Impacts of Vulnerabilities and Climate Change on Sustainable Agriculture for Caribbean Small Island Developing States (CSIDS)

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1 Introduction

Small Island Developing States (SIDS) are small islands and low-lying coastal countries with varied geography, climate, social, cultural, political and economic development. Currently, fifty-one (51) SIDS are included in the list used by the United Nations Department of Economic and Social Affairs (UNDESA) in monitoring the sustainable development of SIDS (UNEP 2008). These countries are often categorized by their three regions; the Caribbean, the Pacific, and the AIMS (Africa, Indian Ocean, Mediterranean and South China Sea). These states and territories often work together in the United Nations (UN) through the Alliance of Small Island States (AOSIS)[1]. These countries share a number of environmental and socio-economic characteristics which highlight their vulnerability to emerging challenges and climate change, which undermine efforts to achieve sustainable development.

Most SIDS recognize the importance of sustainable development[2] as a key component in their developmental path due to a number of structural problems that they may have (UNEP 2005; UNFCCC 2007b):

[1] The Alliance of Small Island States (AOSIS) is a coalition of Small Island and low-lying coastal countries that share similar development challenges and concerns about the environment, especially their vulnerability to the adverse effects of global climate change. It functions primarily as an ad hoc lobby and negotiating voice for SIDS within the United Nations system. AOSIS has a membership of 43 States and observers, drawn from all regions of the world: Africa, Caribbean, Indian Ocean, Mediterranean, Pacific and South China Sea. Thirty-seven are members of the United Nations, close to 28% of developing countries, and 20% of the total membership of the United Nations. Together, SIDS communities constitute some 5% of the global population. http://www.un.org/esa/sustdev/sids/sids.htm.

[2] According to the International Institute for Sustainable Development (IISD), sustainable development has been defined in many ways, but the most frequently quoted definition is from Our

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- Their populations, and markets, are small; and depend on international trade
- Their resource base is usually narrow (e.g. limited land space and finite natural resources), fragile (e.g. their ecosystems) and can be prone to disruption by natural disasters especially among low-lying islands;
- Serious vulnerability to extreme climate events and other environmental disasters;
- Isolated geographically from the global market and vulnerable to global developments
- Typically SIDS depend on foreign exchange on a small range of primary product exports; as well as high import food bill and
- Local capital for productive investment is limited.

Climate change has been identified globally as the single environmental issue of the twenty-first century that poses unprecedented threats to mankind. The accelerated rate of climate change as a result of human activity, can be attributed to the increases in concentration of greenhouse gases in the atmosphere as a result of deforestation, fossil fuel combustion, industrial processes and waste management (IPCC 2007a). Climate change is anticipated to have far reaching effects on the sustainable development of SIDS including their ability to attain the United Nations Millennium Development Goals by 2015 (UN 2007). Caribbean Small Island Developing States (CSDIS) are particularly vulnerable to severe consequences of climate change, which results in sea level rise, increased flooding, an increased frequency and intensity of hurricanes, hillside erosion, and loss of coastal habitats. These environmental concerns, combined with their particular socio-economic situations, make CSIDS, some of the most vulnerable countries in the world to climate change, despite the fact that they produce very low levels of greenhouse gas emissions. The main sectors in CSIDS that are likely to be impacted are agriculture, human health and settlements, coastal zones, and water resources as well as cross sectoral socio-economic systems (UNEP 2005).

Agriculture has been the backbone of many CSIDS economies; however the impact of climate change on the agriculture sector and its effect on food and nutrition security is of great concern. Figure 1 shows the different components of food security that are affected by climate change. In the Caribbean, agricultural productivity has declined and this has been exacerbated as a result of environmental issues such as depletion of marine and coastal zone resources, contamination of fresh water resources, deforestation, decline in biodiversity, extended periods of the dry season, hurricanes, flooding, lack of proper water supply, land degradation and soil erosion, loss of soil fertility and shortening of the growing season, all of which lead to major economic losses and seriously affect food security. In the Caribbean region, the 2004 hurricane season caused damages estimated at US$ 2.2 billion in four (4) countries alone: Bahamas, Grenada, Jamaica and Dominican Republic. The relative magnitude of economic losses due to climate change is likely to differ among

Common Future, also known as the Brundtland Report (1987), which states that: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Fig. 1 Climate change linked to components of food security. (Reproduced from Ericksen et al. 2011)

islands (UNFCCC 2007b). Food and nutrition security is now an important item on the political agenda in this region.

The term sustainable agriculture has been defined (U.S. Code Title 7, Sect. 3103) as an integrated system of plant and animal production practices which will have a site-specific application that will, over the long term:

- Satisfy human food and fiber needs
- Enhance environmental quality and the natural resource base upon which the agricultural economy depends
- Make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
- Sustain the economic viability of farm operations and
- Enhance the quality of life for farmers and society as a whole.

Adaptation is a process through which societies make themselves better able to cope with an uncertain future. As a result, CSIDS require a diversity of adaptation measures very much depending on individual circumstances in order to propel economic development. This chapter will highlight and discuss the challenges and constraints of sustainable agriculture including the impacts of climate change most commonly faced by the agricultural sector in CSIDS and also present the opportunities and options that can allow for sustainable farming systems and sustainable agriculture.

2 Agricultural Production Systems

Traditionally CSIDS practice subsistence agriculture including livestock farming where family labour and few purchased inputs are employed. This practice has the advantage of being environmentally friendly but the output is low productivity.

Today the growing population and economic pressures faced by CSIDS are disrupting ecologically sound farming practices, such as fallow rotation systems. This has led to a change from traditional subsistence agriculture to moderate input systems becoming more popular. The agriculture sector in many CSIDS generally comprises:

- A large number of traditional small-holder farming systems which consists of felling and burning high forest, planting food crops for subsistence for one or two years before the land is left to recover under fallow. Staple food such as corn, rice and beans are grown while mixed cropping (root crops, pulse, vegetables, and perennials) is practiced mostly for home-consumption with a view of spreading their risks. Intercropped are plantains, yams and sweet potatoes. These small-holder farms are usually found in rural areas, have limited access to traditional or formal credit sources and are the most disadvantaged and vulnerable groups.
- A small number of small commercial farms. These are a transition between subsistence and mechanized production and primarily use family labour and on occasion, hire seasonal labour. Land as well as all other production practices are done manually by family and usually the women in the family are responsible for marketing. Technological inputs such as improved seeds and irrigation are either by hand or simple systems involving a pump for farms located near ponds and rivers. Output is staggered to provide a small but steady stream of income. Farms are located near roads that increase access to transportation, have high capital base and easy access to traditional credit source. Subsystems are:

1. Domestic crops—plantains, rice, corn, beans, peanuts
2. Vegetables—potatoes, onion, cabbage, tomatoes, sweet peppers, carrots
3. Fruit Trees—mangoes, coconuts, soursop, guavas, avocado, cashew
4. Livestock—beef, pigs, poultry, eggs, dairy, sheep (local and improved breeds reared on mostly natural pastures)

- A small number of large commercial farms with high resource base and access to commercial credit. These farm systems dominate the agricultural sector and account for a large portion of production of traditional export crops (banana, sugar, coconuts, cocoa, coffee etc.). Such farms are family owned with hired labour during harvest and the land is normally cleared by hand and then planted. Most farms are owned by persons having other employment. The large farm units with mechanization can be found in Guyana, Belize, Trinidad, Jamaica and Suriname. There is also use of improved technology such as protected agriculture and inputs. Two subsystems are identified:

1. Traditional crops—such as sugarcane, bananas and citrus primarily grown with other food crops on a smaller scale.
2. Non-traditional crops—such as papayas, hot peppers, cacao

- A small number of large farms and estates which are currently idle, even though there is severe competition for limited agricultural land space. This group is beginning to consider investment in traditional commodities. These large acreage farms which are not idle, are highly mechanized and have large investments

that include technological inputs as well as secure land tenure. Such farms grow grains and other non-traditional export crops. The principal characteristic is that they have a well-established marketing system.

