utilizing food waste is essential to reduce widespread and high magnitude impacts. As a response, SAVE FOOD, an initiative of the Food and Agriculture Organisation and Messe Düsseldorf - food packaging event organizer, was established in 2011. SAVE FOOD in 2011 also released a game-changing global study of the extent and causes of food loss and waste carried out in collaboration with The Swedish Institute for Food and Biotechnology (SIK). Koester (at University of Kiel, Germany) noted that reduction of food loss and waste ranks high on the agenda of many policy makers and academics, with as many as 221 publications identified as relevant.

The next section of this Chapter illustrates an option for processing and utilizing waste on a farm enterprise to derive economic benefits and sustainability to the farm, mainly for the production of potting soil and topsoil, and livestock feed supplement.

FEED PRODUCTION AS AN ELEMENT OF FARM DIVERSIFICATION AND INTEGRATION

Keyzer (2017) points to the need to address upcoming scarcity of phosphorus that is a mineral nutrient essential for all life on Earth. He noted that agricultural crops obtain phosphorus, as a macronutrient for plants, from the soil which can be replenished by recycling of organic matter. He also noted the risk of using phosphorus rock that contains other substances such as heavy metals, cadmium, and uranium that end up in fertilizer that pose threats to human and animal health, and he argues for the use of organic phosphorus. Similarly, other macronutrients such as nitrogen, potassium, calcium, as well as micronutrients that plants need can all be obtained from recycling of organic matter.

Jayathilakan, et al (2012), assert that the efficient utilization of by-products from livestock waste has economic and environmental benefits, and not only does it have added value to potential revenues in the industry. They further asserted that there is also added and increasing cost of disposal of these products and can lead to major aesthetic and catastrophic health problems if not disposed in a proper manner. They noted that treated fish waste also has many applications, and livestock and fish waste are most important in the production of animal feed, biodiesel/biogas, dietectic products (chitosan), natural pigments (after extraction) and cosmetics (collagen). They further asserted that although the traditional methods when used in their raw form and mixed with other products, e.g. with molasses to form silage, pose environmental and pathogenic risks, the introduction of cooking technologies, e.g. a bio-digester, mitigates such risk and also reduces the processing time for conversion to livestock feed.

According to Jayathilakan, et al (2012), typical examples of product-specific waste are spent grains from beer production or slaughter house waste from meat production. The product-specific waste from the food industry is characterized by its high proportion of organic material, including animal blood, has a high level of protein and iron, and is an important edible by-product. With regard to environmental impact, they drew attention to the FAO (2011) report noting that processing of poultry by-products into feed is a good way to mitigate the environmental problems, asserting that poultry offals released in the environment are vectors for insects, vermin, bacteria and viruses, which may result in water contamination.

The livestock that utilizes the feed from the same farm can produce raw materials for potting soil production to be used as fertilizer, in turn, to produce

crops from which raw materials are derived to produce livestock feed. There is zero waste and all raw materials! There is also non-farm waste, e.g. wild shrubs such as Gliricidia, Leucaena, and Moringa that have about 21% protein in the leaves and that can be utilized in feed formulations to a feasible percentage; they are also known to have high nitrogen content that is excellent for composting. Spent cooking oil can also be utilized as fat component in feed formulations. Compost has the unique ability to improve the chemical (nutritional), physical (structural) and biological characteristics of the soil or growing media which is beneficial to plant growth. Compost can utilize the entire plants so that not only the fruits are utilized but all that was produced from the input cost. Wild shrubs can be added to composting. Composted material is odorless, fine-textured, and low in moisture. It can be bagged and sold for use in gardens and nurseries, or use as a fertilizer in croplands.

Moreover, fuel in the form of biogas can be produced from the raw materials produced by pigs (and other livestock) to dehydrate the biomass to further produce livestock feed. Such fuel can also be utilized in other ways for the entire farm operation if produced at quantities determined by Plum Tree Farms and which is a part of its medium-term implementation plan, as specified in the pig ranching farm component. The dehydration of biomass for feedstock is essential for storage so that it can be milled and formulated as needed. If formulated and not utilized timely, the feed will decompose and lose its nutritional value.

Another type of non-farm waste that is available and which contributes to environmental degradation is waste motor oil which can be redefined as spent motor oil. When atomized at high temperatures, it can be used as Number 2 fuel for combustion in a modified diesel engine to produce steam for rendering offal for livestock feed. The critical element for rendering offal is high temperatures such as steam. Spent motor oil is otherwise a waste that is not utilized and typically becomes a contaminant in soil and waterways, including freshwater aquifers and coral reefs.

The actual value of raw materials that otherwise go to waste and loss to the enterprise is yet to be calculated, depending on the scale of operation. Plum Tree Farms proposes to demonstrate how waste can be redefined and optimized to produce livestock feed and potting soil in a circular manner to increase productivity. The key design features of the system of production for the livestock feed factory for the Case Study (Plum Tree Farms in St. Kitts-Nevis) are the utilization of:

1. Waste motor oil to produce energy for a boiler

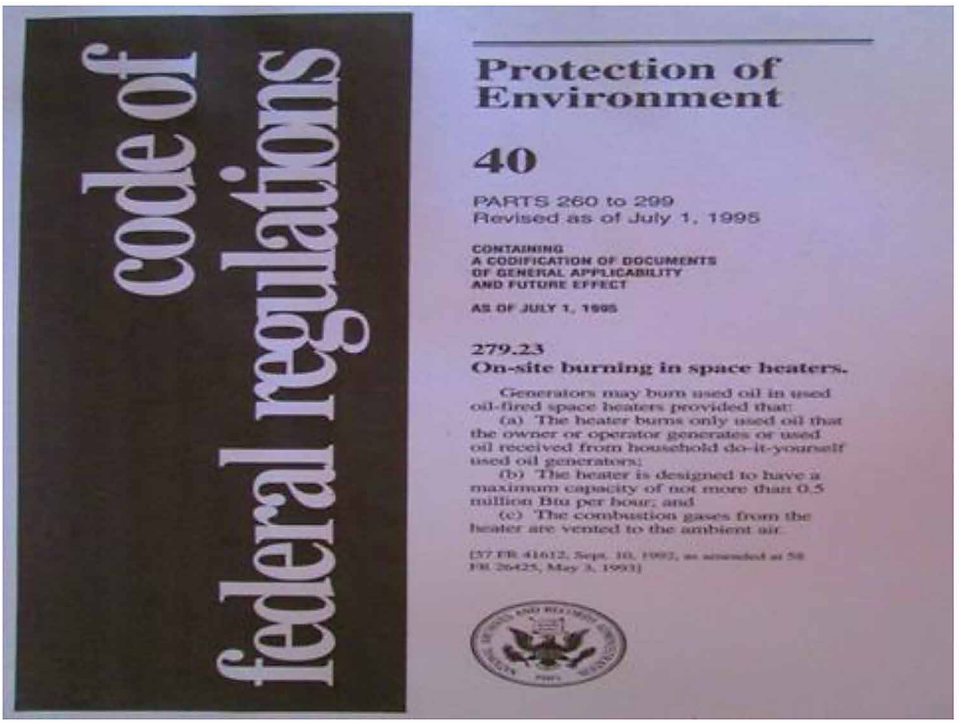
2. Biogas from livestock waste
3. Cooker for rendering organic waste and other biomass with steam under high pressure
4. Animal Protein from Offal (fish and poultry) to be cooked in Bio-digester
5. Vegetable Protein (from Gliricidia, Leucaena, and Moringa; also excellent for composting for enhancement of nitrogen in soil)
6. Brewery Spent Grain (BSG)
7. Used Cooking Oil (from Kentucky, Church's, homes)
8. Passive Solar + Biogas Dryer for fruits and vegetables, e.g. breadfruit, cassava, vegetables
9. Organic Fertilizer from Factory Residual
10. Pet Food Production from Offal (Pig waste).

Waste Motor Oil as No. 2 Fuel for Feed Factory Boiler

Waste motor oil is otherwise dumped soil causing toxic contamination which can eventually reach topsoil and subsoil, waterways, destroy ecosystems, and become dangerous to human health. There is existing policy in St. Kitts-Nevis by which auto service shops are required to dispose their waste oil at a receptacle at the landfill from where it can be shipped to Trinidad for safe disposal or recycling, but this does not appear to be effective at implementation. The use of waste motor oil for powering the boiler for the processing of livestock feed is an excellent way of recycling and adding value to a waste product that is otherwise of little to no value in the national economy, if not detrimental as a hazardous contaminant; the residue from using it for the livestock feed factory is white ash that can be collected and incorporated in concrete construction.

The process is basically heating the waste motor oil to a critical temperature and introducing pressurized air to atomize the hot oil that is then used for combustion as Number 2 fuel oil (diesel) in a conventional oil fired boiler. The heat is used to heat water in a boiler to produce steam which is used in the pressurized cooker for rendering the raw materials to produce livestock feed. The environmental protection aspect for the use of such fuel and where it's already in use as shown in Figure 1.

Figure 1. Showing regulations and technology use of number 2 fuel



Protein and Calcium From Fish Waste

This is a source of raw materials, that otherwise goes to waste, that is rich in protein, calcium, and Omega 3 fatty acids that is useful in livestock feed processing. (Potential yield in St. Kitts-Nevis: 1 ton per month)

Protein From Livestock Offal

The abattoir is a significant source of rich protein that otherwise goes to waste or becomes an issue for disposal. Livestock feed manufacturers utilize such waste by processing them in a cooker under pressurized steam. When mixed with BGS and other forms of plant-based protein, etc., it produces an excellent livestock feed. (Potential yield in St. Kitts-Nevis: 10 tons per month)

Figure 2.

- Technology utilized in:

Australia	New Zealand
Baltic States	Poland
Balkan States	Russian Federation
Belarus	Scandinavian Countries
Bulgaria	Slovakia
Czech Republic	Spain
Hungary	Ukraine
Israel	United Kingdom
Japan	United States
Netherlands	

Carbohydrates From Cultivars and Natural Vegetation

St. Kitts-Nevis has a massive production of breadfruit from "scattered" trees rich in carbohydrates that is a great source of energy for livestock. It is also a good source of fiber and vitamins. The bulk of fruits are wasted due to the rapid deterioration once the fruits are mature or harvested/fallen. If residents were to sell their fruits, which otherwise goes to waste, at a modest price, this can be a useful source of raw materials for livestock feed production. The fruits can be sliced and dried for later use without spoilage.

Figure 3. Showing nature of fish waste

Similarly, cassava and plantains/bananas can also be used as raw materials for livestock feed processing. These produce are not as available as breadfruit in terms of widespread abundance and less spoilage. However, these are crops that can be cultivation in an integrated farming system from the wastewater from ranches for high productivity specifically from the recycling nutrients that can sustain the cycle of: raw materials – feed production – livestock production – livestock waste – raw materials. Other plant material, e.g. Moringa, Gliricida, and Lucieana, are also excellent sources of protein and fiber, which can be incorporated in the cycle of raw materials to finished products. (Potential yield in St. Kitts-Nevis: 10 tons per month)

Fiber From Grain: Brewer's Spent Grain (BSG)

The malted grain used for manufacturing beer loses its carbohydrates and protein once it is spent for brewing. However, it is a useful source of fiber with about 20% protein like most livestock feed. It is an excellent source of raw materials once protein and sugars are added from other sources, e.g. fish offal, to manufacture livestock feed.

Figure 4. Pile of brewer's spent grain (decomposes rapidly if not dried within 48 hours)

It is typically utilized by farmers in a raw form that decomposes rapidly is not used within 3 to 4 days and becomes hazardous with vermin and has a pungent smell of decaying matter if not disposed appropriately. Therefore, the brewery and farmers do not optimize the full benefit of BSG. The key to its usefulness is to dry it rapidly, within 48 hours after brewing. All parties will benefit significantly more from its development into livestock feed. (Potential yield from local Brewer: 50 to 60 tons per month)

Used Cooking Oil

This is a good source of fat, as a substitute to unused cooking oil that is used in livestock feed in relatively small quantities. It is also a good way of utilizing oil that is otherwise disposed of as waste.

Design and Technology for Plum Tree Farms

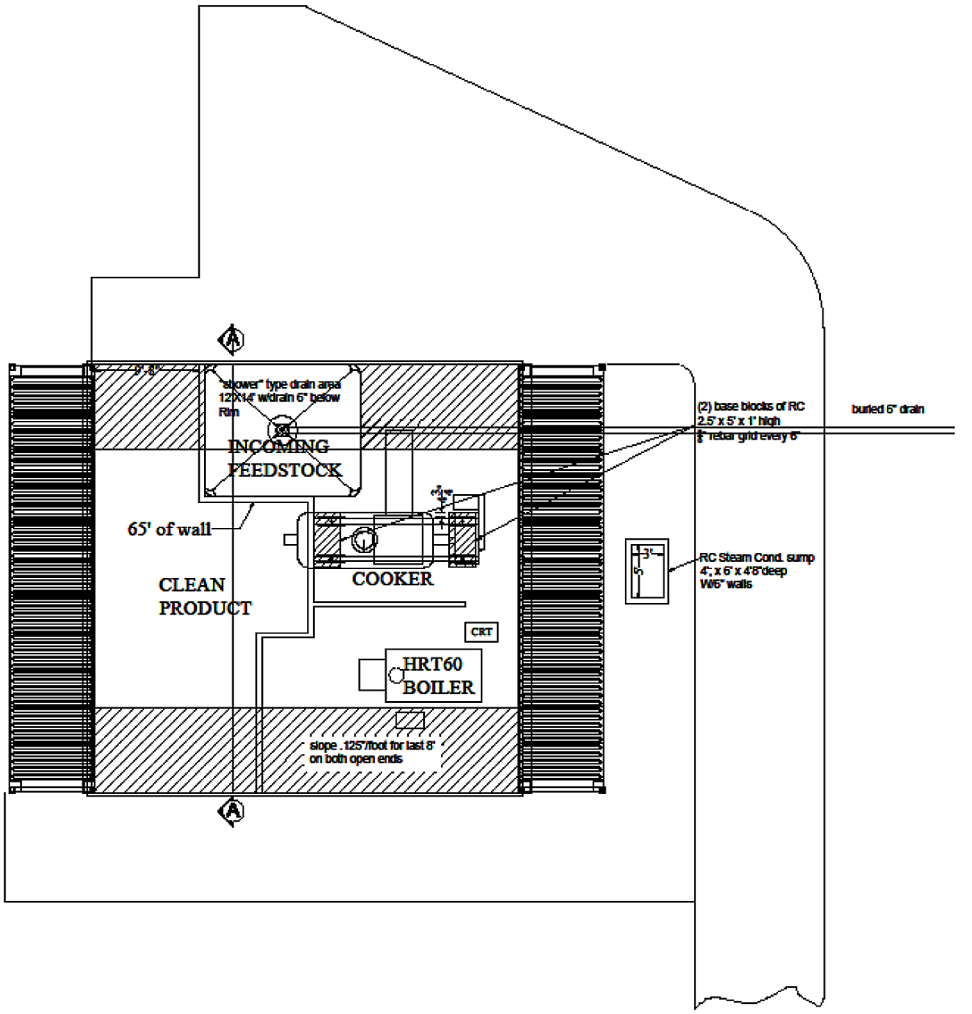
Shown in Figure 5–Figure 9 and Table 1–Table 4.

