



THE AGRICULTURE, FOOD AND HEALTH CHALLENGE

CRITICAL ISSUES, PERSPECTIVES AND OPTIONS



The agriculture, food and health challenge: critical issues, perspectives and options



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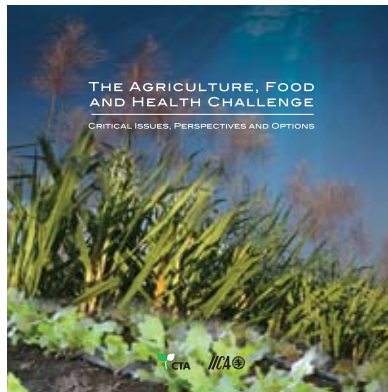
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About the CIPO Series

The CIPO series responds to the need for more regional-oriented thinking, perspectives and opinions on global issues that impact and influence agricultural and by extension, human development in the Caribbean. It synthesises the extensive literature on key topics and relates the issues of development interest to the Caribbean. It also provides an additional and alternative platform for regional professionals to publish on a wider range of topics for a wider audience.



This second issue in the series on 'The Agriculture, Food and Health Challenge' comprises three inter-related papers which explore the topics from a Caribbean situation and perspective. Issues relating to the nutrition and health component, the potential for greater food and fuel security from agriculture and the need to place greater emphasis on water-based food production systems, particularly applicable given the foreboding influence of climate change on rising sea levels, are all explored. All papers recognized the limitations of countries acting alone in addressing the challenges posed by the current agriculture, food and health scenario and for greater regional collaboration in order to achieve success.

This is but a first step. Additional research is needed to expand on the ideas alluded to in the papers. The publication is recommended for use by all those interested in understanding the complex interrelationships among agriculture, food and health and the difficulties involved in designing policies and programmes to generate desirable development outcomes.

The first issue 'Managing Hazards, Reducing Risks and Increasing Investments in Agriculture - Some Perspectives' discussed topics of 'Natural Hazards and Disaster Management in Agriculture', 'A Multi-Commodity Agricultural Insurance for Risk Reduction' and 'Catalyzing and Expanding Investments in Agriculture and Rural Areas'. These related directly to two aspects of the Jagdeo Initiative, namely 'Deficient and Uncoordinated Risk Management Measures' and 'Limited Financing and New Investments'.



Acronyms

ADHD	Attention-Deficit Hyperactivity Disorder
ASD	Asian Development Bank
BPOA	Barbados Programme of Action
CABA	Caribbean Agri-Business Association
CARDI	Caribbean Agricultural Development Institute
CARICOM	Caribbean Community
CARILEC	Caribbean Association of Electric Utilities
CCCCC	Caribbean Community Climate Change Centre
CCJ	Caribbean Court of Justice
CDB	Caribbean Development Bank
CEER	Centre for Environment and Energy Research
CEIS	Caribbean Energy Information System
CERMES	Centre for Resource Management and Environmental Studies, UWI
CET	Common External Tariff
CFNI	Caribbean Food and Nutrition Institute
CFRAMP	CARICOM Fisheries Resource Assessment and Management Program
CIDA	Canadian International Development Agency
CHoG	CARICOM Heads of Government
CIPO	Critical Issues, Perspectives and Options
CITES	Convention on International Trade in Endangered Species
CLICO	CL Financial Group
CNCD	chronic non-communicable diseases
CPA	Caribbean Poultry Association
CPI	Consumer Price Index
CRFM	Caribbean Regional Fisheries Mechanism
CRFN	Caribbean Regional Fisherfolk Network
CRNM	Caribbean Regional Negotiating Machinery
CSME	CARICOM Single Market and Economy
CTA	Technical Centre for Agricultural and Rural Cooperation
DOAM	Dominica Organic Agriculture Movement
EBB	European Biodiesel Board
ECCU	Eastern Caribbean Currency Union