The agricultural sector in most CSIDS have either declined or stagnated in recent years. This is primarily because of the contraction in traditional exports and a reduction in the human resource invested in agriculture. The erosion of the European Union (EU) trade preferences have led to price volatility of sugar, bananas, cocoa and rice in commodity markets. As expected, declining output levels have not only had an impact on employment in the sector but have also led to the growing tendency to import poor quality food displacing nutritionally valuable local crops. The declining contribution of domestic agriculture and traditional food crops and increase in dependence on imported food, often results in unbalanced diets, an increase in incidence of under-nutrition, malnutrition, and diet-related disorders such as diabetes, obesity and cardiovascular diseases. It is estimated that the Caribbean region has a food import bill between US$ 3–5 billion which represents the potential for billions worth of business opportunities for Caribbean producers including jobs, profitable Caribbean business enterprises, and billions of dollars of avoided imports every year, therefore improving external balances (FAO 2013).

CSIDS response to the decline in traditional agriculture, which has been driven by the changing world markets, trade imbalances, the quest for food security and growing human population, have been to implement programmes to raise productivity, differentiate the mix within traditional agriculture and introduce new crops such as papaya, mango, guava, sorrel, spices, herbs and root vegetables. Unfortunately, there are no official data on the performance of non-traditional exports, but countries such as Guyana have benefited greatly from increased trade with its centres of its diaspora for example New York and Toronto in products such as fish, fruits and vegetables.

Today, there is international recognition that CSIDS face special challenges with respect to agriculture sector development and management, and with attaining United Nations Millennium Development Goals (UN 2007). This recognition is increasingly reflected in recent international instruments which are applicable to CSIDS and have a direct bearing on food security such as the 1995 Kyoto Declaration and Plan of Action on the Sustainable Contribution of Fisheries to Food Security, the 1996 Rome Declaration on World Food Security and the World Food Summit Plan of Action (1996). With this recognition and the assistance from key players such as World Bank (WB), International Fund for Agricultural Development (IFAD), World Food Programme (WFP) and Food and Agricultural Organization (FAO) to name a few, CSIDS now have opportunities for increasing agricultural production and growth, and improving farmer's income, provided policies support advantages and address constraints. Before the constraints can be addressed; land, labour and capital markets have to be operating efficiently.

Three essential goals for sustainable agriculture and development in CSIDS include:

1. Food security through an appropriate and sustainable balance between self-sufficiency and self-reliance;

2. Employment and income generation in rural areas, particularly to eradicate poverty; and
3. Natural resource conservation and environmental protection.

Achieving these goals implies a lengthy process requiring a comprehensive approach and significant investments of labour, capital, technology and research, all of which require political intervention in CSIDS. The FAO has offered its expertise in order to help revert the tendency of CSIDS to monoculture and high dependency on fertilizers and pesticides. However it must be noted that a more integrated approach which takes into account the traditional production systems and builds on modern tools and technologies is required with the participation and full collaboration of both environment and agriculture line institutions. Integrated production systems, agroforestry, agricultural tourism, diversified and certified organic products for export markets, as well as increased horticultural production, are some of the emerging trends for agriculture. These require a better knowledge of past and present production systems adapted to local conditions and require coordination and concerted actions amongst all stakeholders.

The key characteristics of successful activities are:

- The return to farm labour where average wage rates are above what was acceptable in the past; avoiding labour intensive activities, unless returns are high;
- Export of fresh produce (e.g. seasonal supply of fruits and vegetables), or with inexpensive processing that can either be done on the farm, or centrally, without the need for substantial economies of scale (e.g. specialist products);
- Improving post-harvest storage so that quality loss of stored produce is reduced within the product life cycle;
- Produce and products must be high value in relation to transport cost;
- Improving produce quality according to consumer and phytosanitary requirements, including presentation and packaging.

3 Macroeconomic Issues and Constraints in Integrating CSIDS into the Global Community

Economic development in the Caribbean started with agriculture and despite it being a key economic driver in many Caribbean countries such as Belize, Cuba, Dominica, Guyana, Haiti, Jamaica and Suriname, the scale of this sector cannot be compared to that in developed countries. In the case of rice, CPEC (2005) reported that none of the major exporters in the region were likely to be competitive on the world market, and that Guyana had the greatest opportunities for selling its rice on the Caribbean Community and Common Market (CARICOM). In 2000, contribution from agriculture sector to Gross Domestic Product (GDP) ranged from 7.7% in St. Lucia, and 9.2% in Grenada to over 21% in Dominica. In Guyana, agriculture contributed to 25% GDP compared to Jamaica, where it contributed 7.3% (Government of Guyana 2002; Government of Jamaica 2000). Agricultural contributions to GDP in Trinidad and Tobago fell from 4.2 to 1.02% between 1984

and 2004. However, during the past five (5) years, Caribbean agriculture has experienced declining production and hence declining contributions to GDP, mainly due to liberalized trading practice, loss from natural disasters and experiences of climate change. The exceptions are Belize, Dominican Republic, Trinidad and Tobago, and Jamaica, where agricultural output has been growing at around 2–5 % per year. The agricultural sector continues to be a major employer of labour in the region, however the percentage of the labour force employed in agriculture range from < 10 % for Trinidad and Tobago, Antigua and Barbuda, Bahamas and Barbados; to 30.5 % in Belize and 60 % in Haiti and between 20 and 40 % in Dominica, Jamaica, St Vincent and the Grenadines, Guyana, Suriname, Dominican Republic and St Lucia (Pemberton 2006; IICA, ECLAC, FAO 2011) . On average Agriculture directly accounts for about 21 % of CARICOM's labour force and 6.5 % of its total GDP (CARICOM 2012).

As agriculture has declined, the role of the services sector has grown in importance, especially in the areas of tourism, construction, telecommunications and financial services. Many economists suggest that the services sector, in CSIDS economies is not achieving the type of economic effect that resulted from high levels of agricultural production and export. As the factors of production in the agricultural sector are locally owned, profits are passed on for consumption, investment and savings in the same local economy. The opposite is true for the service sector, where a significant portion of the capital invested is from foreign investments and hence, the multiplier and distribution effects are less than those from agricultural earnings.

A characteristic of CSIDS that differentiates them from other countries is their high dependence on the international trading systems for their livelihood, which makes them vulnerable to any unexpected changes or "shocks" in the world market. This makes achieving sustainable agriculture more complex and increases their economic vulnerability[3].

The issues and constraints which contribute to the difficulties on successfully integrating CSIDS into the global economy are:

- Size—the smallness of CSIDS usually means limited or poor natural resources and a narrow resource base, which can result in relatively high imports of capital and consumer goods in relation to GDP. The need for a large amount of foreign exchange to pay high import bills, leads to a high dependence on exports. The small size also restricts the ability of many SIDS to diversify exports, rendering them dependent on a very narrow range of goods (primary products from agriculture, forestry, fisheries and mining) and services and hence intensifying the problems associated with dependence on international trade and on foreign exchange earnings (Briguglio 2004).

[3] One of the central themes that informed the deliberations at the United Nations Global Conference on Small Island Developing States was the proposition that the "sustainable development capacity of SIDS was severely undermined by a number of characteristics that were unique to such entities and which trans-late into specific development problems that impede their achievement of such development". (ECLAC 2000, p 2)

- Vulnerability to exogenous environmental shocks—CSIDS appears to be disproportionally vulnerable to natural disasters as compared to large nations. The effects of a disaster are expected to be greater, that is the damage per unit area and costs per capita are higher due to their small size.
- Geographic dispersion or remoteness—since islands are separated by sea, they are constrained to using air and sea transport, for their imports and exports. This places many CSIDS at a disadvantage economically, leading to high freight costs, inability to respond efficiently to unexpected changes in demand and reduced competitiveness (Pelling and Uitto 2001).
- Price competitiveness on exports—Many small-sized farms use low levels of technology and coupled with low levels of investment, producers in the CSIDS are unable to achieve economies of scale and are high-cost producers. This negatively affects the price competitiveness of exports. Comparative studies of banana exporters have shown that the Caribbean islands with smaller farms are higher cost producers than most of their competitors. Companies charged with marketing produce from Caribbean islands, usually have no control over production costs or supply quantities. In addition to the negative effects of weather, farmers in the Caribbean islands enter and exit the industry regularly depending on available prices.
- Vulnerability to exogenous economic shocks—CSIDS are more exposed to trade related shocks, including slumps in demand, instability in world commodity prices and international fluctuations on interest rates (Guillaumont 2010). The per capita income of many CSIDS are higher than those of other developing countries as a group and this leads to CSIDS having limited access to concessionary resources. Current incomes of CSIDS are often facilitated by migrant remittances and preferential market access for some major exports. The EU and the US, grant preferences to a number of SIDS under the Generalized System of Preferences. The EU also provides additional preferences to 26 SIDS under the Lomé Convention for African, Caribbean and Pacific (ACP) countries.
- Limited internal market hinders CSIDS ability to reap the benefits of economies of scale—a relatively low population can mean that domestic demand is below the minimum efficient scale of production. This leads to an inability to capture the benefits of economies of scale and also implies that typical import substitution possibilities are limited.
- Small population and migration of population that are "highly skilled"—CSIDS have small populations in absolute terms, insufficient to generate economies of scale in several areas. They therefore have limited scope for the full utilization of certain types of highly specialized experts. This results in unpredictable shortages of specific skills and difficulty in adjusting to shortfalls or surpluses in labour market segments. Thus they experience high levels of migration, particularly with respect to skilled human resources, which not only places a burden on training facilities but also forces the import of high-cost foreign expertise. A small labour pool also implies that CSIDS are unable to compete with larger nations that have large endowments of low-skilled and skilled labour.