Figure 5. Showing boiler equipment and boiler using waste motor oil as number 2 fuel to produce steam for cooker

Figure 6. Harnessing of boiler discharge to steam cooker for rendering raw materials. Water vapor from the cooker is condensed and reused for crop irrigation.

Figure 7. Discharge view from steam cooker and finished livestock feed protein supplement from cooker

Figure 8. Site plan and profile of proposed livestock feed factory



Biogas

Livestock ranching produces significant quantities of waste on a continuous basis with much of the energy and nutrients being lost to the natural biogeochemical cycle. Although such waste is often used on farms, it is not typically applied in an environmentally effective manner. This will be used to produce biogas for drying raw materials for producing livestock feed.

When combined with passive solar drying, the effectiveness of the drying mechanism is enhanced to reduce drying time. The dry residual solid mass from the biogas process can be incorporated in the soil composting system.

Digester System Cost

Shown in Table 5.

Sustainability

For this development, Plum Tree Farms would require $317,730 (USD) and approximately 10 additional acres of land contiguous with its existing 4.5 acres to constitute a total of close to the 15 acres requirement for the integrated concept to be fully demonstrated. The income potential from the poultry test ranch by Plum Tree Farms (presented in Chapter 3) would be about $314,906 over the first 2 years of implementation; the break-even point would be about 2.5 years when the test poultry ranch, as well as the existing pig ranch, begin to utilize the feed produced on the farm.

At this scale, as projected, the enterprise can be classified as medium-sized commercial and would be documented as such. With assumptions and projections, the concept can be increased to large scale commercial and replicated in St. Kitts-Nevis to a national scale, other Caribbean countries, and SIDS in general.

Figure 9.

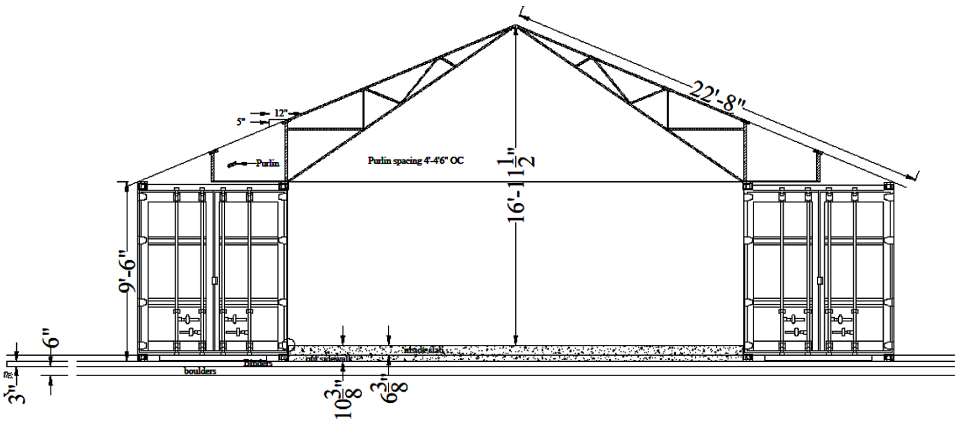


Table 1. Livestock feed factory acquisition and installation

Item #	Name	Specifications	Qty	Unit Cost (USD)
1	Boiler	70 Hp; Webster Engineering; Colombia Burner with Electric Oil Heater and compressor	1	60,000
2	Cooker	5,000 Liter; Pressurized Jacket	1	40,000
3	Insulation	for Cooker	1	3,000
4	Steam Heater for oil	heat exchanger; Alstrom	1	1,000
5	Black Piping	for Steam; Schedule 40		4,000
6	Fittings & Gauges			1,000
7	Jet Condenser	Stainless Steel; 25 gals/min/high pressure water pump	1	2,500
8	Conveyor	1ft x 20ft		10,000
9	Motor	For Conveyor	1	700
10	Containers	40HQ; used	2	6,000
11	Containers/Reefers	40HQ; used, without refrigeration	2	9,000
12	Protein Analyzer		1	40,000
13	Soil Tester			120
14	pH Meter			30
15	Thermometer			30
16	Moisture Meter			30
17	Forklift			2,000
18	Crane			2,000
19	Tractor	With accessories		25,000
20	Trailer	Electrical Dump (with tractor)		6,000
21	Well Harness	Head and Pump; 10K gallons/day		6,000
22	Mixers & Augers			20,000
23	Polycarbonate (multi-wall) for use as solar collector	Lexan or Makrolen; 4’ x 8’ x 0.75”	8	150
24	Black Paint	Enamel Flat	10 gallons	600
25	Container Retrofitting	Including wiring	1	3,000
26	Container Placement	Placement with crane	1	1,600
27	Pulleys			120
28	Bolts			100
29	Metal Drill Bits			100
30	Welder			2500
31	Screen	4’x8’ sheets; 5/16 holes; 46% air; McNichols stainless steel	12	2400

continued on following page

Table 1. Continued

Item #	Name	Specifications	Qty	Unit Cost (USD)
32	Erector Set	Modeling		50
33	Water Tanks	for condensing steam (concrete)	1	2500
34	Water Tanks	for storage (black plastic); 600 gallon	4	1200
35	Concrete	Footing & Slab; reinforced		20000
36	Lumber	Framing		8000
37	Welders	for initial work; company equipment	2	6000
38	Workers	for initial work; Carpenter/Mason, Laborer	5	10000
39	Engineer	Consultant	1	5000
40	Feed Analyst	Part-time staff	1	2000
41	SHIPPING	40HQ	2	14000
	TOTAL			**297,730**

Table 2. Feed production cost analysis

LIVESTOCK FEED COST ANALYSIS - MONTHLY (average grade)							XCD	USD
Ingredient	**Tons**	**%**	**Lbs**	**50/bag**	**Cost/Ton**	**Cost/Batch**	**Cost/50Lb**	**Cost/50Lb**
Animal Protein	4.00	7.14	8000	160	$ 225	$ 900	$ 5.63	$ 2.08
Vegetable Protein	4.00	7.14	8000	160	$ 450	$ 1,800	$ 11.25	$ 4.17
Fish Meal	0.50	0.89	1000	20	$ 225	$ 113	$ 5.63	$ 2.08
Spent Grain	47.50	84.8	95000	1900	$ 200	$ 9,500	$ 5.00	$ 1.85
Overhead						$ 3,000	$ 1.34	$ 0.50
TOTAL Cost	56.00	100	112000	2240	$ 1,100	$ 61,600	$ 27.50	$ 10.19
SALES PRICE							**$ 30.00**	$ 11.11
INCOME/50Lb							**$ 2.50**	$ 0.93
INCOME/56 Tons/Month							**$ 5,600**	$ 2,074
INCOME/672 Tons/Year							**$ 67,200**	$ 24,889
Imported Feed/50Lb Bag							**$ 35.00**	$ 12.96
Cost Reduction of locally produced feed							**$ 5.00**	$ 1.85
Percentage cost reduction							**14%**	

Table 3. Livestock feed factory acquisition and installation

Item #	Name	Specifications	Qty	Unit Cost (USD)
1	Boiler	70 Hp; Webster Engineering; Colombia Burner with Electric Oil Heater and compressor	1	60,000
2	Cooker	5,000 Liter; Pressurized Jacket	1	40,000
3	Insulation	for Cooker	1	3,000
4	Steam Heater for oil	heat exchanger; Alstrom	1	1,000
5	Black Piping	for Steam; Schedule 40		4,000
6	Fittings & Gauges			1,000
7	Jet Condenser	Stainless Steel; 25 gals/min/high pressure water pump	1	2,500
8	Conveyor	1ft x 20ft		10,000
9	Motor	For Conveyor	1	700
10	Containers	40HQ; used	2	6,000
11	Containers/Reefers	40HQ; used, without refrigeration	2	9,000
12	Protein Analyzer		1	40,000
13	Soil Tester			120
14	pH Meter			30
15	Thermometer			30
16	Moisture Meter			30
17	Forklift			2,000
18	Crane			2,000
19	Tractor	With accessories		25,000
20	Trailer	Electrical Dump (with tractor)		6,000
21	Well Harness	Head and Pump; 10K gallons/day		6,000
22	Mixers & Augers			20,000
23	Polycarbonate (multi-wall) for use as solar collector	Lexan or Makrolen; 4’ x 8’ x 0.75”	8	150
24	Black Paint	Enamel Flat	10 gallons	600
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26	Container Placement	Placement with crane	1	1,600
27	Pulleys			120
28	Bolts			100
29	Metal Drill Bits			100
30	Welder			2500
31	Screen	4’x8’ sheets; 5/16 holes; 46% air; McNichols stainless steel	12	2400

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Table 3. Continued

Item #	Name	Specifications	Qty	Unit Cost (USD)
32	Erector Set	Modeling		50
33	Water Tanks	for condensing steam (concrete)	1	2500
34	Water Tanks	for storage (black plastic); 600 gallon	4	1200
35	Concrete	Footing & Slab; reinforced		20000
36	Lumber	Framing		8000
37	Welders	for initial work; company equipment	2	6000
38	Workers	for initial work; Carpenter/Mason, Laborer	5	10000
39	Engineer	Jim Aronson, Consultant	1	5000
40	Feed Analyst	Part-time staff	1	2000
41	SHIPPING	40HQ	2	14000
	TOTAL			**297,730**

Table 4. Feed production cost analysis

LIVESTOCK FEED COST ANALYSIS - MONTHLY (average grade)							XCD	USD
Ingredient	**Tons**	**%**	**Lbs**	**50/bag**	**Cost/Ton**	**Cost/Batch**	**Cost/50Lb**	**Cost/50Lb**
Animal Protein	4.00	7.14	8000	160	$ 225	$ 900	$ 5.63	$ 2.08
Vegetable Protein	4.00	7.14	8000	160	$ 450	$ 1,800	$ 11.25	$ 4.17
Fish Meal	0.50	0.89	1000	20	$ 225	$ 113	$ 5.63	$ 2.08
Spent Grain	47.50	84.8	95000	1900	$ 200	$ 9,500	$ 5.00	$ 1.85
Overhead						$ 3,000	$ 1.34	$ 0.50
TOTAL Cost	56.00	100	112000	2240	$ 1,100	$ 61,600	$ 27.50	$ 10.19
SALES PRICE							**$ 30.00**	$ 11.11
INCOME/50Lb							**$ 2.50**	$ 0.93
INCOME/56 Tons/ Month							**$ 5,600**	$ 2,074
INCOME/672 Tons/ Year							**$ 67,200**	$ 24,889
Imported Feed/50Lb Bag							**$ 35.00**	$ 12.96
Cost Reduction of locally produced feed							**$ 5.00**	$ 1.85
Percentage cost reduction							**14**%	

Table 5. Cost estimate for the principal components of the Penn State 100-cubic-meter anaerobic digester

Foundation (including sludge auger housing)	$2,500
Digester (including insulation)	4,600
Effluent storage	1,900
Roof (including insulation)	1,500
Gas pump	700
Boiler	600
Hydra-ram manure pump (including hydraulic unit)	4,900
Supplies and labor (estimated)	3,300
Total initial cost	$20,000

Total Start-Up Cost (USD):
Feed Factory: $297,730
Bio-Gas Bio-Digester: 20,000
TOTAL: $317,730 (USD)

COMPOSTING AND SOIL PRODUCTION

Any residual from the cycle of raw materials to waste to finished products can be further utilized in soil composting which will be used in the integrated farming system and can potentially reduce the need for imported potting soil. Plum Tree Farms plans to adapt the static aerated compost pile as a start-up method but plans to implement a more sophisticated method developed by the Republic of China (Taiwan) Mission in St. Kitts-Nevis.

Essentially, oxygen enters the pile through sub-channels so that decomposition is more rapid than without oxygen. In this way, the pile does not have to be churned and therefore does not require much input of labor. The Republic of China (Taiwan) Mission to St. Kitts-Nevis technicians have contributed methods and findings from their research and demonstration project in St. Kitts based on the local conditions to the following sections and edited by Cheng and Hanley (2014):

Compost is the product that results when organic matter is consumed and decomposed by microorganisms under favorable environmental conditions. The organic material has been sanitized through the generation of heat and is stabilized. Compose bares little physical resemblance to the raw material from which it originated. It contains plant nutrients but is typically not characterized as a fertilizer. Compost is produced through the activity of aerobic (oxygen requiring) microorganisms. These microbes require oxygen, moisture, and food in order to grow and multiply. When these factors are

Figure 10. Static aerated compost pile

maintained at optimal levels, the natural decomposition process is greatly accelerated. The microbes generate heat, water vapor, and carbon dioxide as they transform raw materials into rich, dark, crumbly, odor free humus. Active composting is typically characterized by a high-temperature phase that sanitizes the product and allows a high rate of decomposition, followed by a lower temperature phase that allows the product to stabilize while still decomposing at a lower rate. Compost can be produced from many "feed stocks" (the raw organic materials, such as leaves, manures or food scraps).