Acronyms

ECLAC	Economic Commission on Latin America and the Caribbean
EEZ	Exclusive Economic Zone
EJ	exajoules
EU	European Union
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GHG	Greenhouse Gasses
GMOs	genetically modified organisms
GSI	Global Seawater Inc.
HS	Harmonised System
IADPA	Inter-American Division Publishing Association
IDB	Inter-American Development Bank
IICA	Inter-American Institute for Cooperation on Agriculture
IMF	International Monetary Fund
IPCC	Inter-governmental Panel on Climate Change
IPOA	International Plans of Action
IUU	illegal, unreported and unregulated
JOAM	Jamaica Organic Agriculture Movement
LAC	Latin America and the Caribbean
LDLs	Low-density lipoprotein
LNG	Liquefied Natural Gas
MDCs	More Developed Countries
MSY	Maximum Sustainable Yield
NOAA	National Oceanic and Atmospheric Administration
OECD	Organisation for Economic Co-operation and Development
OECS	Organisation of Eastern Caribbean States
PAHO	Pan American Health Organisation
PCBs	Polychlorinated biphenyls
PMRI	Preventive Medicine Research Institute
POPs	persistent organic pollutants
R&D	Research and Development
REDD	Reducing Emissions from Deforestation and Degradation

Acronyms

RFB	Regional Fisheries Bodies
RFNS	Regional Food and Nutrition Strategy
SIDS	Small Islands Developing States
SSA	Sub-Saharan Africa
SST	sea surface temperature
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
UNCED	UN Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFSA	UN Fish Stocks Agreement
UN-REDD	United Nations-Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
US	United States
USA	United States of America
USAID	US Agency for International Development
USDA	United States Department of Agriculture
USDHHS	United States Department of Health and Human Service
UWI	University of the West Indies
UWICED	University of the West Indies Centre for Environment and Development
WB	World Bank
WDR	World Development Report
WFP	World Food Programme
WFS	World Food Summit
WHO	World Health Organisation
WTO	World Trade Organisation

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FROM THE EDITOR

It is a pleasure and a privilege to be associated with this unique and timely publication on the theme: 'The Agriculture, Food and Health Challenge'. The Caribbean Regional Agricultural Policy Network (CaRAPN), a collaborative project between the Inter-American Institute for Cooperation on Agriculture (IICA) and the Technical Centre for Agricultural and Rural Cooperation (CTA), must be applauded for spearheading this type of publication; especially for its focus on the Caribbean region. The open economies of the region have been experiencing fluctuating periods of growth and declines in economic activity occasioned by favourable or adverse trade relations, catastrophic events leading to disasters, pests and diseases within the agricultural sector and inappropriate policies and practices to combat emerging problems. This publication identifies critical issues relating to the interrelationships among the agriculture, food and health continuum, carefully analyses the situation using available data from myriad sources and suggests several recommendations which, if implemented, would go a long way in mitigating recurring problems.

The interrelationships among food, nutrition and health have been well elucidated. Food provides the nutrients for energy, growth and development as well as protects the body from diseases. Well-nourished individuals have a greater potential for energy output and productivity, learning capacity, longevity and socially acceptable behaviour. Foods are derived from plants and animal products consumed in their original states or fabricated into various forms through processing.

The food economies begin with the harvesting of wild stocks and progress to the planting of crops, the conversion of crops and wild stocks to meat and milk products and end with the distribution of these products through a complex marketing system. In general private enterprise dominates the production and distribution system in the region. The system is plagued by several problems relating to information flows especially those of a technical nature, entry and exit constraints, product differentiation through deceptive advertising, and consideration of size of operations.

The various stakeholders within the system respond to market signals and make decisions based on the information they have and their desired goals. The government has the unique role of adopting policies to direct the economy to generate optimal results. However, the policy prescriptions and their implementation to affect desirable food, nutrition and health outcomes have eluded most governments and their agencies. Thus in the Caribbean, protein-energy malnutrition exists side by side with obesity and

its associated problems of heart disease, high blood pressure, diabetes, stroke and some cancers to name a few. Anaemia continues to be prevalent, especially among pregnant and lactating women; leading to low productivity among workers.

It is in this context that the three papers contained in this publication attempt to direct the critical issues involved in improving the agriculture, food and health situation in the Caribbean region. The Introduction to the papers provides in an easily readable literary style a summary of the authors' theses and would not be repeated. Rather some general reflections on the papers should enhance the publication.