Table 1 Climate projections for the insular Caribbean, based on global predictions from IPCC (2007b)

Climate parameter	Predicted change for the insular Caribbean
Air temperature	Increase of 1.8–4.0 °C by 2099
Sea surface temperature	~1.7 °C by the end of the century
Sea level rise	Rise of 0.18–0.59 m by 2099
Carbon dioxide	Reduction in pH of the oceans by 0.14–0.35 units by 2099
Hurricanes	More intense with larger peak wind speeds and heavier precipitation

- Limited commodities can lead to a dependence on consumer imports and capital goods. A lack of opportunities for achieving economies of scale, coupled with a narrow resource base, limits the total production of CSIDS to a narrow range of crops, value added products and services. CSIDS attempts to diversify at low cost can be problematic when considering the economies of scale and higher per unit costs of production, infrastructure development and training manpower. CSIDS that adopt protectionist policies to counter difficulties in diversification can run the risk of encouraging inefficient growth, or growth in uncompetitive sectors.

4 Climatic Changes Impacts on Agriculture Sector

In the Caribbean region, climate change involves a symbiosis of threats, risks, challenges and opportunities. The region faces impacts of climate change, a problem to whose making it has had little to contribute (Table 1).

Some expected impacts on CSIDS as a result of vulnerability to the effects of climate change, sea level rise and extreme events are listed below (IPCC 2007b; UNFCCC 2007a):

- Deteriorating coastal conditions, e.g. through beach erosion and coral bleaching, are expected to adversely affect local resources, e.g. fisheries, and reduce their value as tourist destinations.
- Floods, storm surge, erosion and other coastal hazards, exacerbated by sea-level rise that threaten vital infrastructure, settlements and facilities that support the livelihood of island communities.
- Reduction in freshwater resources by mid-century, to the point where they cannot meet demand during low rainfall periods.
- Increased invasion by non-native species as a result of higher temperatures is also expected, particularly on middle and high-latitude islands.
- Economic losses from reduced agricultural yields as a result of shortening of the growing season and drought.
- Loss of mangrove forests and coral reefs due to sea level rise.
- Bleaching and acidification of the ocean.

Table 2 Factsheet on impact of climate change on Latin America and the Caribbean. (Source: International Food Policy Research Institute, Climate Change: Impact on Agriculture and Costs of Adaptation 2009)

Climate change will have a negative effect on crop yields in Latin America and the Caribbean in 2050 with average yield declines of up to 6.4% for rice, 3% for maize, 3% for soybean, and up to 6% for wheat
With climate change, average food availability in the region will decrease by more than 300 kcal per person, a decline of about 12%
Climate change will result in 6.4 million malnourished children in 2050, 1.4 million more than in a no-climate change scenario
Latin America and the Caribbean require additional annual investments of about US$ 1.3 billion, the majority of which should be used for agricultural research, irrigation efficiency and rural road improvements in order to counteract the effects of climate change on nutrition

- Damage to terrestrial forest caused by extreme events.
- Reduction in the size of freshwater lenses and of general water resource availability due to decreased rainfall and saltwater intrusion.
- Inundation of coastal settlements and arable land on the coast.
- Reduction in tourism due to increased frequency and severity of extreme weather.

While the successes in the agricultural sector over the last decade are heralded, the inequitable distribution of benefits and unsustainable impacts on the natural resources in CSIDS are becoming more evident and has direct effects on agricultural production and food security. FAO's assessments have indicated that the target of the World Food Summit to reduce the number of the world's food insecure persons is not being met and that, despite the signing of agreements; carbon emissions continue to rise, and species extinction and climate change effects continue. Paragraph 28, of the Basis for Action of the World Food Summit Plan of Action (1996) notes that, "Small Island Developing States face the threat of land loss and erosion due to climate change and sea level rise and have particular needs for their overall sustainable development." The increasing frequency of storms, flooding and drought have implications on viability of agricultural production and food availability. In many CSIDS, the small holder or lower income farms are forced to move in marginal areas (floodplains and exposed hillsides), putting them at risk from the negative impacts of climate variability and change (Table 2).

5 Production Constraints

5.1 Constraints in Farm Labour

The stigma attached to agriculture from the colonial period has unfortunately branded itself into the Caribbean psyche, where it is percieved that only slaves, paupers and uneducated persons plant crops and actively fish. The out-migration of a large part of the young male population in many CSIDS, the alternative higher-income

employment opportunities in commercial farming, urban areas and the tourist sector have regrettably reduced the human resource invested in agriculture, painting a somewhat uncertain future for the sector. The agriculture sector is also plagued with an aging farming population and a disinterested youth population in farming.

5.2 Constraints in Water Available for Irrigation

In order to feed the increasing population, food and feed production will also need to increase substantially including water to produce the required crops. Even if it is assumed that groundwater extractions can be continued at present rates, approximately 30% of the global irrigation water demand in the year 2100 cannot be met, resulting in a loss of global (irrigated) crop production of around 400 metric t (Biemans et al. 2012). With groundwater already depleting in many regions, due to an uncertain supply source, will only exacerbate crop production losses. Small islands affected by climate change impacts including reduced rainfall, will not have their water sheds and aquifers recharge as effectively. Rural farms may not have the resources to invest in wells to tap into ground water sources or may not have access to pipe borne water or proper road facilities to deliver water to the farms, and thus will rely solely on water from rainfall to irrigate their crops. Unless many efforts are made to increase water harvesting and storage capacity via retention ponds with mobile pumps and to increase water use efficiency in both rainfed and irrigated agriculture, water availability will put a serious constraint on food security by the year 2100 (Biemans et al. 2012). There is a serious challenge in CSIDS in ensuring that water resources for agriculture can be sustainable with respect to competition from other industries for this limited resource. The poor infrastructure for delivery of water to users and the uncertain potential effects of continued climate change make this a high priority issue for CSIDS.

5.3 Constraints in Genetic Resource

Planting material availability is generally inadequate to meet demand particularly if rapid expansion of production is to be undertaken. This leads to a strong dependence of CSIDS on imported seeds for many crops. Although FAO has implemented various interventions in the field of germplasm, information management and seed programmes, availability of quality planting material is still generally inadequate to meet demand. There is also a fundamental problem related to quality control due to the continued and extensive use of planting material from preceding crops rather than certified and clean source of material.

5.4 Constraints in Plant Protection

CSIDS must cope with the stringent quality demands of agricultural produce from importers in industrialised countries and also with the changing requirements of local food consumption patterns especially in the tourist industry. This together with the favourable climatic conditions for pest and diseases, and the high cost of labour, has led to the widespread abuse of pesticide in crop production systems. There is a lack of efficient pest management and monitoring programs in CSIDS. Only a small number of countries in this region are participating in the Convention on the Prior Informed Consent (PIC) arrangement and so only a few are exposed to information between exporting and importing countries about potentially hazardous chemicals.

5.5 Constraints in Livestock and Fisheries Production

Commercially oriented livestock systems in CSIDS are relatively new, because of the high cost and land requirement associated with livestock farming. However, most smallholder farms keep a few domestic pigs, cattle and poultry. Another challenge for commercial livestock farming in CSIDS is their geographic isolation and the associated high transportation costs which can seriously affect the financial viability of any livestock enterprise dependent on imported inputs. Major constraints include inadequate nutrition, ineffective animal health services, high cost of purchased feed, problems in procurement of commercial feed, poor genetic stock, labour shortages and inadequate management of breeding farms and hatcheries. Due to these constraints, the scope for any rapid development of livestock production appears to be limited, but potential exists for import substitution since high transport costs counteract imports.