Benefits of Compost and Its Effect on Soils and Plants

Compost:

- Improves the soil structure, porosity, and density that alleviate compact conditions; thus creating a better plant root environment.
- Increases infiltration and permeability of heavy soils, thus reducing erosion and runoff.
- Improves water holding capacity, thus reducing water loss and leaching in sandy soils that causes drought damage to plants.

- When added to clay soils, compost improves drainage and aeration. Note, however, that adding compost cannot solve drainage problems that resulted from poor surface contours or subsurface conditions. Such problems often must be solved by regrading, berming, or installing drainage tiles.
- Supplies a variety of macro and micronutrients.
- May control or suppress weed seeds and certain soil-borne plant pathogens such as damping off disease and root rots. The microflora present in compost, compete with disease microbes for the sugars and nutrients secreted from plant roots, preventing these pathogens from growing and keeping them inactive.
- Supplies significant quantities of organic matter.
- Improves cation exchange capacity (CEC) of soils and growing media, thus improving their ability to hold nutrients for plant use.
- Supplies beneficial microorganisms to soils and growing media.
- Improves and stabilizes soil pH.
- Can bind and degrade specific pollutants.
- Can be used as a soil conditioner or mulch and reduce the need to purchase lawn and garden products such as fertilizers.

Composting is practical, convenient, and can reduce trash removal cost. Leaves and other garden/yard wastes (that account for almost 20% of the total amount of trash that is thrown away each year) can be added to a backyard pile or bin and left to turn into rich dark humus instead of bagging and throwing into the trash. Composting reduces the need to burn or bury organic material, thus reducing pollution.

Composting Process

Choose a convenient place for the compost pile; one that is close by and or easily accessible. A level, partially shaded spot is ideal. However, there is the option to build the pile or bin in full sun and achieve excellent results. Easy access to a water supply is also desirable. Do not build compost piles against wooden buildings or trees because the wood will eventually decay.

An area for storing organic materials, such as leaves, may also be desired. Excess materials should be as dry as possible during storage until a new pile is started. Moist, stored materials will start to decompose and if this occurs, it will not be as effective in the compost pile.

Several methods of composting can be used. The method chosen will be influenced by the amount of organic material available, the need for the finished product and the amount of time that can be devoted to composting.

Three (3) methods of composting are outlined below: Rapid Composting, Standard and Slow Methods. Some of the differences between the methods are highlighted in Table 6.

Rapid Composting Method

The old method of composting was to pile organic materials and let them stand for a year, at which time the materials would be ready for use. The main advantage of this method is that little work time or effort is required from the composter. Disadvantages are that space is utilized for a whole year; some nutrients might be leached due to exposure to rainfall, and disease producing organisms, some weeds, weed seeds and insects are not controlled.

Recently, a new method has been developed which corrects some of the problems associated with the old type of composting. With this process, compost can be made in two (2) to (3) weeks. Extra effort by the composter is required in exchange for less composting time. But for those who want

Table 6. Approximate nitrogen concentration and carbon-to-nitrogen (C/N) ratio of compost materials

Material	Nitrogen (% dry weight)	C/N ratio
Grass clippings	2.15	20
Leaves	0.5 – 1.0	40-80
Sawdust	0.11	511
Wood (pine)	0.07	723
Fruit wastes	1.52	35
Paper	0.25	170
Table scraps	none	15
Livestock manure	1.0	20
Corn stalk	0.06-0.8	60-73
Straw	0.3-1.1	48-150
Bark, hard woods	0.1-0.4	116-436
Bark, soft woods	0.04-0.39	131-1285
Newsprint	0.06-0.14	398-852
Woodchips	0.04-0.23	212-1313

large amounts of compost, or wish to convert materials which are usually wasted into useable compost, the effort is worthwhile.

There are several important factors essential to the rapid composting method. All are important and there is no significance to the order in which they are listed.

1. Materials will compost best if they are between 1/2 to1-1/2 inches in size. Soft, succulent tissues need not be chopped into very small pieces because they decompose rapidly. The harder or more woody the tissues, the smaller they need to be divided to decompose rapidly. Woody material should be put through a grinder, but avoid grinding too finely, or else it will not be good for composting. Chopping material with a sharp shovel is effective. When pruning plants, cut material into small pieces with the pruning shears.
2. For the composting process to work most effectively, material to be composted should have an initial carbon to nitrogen (C/N) ratio of 30 to 1. Over time, the C/N ratio will generally decrease. (Refer to Table 1. for approximate nitrogen concentration and carbon to nitrogen ratio of compost materials.) This can be achieved by mixing equal volumes of carbon-rich naturally dry, brown with nitrogen rich green plant materials. Dried material can be dead, fallen leaves, dried grass, straw and somewhat woody materials from pruning. Paper bags, cardboard boxes, cereal and milk cartons and paper can be used for dried materials but they must be finely chopped or shredded. Newspapers can be used if shredded and separated from plant tissues (so that they do not mat; matting results in the exclusion of oxygen from the composting material). Green material can be grass clippings, old flowers, green pruning, weeds, fresh garbage and fruit and vegetable wastes. Any material that is cut green and allowed to dry is considered green. Some green materials, such as grass clippings may also mat if care is not taken to separate them using dry materials.
3. Keep compost only as moist as a wrung-out sponge. Composting works best if the moisture content of materials in the pile is about 50 percent. The "squeeze test" is an easy way to judge the moisture content of compost. Tightly squeeze a handful of materials, a drop or two of liquid should be produced. If squeezing the handful is like wringing out a sponge, it is too wet. Stirring or mixing the pile loosens the materials and allows air to circulate. If the handful falls apart or feels dusty, it is too dry. Use a hose to sprinkle water to increase the moisture in the pile. Check after twenty-four (24) hours to see if additional water is needed.

Microbes can only use moist materials for food. If the materials are too dry, the microbes may become dormant and the composting process will slow down. If the materials are too wet, nutrients are lost, aeration is reduced, odors are produced, and the process is slowed.

4. If done correctly, a pile will heat to high temperatures within 24 to 48 hours. If it does not, see Table 2 for possible cause and solution. The compost pile needs to be turned to prevent the pile from getting too hot. If it gets way above 160°F, the microorganisms will be killed, the pile will cool, and the whole process will have to start from the beginning. By turning the pile it will be aerated and not overheat, both of which are necessary to keep the most active decomposers functioning. If the material in the pile is turned every day, it will take two (2) weeks or a little longer to compost. If turned every other day, it will take about three (3) weeks. The longer the interval between turnings, the longer it will take for the composting to finish.
5. A hot pile will compost quickly whilst a cool pile will take much longer. The compost pile needs to be large enough to hold heat, but small enough to allow for proper aeration. A very important necessity in rapid composting is heat; it is supplied by the respiration of the microorganisms as they break down the organic materials. To prevent heat loss and build the amount of heat necessary, a minimum volume of material is essential: a pile of at least 36" x 36" x 36" is recommended. Piles larger than 60" wide or 60" tall are not recommended because they are difficult to aerate. If the pile is less than 32", the rapid process will not occur. Allow for enough space to work around the pile. Heat retention is better in bins than in open piles, so rapid composting is more effective if bins are used. In addition, the use of bins is much neater. High temperatures favor the microorganisms which are the most rapid decomposers; these microorganisms function at about 160°F (71°C) and a good pile will maintain itself at about that temperature. A thermometer to measure temperatures inside the pile is helpful although not necessary.
6. Once a pile has started, do not add anything. The reason is that it takes a certain length of time for the material to break down and anything added has to start at the beginning, thus lengthening the decomposition time for the whole pile. Additional organic materials are not needed to initiate decomposition. The microorganisms active in the decomposition process are ubiquitous where plant materials are found and will develop rapidly in any compost pile. There is one exception though. If the C/N ratio is

less than 30/1, the organic matter will decompose very rapidly and there will be a loss of nitrogen. This will be given off as ammonia. If an odor is present in, or around a composting pile, it means that valuable nitrogen is being lost in the air. This can be counteracted by the addition of some organic material with a high C/N ratio (such as sawdust) to that part of the pile where there is an ammonia odor – sawdust for example is very high in carbon and low in nitrogen (a high C/N ratio) and therefore will counteract the excess nitrogen. This is the only time that anything other than water should be added to a pile (should the pile become dry), once it's started. Composting can be done at any time but during the rainy season, covering of the pile may be necessary to keep the composting materials from becoming too wet.

7. The rapid decomposition can be detected by a pleasant odor, heat produced (which is visible during the turning of the pile, given off in the form of water vapor/steam), presence of white coating (that is fungi growing) on the decomposing organic material, the reduction of volume and the change in color of the materials to dark brown.

As composting nears completion the temperature drops until little or no heat is produced. Most of the original material will no longer be recognizable. If in the preparation of the compost, the materials were not chopped small enough, screening of the material through a 1-inch-mesh chicken wire will separate such pieces. These larger pieces can be added to the next pile and eventually they will decompose.

8. After aging for a month or more (after the temperature drops), the compost is then ready for use. Finished compost will have a pleasant earthy odor, look dark and is crumbly.

Standard Method

The standard method is recommended if you have a variety of organic materials such as leaves, grass clippings, kitchen scraps and yard/garden waste. You will spend time building and mixing the pile each week. A small area will be needed for the compost pile and the temporary storage of organic materials. This method produces compost in six (6) to eight (8) weeks.

In the standard method, the pile can be made by combining stored materials, or by placing items in the pile as they become available. When gathering and storing organic materials, browns and greens should be kept in separate

piles. Most greens cannot be stored very long without having a foul odor or attracting pests. It is best to incorporate greens as soon as possible into a compost pile.

Follow these steps:

1. Start the compost pile by mixing one (1) part brown to three (3) parts green organic material with a pitchfork or shovel. Refer to Table 4. If the organic materials are coarse, chop or shred them into smaller pieces so that they can decay faster.
2. Keep compost moist, the pile should feel damp. Use the squeeze test (refer to page 3, #3.) to be sure that your pile has the right amount of water for the composting process. Add water or additional dry material when necessary.
3. Turn the pile after one week. This will aerate the pile. Check for proper moisture and move coarse or less decayed material from the outside to the center. Adjust the moisture by sprinkling with water or adding dry material. Steam may be seen when mixing the pile. (If the pile is not warm or if foul odors are noticed, refer to Table 7 – Trouble Shooting Guide).
4. Continue mixing the pile every week or two and maintain proper moisture. During this time the compost will take the form as in the rapid composting method (see page 4. numbers 7 and 8).

Table 7. Troubleshooting guide

PROBLEM	POSSIBLE CAUSE	SOLUTION
foul odor	excess moisture	turn pile or add dry material such as straw
	compaction	turn the pile or decrease its size
ammonia odor	too much nitrogen	add high-carbon (brown) items
low temp	pile too small	enlarge pile
	too little moisture	add water and turn
	poor aeration	turn pile
	cold weather	increase pile size or insulate pile with a layer of material such as straw
high temp	pile too large	reduce pile size or turn more frequently
	too much nitrogen	add high-carbon (brown) items
pests such as rats and insects	presence of meat scraps or fatty food wastes	remove meat and fatty foods from pile and cover with a layer of soil or saw dust; or switch to an animal proof compost bin

Slow Composting Method

The slow method is recommended if you do not have a steady supply of organic materials. This method will take very little of your time, but it requires six to twenty two months to complete. Storage space is not needed since organic materials are added to the pile as they become available. With the slow method, time is not spent checking for the proper mixture or moisture. As a result, little heat is produced and the process takes longer to complete. The slow method is similar to the standard method with the following modifications:

1. There is no need to check for the proper mixture or moisture. Build the pile with green or brown materials as they become available.
2. If kitchen waste is added, bury it deep into the pile by digging a hole in the top or side of the pile. Cover the scraps with several inches of brown material or active compost. Foods left on the surface may attract pests or cause odors.
3. After six months or more, finished compost will be found at the bottom or oldest sections of the pile. It may be collected and used as it is produced.

What Materials Can Be Used in Composting?

Anything that was once alive can be composted but certain items are best left to professionals and kept out of the home composting system.

When selecting materials for your compost pile, AVOID:

- Wastes that attract pests

Table 8. Differences between the rapid, standard and slow composting methods

	Rapid	Standard	Slow
Time and effort	requires much time and effort	moderate	little
Composting time	2-3 weeks	6-8 weeks	6 months to 2 years
Storage space	necessary	necessary	not needed
Amount of finished product	large	moderate	small
Frequency of turning	daily or every other day	weekly or bi-weekly	none
Temperature	160 °F (within 24-48 hours)	about 160 °F	Very low
Add materials after composting process has started	No	Yes but not recommended	Yes (as they become available)

- Diseased/Insect ridden plants

Fatty food items, such as meat or cheese, should be avoided since they can attract rodents, dogs, cats, flies and other pests. Cat and dog wastes should not be added because they can spread certain diseases. You may also want to leave out plants that are heavily diseased or pest-infested unless you are confident they will be composted hot enough and long enough to thoroughly break them down. This is also true for the reproductive parts of troublesome weeds (e.g., seed heads, rhizomes etc.).

Refer to Table 9 on what should and should not go into the composting pile.