Gillian Goddard, by approaching the agriculture, food and health interrelationships from the nutrition and health component, makes a strong case for collaboration among the various sectors in developing policies and programmes in the context of overall development. Health as a development goal and as a necessary input in the development process has only recently been given its due recognition. Health conscious individuals with the appropriate information and will power to adopt healthy lifestyles will send correct signals through the marketing system to direct decisions of producers. This demand side approach is intuitively appealing and should form the basis of development planning. However, any demand has an income and a price component among other factors as tastes and preferences and social customs. This raises the issue of equity in the development process. When low incomes and high prices militate against households making judicious food purchases for well-balanced diets, inappropriate signals are transmitted through the marketing system and desirable changes are forestalled.

Agricultural production does not take place in a vacuum. The system requires inputs such as land, labour, fertilizers, herbicides, pesticides and the important component, fuel, for electricity, transportation and tractor power. Al Binger took on the agriculture system geared to food production versus that for fuel debate and rightly argued that the potential for greater food and fuel security could be enhanced by adopting policies that make more efficient use of the land and sea resources in the region. By pitting agriculture for food versus fuel, the debate misses the opportunities for complementarities within the agricultural sector. However, given the declining productivity in food agriculture, it is questionable whether diversification to fuel production would fare any better. Abundant land is available only in few Caribbean countries; namely, Belize, Guyana and Suriname. Much of this land is inaccessible and the capital and labour requirements are high. Should agreement be reached on compensating countries to maintain forest cover to protect against carbon emissions, governments may opt for maintaining current land use patterns.

The harvesting of wild stocks for food stated above relates especially to the acquisition of fish and other food products from the seas, rivers and lakes. Marcia Creary explores water-based food production systems. Such systems are particularly applicable given the foreboding influence of climate change on rising sea levels. The beneficial effects of some seafood on health provide additional support for such ventures. It must be noted that the Caribbean Sea with its inviting turquoise waters has limited potential for capture fisheries. The potential is somewhat better on the continental shelves of Suriname, Guyana and Belize. In addition the production systems will have to contend with the problems of overfishing, pollution and invasion by undesirable species. These problems could be overcome by investments in technology designed to enhance the economic potential of utilizing the available land and water resources. Aquaculture (fresh or saline) has the potential of creating employment opportunities while contributing to food and nutrition security.

All papers recognized the limitations of countries acting alone in addressing the challenges posed by the current agriculture, food and health scenario and for greater regional collaboration in order to achieve success. This implies that Caribbean governments and their supporting agencies must redouble their efforts in taking on the challenges facing the region. IICA and the CTA, through their continuous support to CaRAPN and production of this publication have demonstrated in a tangible way how success in solving problems could be achieved.

This is but a first step. Additional research is needed expand on the ideas alluded to in the papers. For example, details of the benefits and costs involved in using various types of land resources for food versus fuel must be explored for both the short- and long-term. The authors must be commended for undertaking the laborious task of retrieving the data on the agriculture, food and health challenge, analyzing the data and presenting relevant conclusions and recommendations. The publication is recommended for use by all those interested in understanding the complex interrelationships among agriculture, food and health and the difficulties involved in designing policies and programmes to generate desirable development outcomes.

Curtis McIntosh

INTRODUCTION

In 1975, the Heads of Government of the four More Developed Countries (MDCs) of the Caribbean Community (CARICOM) set up a Food Working Party. Its main task was to consider and make proposals for *"a specific plan for the increase of food production, including fish, in the entire Caribbean Community area designed to achieve the greatest possible measure of food self-sufficiency in the Region."* The Food Plan was endorsed in 1975 and subsequently expanded in to order to introduce health and educational components. The expanded 1981 Regional Food and Nutrition Strategy (RFNS) was an effort to develop an integrated (national and regional), multi-disciplinary and multi-sectoral approach to the development of the food and agriculture sector that explicitly recognised the link between health, food, nutrition and agriculture. In 1982, Heads of Government made a commitment to give the highest priority to the implementation of the proposals RFNS.

By the end of 2009, the importance of ensuring these linkages is still well recognised. Since the early 1980s, some progress has been achieved. However, and unfortunately, the region has still not achieved optimum success in developing the important linkages between food, nutrition, health and education and in recognising the important role of agriculture. This became painfully clear as the food price crisis rapidly unfolded from 2007. The unprecedented sudden and sharp escalation of food prices from 2007 seriously impacted the quality of life and threatened several families in the region with food insecurity and diet-related illnesses.