Fishing resources are being depleted in the oceans as a result of environmental and climate change issues which also puts at risk food and nutrition security. The fisheries sector in CSIDS have been neglected over the years with poor infrastructure for fish landing sites, fish repair nets, boat repair sheds and jetties which do not meet international standards. Global research done by the FAO have concluded that offshore seismic survey activity has negative impacts on fish stocks and even stated that there was an "urgent need for the development of a strongly regulated regime for the mitigation of seismic surveys and for further research so as to minimise the impact on coastal communities and fishers" in their 2010 dossier (FAO 2013). However to this day, no research has been done regionally on the impact of seismic surveys on marine life in the Caribbean. Invasive species such as lionfish have also negatively impacted Caribbean marine ecosystems and fish stocks. Traditional inland aquaculture farms and hatcheries in CSIDS, with the exception of Belize and Jamaica, cannot compete in the regional and global market because it is almost impossible for them to competitively produce and distribute large and uniform fish in mass production. Technical personnel with training in aquaculture both at university and lower level are lacking within the region with the exception of Jamaica, Dominican Republic, and Trinidad and Tobago. With respect to higher education,

various universities are active in aquaculture, both at the regional level, such as the University of West Indies (UWI), and at the national level in the Dominican Republic such as the Universidad Autonoma Central de Santo Domingo (UASD) and the Universidad Central del Este (UCE) (FAO 1993). Aquaculture training at the technician or skilled level is not easily available and is a common constraint for the development of the industry throughout the region. Many CSIDS are net importers of fishery products which are for use both by island populations and, in some cases, for the tourist industry. In view of this situation, and the need to ensure that fisheries continue to contribute to the maximum extent possible to food security in CSIDS, every effort should be made to facilitate long-term sustainable resource use.

6 Food Losses

One-third of all food produced in the world is lost or wasted from farm to fork, according to estimates calculated by FAO (2011). This wastage not only has an enormous negative impact on the global economy and food availability, but it also has major environmental impacts. The direct economic cost of global food wastage of agricultural products (excluding fish and seafood), based on producer prices only, is about US$ 750 billion, equivalent to the GDP of Switzerland, (FAO 2013).

Since 2005, the cost of food and its imports have been spiraling upwards. There is a more heightened awareness of food loss in the Caribbean amid concerns about nutrition and hunger, resource conservation, and economic costs associated with food security and waste management. Currently no public or private efforts have been made to improve available food supplies or recover safe and nutritious food that would otherwise be wasted. Food security problems will persist if the Government's action plan for the sector looks only inwardly to identify growth poles for development and not consider measuring and reducing food wastage. There have been quantifications of consumption of six commodity groups, namely staples, vegetables, legumes and pulses, fruits, livestock and aquaculture but to this date no public or private efforts have been made to quantify food that is wasted or lost, or to better use available food supplies, or recover safe and nutritious food that would otherwise be wasted (Figure 2).

It is expected that not all food that is lost would be suitable for consumption nor be economically recoverable. However, large quantities of wholesome, edible foods, such as blemished or over-ripe produce, which may be unmarketable for cosmetic reasons, but are otherwise nutritious and safe, are lost at every stage of the food value chain. In the developing world, losses are mainly attributable to the absence of food-chain infrastructure and the lack of knowledge or investment in storage technologies both on and off the farm. Food losses in the agriculture sector of CSIDS occur at both the farm (post-harvest) and farm-to-retail level (processing and wholesaling):

1. Farm and post-harvest level
   - Pre-harvest losses due to severe weather, disease, and predation.

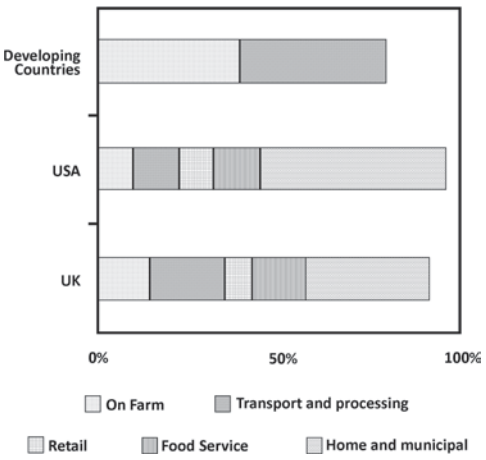

Fig. 2 The makeup of total food waste in developed and developing countries. Retail, food service, and home and municipal categories are lumped together for developing countries. (Reproduced from Nellemann et al. 2009)

- Harvest losses attributed to manual or mechanization, production practices, and decisions.
- Storage losses due to insects, mold, deterioration, shrinkage, and spoilage.

2. Processing and wholesaling level

- Removal of inedible portions bones, blood, peels, pits, etc.
- Discard of substandard products (bruised and diseased fruit, etc.)
- Deterioration and shrinkage in storage
- Poor handling or package failure
- Transportation losses

A lack of knowledge and appropriate post-harvest technologies have led to improper selection of produce for harvest and post-harvest handling, packaging and storage techniques, which in turn contribute to the substantial post-harvest losses in many CSIDS. Exports of smallholder-grown root crops, fruits and vegetables are constrained by the irregular supply and frequent failure to meet the quality and quarantine standards of importing countries.

Even a modest recovery of such wholesome foods could improve food security by supplementing food-assistance efforts and lessen the environmental impact of waste disposal. In order to drive this reduction in food wastage, there must be an understanding of where and how much food is lost along the food value chain. This information should be used to plan and increase the efficiency of food recovery efforts and measures adapted to reduce the amount of food lost in different areas of the food value chain.

7 Market Constraints

Agriculture has traditionally benefited from special arrangements which sheltered it from the full impact of General Agreement on Tariffs and Trade (GATT)[4] disciplines. The World Trade Organization (WTO) framework is a legal term indicating the government-imposed conditions under which a product may enter a country and be released for free circulation within that country under normal conditions. WTO Members agreed upon a set of principles and disciplines that were designed to help liberalize international trade in agricultural products.

The Agreement on Agriculture (AoA) seeks to reduce restrictions on trade in agricultural products by introducing disciplines to:

- increase market access;
- reduce domestic support measures;
- reduce subsidized exports.

The domestic marketing system in CSIDS is usually based on non-institutional channels formed by private intermediaries and is generally poorly developed. Establishing an efficient marketing system is difficult due to several reasons: farms are remote, infrastructure is poor which can lead to high transport costs, a lack of investment in market research and rudimentary market information systems. Small-volume producers and exporters have no control over production costs or supply quantities since these farms enter and exit the industry regularly depending on available prices. Thus marketing economies of scale, or the bargaining power possessed by larger entrepreneurs, are not available to smaller farmers. There are provisions for CSIDS domestic support of their agriculture products however not all the Governments of CSIDS have the fiscal resources to provide such support to the extent that it will result in lower prices of key foods and contribute to overall food security.

The situation for export subsidies is similar to that for domestic support. CSIDS are net food importing countries and thus benefit from cheap, subsidized exports from developed countries, except, where such products are in competition with domestic products. The modalities of export competition are not likely to have any significant impact on any of the targeted commodities in CSIDS.

The critical areas of market access for the CSIDS, in terms of the AoA and the on-going negotiations, are in the areas of tariff binding reductions, tariff peaks and escalation, tariff rate quotas (TRQs), special agricultural safeguards (SAGs) and non-trade concerns. The latter issues have implications for key exports that traditionally benefited from preferences, as well as products targeted for food security and rural development.

[4] GATT (1994); the Agreement on Safeguards or the Safeguards Agreement; the Agreement on Import Licensing Procedures or the Import Licensing Agreement; the Agreement on the Application of Sanitary and Phytosanitary Measures or the SPS Agreement; the Agreement on Technical Barriers to Trade or the TBT Agreement and, the Agreement on Trade Related Aspects of Intellectual Property Rights or the TRIPs Agreement.