Composting of Manure

Manure from cattle, swine, sheep, goats, horses, poultry and other animals can be composted by considering their manure characteristics and other important factors for proper composting. Temperature, water content, C: N ratio, pH level, aeration rate, and the physical structure of organic materials are important factors influencing the rate and efficiency of composting. Ideal values for these factors are given in Table 11. Homogeneous manure solids can be composted alone without mixing with bulk materials. Bulking agents are needed to provide structural support when manure solids, or other organic residues are too wet to maintain air spaces within the composting pile, and to

Table 9. Materials that can be used for composting

Do Compost		Do not compost
Greens (high in nitrogen)	**Browns (high in carbon)**	
grass clippings	leaves	bones
prunings	bark	dog/cat faeces
fruits and vegetables	straw	oil, grease, fat
houseplants	woodchips	wood ash
manure: e.g., cow, horse, pig chicken or rabbit	sawdust	meat /fish scraps
	newspaper (shredded)	dairy products
kitchen scraps: e.g., stale bread, egg shells, coffee grounds (filters too), tea bags, citrus rinds fruit and vegetable peels	brush (chopped)	weed seeds
	corn stalks	diseased plants
	-	dirt/ soil
	-	-
	-	-

Table 10. Range of manure characteristics from livestock species

Characteristics	N	P	Water content	C:N	pH
---------- % ----------					
Beef feedlot	0.2-3.0	0.1-1.2	20-80	10:1-20:1	6-8
Swine	0.3-0.5	0.1-0.2	70-85	15:1-21:1	7-8
Chicken manure	0.8-2.5	0.3-0.7	50-87	4:1-18:1	6.0-7.5
Broiler litter	1.7-6.8	0.8-2.6	22-29	6:1-24:1	6.5-8.5

Table 11. Recommended conditions for rapid composting

Conditions	Reasonable range	Preferred range
Carbon to nitrogen ratio	20:1 - 40:1	25:1 - 30:1
Water content	40 - 65%	50 - 60%
Oxygen concentration	>5%	5 - 15%
Particle size (diameter)	$^{1}/_{8}$ - ½ inch	Depends on the material
pH	5.5 - 9.0	6.5 - 8.0
Temperature	110 - 150	130 - 140

reduce water content and/or to alter the C: N ratio. Dry and fibrous materials, such as sawdust, leaves, finely chopped straw, or peat moss are good bulking agent for composting wet manure or organic residues.

Composting Methods

There are various methods of composting organic materials. These include active windrow (with turning), passive composting piles, passively aerated windrow (supplying air through perforated pipes embedded in the windrow), active aerated windrow (forced air), bins, rectangular agitated beds, silos, rotating drums, containers, anaerobic digestion, and vermicompost (using earthworms).

Due to the differences in manure characteristics and handling systems for different livestock species, the composting process for various livestock species will be analyzed separately.

Cattle Feedlots

Manure collected from feedlots can be composted with high carbon material (Table 1.) to increase the C: N ratio and reduce nitrogen loss or as is; with no bulking agents. Feedlot manure can be composted in 60 – 120 days.

Swine

Swine manure production and characteristics are given in Tables 5 and 6. Swine manure consists of faeces, urine, waste water and feed. Manure solids need to be separated from liquid for composting. Adding flocculants (which promotes clumping of the solids that are suspended in liquid) such as polyelectrolytes and organic polymers to manure slurries prior to separation can significantly improve the separation efficiencies. Higher water content manure can also be composted if high carbon bulking materials are added to form a composting mound. (See table 1.). After the bulking materials have been added to swine manure, it can be composted in bins 3 feet high and 10 feet wide. Frequent turning may be needed to dry the material, increase the temperature in the composting pile, and reduce odor.

Poultry

Chicken manure production and characteristics are given in Table 5. Chicken manure, broiler litter contain approximate 60 and 25 percent water respectively. When composting broiler litter, water should be added to the material to achieve

Table 12. Manure production per 1,000 lb live animal weight per day

Livestock		Wet mass (lbs)	Total dry solid (lbs)
Feeder cattle		52.0	7.1
Dairy		78.0	10.7
Swine (100 lb hog)		88.4	8.1
Poultry	Broiler	87.9	24.6
	Hens	72.7	17.8
Turkey		55.0	12.3
Sheep		39.0	11.3
Horse		54.0	16.5

a water content of at least 40 percent. Nitrogen loss during composting is a major concern if manure or litter are not mixed with high carbon materials because broiler litter contains about 3 percent nitrogen and manure contains about 4 percent nitrogen. Poultry manure can be composted in bins. Bins may be plain structures with wood slatted floors and a roof, conventional grain bins or bulk storage buildings

Management of Composting

Temperature is the most common indicator of how composting is progressing. Elevated temperature is necessary to destroy pathogens and weed seeds in manure or other organic materials. A temperature that is maintained at 131^{o}F for at least three (3) days is required to destroy pathogens whilst at 145 ^{o}F weed seeds are destroyed in the compost pile. The complete composting process may take two (2) to six (6) months. The water content of mature compost should be less than 50 percent and preferably in the range of 30-35 percent. The C: N ratio should be less than 20.

The composting material should be turned whenever the temperature rises above 145 ^{o}F to prevent overheating, which kills the composting organisms. A temperature below 104 ^{o}F may indicate the lack of adequate oxygen and a need for turning. If the temperature does not rise above 104 ^{o}F after turning, the compost should no longer be turned and left for at least one month of curing to complete the composting process. If the material is dry (water content is less than 40 percent), add water to activate the composting process. In some cases, water content lower than 40 percent may result in overheating and a need for watering. If adding water is not an option, regulate the temperature by turning. The composting period may take longer if water content is not maintained at a proper level.

Land Application of Compost

When the composting process has been completed, screen and allow compost to age for an additional two weeks if it will be used in and around established plants. For general soil enrichment, the ideal time for applying compost is 2-4 weeks before planting. To improve structure and fertility of poor soil, give it a thorough compost treatment by spading 6″-12″ deep and mixing in the compost. Leave the surface rough and cloddy for the approximately three (3) months.

Flower Gardens

Loosen the top few inches of soil in the annual and perennial beds and work in an equal amount of finely screened compost.

Lawns

Use compost when planting new lawns and maintaining existing lawns. Try to produce a thick sod with roots that go down six inches. In building a new lawn; work in generous amounts of compost 4" - 6" deep. If the soil is made of clay, at least a two-inch depth of compost should be mixed in thoroughly to build it up. To renovate an old, patchy lawn, dig up the bare spots about two inches deep, work in plenty of finished compost and rake well. Sow seeds after the patches have been well soaked.

Trees and Shrubs

When planting trees and shrubs; make the planting hole twice the size of the root ball. Blend enough compost into the removed soil so that the mix is approximately 25% compost. Rough up the sides of the hole and backfill with the compost amended soil. Water the ground well, then spread an inch or two of compost on top. Established shrubs should be fed annually by working compost into the soil, then mulching. The "ring" method works best for feeding trees. Start about two feet from the trunk and cultivate the soil shallowly to a foot beyond the drip line of the branches. Rake an inch or two of compost into the top two inches of soil.

Vegetable Gardens

Add compost to soil about one (1) week before planting. When the plants begin to grow at a rapid pace, use compost as a top dressing. In addition, nutritious compost "tea" can be made. Place 2-3″ of cured, finished compost at the bottom of a five-gallon pail, cover with a foot of water, stir well and allow to soak for three (3) days. Strain through a burlap or cheesecloth and sprinkle on and around plants.

Table 13. How much compost to apply

Plant/Soil Application	Compost Application Rate
General Soil Enrichment	1/2" to 3" into top 4" of soil
New Lawns	1" - 2" mixed into top 4" - 6"of soil
Topdressing for existing lawns uniformly	1/8" - 1/4" screened compost spread
Topdressing for vegetables, flowers, & shrub	1" - 2" spread uniformly
Ground cover for annual beds	3" mixed into top 6" of soil
Garden soil	1" - 3" mixed into top 6" of soil
Incorporation around shrubs	3" mixed into top 6" of soil
Potting mix	25% to 30% by volume
Mulch for deciduous trees, & rose beds	3"- 4" spread uniformly
Mulch for vegetables, annual perennial & planting beds	2" to 3" spread uniformly

House Plants

Add compost to potting mixture to provide an enriched soil for plants. To rejuvenate soil in indoor plant boxes, add an inch of compost into the surface twice a year.

CONCLUSION

Once these livestock feed production and composting technology and raw material sources are utilized from the current availability, they will contribute to a thriving and evolving livestock and crop production farm enterprise that, in turn, will expand to higher production of offal and crop production (with nutrient recycling for soil production) and perpetuate a manufacturing plant that can fully meet local demand with the potential of exporting on a number of fronts. The integrated farm in St. Kitts-Nevis can meet the objectives of exporting meat and produce from various crops to other Caribbean countries.

The factory has the capacity to produce approximately 80 tons of livestock feed per month to meet the current needs of St. Kitts-Nevis so that it can replace the quantities of imported feed. Once the system is established in the integrated farm, it will self-propel to larger scales to meet optimum demand of future growth in the near- to medium-term. The central purpose of the concept of integration is to build internal efficiencies to counter low economies of scale. If practiced at an enterprise level higher productivity can

be achieved, while it can form the initial basis for larger economies of scale to be developed by vertical and horizontal linkages with other industries and similar or related enterprises.

Composting further enhances the output and productivity from raw materials that would otherwise go to waste. The composting helps to connect the circular system of sustainability with efficient recycling of nutrients.

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Chapter 5
Farm Enterprise Value Chain for Plum Tree Farms

ABSTRACT

Profitability of a farm enterprise is determined in large part by the value output that is derived per unit of input. Typically, there is significant loss to the enterprise when the farmer makes all the input from investment in equipment, materials, and labor but does not have control over the market value of what is produced and distribution. A significant percentage of profits from farm production lies in the hands of "middle-men" or "turn-hands" and retailers by basically cleaning, packaging, transporting, and displaying them – with time of the seller involved. Other more involved opportunities in the value chain are mainly agro-processing items that would otherwise be wasted, rendering, and specialty or other products that transition from the primary to secondary and tertiary economic sectors. This can occur within the farm from waste conversion to raw material for use on the farm, and also outside the farm and into the marketplace.

INTRODUCTION

This chapter identifies various opportunities for farmers to benefit from the value chain. After all costs have been paid into land preparation, irrigation, planting, maintenance, and harvesting, etc., an enterprise is expected to benefit from the sale of produce. Post-harvest loss continues to pose high risk to farmers when produce is not sold due to lower market demand. Locally

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produced foods are also in direct and fierce competition with imported foods. When foods are imported that can otherwise be produced locally, the local economy loses out on the multiplier effect of farming activities. Therefore, it is prudent to build an economy around the primary sector with import substitutes where possible, while reducing dependency on imported foods. However, supermarket owners and some restaurant owners argue that local supply is not consistent and reliable, and also do not have the standards as imported foods, according to interviews of stakeholders in St. Kitts by Naraine in 2005. However, in the interviews of stakeholders during the same period indicated that consumers prefer the richer and fresher taste of locally produced vegetables, melons, and meats in which hormones are not induced as is typically of large volumes of imported foods at the "low end" of the market; it is not necessarily the same for "high end" or premium foods. One relatively low-cost improvement that brings greater value to local produce is presentation so that they appear attractive to be on par or surpass the appeal of imported produce. The perspective that lower cost produce at the point of sale is better does not take into consideration the multiplier effect of locally produced goods and services, but this aspiration is required to include data on related services for imports vs. related services for local agriculture products.

However, the reality of it is that locally produced agriculture products in some instances are more expensive than the same or similar imported produce. This is so because of the local cost of production which is in part due to the low economies of scale and the cost relatively high cost of input in a tourism oriented economy. The diversified-integrated model shows how the cost of production can be accounted for so that the cost of production is more competitive with imported produce, as well as the limited to no benefits in the potential value chain, to which this chapter now turns.

DERIVING MORE VALUE FROM LOCAL FARM PRODUCE

Retailing vs. Wholesaling

This is an area of missed opportunities for most farming enterprises in St. Kitts. For example, one pound of ochre, one of the main short-term crop of Plum Tree Farms, is sold to supermarkets at $1.10 per pound which is retailed at about $2.50 per pound. This same products has been tested in the retail market by Plum Tree Farms at $2.00 per pound, which is approximately

100% more that the wholesale value. It is a similar scenario for all other crops produced at the enterprise.

There is a different scenario for livestock but can potentially present the same opportunities as crops if it were to be marketed retail by the enterprise. There is severe difficulty in competing with the relatively low price of imported beef, chicken and pork. For example, a pound of regular imported beef, chicken, and pork retail for approximately $2.00, $1.25, and $1.75 per pound, respectively. There are also special cuts of meat with much higher prices, e.g. beef at about $10 per pound. Local beef, chicken, and pork retail for approximately $2.75, $2.00, and $2.50 per pound, respectively, which is an approximate average of 60 percent more than imported meats. Local meats are all regular cuts. Therefore, there is an opportunity to introduce professional butchery to add specialty to local meats to make them more competitive, while adding value. Moreover, meats can be sold retail by the enterprise than selling wholesale at a much lower cost.

For the individual enterprise to market its own produce is not necessarily a simple undertaking but, if arranged in a structured manner, it can accrue benefits to the enterprise. Consider that the wholesale value of produce is almost equal to or marginally higher than the input cost and, more significantly, the risk associated with farming. In the first instance, Plum Tree Farms has to justify the cost of paying one employee to retail its produce, have a sufficiently diversified offering to consistently attract a customer base, and sell a sizeable volume to make a profit of more than the wholesale value for the same volume. Over time, the customer base would naturally increase with good service and quality produce. The enterprise has to caution against taking an existing farm worker to sell at the market, as it can potentially compromise the production on the farm. There was a tendency for this to happen in the beginning stages to test the market.

There is a traditional West Indian near the downtown area of the City of Basseterre marketplace that houses stalls and a meat market. This facility is not quite in the central business district where most of the pedestrian activity takes place. There is also inadequate parking for the potential volume of traffic for such a market activity. However, there is expression of interest to redevelop the facility to improve the conditions. The resultant response is that of street vending that has not been approved and has evolved over time that is typical of small West Indian towns. Although this may be a culturally accepted norm, a major problem is compliance with health standards. Regardless of what direction this goes, there ought to be a mechanism for ensuring that standards are met as if the vendors were in the proper market facility.

Direct retailing of produce by the enterprise can attract restaurant clients, so long as consistency and reliability are assured. Restauranteurs can have the benefit of a lower price based on quantities, which is mutually beneficial to them and the farm enterprise. Wholesaling, remains an option but requires a structured relationship, with responsibilities and commitment on the side of the farm enterprise and the supermarket. One essential consideration, as mentioned earlier, is consistency and reliability of supply. By the same token, the supermarket should commit to a contract to a minimum quantity order so that the farmer does not produce that quantity with the risk of post-harvest loss from no assurance that such quantity will be sold. Obviously, the primary objective ought to be minimizing risk in the interest of both parties. Another objective is to create opportunities for consumers to have the option of local produce at appropriate prices.