Price increases spread throughout 2008, causing food riots in more than 30 countries, including Haiti in the Caribbean. Between July 2006, when world food prices started to escalate, and March 2008, food inflation surpassed headline inflation – i.e. Consumer Price Index (CPI) inflation – in all cases so that it played a key role in the acceleration of inflation in the Caribbean during this period (Table 1).¹ In percentage points of headline inflation terms, the highest impact of food inflation was recorded by Jamaica (14.6 percentage points), Guyana (13.8), St. Vincent and the Grenadines (10), Trinidad and Tobago (9) and Suriname (7.6). On the contrary, the lowest effect was felt in the Bahamas (1.1 percentage points) followed by Antigua and Barbuda (2.1). Looking at the contribution of food inflation to overall inflation, in most countries the former accounted for more than half of the latter. The exceptions were Bahamas (27.1% of contribution), Suriname (46.9%), Anguilla (41.8%) and Antigua and Barbuda (39.2%). In Barbados, Belize, Guyana, Dominica, Montserrat, St. Kitts and Nevis, Saint Lucia and St. Vincent and the Grenadines, food inflation explained between two thirds and three quarters of headline inflation in July 2006 - March 2008.

¹ 'The escalation in world food prices and its implications for the Caribbean', (2008) Economic Commission for Latin America and the Caribbean (ECLAC), LC/CAR/L.179. 19 November 2008

Table 1		
Contribution of food inflation to headline inflation, July 2006-March 2008		
	Percentage points	Percentage
MDCs		
Bahamas	1.1	27.1
Barbados	4.8	67.2
Belize	4.8	76.6
Guyana	13.8	67.4
Jamaica	14.6	56.2
Suriname	7.6	46.9
Trinidad and Tobago	9.0	58.3
ECCU		
Anguilla	5.1	41.8
Antigua and Barbuda	2.1	39.2
Dominica	5.9	77.3
Grenada	5.6	59.0
Montserrat	4.0	79.6
St. Kitts and Nevis	6.8	72.7
Saint Lucia	6.6	68.4
St. Vincent and the Grenadines	10.0	71.2
Source: ECLAC's calculations based on official data.		

Increases in global wheat prices reached 181 percent over the 36 months leading up to February 2008, and overall global food prices increased by 83 percent by the end of 2008. The 'silent tsunami', according to the World Food Programme (WFP) and an unprecedented challenge of global proportions, according to the World Bank (WB), prompted immediate response. The WB announced planned immediate expenditures of about US\$1.2 billion to boost crop production in the world's poorest countries; the United States (US) committed approximately US\$360 million in emergency food aid; while the Asian Development Bank (ASD) announced its intention to give US\$500 million in emergency loans to the hardest-hit countries.

For Caribbean countries, a food crisis is a fairly new phenomenon. However, a 'food problem' has been deemed to exist since the late 1970s, as recognised in the RFNS. This food problem manifested itself 'in acute nutritional and health problems'. The RFNS also concluded then, that the 'nutrition problem in the Caribbean generally, is one of insufficient food rather than an imbalanced diet'. Since the late 1970s, the food issue was inextricably linked to nutrition and health, to agricultural production in terms of the availability aspect, and to deficiencies in the distribution system.

In terms of availability, primary agricultural production has traditionally been a major source of food supplies and exports earnings that have largely financed food imports for over four decades. However, since 1995, agriculture and food imports in CARICOM have grown 73 times as fast as similar exports. This

has resulted in, not only increasing economic vulnerability for the majority of the countries, but also a deterioration of an already weak situation in agriculture.

There have been several proposals to address the worsening situation in agriculture as a region. At the 25th CARICOM Heads of Government Conference (CHoG, June 2004), the Heads endorsed a process to prioritise the top ten constraints to agricultural development. National and regional consultations specified ten constraints which were subsequently consolidated into nine (9) Key Binding Constraints. A set of interventions proposed to alleviate these constraints were submitted by President of Guyana, Bharrat Jagdeo Lead CARICOM Heads of Government responsible for Agriculture to the Sixteenth Inter-Sessional Meeting in Suriname, in 2005. This proposal, commonly known as the Jagdeo Initiative, focused on strategies including increased production and competitiveness through technology and product diversification to alleviate critical constraints to the agricultural sector. For ease of reference, these nine (9) Key Binding Constraints are included in this publication (Box 1).