> A tariff is a trade barrier that takes the form of a government tax imposed on goods (usually imports and occasionally on exports) when they cross borders. Like internal taxes, a tariff generates revenue for the government of the importing country.
> A tariff quota is a quantity of imports or exports within which a lower tariff applies. A higher tariff applies within the border (UN 2003)

CSIDS that lack the fiscal resources to provide most types of domestic support, have used common external tariffs (CETs) as a measure to safeguard domestic producers from declines in world prices, protect them from cheap imports and stimulate domestic production. Tariffs are the only mechanism allowable under AoA that can be placed to safeguard domestic production. Without flexibility in the use of tariffs as a safeguard, Caribbean producers of vegetables, eggs, poultry, pigs and vegetable oils, in particular, will be at a significant disadvantage unlike their competitors in the developed world. These commodities are key elements of food security strategies in the CSIDS. The reverse is true for bananas, where erosion of tariff preferences places banana producers at a significant disadvantage.

Trade liberalization has disadvantaged CSIDS from earning foreign exchange, employment and economic growth from exports, especially banana export. The inherent characteristics of CSIDS have placed them at a disadvantage in banana exports and will plague them in other economic endeavours as well. Thus tariff preferences must be tied to assistance to improve competitiveness as well as market-based options such as branding, organic production and fair trade.

Given their high dependence on banana exports, the Windward CSIDS would benefit if historical allocations were maintained in TRQs. The AoA can explicitly recognize the need for full compensation (by developed countries) for the loss of preferences as a condition for developing countries agreeing to give up country-specific quotas, from which they have historically benefited. Such compensation would reflect the losses incurred by the country's economy in terms of foreign exchange, employment and linkages to consumption and investment. For the estimated 4000 farmers that have left the industry, the Government of St. Lucia, with assistance from the EU, has initiated a US$ 44 million programme of diversification and social revival (CARDI 2011).

8 Institutional Constraints

Currently, in most of the Caribbean, resource allocation to Research and Development (R&D) is much less than the benchmark figure of 1% of the GDP. In fact, between 2000 and 2005, Caribbean countries such as Trinidad and Tobago and Jamaica spent approximately 0.1% of its GDP on R&D (UNDP 2008). Most of the knowledge creation in this region is done in Cuba, Puerto Rico, Jamaica, Barbados and Trinidad & Tobago universities, where research capacity is related to academic knowledge creation.

Another institution that faces constraints is farmers organizations that generally suffer from weak management, low level and quality of services, low participation of members and inadequate financial resources. However, there are some farmers

organizations where private exporters are the backbone of the export trade in non-traditional crops. These small and medium size operators tend to avoid formal credit institutions because of fear of debt and the associated collateral requirements.

9 Agricultural Policy Constraints

The policy goals for agricultural development in CSIDS have been pursued through a mix of national, regional and international policies and have focused on key areas of export promotion, food security, agricultural diversification, biodiversity and environmental concerns.

The main trading partners for food are the United States (US), the United Kingdom (UK) and CARICOM, especially Trinidad and Tobago and Barbados. With the exception of phytosanitary considerations, OECS countries can trade freely with each other in agricultural goods. At the regional level, CARICOM countries have agreed a common external tariff (CET), and goods from other CARICOM States are allowed tariff-free access to the Caribbean Windward Islands.

Some CSIDS have import-substitution policies that use quantitative restrictions as a means of protection of local agricultural production. Pigs, poultry, vegetables and food crops are the major beneficiaries of such restrictions. These are key commodities for domestic food security; as limited land space does not allow any significant ruminant, pig and poultry production. These commodities face significant competition from US production, especially chicken, as domestic support policies in that country result in low prices, which allows chicken and its subsidized cuts to be readily imported into the Caribbean. Import substitution for some commodities such as egg, fish, vegetables and pig production have increased in some CSIDS however chicken and tilapia production continue to experience difficulties due to lack of scale in production and processing and makes it difficult for local producers to compete with giants such as US and China. In other sectors such as fruit production, endeavours at import substitution and diversification achieved less-than-anticipated success for several reasons. These include the lack of a holistic approach, an inadequate focus on shipping and transport, the low involvement of industry partners and insufficient emphasis on commercial production and marketing.

Food security and agriculture are tightly linked to overall rural development in CSIDS. The potential of many farmers and farm workers to participate in areas such as financial services and information technology are limited by low levels of education. In the foreseeable future, agriculture is the sector with the largest employment possibilities and multiplier potential for rural communities. In Dominica, it is estimated that there are three persons dependent on each person employed in bananas. Employment statistics for St. Lucia show that a number of rural communities experienced unemployment that was significantly higher than the national average of 17.5%, and increases in rural unemployment and poverty are linked to the decline in banana exports (CDB 1999). This statistic has since increased to 20.6% unemployment in 2010 (CARICOM 2010).

The effective design and implementation of diversification initiatives has many challenges including the difficulties that technicians and administrators will encounter in sorting out the complex rules of any new trade environment and developing policies that can realistically achieve their objectives.

The main environmental issues with respect to agriculture in the CSIDS include:

- Deforestation,
- Solid and liquid waste management,
- Unplanned development,
- Natural disasters, and
- Squatting.

Until the removal of quantitative restrictions on key commodities, including fruits, vegetables and meat products, the impact of liberalization on domestic agriculture is difficult to judge. The only real changes in trade measures in agriculture since the inception of the WTO, has been the implementation of the common external tariff (WTO 2001).

10 Strategies for Addressing Issues and Constraints

The reality is that there remain significant impediments to agricultural sustainability and food security in the region, and there are many pre-requisites that need to be met in order to realise this objective. Figure 3 shows the key elements that should be considered when governments of CSIDS are implementing or adapting strategies to encourage sustainable agriculture. There must be political, entrepreneurial, and popular will to achieve sustainable agriculture and food security in the Caribbean region. A key enabler must be a binding political undertaking by decisions makers at the highest level, both regionally and within individual national jurisdictions, that regional agricultural sustainability is an objective to be pursued with a unified approach. The region's private sector must also be recruited to the view that food security is good for regional business and for the other indirect economic advantages that it will bring to the regional economy. The declining role of agriculture in the region, the continuing loss of preferential markets for the region's traditional products and the rapidly increasing extra-regional food import bill are among the serious and challenging issues highlighted in the Jagdeo Initiative (Private Sector Commission 2007). Efforts should be made to:-

- Ensure all appropriate steps taken to establish the physical infrastructure conducive to private sector investment in agricultural and food production in the region. This includes investment of public resources in food processing infrastructure areas including in farm to market roads, drainage, irrigation, in affordable energy including renewable sources for food processing and packaging and downstream production.
- Large scale private investment in agricultural enterprise must be promoted and facilitated. Also small scale farmers must be supported with extension services,

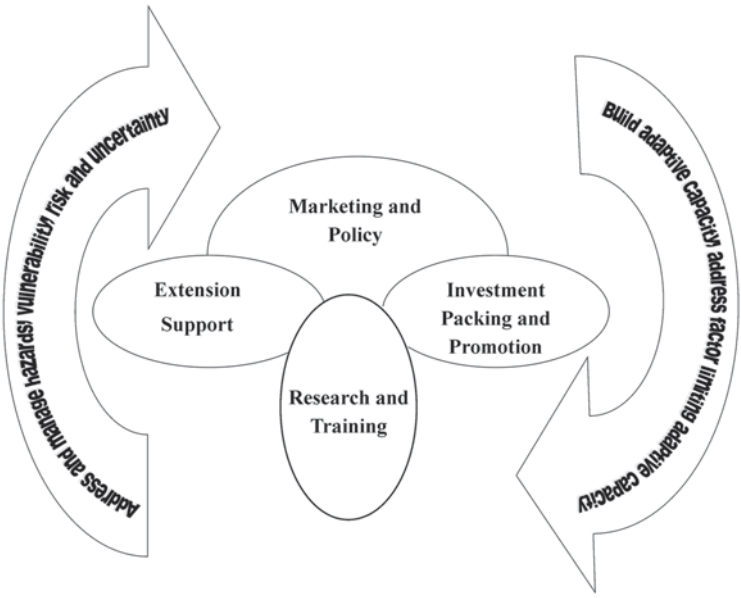

Fig. 3 Elements that should be considered to achieve sustainable agriculture

supportive services to access markets, technology and technological advice including disease resistant crops and improving productivity.

- Affordable and efficient intra-regional transport so that if we produce the food for example in the southern Caribbean for example Guyana, transportation costs should make it affordable for the purchaser in the northern Caribbean to source their food products from within the Caribbean, thereby promoting regional food security.
- Establishing a unified system of sanitary and phytosanitary standards to facilitating trade in agri-food products which facilitate intra-regional trade and not perceived to be used to protect inefficient domestic producers against more competitive extra-national regional producers.
- A competitive agriculture sector in the region undoubtedly requires scientific research and development, in such areas as crop development and husbandry, soil management and enhancement, disease diagnosis and response, plant and animal productivity, to name just a few.