There is also opportunity for farming enterprises to market their produce collectively so that there is a cluster of offering. This is easier said than done, given the inherent issues of organizing groups. In terms of group dynamics, if there is no significant benefit to each group member and no significant difference if a member were not to contribute to the group, then the group may be too large or have not recruited members strategically and with clear exit strategies. Each group member ought to have a functional role. It is basically the same principle as a cooperative, although the perception of cooperatives in the Caribbean is that they do not function well in actual practice. The approach of collaboration around common interest has its advantages if structured and manage well. The Famers' Market model is a great option, with minimal organizing needed, except to arrange a common meeting place and having a theme and promotions.

The bottom line is that farmers ought to derive more than merely a marginal income from their high risk investment.

Professional Butchery

Imported meat in most Caribbean countries comes in various cuts to the preference of various consumers. With that there is variability in costs, with prime cuts demanding as much as 200% more than ordinary cuts. For example, imported chuck and briskets mainly for stewing are approximately $2.00 per pound, and prime rib or loin is approximately $6.00 per pound. Local beef is lumped together as stewing meat (without special cuts) and sold at approximately $3.00 per pound. The factor of professional butchery

plays a significant role in how this example of beef is appears to be more expensive that imported beef but without distinguishing the meat quality and associated prices from which local beef does not have competitive advantage. This factor does not include an analysis of how the animals are bred and fed which is certainly a completely different factor that most point of sale consumers may not even take into consideration. This scenario is similar for other types of meat, e.g. chicken, pork, and mutton, as well as fish. It is here implied that more value for farmers can be derived for local meats if they were to be butchered professionally for the market.

Professional butchery requires equipment and training. However, the initial capital outlay for such input is likely too difficult for individual farmers. Therefore, the feasibility lies with collective action, e.g. a cooperative that specializes in butchery.

Agro-Processing

One way to reduce post-harvest loss is by processing of produce, while adding value to the items. It appears that locally packaged produce are not competitive and the perception of farmers or entrepreneurs is that they have to lower their prices to compete with imported packaged foods. However, indications by agro-processors in some Caribbean island nations are that there is a demand for locally packaged foods with growing preference by tourists and local residents alike, and they are likely to be more "fresh" than the generally longer shelf-life and higher quantities of preservatives in imported packaged foods.

Food processing is an extension of the postmodern agricultural industry that involves different sectors like research and development, equipment investment, production and marketing management. It needs to integrate different technologies and production equipment to make mass production possible. Data from the Agro-processing Unit shows that juices and snacks have a high market demand (juice revenues ratio is 37.2%, and snack foods is 29.2%). The St. Kitts and Nevis food service sector country report 2006 states that snack food is the third largest imported food, and juices is the fifth one (in accordance with order is meat, seafood, snack food, processed fruits and vegetables, and juices). Based on this information there is an opportunity to create economies of scale in juices and snacks in St. Kitts and Nevis.

The St. Kitts-Nevis experience in agro-processing, with infrastructure and technical support from the Government of St. Kitts-Nevis in cooperation

with the Republic of China (Taiwan), has been growing steadily over the past few years and still has significant room to grow with the same products to meet local demand. There is potential to grow multiple times even with local demand. One line of products possible from the diversified-integrated model that can be tested and introduced is bacon, ham, and sausage from the diversified farm having livestock components, e.g. blood and intestines in the case of sausage, with Seasonings for such processing can be readily produced on the same farm. There is already a traditional style blood pudding in the Caribbean that is considered a delicacy special snack. The feet of livestock is also used widely in the Caribbean for making souse which is basically cooked feet with pickled onion and cucumber added. Component parts for souse can be produced and packaged as a complete set of ingredients on the model farm. The processing of ham and bacon is a great way of adding value to produce while also serving as an avenue to take out livestock when they would have reached maturity and the threshold for feed conversion beyond which it would be wasteful, even if frozen that utilizes energy for cooling.

Another product line that can be introduced successfully is the processing of pet food. The ownership of pets and demand for pet food has been increasing with the growing trend in affluence related to tourism development, returning nationals, and ex-patriates in the Caribbean. There are also large offshore or foreign-owned veterinary universities in some small island developing states, e.g. Dominica and St. Kitts-Nevis, where it is typical that the students own pets and buy imported pet food year-round. In the diversified-integrated farm model, there is scope for processing pet food from left over carcass after slaughtering and sale, with the potential of adding to the value chain from what would have otherwise been considered as waste.

Drying and Cold/Chilled Storage

Postharvest loss of almost any produce can be reduced with dehydration (drying) to about 15% moisture content, e.g. grain, root crops, fruits, and vegetables. Dehydrated biomass is stabilized which would otherwise decompose rapidly, especially in tropical conditions where the climate is typically hot and humid. Warmth and moisture are two major contributing factors in the growth of fungus, pests, and decomposition. Ironically, dehydrated and frozen produce is imported to the Caribbean, e.g. beans, carrot, cassava (yucca), corn, ochre, and tomato. Additionally, when produce and other biomass rich in protein and vitamins are allowed to decompose without direct use to a farm, it is a

missed opportunity for the production of feed or supplement for livestock which is otherwise imported.

The input cost for dehydration and cooling are definitely major and with a high probability be prohibitive at the individual farmer enterprise level. The diversified-integrated farm model has opportunities to produce biogas from livestock waste with relatively inexpensive low-level technology that is used effectively in LDCs, e.g. Belize, Cuba, and Honduras.

There are also opportunities for passive solar drying, given the generally semi-arid conditions alternating between wet and dry conditions even during the rainy season in this changing climate. This farm model has in its design a passive solar drying system. Basically, it utilizes the incoming natural air by channeling it through a tunnel with a clear plastic below which there is a black matting on the ground to absorb the heat from the sun coming through the plastic. Instead of a plastic, a solar collector can be used to increase efficiency in converting light to heat energy. The tunnel is positioned on a gradient so that the hot air rises as it passes through and then into a tower in the back to accommodate the biomass to be dried. At the top of the tower is a chimney that can be regulated to allow the passage of air without releasing much heat. The heat in the tower can be supplemented with biogas that is produced from livestock waste.

As the biogas quantities increases with the growth of the livestock ranch, opportunities will be opened up for generating power from biogas to run the cooling system for the storage. The storage has insulated wall panels to prevent too much natural heat from the exterior to enter the interior while at the same time not allowing much of the cool air to escape.

Packaging and Branding

Although it may appear that any produce for sale is marketable due to high demand, consumers have preferences and would likely opt for those that are attractively packaged or presentable, based on a consumer survey in 2014. Packaging requires that the produce is washed and covered from the incidence of house flies and dust in some cases, e.g. cut pumpkin, cut watermelon, pak-choy, and spinach. Local farmers tend not to care or have the ability to spend on packaging. The additional advantage of packaging is that the produce can be labeled so that consumers can relate it to a particular brand or farm and which is essential to boost consumer confidence and recognition in order to build a clientele. This is a marketing strategy that farmers in LDCs seldom

consider or utilize, compared to imported produce that are all branded. Supermarkets tend to attract consumers with presentable packaging and branding from their suppliers.

Food Distribution Network

Belize and Guyana are in a commanding position to supply food to the Caribbean, given their abundance of land and freshwater, and their widespread agricultural practices. Unequivocally, productivity may not be high, although production is very high in all respects, i.e. for fruits, vegetables, meats, and seafood (from aquaculture). This includes primarily extensive farming of grain crops that make their livestock feed production viable. However, there is much improvement that can be made in all aspects if they were to adopt the diversified-integrated model proposed in this book, as there is widespread waste production that is not effectively utilized. Moreover, there is significant post-harvest loss in many respects but mostly due to lack of marketing and distribution and to the wide range of other post-harvest loss as stated in the above sections of this chapter. Invariably, they do not benefit much from the value chain model.

The main problem lies with lack of distribution within these countries with relatively large landmasses and with remote regions under agricultural production. They require more effective distribution networks that can be enhanced not only by marketing strategies but also by greater efficiencies to be derived from a value chain integrated model and linkages with suppliers and distributors within these countries and in the Caribbean. For several decades Guyana has been referred to as the "food basket of the Caribbean." However, it never appeared to have been a reality for various reasons, perhaps mainly due to policy negotiations and lack of efficient distribution networks. The Caribbean remains a great potential market for food supply from Belize and Guyana.

One farm that has expressed interest in scaling up the Plum Tree Farms Diversified Integrated Model is located in the Supenaam-Tapacuma area on the East Bank of the Essequibo River, consisting of 189 acres, 80 of which are under rice cultivation. The farmland is strategically located along one side the Supenaam River/Creek which is a tributary of the major Essequibo River. The source of the Supenaam Creek is the Tapacuma Lake with nutrient-rich water – referred to as black water from the coloration of decayed leaves from the dense tropical rainforest. The point at which the farmland joins the

Figure 1. Aerial photo of proposed Tapacuma farm site for scaling up and replication of diversified integrated farm model

Supenaam Creek is ideal for large ships to facilitate transportation to distant markets. Additionally, much of the farmland has a smaller tributary to the Supenaam Creek that renders it highly efficient for irrigation and drainage, and ideal for rice cultivation as well as other types of farming. The farmland is also accessible by unpaved roads for about 3 miles to settlements with paved roads. The illustration, below, shows the parcel of farmland and its accessibility to irrigation sources, as well as river transportation.

Although the cost of inland transportation across long distances (averaging 100 miles) of unpaved roads and large rivers is relatively high, farmers get their produce to markets in towns and cities on a regular basis but not without difficulties, including some produce that perish and much that is not sold and goes to waste, given the major lack of storage facilities and processing.

Government interventions have been made in several Caribbean countries, for example, CEMACO in St. Kitts-Nevis, that were based on good principles for farmers to collectively like in a co-operative have an outlet for their produce where storage was provided. However, it depended on government employees for the operational aspect. According to the tenets of public policy, it is typical to recognize government as a policy-making body but not as effective operators of enterprises. Lessons learned from this type of arrangement, like in many other Caribbean countries, can be beneficial in determining the organizational structure and operations of such enterprise that should have shared governance and independent oversight for monitoring and auditing. Farmers' Association also tends to suffer chronically from failures due to inconsistent interest and support to make it consistently successful.

The principle of group size and dynamics is an important consideration. Optimum group size requires that each member's input to the group is a fundamental to its effective functioning. If a member's input does not make a difference to the group, then the group size is too large. On the other end of the spectrum, if a group is not functioning effectively because there is need for an additional function, then the group size is too small. Each member ought to have a specific role and objectives that are measurable and with a designated group leader on a rotational basis. Overall, the marketing and distribution must be private-sector and profit oriented. The responsibility of achieving food security should not be on the farmer but to all groups in society.

The organizational structure for governance and operations should come from a public-private partnership (PPP) with input of expertise to be paid as professionals by the enterprise and whose role is to provide source support for science and technology, public policy, management, networking farmers for production and marketing, quality control, evaluations, and sourcing of financial input requirements. Any expertise to be hired must be justifiable with output from affordable input generated from the activity.

The private input would manage the operational aspect of the enterprise for production, processing, packaging, and marketing and distribution. Farmers operating at any scale would be considered for networking. Linkages with other farming enterprises will be established to transfer technologies and also engage in joint marketing. This approach is essential for farmers to network and increase profitability as a collective unit. They can also benefit from joint sourcing of materials, equipment, and farming supplies, similar to the practices in the poultry farming enterprise in Jamaica and Trinidad. In this way, the farming enterprise will build capacity by strengthening relations with institutions and community and by the demonstration project providing incubation and support to the enterprise. There will also be opportunities for training and education through associations with research and training institutions, e.g. the National Agricultural Research Institute in Guyana, the Guyana School of Agriculture, and other institutes in the Caribbean, e.g. Belize, Cuba, Dominica, Jamaica, Trinidad and Tobago, and others where successful production-oriented programs have already been established.

Knowing that one of the major disadvantages that farmers face is post-harvest loss, this will be minimized with more effective marketing through a distribution network. Collectively, farmers can have the opportunity of processing, also to reduce post-harvest loss, which often is not feasible on a small scale. When farmers are directly connected through a distribution network, more profits can accrue to the farmer that would otherwise go to

"middle-men." There is opportunity to build on or adopt the practice already in place by the "Dominica Provisions Boat" which has a weekly service to other Caribbean countries. It has been providing valuable and much needed food supplies, such as ground provisions/root crops, vegetables, and fruits. However, like other small island developing states, Dominica too has its constraints with productivity due to the myriad of issues facing farmers. Tropical Integrated Farms will dispatch a cargo boat from its farm location, strategically located with shipping access, to Caribbean countries. On the "back haul" it can bring supplies for the farms and other consumer goods in demand but which are not produced in the home country or community. In time, as the distribution network would expand to trade by which each participating country would enter the supply chain with niche market products that is typically produced in small Caribbean island nations. If the hub were to be strategically located within proximity of the physical geographic or spatial center coupled with a high population center where there is a large market of consumers and relatively large labor force, it will provide a point source for manufacturing excess or surplus produce that can be redistributed on the back haul to the various member countries within the chain. It can also be a point source for export to other international markets.

Regional/Inter-Island Transportation

The notion that the problem of food supply does not lie with production but with distribution is a reality only to some extent. This book identifies the various challenges with production, but transportation remains a major concern in the Caribbean region. Primarily, the difficulty of transportation is related to fragmentation of the many small island nations and low economies of scale so that there is not a sufficiently high volume of goods to be transported at a sufficiently high frequency for intra-regional movement of produce to be competitive. For this reason the technology for storage, e.g. temperature control while in transit, is also not feasible, and the problem is exacerbated with the relatively long duration for produce to be moved from one country to another. This scenario stifles trade within CARICOM countries as well as other international markets.

However, one way to account for low economies of scale is by integrating several farm enterprises within the region so that the volume of production is increased and specialized around agricultural produce that have similar transportation and storage requirements. The advantages will be optimized

by networking the various farm enterprises so that there is shared cost and profits, while having leverage with market supply and prices and by which the profit is more to the advantage of farmers within the network. The expertise based on functional need for this arrangement and operation that assumes the character of an exclusive professional body would be borne by the network as input cost to the farmers, but it will eliminate the need for "middle men" who are in constant search for suppliers and are footloose, i.e. having options and not committed to the individual farm enterprises. Basically, farmers need to have more control over markets and profits than what currently exists, especially in view of the wide range of risks they face almost infinitely.