Box 1: Strategies to Alleviate Key Binding Constraints to Agriculture in CARICOM	
Key Binding Constraint	Lead Minister/Agency
(i) Limited Financing and Inadequate Levels of New Investments	Barbados/CDB
(ii) Outdated and Inefficient Agricultural Health and Food Safety (AHFS) Systems	Trinidad and Tobago/ CARICOM Secretariat
(iii) Inadequate Research and Development	Guyana/CARDI
(iv) Fragmented and Disorganised Private Sector	St. Vincent and the Grenadines/ CABA
(v) Inefficient Land and Water Distribution and Management Systems	Saint Lucia/FAO
(vi) Deficient and Uncoordinated Risk Management Measures	Antigua and Barbuda/IICA
(vii) Inadequate Transportation Systems, Particularly for Perishables	St. Kitts and Nevis/CARICOM Secretariat
(viii) Weak/Inadequate Non-Integrated Information and Intelligence Systems and Marketing Arrangements	Jamaica/CARDI
(ix) Lack of Skilled and Quality Human Resources	Dominica/UWI

At the end of 2009, the food, health and agriculture relationship remained at the centre of political, business and civil society's attention. Member states, regional and international agencies have been in continuous dialogue in attempts to identify appropriate responses. There have also been several proposals to alleviate the problem and to build capacity in agriculture for food security in the region.

Virtually all Member States have embarked upon national food security initiatives to treat with the problem of rising prices, dependence on imports and reduced capacity for food production. Small states, such as those in the Organisation of Eastern Caribbean States (OECS), have identified vegetables, fruits, root crops, food crops (breadfruit, breadnut, corn, plantain, etc.) and small livestock (pigs, sheep, goat, poultry and rabbits), fish and fish products and livestock feeds from local products. Larger states, such as, Trinidad and Tobago and Jamaica, have identified cereals, fruits and vegetables (organic & protected farming), root crops, starches, dairy, beef, small ruminants, poultry, marine fish and aquaculture. Guyana, though the only net exporter of food in the region prioritises cereals (rice), sugar, fruits and vegetables, livestock and aquaculture.

IICA, the FAO and the CARICOM Secretariat have been keeping track of initiatives taken by CARICOM Member States in terms of the responses to the food security crisis. The information indicated that some governments have resorted to fiscal and market management measures and other measures aimed at direct increases in production. There were also several Social and Technical support programmes developed to assure increased Food Security in the respective territories. These initiatives were all geared to allow consumers greater access to food. In all cases the expected outcome was some redress on the declining purchasing power of consumers.

In the 21st century, agriculture will remain critical to both food security and economic growth for Caribbean countries. However, with the rising and double burden of the impacts of malnutrition and obesity, increasingly, agriculture's role is being emphasised more in terms of production of both adequate and wholesome supplies of food. This is in response to the alarming rise in diet-related illnesses and chronic non-communicable diseases (CNCD) that are affecting all segments of the population. Consequently, the notion of 'food' has come under much closer scrutiny and much of the 'finger-pointing' has been directed at 'food and beverage' industries. These industries churn out and distribute massive amounts of an increasingly wider range of 'factory' high-energy 'food' products, loaded with chemical additives, sweeteners and other ingredients that are now linked to health problems of obesity, hypertension, diabetes and cancers.

This 'Critical Issues, Perspectives and Options' (CIPO) publication provides some broader long-term development perspectives on the subject. This issue builds on a previous and first such publication which addressed critical issues related to the first Key Binding Constraint – Limited Financing and Inadequate Levels of New Investments in Agriculture. The perspectives on 'The Agriculture, Food and Health Challenge' is offered in contribution to the regional dialogue and decision-making on the widening challenges and roles of agriculture in meeting the food and nutrition needs of CARICOM.

The perspectives in this issue, address three separate, yet inter-related topics of the theme. They are Agriculture - Linking Food to Health; Agriculture for Food, Fuel or Both; and Food from the Sea. These perspectives are offered to broaden the thinking regarding the range of new and emerging options for agricultural development and food production.²

The first paper on 'Agriculture – Linking Food to Health', by Gillian Goddard explores the inter-relationships among agriculture food and health.