10.1 Sustainable Farming Systems

Domestic market needs will increase with an increasing population and this coupled with a growing competition for land use, water and energy normally results in intensification of agriculture production in CSIDS. However intensification can lead to

poor environmental practices which can result in soil loss, reduction in soil fertility, water pollution from nutrient run-off, an increase in greenhouse gas production and even loss of biodiversity. Overarching all of these issues is the threat of the effects of substantial climate change and concerns about how mitigation and adaptation measures may affect the food system. In order to protect the fragile ecosystem of CSIDS, sustainable production systems need to be developed. In order to achieve sustainable and environmentally-friendly production, integrated crop management and conservation farming principles should be applied to the cultivation of both traditional and new crops, and contribute to the conservation and sustainable use of local biodiversity.

Maintenance of CSIDS biodiversity is essential for the sustainable production of food and other agricultural products and ecosystem services such as soil and water conservation, maintenance of soil fertility and biota, and pollination, all of which benefits humanity, including food security, nutrition and livelihoods. The importance of agricultural biodiversity encompasses socio-cultural, economic and environmental elements. All domesticated crops and animals result from human management of biodiversity, which is constantly responding to new challenges to maintain and increase productivity under constantly varying conditions (Bridgewater et al. 2012). Since farmers' communities play a key role as custodians and managers of agricultural biodiversity local and traditional knowledge and culture are integral parts of agricultural biodiversity management. Much agricultural biodiversity is now conserved ex situ in gene banks or breeders' materials. The interaction between the environment, genetic resources and management practices that occurs in situ within agro-ecosystems often contributes to maintaining a dynamic portfolio of agricultural biodiversity.

Conservation agriculture (CA) is recognized as essential for sustainable agriculture and covers three core principles: minimal soil disturbance, retention of soil cover and a rational use of crop rotations. Land and water use in the Caribbean region are not only being threatened by the impacts of climate change but by improper human practices. Contamination of water courses by agro-chemicals and improper disposal of household waste as well as the high sedimentation rates as a result of soil erosion during the rainy season threaten aquatic ecosystems and food security due to intense flooding of rural homes and agricultural lands. These challenges require changes in the agricultural production system that currently exists in CSIDS.

The following actions merit consideration in trying to achieve sustainable agriculture by using technology and sustainable practices while reducing negative externalities:

- Develop sustainable *agro-forestry systems* to raise and diversify production, improve soil fertility, prevent soil loss and environmental degradation, and reduce dependence on external inputs. Leveraging endemic species (flora and fauna) should be an important feature of our development strategy for sustainable agriculture development. The Caribbean is a unique place in that many plant species including those for herbal and medicinal purposes can only be found in this part of the world.

- Applying *precision agriculture* by implementing technologies that allow the application of water, nutrients, and pesticides only to the places and at the times they are required, thereby optimizing the use of inputs. However it should be noted that maintaining and increasing, productivity depends on continued innovation to control weeds, diseases, insects, and other pests as they evolve resistance to different control measures, or as new species emerge or are dispersed to new regions.
- Introduce short-duration cover crops and legumes to improve soil fertility and structure, conserve moisture within *intensive high-input agricultural systems on lowlands*, to reduce build-up of weeds and pests, reduce reliance on imported chemicals and fertiliser, minimise environmental degradation, and increase green fodder availability.
- Using *farming systems research* techniques to appraise socio-economic issues and feed this information into cropping trials and extend technology to the farming community using a farmer-to-farmer approach (e.g. Farmer Field Schools).
- *Focus research* on tree crops, introduction of new crops, mixed perennial cropping systems, the multi-crop smallholders that utilise agroforestry systems, and livestock and fisheries rearing to optimise production.

10.2 Plant Genetic Resources (PGR)

Modern genetic techniques and a better understanding of crop physiology allow for a more directed approach to selection across multiple traits (Charles et al. 2010). Currently, the major commercialized genetically modified (GM) crops involve relatively simple manipulations, such as the insertion of a gene for herbicide resistance or another for a pest-insect toxin. Future advances in this technology can eventually produce crops with a combination of desirable traits and the introduction of new traits such as drought tolerance. Biotechnology could also produce plants for animal feed with modified composition that increase the efficiency of meat production and lower methane emissions rather than direct plant food resources that can be used for human consumption to feed animals. CSIDS will need the expert assistance from the developed world and their research into unexploited genetic material from land races, rare breeds, and wild relatives and the adaptation of this locally so that breeders can respond to new challenges.

Intensified and diversified crop production requires a strong seed programme, either at regional or sub-regional level. Elements of such a strategy include: (i) the development of regional technical capability for seed supply; (ii) the development of appropriate seed policies to enhance national and regional efforts in PGR utilisation and seed supply; and (iii) development of a germplasm information network to link the separate islands and to bridge information gaps in the region. However it is important that countries who have access to seeds from international gene banks ensure that locally adapted crop and livestock germplasm is not lost in the process of their displacement by modern, improved varieties and breeds.

10.3 Plant Protection

There is a need to review the current pest and disease control strategies in CSIDS as these are based mainly on the use of pesticides. Integrated Pest Management (IPM) should be considered as an alternative strategy for effective, efficient, balanced and environmentally safe pest control. Due to the small size of CSIDS and the fact that pests cannot easily spread to the neighbouring territories that are separated by oceans biological control can be effective and relatively easy to implement in CSIDS. Production could be undertaken in official Pest Free Areas (PFA) so as to meet the special needs of niche export markets.

At the special Ministerial Conference on Agriculture in Small Island Developing States held in Rome on March 1999, the issue of Plant Protection by Integrated Pest Management (IPM) as an alternative strategy for effective, efficient, balanced and environmentally safe pest control was discussed as follows (Sustainable production 1999).

> Pest eradication programmes should be seriously considered when dealing with important crops and a small number of pests with a simple life cycle and infection/infestation process. Other areas of intervention are: (i) establishment of harmonised pesticide legislation and registration requirements to establish a common legal framework for the importation and distribution of pesticides; (ii) monitoring of pesticide residues in the environment (for e.g. drinking water) and in agricultural produce; (iii) active participation and joint decision making within the PIC procedure; (iv) verification of the existence of obsolete pesticides and their improved storage.

10.4 New Crops

CSIDS in general have a strong comparative advantage in the production of certain tropical crops (e.g. papaya, banana, plantain, mango, pineapple, watermelon, hot peppers etc.), tuber/root crops (e.g. dasheen, tania, taro, yams, sweet potato, cassava), nuts and spices (e.g. coconut, nutmeg) vegetables and cut flowers. Production of these indigenous crops for domestic consumption and export can be increased as these would be consumed in either the domestic market (e.g. local tourist market) or as substitute products for the export markets. In the latter case, the potential of these crops—possibly under organic farming conditions—for niche markets should be explored with the assistance of the global experts in this area.

Developing sector niches that offer opportunities to create value and develop businesses that have strong long term growth prospects can increase export earnings. Cocoa, hot peppers and herbs are potential crops that could be cultivated for niche markets. It must be noted that fresh produce exports must comply with sanitary and phytosanitary regulations while processed foods must comply with the regulations of the importing countries. Shipping foods to the USA requires an understanding of the Food Safety and Modernisation Act (FSMA), and in Canada an understanding of the regulations set out by the Canadian Food Inspection Agency (CFIA). Products entering the EU markets are also subjected to European

Commission Marketing Standards. The EU also monitors pesticide levels in produce sold in their markets. Capacity building in terms of research and development and quality infrastructure which encompasses accredited laboratories, regulatory and institutional frameworks must be enhanced in Caribbean region if we are serious about having a competitive advantage from niche products.