Although some farmers in their respective countries may have more advantage than others based on local conditions to have higher productivity for particular crops and it may appear that it would be better to specialize and view the overall diversification collectively, the diversified-integrated model at the individual farm enterprise level proposed in this book ought to remain the same for every enterprise within the network so that the inherent risk of monoculture is eliminated. The viability of the individual enterprise must remain by benefiting from its internal value chain (as discussed in Chapter 4 on the diversified-integrated model) but it can have added benefit by contributing its favorable produce type(s) to its diversification and promoting such produce type(s) in the network, while contributing other produce types to its local clientele. Through the same network, the local enterprise can also benefit from a wider range of offering to its local clientele. In this way, there would also be good productivity as a stand-alone farm enterprise but which can increase within the network. Also, raising the productivity of domestic food production, the supply price of labor likely increase and would counter the status quo of low-paying, menial work and subsistence characteristics in agriculture. The success of the network hinges upon the strong contribution of the various successful individual enterprises. As such, it is here suggested that membership to the network must be based on individual success which may be measured by an index to be determined from its diversified-integrated characteristics as well as functional need in terms of expertise to the network.

Inter-Sectoral Linkages and Transformation

In order to achieve the above stated objectives requires a revolution in the approach to agriculture. Over the several decades of tinkering with the critical human necessity of food supply and achieving only a small fraction of real

output. The governance by agencies and departments, both international and local, have produced comprehensive documents and research over those decades to the extent that their objectives have been fully met but without the production of food and building livelihoods. There are opportunities for farmers to be competitive and raise their standard of living on par with other professions and enterprises. This can be achieved if linkages are formed with other sectors from primary to secondary to tertiary sectors in the value chain, and even in the quaternary sector with participatory research and development and planning.

While there is not much control that farmers have directly over the structure of a national economy and for them to get an equitable share if other sectors have significant contribution to the economy, the diversified-integrated farm model at the enterprise level puts more benefits in the hands of farmers. Collectively, farmers can play a great role in the transformation of agriculture in Caribbean states and SIDS from a primary to a secondary sector. With tourism as the engine of growth in most Caribbean nations, there is scope for rendering and packaging produce for tourists and other consumers. Agriculture will continue to be difficult as mainly a primary sector activity and without equity for farmers at the low end of the spectrum of socio-economic status. The constraints that have stood in the way of agricultural progress are hardly insurmountable but have persisted for decades. It has to revolutionize its structure so as to attract professional and capital inputs at the farmer level which it needs. Farmers will be in a position to offer higher wages for hired labor, with higher income to the farmer in the first instance, given the higher productivity scenario. They will create or attract market access, credit and insurance, and also influence state policy. They will have more influence on trade agreements, regulations, and policy. The diversified-integrated model is modern and progressive, yet utilizing original natural mechanisms as well as non-traditional but simple technologies, all based on scientific and commercialization principles to have leverage on infrastructure development.

It is interesting and ironic that emerging economies in the Caribbean have been critical to the monoculture (in agriculture) and its legacy thereof that was tied to colonialism. Yet they have shifted to the "monoculture of tourism" with high dependency on foreign investments and expatriation of wealth. The new trend of sustainable tourism is attempting to change this form of monoculture by greater inclusivity of local communities and environment. It includes local farmers but has a far way to achieve its objectives in this regard because it does not bring structural transformation to farmers that will enable them to benefit from the offer which is more, by far, in the favor of the

tourism services that dictate the negotiations and bargaining. The diversified-integrated farm model can be a catalyst in achieving such objectives.

In the principles of structural development, economic transformation ought not to jump from one sector to another by neglecting the value of the primary, secondary, tertiary, and other sectors, progressively as in the Stages Growth Theory (Rostow's Model in Waugh, 2014) because there are conditions at each stage on which the next higher stage depends. Therefore, each stage needs strengthening to link with the other stage so that strong inter-sectoral linkages are formed and sustained to the overall advantage of all economic sectors for a robust national economy with equity to farmers and all other occupations and enterprises.

CONCLUSION

In effect, agriculture needs a revolution or structural transformation to redress the imbalance by raising the return to agricultural activity and the viability of rural development by investment in human and physical capital in farming. Although many emerging economies have had their primary products as raw materials for trade, agro-processing adds value to primary products either for local consumption or for exporting. For too long agriculture has remained for the most part a primary sector economic activity or segmented with farmers in the primary sector and not benefitting in the value chain from the increased percentage profitability that is typically derived progressively in the secondary and tertiary sectors.

Various models have addressed contemporaneous issues in agriculture and recapping the "buzz words" of the knowledge base about agriculture without focusing on the fundamental issues to the problem facing agriculture. Sharp focus on the building blocks of the sector and food security is an imperative which is the dependence on the success at the individual farmer enterprise. The model for the long-term success at the individual enterprise level is the diversified-integrated model. The sustainable success of an individual farmer from such a model can be potentially successful for all other farmers if they were to adopt the long-term strategies over the decades, in any event, famers dedicate to farming.

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Chapter 6
The Transitional Funnel Model of Farm Sustainability

ABSTRACT

Achieving sustainability in agriculture is a complex, dynamic, and ideal state that may never be fully achieved and a progressive process where the influential factors are also changing. In a dynamic environment there is a state of equilibrium reference point to which the sector can analyze its status in relation to that reference. A change in one variable among several will affect a change in the equilibrium status that is always in a state of constant change. An individual farm enterprise is, by far, less complex and dynamic than the agriculture sector and can be defined in more specific terms with achievable measures. However, it remains an ideal but not as elusive. This chapter shows how such an ideal diversified farm model from initial start up to mature sustainability may be represented with a theoretical model based on the actual practice of diversified-integrated farming.

INTRODUCTION

Emerging concepts for agricultural sustainability include the circular economy, circular ecology agriculture, and climate-smart agriculture. Borrowing from the definition of environmental sustainability is utilization of natural resources to meet the needs of a community in a manner that does not destroy its capability regenerate itself to meet the needs of current and future generations. Sustainable agriculture can be achieved by natural

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methods, in part organically grown, or by technology to increase production to reduce the need for natural methods that would have less impact on the natural environment. The question is, "Can natural methods produce sufficient food to meet the demand of an exponentially growing population?" With technology, the rate of production can potentially increase exponentially as well! Some important aspect of technology that are not often included in the equation are the life cycle costs, impact on environment to produce, impact on human health and other organisms, and the sustainability of technology to the development status of the society in which it is applied.

Traditional agriculture requires large acreages of land that require clearing of natural vegetation and land preparation that have significant impacts on the environment, including erosion, leaching, and microclimates. It also requires, inter alia, large volumes of water, and productivity is generally low. Sustainable agriculture in open field does not necessarily mean the same as traditional agriculture because significant intervention can be made to increase productivity and without as much environmental impact and land requirement as traditional farming. Sustainable agriculture in this context can also mean producing food with the use of sustainable technology, e.g. climate smart hydroponics (LaPlace 2014), organoponics and hybridponics (Naraine, et al, 2015), and aquaculture (as indicated in Chapter 4) to reduce the impact on the environment by requiring less land and water, etc., particularly for crops or food sources that are extremely difficult to cultivate in current condition with climate and environmental change.

Perhaps the most significant problem with sustainable agriculture is relatively high initial input cost with corresponding relatively low output. This is likened to the shape of a funnel in which the input is vast as in the width of the top of the funnel compared to the relatively small output as in the narrow width in the spout of the funnel. This may be referred to as the funnel concept in the initial stage of a sustainable farm development. The funnel concept has been used in businesses analysis, with some proponents referring to the flipped funnel as well to achieve transformation from maximum input and minimum output to minimum input and maximum output. In cost-benefit analysis, this may be referred to as a maxi-min scenario transforming to mini-max. The usefulness of the Transitional Funnel Model of Farm Sustainability are for analysis and planning of actual farms.

THE TRANSITIONAL FUNNEL MODEL

According to Viaux (1993), integrated production is defined as a farming system which integrates natural resources and regulation mechanisms into farming activities to achieve maximum replacement of off-farm inputs, secures sustainable production of high quality food and other products through ecologically preferred technologies, sustains farm incomes, eliminates or reduces sources of present environmental pollution generated by agriculture, sustains the multiple functions of agriculture. There are many opportunities to implement an integrated farming system with multi-functionality and environmental integrity, but requires significant investment to set up the requisite systems for which the returns are protracted. Basically, it is a long-term process.

The funnel analog here proposed is a funnel that is neither upright nor flipped with permanence. Instead, it is a funnel that goes through a transition from upright in the beginning of the farm enterprise to a flipped position as the farm enterprise achieves maturity or sustainability, herein referred to as the Transitional Funnel Model of Farm Sustainability. The term "flipped funnel" has been used in business sales to mean working from a small base of customers to derive a large base of customers, or a pyramid scheme. However, the "funnel" concept proposed in this book is quite different from the business sales strategy.

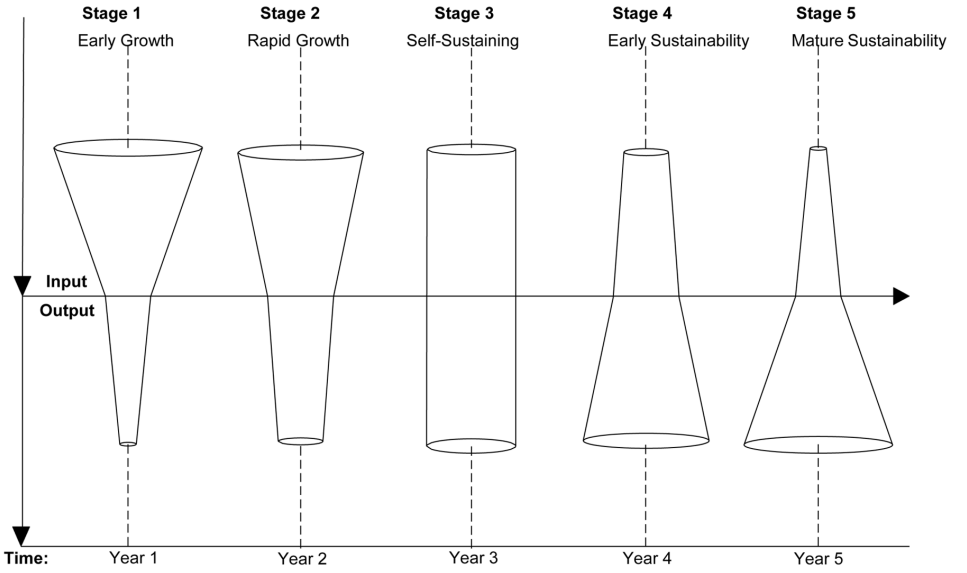
Achieving sustainability at the national or regional level would be almost impossible due to significant variations and complexities in culture, society, economy, technology and environment, all within the same country or region. It is feasible at an individual farm enterprise level or a collective group with shared interest and common objectives but, even so, the enterprise can fluctuate while perpetually trying to readjust to achieve stability as an ideal state.

The diagrammatic representation of the Transitional Funnel Model of Farm Sustainability, below, shows four (4) stages in transition from early growth, to self-sustaining, to early sustainability, to mature sustainability that can be achieved over a 4-year duration.

There are three dimensions to the transition represented in the Transitional Funnel Model of Farm Sustainability as follows:

1. Transition over time from early growth to maturity over a 5-year period (in the case of strategic planning for Plum Tree Farms example) represented on the horizontal axis across the various funnels

Figure 1. The Transitional Funnel Model of Farm Sustainability
Drawing contributed with compliments by Raudel Moreno Alvarez – Mechanical Engineer, 2018



2. Transition from relative *high input–low output* to relative *low input–high output* represented on the vertical axis within each funnel
3. Stages in Transition (outlined below).

The Transitional Funnel of Farm Sustainability is based on the following 2 assumptions:

1. The input factors of initial capital, land, and permits are met.
2. There are no major disasters or extraneous event that changes the objectives or decision-making of the plan set forth to implement the model.

However, this model will help to cope with changing circumstances, including disasters to some extent, with the aim of building resilience and sustainability.

These transitions encompass 5 Stages, further explained and depicted by the characteristic shape at each stage in the Transitional Funnel Model process as outlined below:

Stage 1: Early Growth: Upright Funnel with *Input* > *Output* (pronounced)

Stage 2: Rapid Growth: Upright Funnel with *Input* > *Output* (from Stage 1 but relative reduced input and increased output)
Stage 3: Self-Sustaining: Cylindrical with *Input* = *Output*
Stage 4: Early Sustainability: Flipped Funnel with *Input* < *Output* (beginning to have relative input less than output)
Stage 5: Mature Sustainability: – Flipped Funnel with *Input* < *Output* (pronounced)

CHARACTERISTICS OF INPUT AND OUTPUT AT EACH TRANSITIONAL STAGE

Stage 1: Early Growth – Year 1

Input Characteristics

The initial investment can be approximately $200,000 USD in the context of St. Kitts-Nevis to set up a five-acre farm. It requires installing basic infrastructure such as land clearing, access road/trail, fencing, plumbing, electrical power, storage, cabins and septic tank/sewage system, and new employees. All of these have no immediate output, while they can take up to about 6 months for installation with significant input of capital and time. Additionally, there is need for vehicle, equipment, tools, materials, and supplies.

Then it requires cultivation of short-term crops that can mature in about 2 to 6 months, as soon as possible, after the area is fenced and irrigation installed. The sale of produce will offset some of the wages, while utilities and maintenance have to be paid from initial capital investment. The short-term crops have to be planted in cycles so that there is continuous supply of produce by the end of the 1st year.

Output Characteristics

Although assets are considered output on which there is dependency for long-term development of the enterprise, there can be drastic failure if there is not sufficient cash flow pay wages and maintain the farm infrastructure, utilities, and supplies which are rapidly recurring.

The sale of produce from short-term crops can amount to approximately $1,500 per week, starting off with about less than $1,000 per week and

gradually increasing to about $1,500 per week, which is adequate to pay wages for 3 persons and supplies and utilities. However, it falls short of cash-flow for expansion into medium- to long-term crops and livestock that would require more workers.