Goddard begins with a discussion on the issue of 'health' against the backdrop of the scientifically proven, yet often overlooked role of nutrition. She contends that the Caribbean needs to make a strategic shift in the approach to health and wellness through the food system. Such shift has already occurred in developed countries through partnerships with environmental, economic and community development. Goddard recognises that in today's society, both 'food' in of itself and its source mean different things to different people. The author argues that given the increased challenges to maintaining health and well-being, that the issue of food and consequently, agricultural production, must be driven from a nutritional perspective. This perspective should also begin to differentiate 'food' consumed from a purely nutritional value, from other edible products that are consumed more for their entertainment and taste experience, than for their nutritional value. As controversial as this may sound, the time may come, when such a differentiation, grounded in nutrition, may become the norm. This is not far-fetched, since the 1981 RFNS recognised the need to closely monitor the 'importation of certain nutritionally critical foods' as a measure to control the adverse impacts on nutrition and wellness of over consumption of certain types of foods obtained largely through imports.

While the issue of nutrition has generally been an invisible aspect of agricultural development and trade (food import) decisions, Caribbean countries have clear guidelines regarding nutritional needs. The Caribbean Food and Nutrition Institute (CFNI), established in 1967 to improve the food and nutrition situation in its member countries, has defined and continues to develop nutritional guidelines and food baskets for a healthy and secure daily diet. However, CFNI surveys have shown that consumption patterns in the Caribbean, generally, do not match these recommendations.

In recognising this, the author points to a number of increasingly popular approaches to food use, from a human groundswell, that is beginning to positively influence shifts in diets and agricultural production choices and practices.

2 This publication adopts the World Trade Organisation's (WTO) definition of agriculture that includes primary production, food based manufacturing and processing in Chapters 1 to 24 of the Harmonised System (HS) Classification that also includes Fish and Fisheries products.

With respect to the changing role of agriculture, the author observes that an artificial divide exists between the public perception of the raw materials of food (farm produce) and the public perception of prepared food (processed products). This underpins the fact that the Caribbean continues to be challenged in its efforts to link agriculture and food production to nutrition-based and public health guidelines nationally as well as regionally. The discussion also takes issue with three areas that could have been 'over-looked' in the early rush to develop and diversify agriculture primarily through expansion in 'value-adding' to local farm produce.

The author concludes by drawing attention to the notion, inconceivable as it may be, that despite the foundations laid by the RFNS and the continuing work of the CFNI, serious issues such as health and agriculture continue to be addressed using a largely disconnected sectoral approach. Industrialised countries are already witnessing the drawbacks of such an approach and are increasingly designing alternative farm and food policies, with explicit public health goals. The paper recommends a revisit to the bases of the RFNS and the primary and facilitating objectives defined as a base for moving forward. The author also emphasises three key issues that should also occupy the attention of decision makers if agriculture and health policy and public management were to take a central role in the discussions of food and health.

The second paper, on 'Agriculture for Food or Fuel or Both', deals with the inescapable 21st century dilemma for Caribbean policy makers and investors, that is, the growing imbalance of use of agricultural lands and crops for non-food production, mainly, bio-fuels.

Al Binger, world renowned energy expert, contends that the current focus of Caribbean agriculture appears to be neither on food nor energy. The author concludes that despite attempts to modernise agriculture, production of traditional agricultural commodities, whether fresh or processed foods, for exports, continues to be the key focus. In this context, the author advises that for the Caribbean, the food vs fuel debate is one of a double-dilemma and not an either-or proposition. Unfortunately, the urgent need to diversify the region's economy has pitted the food and bio-energy sectors one against the other, feeding the debate.

Binger contends that the Caribbean can, in the short- and long-term, implement policies and programmes that could enhance both food and energy security across the region. In arriving at this conclusion, the author shows that energy security and food security issues are inextricably interwoven and share a common threat - climate change! Consequently, bio-fuels, as a renewable energy source can help to mitigate climate change, reduce dependence on oil and as well, offer large and new markets for Caribbean agricultural producers. However, whether bio-fuel production is deemed to be a threat or an opportunity will depend on the specific context, including the type of feedstock used (raw material), production process, type of land and what

the alternative uses of that land might be, and who benefits. In this regard, the author notes that for Caribbean countries, sugar-cane, coconut and crops that produce seeds are among those whose production could be expanded to provide the biomass feedstock for the production of bio-diesel. This will limit the competition for crops as food.