10.5 Irrigation

Poor management of watershed catchment areas, over-exploitation of aquifer resource and of water flowing through agro-ecosystems, particularly irrigation supplies, can lead to water scarcity, pollution of downstream supplies, salt water intrusion in lands near the shore and salinisation of groundwater. All of these translate into less water being available for agricultural purposes. Irrigation is an opportunity to reduce the unit cost of growing a crop by increasing yields and improving quality, and diversifying into other crops. However, technologies for new irrigation schemes should be thoroughly evaluated not only from an efficiency and ecomonic point of view but also with respect to their potential conflicts with other land uses. In islands where water is scarce, localised irrigation systems, such as high tech commercial drip systems and micro-aspersion, or low-tech simple drip irrigation systems appropriate for gardening, can be introduced for high-value crops. Drip irrigation when combined with training has been proven to increase productivity, increase yield, positively impact individual farmers and address water challenges, arable land reduction and soil erosion in India and Kenya. These technologies and training should be easily adapted to CSIDS. In the highlands of semi-arid islands, various types of water harvesting and runoff capture techniques for drinking water, water for animals and gardening can be introduced. All new irrigation schemes should be accompanied by an environmental impact assessment, depending upon the scale of the scheme, in case significant negative environmental impacts are expected. Technologies for new irrigation schemes should be thoroughly evaluated, including their potential conflicts with other land uses. The active involvement of water-users groups is a supporting objective. It is not only important that all the different water user groups be consulted and actively involved when water from fresh ground water resources and water sheds is extracted. Policies should also be put in place that can control potential environmentally unfriendly facilities from extracting and contaminating these water sources. Introducing irrigation technology and training farmers on these will require a significant investment. For this reason it is important to do studies on how much additional water could be saved through water use efficiency improvements so that the best technology can be applied to each individual farm that may have unique constraints. For example, it may be best to improve irrigation scheduling using local climate and soil information to more precisely meet crop water needs during the “rainy season” or use a regulated deficit irrigation system where crops are watered less during any drought-tolerant growth stage in their life cycle which can lead to an improved crop quality or yield.

10.6 Agro-processing

The government of CSIDS should mount programmes to introduce or extend appropriate technology and to develop expertise in agro-processing. Farms in CSIDS should be encouraged to develop small-scale, low-cost agro-processing ventures to increase the value and market potential of products. The market for chilled fresh-cut produce has witnessed dramatic growth in recent years, stimulated largely by consumer demand for fresh, healthy, convenient and additive-free foods which are safe and nutritious. Apart from presenting the consumer with a range of options in a single package, fresh cut produce reduce wastage at the household level, in that they allow the consumer to procure only the quantities of fresh produce required, while allowing the opportunity to readily assess the quality of the produce being purchased. In the US and Europe, shifting population demographics have also indicated a growth trend in the consumption of ethnic foods. Growing consumer interest in international markets in new or exotic tastes has promulgated growth in the international trade of fresh-cut products, exotic spices, flavours, oils and food colourings. CSIDS need to respond to this growing demand by producing fruit and vegetable fresh-cuts, spices and other "exotic" or "ethnic" food products for export. Rather than just look at exporting new crops, CSIDS farms should be encouraged and be given assistance with making the investment in technology, equipment and training on food safety principles and practices so that they can transform their crops, into pre-packaged ready to use goods.

10.7 Animal and Fisheries Production and Health

Small scale poultry and pig farms should consider using locally available feeds from high energy crops—coconuts, yams and cassava, to reduce their costs. The CSIDS that have a fishing industry have an added advantage where the fish waste from processing can be used to make silage that can provide a high quality protein supplement which can complement the "energy" feed available locally. The development of feed mills that use these local ingredients could encourage semi-intensive indigenous livestock industries that can meet the demands of urban markets. Farms that have integrated livestock into their mixed farming systems should be educated and trained to practice recycling and reusing wastes. The wastes from the livestock pens can be diverted to biogas digesters which can produce nutrient rich irrigation water, fertilizers and methane gas for any agro-processing or energy consumption activities. Farmers can also optimise use of crop residues and vegetation on uncultivated land, as well as to assist the recycling of soil fertility. Farm animals such as goats and sheep can be used as an environmentally friendly and cost effective method of clearing land in preparation for planting rather than use fire or machinery. With the incorporation of livestock into mixed farming or increasing the intensity of livestock farming management skills should be upgraded and feeds and pastures improved in order to realise the full potential of the selected breeds. Rather than just having fresh milk or meat as products from livestock, processing should

be done to supply more versatile products where niche markets for yoghurt, cheese, ready to eat or pre-seasoned vacuum packed steaks and burgers could be developed.

Governments of CSIDS should promote aquaculture development and intensify and diversify existing production systems. Cultivation of tilapias should be encouraged as they are suited to low technology farming systems and can be cultivated in ponds, concrete tanks intensively at both the large and small scale level. Technology for combating problems of overcrowding and market demand for large and uniform tilapia sizes is well established and tested in some of the Caribbean countries as well as Nigeria, Thailand and Japan. Strategic partnerships with regional global leaders in aquaculture should be fostered so that aquaculture training at the technological and skill level can be increased and proven technologies and policies can be adapted. CSIDS should become members of Council overseeing the Caribbean Regional Fisheries Mechanism (CRFM) where they can benefit from partnerships and strategies to increase the supply of fish, adopt an ecosystem approach to aquaculture and guide on best management practices and standards.

Farm workers should be trained on animal health and food safety, farms should readily have access to animal health services and specific disease eradication programmes should also be promoted (e.g. Tropical Bont Tick in the Caribbean).

10.8 Reducing Climate Change Shocks

There exist a multitude of proposals for measures that effectively mitigate climate change, including from the Committee for Development Policy (CDP). Many SIDS have called for more ambitious international climate change negotiations however to this day attempts to find effective international solutions have been elusive. In a 2013 background report submitted by the CDP secretariat, Bruckner (2013) highlighted that, "Climate change mitigation requires massive investments in technology and infrastructure, in particular in the generation of low-carbon emission energy but also in transport and buildings. Such investments simultaneously contribute to other sustainable development objectives such as expanding access to electricity or increased eco-efficiency in consumption patterns". However why should CSIDS have to make these heavy investments when they are not producers of very high levels of greenhouse gas emissions? The larger emitters of greenhouse gases in the developed world should bear the majority of responsibilities and costs of not only reducing their carbon emissions but in the mitigation of the effects faced by CSIDS with respect to reducing land degradation, biodiversity preservation and food production. Agreements on this should be done at the international level and expressed in either the Kyoto Protocol, the Durban Platform for Enhanced Action or in other forms.

Effective climate change mitigation should be integrated into the broader sustainable development agenda and not treated as a stand-alone environmental concern. Transformation of socio-economic paradigms should also be a focus rather than simple technological fixes. This should all be done at both an international and Caribbean Regional level since uncoordinated actions by individual or small groups of countries cannot be expected to lead to sufficient emission reductions.

10.9 Recovering Lost Food or Reducing Food Losses

Post-harvest food losses can occur on the farm, between the farm and retail levels or even when a commodity moves into the marketing system, to the point of consumption. This can be due to several reasons such as severe weather, including droughts and floods, pest and disease infestations, selective harvesting leaving small, misshapen, or otherwise blemished produce in the field, or discarding blemished products in the packing shed or processing plant. Farmers can mitigate post-harvest losses by using leftover crops for secondary processing or as fertilizer or animal feed.

During processing and marketing, food is subject to additional loss as it leaves the farm and enters the food marketing system. Some loss occurs in storage, due to insect or mold infestations, deterioration, or improper transportation and handling. The post-harvest losses experienced at this stage can be mitigated through improved farm management, marketing practices and through use of technologies. Food waste from agro-processing can be recovered by diverting it for use in animal feed or as ingredients in other food products. For example, cassava lose significant weight when they are processed into frozen wedges or fries. Although this appears to represent a "loss" of edible fresh cassava, most of the "loss" can be recovered and used by processors for other products, such as animal feeds.

10.10 Marketing

Food production in CSIDS can be severely affected by market interventions in the developed world, such as subsidies or price supports. These need to be carefully designed and implemented so that their effects on global commodity prices do not act as disincentives to production in other countries (Anderson 2009).

The marketing strategy for entry of agricultural exports into mainstream markets and building strategic alliances with market participants should be a joint venture between marketing services of the private sector and farmer organisations (FOs). Both entities should be knowledgeable concerning available markets, set standards, provide information and co-ordinate decisions on buying raw materials, transportation, packaging, training, quality, etc. in order to be more competitive. The agencies that are best placed to provide market intelligence and information; exporter facilitation, and develop FOs are the existing marketing boards, cooperatives and private exporters in CSIDS. A proactive, project oriented and multi-disciplinary approach to develop the production and marketing system of non-traditional agricultural crops is required for agricultural diversification.