Stage 2: Rapid Growth – Year 2

Input Characteristics

There is also need for construction of houses for livestock and initial stock, e.g. piglets, which will take at least one year to mature for sale and reproduction. Due to the high cost of livestock feed and risk of poultry when feed is not available, it is better to begin with pigs that are more resilient to fluctuations in feed supply. Some imported feed can be bought, while some can be supplemented from excess produce. In this phase and during the time that short-term crops are producing to a limited extent, medium-term crops can be cultivated for maturity in about 9 months to one year, and some of which can be feed supplement for pigs to reduce the dependency on costly imported livestock feed. When sufficient produce from the farm becomes available and can be processed into a more consistent supply of feed supplements, which can take up to about one additional year from the beginning of Stage 1, then it would be feasible to make preparations to introduce poultry. An additional input of about $100,000 is required in this phase.

Output Characteristics

By this time, the short-term crops will expand to the maximum carrying capacity of the space and labor allocated for such production. By the end of Stage 2, the sales per week should increase to about $2,000 per week which is sufficient to add a 4th worker for further expansion and investment for Stage 3.

Stage 3: Self-Sustaining – Year 3

Input Characteristics

It is time for further expansion into long-term crops and more medium-term crops which will enhance the production of livestock feed supplements and also grains for stock feed to replace imported feed. More houses for livestock are required. Of critical importance is the development of facilities and equipment for waste to energy and waste to livestock feed and organic fertilizer are critical to achieving increased productivity. An additional input of approximately $120,000 is required at this stage. Therefore, the total capital input is approximately is about $420,000, after which the farm would have achieved a self-sustaining status and beyond which all input would be primarily recurring expenses.

Output Characteristics

By this time, there is increased sales of short-term crops and beginning of sales from medium-term crops, as well as sale of pork from the initial stock, in total amounting to about $2,500 per week. This is sufficient to add another worker and invest in processing facilities and equipment. Some of the farm output is recirculated within the system as waste to raw materials to enhance productivity, but it still not at a positive cash flow position but rather a point at which the cost of full expansion is produced on the farm for reinvestment to reach optimum capability of production in all components of a fully diversified and integrated enterprise.

It may be argued that if there were higher initial capital investment initially, in Stage 1, then the enterprise could have reached this stage much earlier. This may be true to the extent that cultivation of short-term, medium-term, and long-term crops could all begin at Stage 1 with more workers, and facilities and feed for livestock could begin much earlier as well. The constraint is time for crops to mature as feed supplements and stock feed for livestock, otherwise utilization of costly imported feed would be required that would render the activity unfeasible, and keeping in mind that the feed currently imported is of poor quality. Additionally, a larger staff from the initial stage working continuously would require much higher capital input but delayed return on investment. The Transitional Funnel Model has a time dimension for all components of the enterprise to reach maturity and sustainability.

Stage 4: Early Maturity – Year 4

Input Characteristics

More time is now devoted to harvesting, storage, processing, packaging, and marketing, as the enterprise begins more and more to benefit from the value chain and accruing more income from all the investments already made. Agro-processing is the major additional activity at this stage. An additional employee is needed for agro-processing, while marketing and profitability will increase in the value chain. Cultivation and harvesting cycles are in sync and more experience of workers would result in overall profitability with output now becoming greater than input required at this stage, represented by a flipped funnel. The farm would have reached its optimum level of diversification and integration of its diverse activities. There may only be very insignificant capital investment input required at this stage. Any further expansion would require more land.

At this stage, optimum diversification and integration achieved. An index of diversification is found in Chapter 2, and a measure of integration can be computed as a percentage of waste unused from crop and livestock where the lower percentage is of greater value. The farm is now in its early state of sustainability, that is, in a state of stability and positioned for further growth. It would have also reached a level of resilience even if the entire farm were to be devastated in a tropical cyclone or other disaster because there would be sufficient reserve and experience to recover and rebuild faster than it took to build initially. Protection and preparation would have already been activated in the case of a tropical cyclone. The key is to have sufficient reserve to pay wages for at least 6 months which is the average time-frame to cultivate and have returns from short-term crops. Most medium-term and long-term crops would re-establish themselves.

Output Characteristics

By this stage the farm enterprise can have a weekly cash sales of about $3,200 per week that is sufficient to pay the additional worker and at the same time realizing a positive cash flow without further need for reinvestment. Prior capital input can be recovered.

Stage 5: Mature Sustainability – Year 5

Input Characteristics

At this final stage of the farm enterprise, optimum diversification and integration, having achieved to the optimum in Stage 4 and early sustainability, would have been achieved. The Stage 1 characteristic funnel shape is now fully flipped with minimum input and maximum output. However, the level of sustainability can be more mature with a higher reserve for recovery from natural disasters, given that profitability would have peaked. The farm enterprise would have also reached a zero-waste scenario.

It is also at a stage where scaling-up and/or replication of the model becomes feasible, and linkages with those replicated would strengthen the agricultural sector as well as with other sectors.

Output Characteristics

All crop waste is now reclassified as raw materials and fully utilized to produce livestock feed, top soil and fertilizer, and all livestock waste is utilized to produce topsoil, fertilizer, and biogas. Additionally, non-farm waste is utilized to produce energy as food and fuel. Cash flow from sales would now peak at about $4,500 per week, with only recurring expenses to be paid. This comparable to any enterprise of its scale or level of investment in any sector. The enterprise is now in a stage for full recovery of all the capital invested.

Farm Enterprise Sustainability

The farm enterprise having gone through the transitional stages with characteristic funnel shapes in the model presented above, ought to achieve sustainability from its diversified integrated practices. Farm enterprise diversification can be calculated at this time as a measure of agricultural diversification explained in Chapter 2. This can be considered as one level of sustainability but requires other components or variables to constitute a full measure of sustainability. The following ten (10) variables are recommended as measures from which an index of farm sustainability may be calculated for specific farm enterprises (in random order):

1. Diversification

2. Integration
3. Marketing and Distribution
4. Profitability
5. Natural biological/ecological pest control mechanism
6. Conversion of waste to raw material and energy
7. Soil conservation
8. Water conservation
9. Capacity Building – Training Sessions with all employees understanding the mission and objectives of the farm enterprise
10. Resilience to environmental and change.

Some sustainable practices in addition to those implied as variables of sustainability at the farm enterprise level are:

1. **Low Tillage and Point Tillage:** These are practices of tilling the soil only the extent of plant requirements. Too often farmers do heavy and deep ploughing that exposes the soil to erosion and leaching. For example, there is no need to plough extensively to cultivate ochre, except the rows where the seeds will be placed. Similarly, there is no need to for extensive and deep ploughing to cultivate watermelon and pumpkin but only till at the points (point tillage) where the seeds will be placed. It may be necessary to do initial ploughing to prepare the land if it were not suitable for crop cultivation, but a light rototiller can be used effectively, instead of a heavy duty tractor, for future cultivation. With the variability of rainfall and drought conditions within the same season under changing climate, the land is vulnerable to rapid degradation. Low tillage and point tillage can also help with water retention in soils that have low water retention capacity and similarly can be good for drainage systems in soils that are prone to flooding.
2. **Ground Cover:** This prevents the loss of evaporation of soil moisture as well as the growth of weeds that compete with cultivated crops for nutrients from the soil and is suitable for some crops. Except for plastic mulch, which is not recommended as a part of this model of farming, there are other forms of ground cover such as natural material, e.g. wood chips and Sargassum Seaweed (which is in abundance and a problem for coastal areas of almost every Caribbean country), that can add nutrients to the soil upon degradation, while allowing much needed water to infiltrate the soil when it rains.

3. **Wind Breaks and Natural Shade:** These provide beneficial effects for some crops that are vulnerable to strong winds, even though the plants to provide these benefits ought to be food crops that are themselves vulnerable to wind damage. The plants that provide wind protection can be those that re-establish themselves if they were to be destroyed, e.g. banana and plantain because they are likely to be damaged anyway, whether or not they are used as wind breaks. Typically, some fall while other remain standing with support of some fallen trees so that they are still capable of providing protection. These are suitable plants as wind breaks, especially where land space is limited. The plants for the windbreak can also provide a zone of shade for other crops that require it. Moreover, the wind break plants help to intercept precipitation and water retention for the benefit of both themselves and the shaded plants.
4. **Composting:** This is a very effective way of recycling waste to raw materials. Composting helps to restore soil fertility and raw materials can be sourced from both crops and livestock within the farm and supplemented, if necessary, from outside sources such as wild shrubs and livestock lots or pasture.
5. **Waste to Energy:** The biogas that is produced from pig waste is particularly important to power crop drying systems and ultimately for conversion to electrical energy if feasible. Passive solar drying which is not a farm waste but naturally occurring ubiquitously in absolute abundance and unutilized for the most part may be considered as a form of waste to energy. A simple system with a solar collector and gradient for rising hot air is effective as a stand-alone system or supplemented with biogas.

All of the above aspects of sustainability (variables and practices) depend on the carrying capacity of the farm enterprise and availability or access to non-farm waste. The key is to derive maximum output from the available space and a mix of crops and livestock so that adequate quantities of both are in balance for the optimum productivity of each.

Introducing agro-tourism in economies where tourism is a major economic activity, such as most small island developing states in the Caribbean, is prudent to increase productivity. Therefore, it's a potential opportunity if the farm is laid out and organized in such a way as to attract tourists. It is not only about rendering of local cuisines and supplying them offsite, but also offering tours of the farm site where the experience may be unique and

enjoyable. This is a great way of adding value to farm activities that already exist without necessarily a major increase in physical resources, except for the services on which there is a significant return.

CONCLUSION

This chapter shows how a farm enterprise can be conceptualized, planned, and analyzed for optimum output from a diversified integrated farm to achieve sustainability. Although the Transitional Funnel Model of Farm Sustainability is theoretical, it is based on the practical implementation of diversified integrated farming. Its usefulness goes further to the extent that it can help to guide replication and scaling up so that the agriculture sector can be effectively developed.

This Transitional Funnel Model of Farm Sustainability explains the characteristics of the farm at various stages and also the processes that are required to achieve sustainability, and which will also help to guide planning for the farm. Additionally, it will aid in promoting innovations for environmental integrity.

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Chapter 7
Directions for Future Research and Innovation and Conclusion

ABSTRACT

The agriculture sector appears to have more research than is actually utilized in a practical way. Most of the research and innovation fall in the domain of academia and consultancies and, by their very nature, do not address the main problem from the individual farm enterprise perspective. They tend to follow the sources of project funding channeled through agencies, departments, and ministries and, therefore, produced in favor of such organizations. The argument presented in this book for success in productivity and food security requires action research and innovation at the individual farm enterprise level. It is here proposed that action research is integral to innovation, and the major source of innovation ought to be around practical systems and activities on farms to make them successful. The theoretical transitional funnel model for farm sustainability offered in this book presents opportunities for testing, scaling-up, and replication of the diversified-integrated farm concept.

INTRODUCTION

Agriculture appears to be under the control and responsibility of agencies, departments, and ministries with ongoing input by academics and consultants. This involvement and orientation added complexity to the basic necessity of food production that has evolved since time immemorial. The business of food production needs to continue with farmers and the major proportion of

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benefits going back to the producers. When the profitability of farm production is mainly in the hands of entities other than the farmer or farm owner, it is a formula for enterprise failure and, by extension, food security failure.

The approximately five decades of attempts at agricultural diversification has had very little success in many small island states of the Caribbean to the extent that they are all highly dependent on imported foods. There is no impactful production of local fruits and vegetables, and the production of meats locally is a worse scenario than that of fruits and vegetables.

In this concluding chapter, the salient issues are identified and placed in a comprehensive view in order to distinguish the relative importance of each. While economists may apply correlation and regression analysis to determine relative importance of variables, this book suggests a pragmatic approach to distinguish relative importance, significance is derived from a determination of the nature of issues based on overall experience from observations and exposure to the issues, as well as from interaction with farmers at the implementation level. This approach helps to derive recommendations that logically follow from experience in implementing the diversified-integrated farm model and how to follow the pathway to building a sustainable enterprise.

This book recommends that further work needs to be done, such as testing the model for applicability in more diverse environments and conditions. The model also requires scaling up and replication to achieve food security. While food security is feasible to accomplish in a step-by-step fashion over an approximate 5-year period, more upfront investments in the model would render it successful in shorter timelines, such as within 2 years. There is still a factor of time that is essential to progress from its initial stage of implementation to mature sustainability. It is also the case that investors would typically dismiss exploratory concepts and innovations because of the perceived and inherent risks associated with farming. This model addresses the risks so that they are minimized like in any other venture. Some investors are also doubtful about the credibility and experience of farmers without understanding the transformation from subsistence farming to non-traditional and innovative techniques available to farmers.

FINDINGS AND RECOMMENDATIONS

The recommendations need not be extensive because of the extensiveness of issues and complexity of the phenomenon occurring in agriculture. The key is to simplify the issues and focus on the "root" cause and solutions. Agriculture tends to get attention and donor funding because of its very nature as the source of food and support to life, but this does not justify the tremendous funding but poor results. Instead, it is a sector that ought to be held accountable for results that is critically essential to health and wellbeing.

The significant findings and recommendations are:

There is ongoing and endless debate about the legacy of colonialism and stigma to agriculture. Now there is environmental degradation that is exacerbated by the effects of changing climate that adds to the already ailing sector. Food imports in the small island nations have been increasing, while food exports have been decreasing; some of the increase in imports is attributed to the growing tourism sector demanding more food products, but here lies an opportunity for farming to fulfill that additional need with produce and agro-tourism to enhance income of farmers. Diversification at the enterprise or micro level is different from diversification at the national or macro level; at the macro level it is generally higher due to the collective efforts of individual enterprises, but the performance of individual enterprises is what contributes collectively to national diversification.

These issues can be solved by a systems approach to management for which there is planning with purpose, clear objectives, and strategies for implementation of process to achieve desired outcomes. Good management also includes vision and strategic goals, innovation, performance, and businesslike orientation with evidence-based decisions that are required in such a long-term context to achieve sustainability. At the sectoral or national level, there is inherent complexity and long history of under-performance. Focusing on a smaller unit is less complex and, therefore, more manageable, while the success of individual farm enterprises is the foundation for success in the agriculture sector.

The problem of land tenure and availability for agriculture requiring land reform is a historical issue mainly because agriculture has been the least competitive of all economic activities and its seemingly perpetual failures. Agriculture would not be so dependent on land reform if it were a profitable activity. The practice of farming has remained over the past five or so decades largely as subsistence and traditional. This requires urgent

change with sustainable technology that is simple to operate and maintain at the aptitude and skill levels of farmers and the status of development in the country. Contrary to the literature, there is evidence that young people and women are interested in farming, although not at the subsistence level.

One aspect of transformation of agriculture from traditional to non-traditional will attract more entrants while curtailing exits so that it becomes a viable form of livelihood from both the positions of employment and entrepreneurship. This transformation will also attract more trained persons into the sector.

Over the past five decades, agriculture has also remained largely a primary sector activity. While this reality cannot be changed because the production segment is indeed a primary sector activity and forms the base for supply of food, the activity has opportunities to transcend to other sectors such as manufacturing and services where the percentage profitability is progressively greater than in the primary sector. By making this aspect of transformation, the returns on agriculture will be amplified tremendously in the value chain. However, the key question remains within such transformation of whether or not the individual farm enterprise or farmer is successful.

At the farmer enterprise level, the transformation must also occur. With a sufficiently diversified farm there are opportunities for integration and transcending from primary to secondary and tertiary activities so that the farm can benefit from the value chain model. Profitability must come to the primary activity and not siphoned off by others. There are opportunities for larger scale operations through collective activities but successful and sustainable as a sector only if there is shared and equitable benefit to include the farmer. The farmer has the opportunity to include its own marketing strategy to derive a competitive income, so long as there is consistent and reliable production. Diversification accounts for externalities such as unexpected failures of some farm activities while some activities continue to flourish, unless there is a total natural disaster that can potentially affect an entire economy. Diversification also opens up opportunity to build internal efficiencies and derive benefits from the utilization of waste from the transfer of energy (from waste to raw materials and waste to power source) to achieve a zero waste scenario. At the core of diversification and integration is the major output of livestock feed, without which the agriculture sector cannot be successful to its optimum potential. This requires careful planning and implementation strategies.

Even with a natural disaster, there are opportunities to plan for recovery within specific timelines and at predetermined costs. The case study identified in this book has experienced the effects of two hurricanes in 2017 in quick

succession of only two weeks apart; in the passage of the 1st hurricane about 15 percent of crops were damaged, but by the time the 2nd hurricane struck, 95 percent of crops were wiped out, about 10 percent of livestock destroyed, and fencing protection from stray roaming livestock and wild pigs was also breached. The farm was rebuilt in about 10 months with sustained deficit and setback in plans towards achieving mature sustainability by about one additional year. But in terms of planning and implementation, it is best to apply the Transitional Funnel Model of Farm Sustainability as an original concept proposed in this book.

The main findings from investigation by extensive field observations and survey of farmers by Naraine in 2005 on farming in St. Kitts are (these have led to justifying the need for a diversified integrated farm model):

1. Very significant is that about 75 percent of the land occupied by farmers is government owned.
2. Many farmers do not live in the same parish as the farm location.
3. About 50 percent of all commercial farms are below one acre in size, with a combined total of about 70 percent being less than 3 acres, or 75 percent being less than 5 acres.
4. At the national level, there are about 45 to 50 crop types and about 5 livestock types in any given year.
5. Of the collective 47 crop types surveyed, 16 are considered as significant, based on their percentage value to the total value of all crops produced, as well as the number of farms cultivating such crops. However, only 4 crop types are really major: peanut, tomato, pumpkin, and water melon.
6. Livestock types are traditionally the five main types: cattle, goats, pigs, poultry, and sheep. However, there is an insignificant production of chicken in St. Kitts resulting on a heavy dependence on imported chicken.
7. There is a prevailing high demand for food crops and livestock products but a typically inadequate domestic supply. As such, there is hardly any difficulty in finding a market or needing storage.
8. Apart from diseases and pests, monkeys, and theft/praedial larceny, and stray roaming livestock are significant problems for crops, while dogs and theft are problems for livestock.
9. There is good use of crop rotation practices and rotational grazing, but there is heavy reliance on chemical fertilizers and disease/pest control.
10. About 75 percent of farmers have no formal training in applying disease/pest control.

11. About 65 percent of farmers, whether crop or livestock or both, indicate a profitability of less than XCD $25,000 per annum.
12. Almost 40 percent of all farms have never been inspected or monitored by the Department of Agriculture.
13. About 60 percent of all farms use irrigation, and about 70 percent use overhead sprinklers. However, about 60 percent of those irrigated depend on rain-fed, catchment supply.
14. The majority of farmers, by far, receive farming information from radio and other farmers.
15. Over 90 percent of all farmers do not have any membership or affiliation with agricultural based organizations.
16. Less than 15 percent of all farmers received farm input credit, and the main source of credit is private lending institutions with as much as 13 percent rates.
17. About 80 percent of all farmers do not keep business records, and over 90 percent do not have a farm business plan.
18. About 25 percent of household members working on farms are below 18 years old, while there is about an overall 60 percent below age 35 years. This further conforms that many young persons are involved in farming, quite contrary to the literature and to the general St. Kitts' public perception that mostly old, retired persons are in farming.
19. Among the almost 150 farms surveyed, only about 50 persons are employed on about 30 farms. There is an almost even distribution of male and female employees working on an occasional basis.
20. Among the 50 employees, there are about 10 overseas workers – mainly from Guyana.
21. With regards to farm assets, real property averages only about XCD $12,000, but average vehicle values are about XCD $35,000. The great majority of farms have one vehicle.
22. Heavy equipment averages about XCD $25,000, while light equipment averages about $3,000, with almost all farms having light equipment.
23. Only about 55 percent of all commercial farmers are aware of the current 5-year Agricultural Diversification Plan, launched in 2002 by the St. Kitts Department of Agriculture.
24. Over 80 percent of all farmers reported annual household income of less than XCD $35,000, consistent with the national median income of about XCD $20,000 per person, but for a household with two persons employed.

25. However, it very significant to note that about 70 percent of all farmers indicated that less than 25 percent of their household income is attributed to farming activities.
26. The great majority of crop farms have a low level of diversification compared to the optimum level, while it is even lower for livestock farms with the majority at zero diversification. Mixed farms (crop and livestock) show a slightly higher level of diversification but are still generally below the optimum.

Note that the above findings are not prioritized according to significance of the issues. This would require in-depth policy analysis that would go beyond the scope of this research. However, this research identifies the factors

Table 1. Model for agricultural diversification policy

Problem/issue Identification	Interest-group Identification	Problem Definition	Recommended Policy Tool	Responsible Institution (s)	Oversight Institution
List the problems or issues identified in the research. Apply policy analysis to determine the statistical significance of the each problem. Apply Professional judgment to prioritize the problems.	Identify the various stakeholders affected by the problem or having interest in the issue. Identify the target population for which the intended policy is expected to reach. The target population is not necessarily the individual enterprises alone, but also those charged with the responsibility of institutional support.	Define the problem in free-market failure typologies. Failures include public good, monopoly, information asymmetry, and externality, but issues of equity may be added. Also identify government failures.	Depending on the type of failure, identify the policy tool most appropriate to correct the failure. Policy tools for free-market failures include, taxes, incentives, disincentives, regulations, provision of good or distribution, and redistribution. In order to moderate government failures, formulate a plan for performance evaluation and adjustments, or institutional restructuring for major failures.	Identify most appropriate institution(s) technically qualified to implement particular policies. There may be multiple institutional involvement or diverse technical expertise. Identify one institution as the lead agency that would collaborate with others, including a citizens' advisory committee, including farmers, to formulate implementation strategies.	Identify institution to perform Evaluation. Evaluation plan should include performance measures and monitoring system with timelines. Also include measures to identify regulatory capture, and whether the policy is reaching the target population for which they are intended.

influencing agricultural diversification policy and provides the findings to form the basis for policy analysis for potentially interested stakeholders. Nevertheless, this research provides a framework or model for which policy analysis for agricultural diversification in St. Kitts may be guided. Specifically,

policy analysis should address, among other things, issues of prioritizing among the problems identified with a view to implementation, and policy design features and implementation strategies with performance measures and monitoring. A policy framework follows in Table 1.

SCALING UP AND REPLICATION OF THE DIVERSIFIED-INTEGRATED FARM MODEL

Testing

The Transitional Funnel Model for Farm Sustainability is theoretical based on the actual farm implementation of the diversified integrated farm concept. This is demonstrated on case study of Plum Tree Farms of about 4.5 acres located at Lower Plum Tree, Cunningham Estate, in St. Kitts. However, there are three limitations that require further work.

The first limitation is that the theoretical model can only become accepted and recognized as a theory if it has been tested widely to varying situations or conditions. Over a regime of testing, some assumptions would likely emerge to account for variability in situations but the theory would become applicable to all situations that would include variability in environmental, human (culture and society), scientific and technological, and economic conditions. The benefit of the theory will be to facilitate planning and implementation so that the farm enterprise concept can be scaled up and replicated towards building a sector and food security.

Scaling Up

Although the concept of integration is to enhance benefits where economies of scale are small, the utilization of waste as raw materials becomes more effective when the scale increases so that the investment in technology and facilities for the diverse activities can become justified in shorter timeframes. Also, the greater the effectiveness and shorter the timeframes to achieve mature sustainability, the more convincing the model will appear to policy makers and consumers.

One way of scaling up this farm concept is to expand on the individual enterprise in which the farm can be operated on higher than 5 acres. The case has been made in previous work by this author that more than 2 acres to 5

acres is semi-commercial, while more than 5 acres is commercial. Note that 2 acres or less is considered as small or subsistence level farming. Although sustainability can be reached at the subsistence level, it would be more difficult to achieve optimum farm diversification and integration of activities. The demonstration model with the features of a mix of enterprises presented in this book is best achieved at the semi-commercial or commercial scales.

Another way of scaling up this farm concept is to form linkages with similar farms. Ultimately, it would be increasingly difficult to achieve sustainable food security from a single sustainable farm. This approach to scaling-up therefore requires replication of the diversified-integrated farm concept.

Replication

The key to scaling-up by linking similar farms is replication. If different types of farms are linked, then there would be varying degrees of advantages and disadvantages. This is an essential consideration for group dynamics. If roles are not balanced, then it can be a potential source of conflict. Likewise, if the role of an individual enterprise within the linkages does not make a difference in the output of the collective effort, then that enterprise is not a necessary member of the consortium. Overall, the diversified-integrated concept will be strengthened to realize greater benefits to the various enterprises within the consortium than if they were operating independently. This is the foundation of building a sustainable agricultural sector.

Building a sector from the ground up provides for a strong foundation on which to foster the transfer or sharing of knowledge so that there is greater benefit to all participants that would naturally lead to vital innovation in the private sector where most innovations occur, not by government or by consultants or academics. It is important for participants to become good at what they do and, in turn, become recognized and build reputation which is good for consistency and reliability for the purposes of marketing and building entrepreneurship. This would be a powerful force to reckon with and for policy makers to recognize and support.

CONCLUSION

In the numerous and widespread attempts to enhance local food production and food security, there has been no successful model at the national level

in any small island developing state in the Caribbean. It is important to view the issues from a different contextual perspective than which obtained at national levels. This book argues that emphasis ought to be on the success of the individual farm enterprise level and adapting the diversified integrated farm model so that, collectively, national agricultural diversification and food security can be achieved. A diversified enterprise has opportunities for integrated activities the core of which is the utilization of waste from crops to livestock feed and livestock waste to soil. Individual farm sustainability is essential to achieve success, as articulated in the Transitional Funnel Model of Farm Sustainability based on experiences of developing actual farms.

The purpose of the research was to examine the factors influencing agricultural diversification in St. Kitts. The purpose is achieved by attainment of several objectives at two levels. One level is at the national level, but the emphasis is placed on the micro-level, i.e. with the individual enterprises that actually determine the ultimate outcome of any implementation plan suggested at the national level. Therefore, the greater proportion of findings derives from the data set derived from the questionnaire survey. However, it should be emphasized that the macro and micro environments are intertwined, and therefore all recommendations hinge upon the total perspective of agricultural diversification in St. Kitts.

Development of the diversified-integrated farm concept to optimize the use of farm and non-farm waste must be guided by the Transitional Funnel Model for Farm Sustainability so that the "guess work" is taken out of the process. It is a systematic process so that output has some degree of assurance, depending on how well the process is implemented. Metrics for measuring sustainability needs development, particularly with respect to the greater benefits of the multi-functions of sustainable agriculture. There is some overlap between scaling-up and replication and both are highly important for the achievement of higher productivity and food security. As such, there is scope for future work on the transfer of knowledge on the systems in this model so that the concept can be promoted by further innovation and development of entrepreneurship at the farm enterprise level to build the agriculture sector.

There is a multiplicity of factors influencing diversification, and, to be sure, it is not necessarily easy to accomplish changes. One caveat is that there is a danger in oversimplifying issues that are complex, involving such widely differing components as the human and physical phenomena. For the purpose

of analysis, reality is taken apart by identifying specific factors influencing diversification, but it must be realized that all the variables identified work in combination and therefore have a combined effect on diversification. This research recommends that all the issues identified should be put into one model and apply both policy science and professional judgment in formulating policy and implementation strategies.

In the final analysis, it is important to move forward with what is most politically and financially feasible. Therefore, any implementation strategy should strongly consider a demonstration project that can inform any larger-scale undertakings. This research provides direct interpretation of the St. Kitts experience with agricultural diversification based on extensive empirical work. It forms the basis for future policy design and implementation for agricultural diversification in St. Kitts. The diversified integrated farm model can be used for the wider Caribbean, but empirical research must be done to interpret the circumstances for every territory.

Related Readings

To continue IGI Global's long-standing tradition of advancing innovation through emerging research, please find below a compiled list of recommended IGI Global book chapters and journal articles in the areas of food security, agricultural development, and sustainable agriculture. These related readings will provide additional information and guidance to further enrich your knowledge and assist you with your own research

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