10.11 Institutional Policies

Governments need to commit to funding research, creating government-industry-academia alliances and collaboration networks to enhance competitive capacity of the region's knowledge societies and develop innovative and sustainable responses to Caribbean issues.

FOs should have access to low interest credit, entrepreneurial development and marketing support to develop strategies that include; infrastructure development in the form of feeder roads and marketing facilities, input supply, setting of grades and standards, and agro-processing of targeted commodities. In order to further commercialise agricultural operations, there is a need to change negative attitude to credit and a need for the credit institutions to devise financing schemes for small to medium commercial operators.

10.12 Agricultural Policies

Generally, agricultural policies should incorporate the following elements:

1. Protection for local production as a means of import substitution, foreign exchange savings and food security;
2. Agricultural diversification to reduce overdependence on a few exports;
3. Removal of barriers to trade at both the sub-regional (OECS) and regional (CARICOM) levels to stimulate trade in the regional market; and finally
4. Tax concessions and subsidies to local farmers to stimulate increased local production and exports.

However successful implementation of revised and newly drafted national agricultural policies/strategies to address constraints that affect agricultural production and trade can only be achieved through programmes and projects in technology transfer (e.g. irrigation, germplasm and product quality), fiscal incentives, trade policy development, market development and entrepreneurial development.

Import-substitution policies are only successful when a non-governmental entity e.g. farmers' marketing cooperative carries out the processing and marketing functions and does checks on the evasive measures commonly employed by importers. Quantitative restrictions have been used by government as a means of protection of local agricultural production. These measures can create a balance between: (i) protection for food security and overall import substitution; and (ii) revenue generation and provision of food for the populace. Protection measures include non-automatic licensing, local-content requirements and import quotas. Governments can grant concessions to farmers, including waivers on income tax payments for incomes below a set level and duty free concessions for farm vehicles and certain agricultural inputs. Governments should be fully cognizant of the need to convert quantitative restrictions to tariffs, as part of their Uruguay Round commitments, and must commit to the process.

The Governments of CSIDS, in collaboration with the FAO and CARICOM, are developing a regional Food Security Programme targeting the development of production and marketing of a group of select commodities for national and regional food security. These commodities include, hot peppers, small ruminants, poultry, sweet potatoes and herbs and spices.

Diversification policies can be revamped to include low interest credit, entrepreneurial development and marketing support, infrastructure development in the form of feeder roads and marketing facilities, input supply, setting of grades and standards, and agro-processing of targeted commodities. A major aspect of these policies should be the redirecting of marketing boards from a buying and selling operation to that of providing market intelligence and other facilitation support.

10.13 Human Resource Development

Education at all levels and research institutions should begin the process of sensitization to vulnerabilities among children, as well as to educate and train technical persons especially at the tertiary level. The acquisition of appropriate skills and technologies will constitute an essential part of the process of building the resilience needed to reduce vulnerability to global threats, whether natural, economic, social or political.

Caribbean agriculture needs a continuous flow of competent professionals trained in agriculture and the conduct of relevant research to support its transformation from an agriculture based on protected markets to an agriculture that is technology-driven, competitive and market oriented. Continued modernization of the sector requires agricultural workers with far greater levels of skills and competencies than currently obtains. Agricultural research is mainly government-funded and in CSIDS is constrained by limited human and financial resources. Governments also provide technical assistance in the form of extension research, testing and other services but the links from extension services to the farming community, and to other key sectors such as agro-processing and agri-tourism are weak. Few CSIDS have clearly identified research priorities, which are relevant to the smallholder sector. There is a considerable need to train local manpower in research and technology development at the post-graduate level.

At the national and regional level, both Governments and donors need to significantly increase the resources allocated for human resource development consistent with the goal of the Social Summit and the in the spirit of United Nations Agenda 21. Incorporation of ICT should be considered in the formulation of strategies in this area. In the Caribbean there is concern over the rural-urban drift accelerated by income disparity and producing a fall in employment, wages and productivity in rural areas as skilled workers move to higher-earning, urban opportunities. Youth involvement in agriculture has been a major target in the revitalization thrust of agriculture for many Governments in the Caribbean.

At the global level the international community, should play a role in assisting governments and private sector actors in CSIDS to better understand their

opportunities and obligations within the international trading system. The skills of farmers, exporters, administrators, extension personnel and other players need to be upgraded through training. In particular, extension staff will require a reorientation to market-oriented farm management, with attention paid to both increased productivity and better business.

10.14 Integrated Land Resource Planning and Management

Land availability for large scale farming may bring major benefits to CSIDS, especially where investors bring considerable improvements to crop production and processing, but only if the rights and welfare of the tenants and existing resource users are properly addressed (Cotula et al. 2009).

In the past government's solution to producing more food involved bringing more land into agriculture. The competition for land from other human activities makes this an increasingly unlikely and costly solution, particularly if protecting biodiversity and the public goods provided by natural ecosystems (e.g., carbon storage in rainforest) are given higher priority (Balmford et al. 2005). In recent decades, agricultural land that was formerly productive has been lost to urbanization and other human uses, or are no longer arable as a consequence of unsustainable land management.

The lack of secure land rights can be problematic for small holder farms in many poor communities, and can be a disincentive for small farm holders to invest in managing the land productively. This creates an additional challenge by making it difficult to raise investment capital. Modern information and communication technologies (ICTs) need to be applied to the relevant government bodies to assist small holder farms with title definition, land protection and address the rights and welfare of agriculture tenants on leased government land.

CSIDS that do not have this in place can adapt the Antigua and Barbuda Agricultural Land Use Policy. This policy can foster and facilitate rapid development of the island's agricultural land resource, while ensuring the continued productive capacity of its agricultural land resource and guarantee economic profitability of all producers. Any agricultural land use policy that is developed/adapted and implemented should consider the location, size, function and growth of existing and new settlements and their spatial and functional relationships as well as provide a framework for the provision of physical and social infrastructure and opportunities for economic activity, in accordance with a comprehensive settlement strategy. The policy must also articulate a sustainable development strategy that allocates the most appropriate land for various activities and in so doing considers the capacity of such land to sustain development in the long term without degrading or damaging the scarce and fragile land resource base of CSIDS. Improved land management is a key strategy to achieve food security. The use of protected agriculture systems, soilless culture, multi-layered cropping and fully integrated aquaponics all offer adjunct solutions to reduced land availability (Maximay 2013).

An agroforestry strategy that integrates agriculture and forestry including flora and fauna as mutually compatible and complementary can provide a scope for joint development that can bring about mutual benefits. This approach will allow a wider range of agroforestry enterprise mix, optimize land resource utilization, and enhance the income generating potential of agroforestry investments. These approaches can sustain and enhance the growth of the agricultural sector and allow it to become more globally competitive.

Conclusion

This chapter highlights the major agricultural issues and constraints faced by CSIDS and suggest strategies to address them. There is no simple solution to sustainable agriculture in CSIDS, a broad range of options, including those that are highlighted in this chapter, should be pursued simultaneously. A lot of hope is placed on scientific and technological innovation. Any optimism must be tempered by the enormous challenges of making food production sustainable while addressing the wide-ranging effects of climate change, including managing our biodiversity, conserving dwindling water supplies, as well as meeting the Millennium Development Goal of ending hunger. The temptation to further sacrifice CSIDS biodiversity for short term gains in food production must be avoided, not only because biodiversity provides many of the public goods on which mankind relies but also because we do not have the right to deprive future generations of its economic and cultural benefits. Together, these challenges amount to a perfect storm. Reducing the effects of this storm will require further research in the social and natural sciences and partnerships between CSIDS and the developed world should be encouraged. In CSIDS, a multi-sectorial policy is needed to deal with the issues of climate change and sustainable agriculture which can be affected through regional and local strategic development plans. However in order to achieve this, strong decision making in terms of direction and sustained action is required from our leaders in the Caribbean. Institutional mechanisms at the national and regional levels must be put in place, to undertake the regular dissemination of user-friendly information on such technologies as well as to assist with the training of nationals in use of such technology, and introduction of incentives to encourage the use of appropriate technology. The goal of CSIDS in achieving sustainable agriculture should not be to just maximize productivity, but to optimize across a far more complex landscape of production, environmental, and social justice outcomes. Developing a sustainable agricultural sector for the Caribbean region requires collaboration among all stakeholders—economists, agrologists, teachers, researchers, farmers, extension officers, consumers and public and private sector representatives.

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