If the region is to genuinely reduce both its food and energy insecurity, it must then integrate the agricultural and energy sectors and establish regional policies that promote sustainable use of land and ocean resources. It is recognised that there have been missed opportunities to increase local food production as well as to diversify local agricultural production to produce fuels as substitutes for imported petroleum. Hence integrating investments can have positive impacts in sustainable development of agricultural systems. Such investments are not limited to land resources, but also to marine resources. The author emphasises that the region's vast ocean resources is estimated at 80 times more than its land resources. Given available technology, this represents major resources for directly and in-directly addressing food and energy security. The author notes, that in the final analysis, there are few direct linkages between the agriculture and energy sectors in the Caribbean. Specific recommendations are offered for managing and balancing the development of agriculture such that it can reasonably meet the objectives of both food and fuel security in a sustainable manner.

These first two perspectives provide the backdrop for introducing a particular technological advance that for many, is considered as blurring the boundaries between what was previously considered 'science-fiction' to 21st century reality. The perspectives by Goddard and Binger clearly show that the nature of food (highly refined, processed products) and use of crops (for non-food products, including fuel) have undergone fundamental change. Such changes are both drivers and evidence of extremely rapid advances in the scientific and technological frontier. This was brought into sharp focus with developments taking place in Japan that could revolutionise food production (Box 2). The general response, gleaned from contributions to an FAO e-forum was varied, ranging from an appreciation of the value of research and commercialisation of same, to concerns over the impacts on the nutrition and the human form that could result from consumption of food grown without sunlight - summed up in the phrase - you are what you eat - and on the cost-benefit of investment in such highly capital- and energy-intensive scientific and 'un-natural' 'food' production systems!

Many countries, especially those in the Caribbean, are worlds away from such advances of the Japanese. However, in terms of securing the nutritional content of food, there are yet unexplored frontiers of food production that may yield more productive results in terms of investment resources for the Caribbean.

Box 2:
Is this the future of food?

By David Derbyshire

In a perfectly controlled and totally sterile environment, un-contaminated by dirt, insects or fresh air, Japanese scientists are developing a new way of growing vegetables. Called plant factories, these anonymous looking warehouses have sprung up across the country and can churn out immaculate looking lettuces and green leaves 24 hours a day, seven days a week.



Every part of the plant's environment is controlled - from the lighting and temperature, to the humidity and water. Even the levels of carbon dioxide can be minutely altered. Rather than the conventional scruffy clothes and dirty fingernails of vegetable growers, the producers wear gloves, surgical masks and sort of dust proof protective suits normally seen in chemical plants. The vegetables from plant factories - which include green leaf, romaine lettuce and garland chrysanthemum - are sold at a premium to Japanese shoppers. No pesticides are used - and there is no risk of contamination with food poisoning bugs. Because the plants are grown in a clean room, they can be eaten safely without washing. Lettuce grown in the factories can be cropped up to 20 times a year. Some factories are vast - and can produce three million vegetables a year. The results are hygienic, but it's about as far from real food as you can possibly get.

Source:

Online 3 June 2009, <http://www.dailymail.co.uk/sciencetech/article-1190392/>

The third and final perspective in this series on 'The Agriculture, Food and Health Challenge' explores another critical yet under-developed aspect of food and nutrition security for the Caribbean, "Food from the Sea". The 'seas' is one such frontier. Recall Al Binger's estimation that the oceans surrounding the Caribbean region were roughly 80 times the available land resources, and represented an under-exploited frontier for both food and fuel security.

Marcia Creary notes that in today's world, the critical issue of 'food from the seas' requires an interpretation that, of necessity, goes beyond the traditional one of 'seafood'. Climate change and its inescapable consequence of rising sea levels, has led to an emerging interpretation of using seawater for saline agriculture.

Traditionally, obtaining food from the sea has been a fundamental source of livelihood for coastal societies that predates land-based agriculture. Global consumption of 'seafood' which encompasses aquatic plants and animals for human consumption, including capture fisheries and aquaculture, has grown substantially. This growth is associated, in part, with the widely promoted health benefits of sea-foods. This notwithstanding, there are certain factors that have resulted in severe impacts on the biological production of the world's oceans and the contributions to lives and livelihoods. Chief among these include marine pollution, over-fishing, exotic and invasive species and increased sea temperatures, sea-level rise and ocean acidification caused by climate change. These issues have become a shared global concern that requires similar global and shared responses and greater international cooperation in the management of the ocean's fish stocks.

Management of the marine resources in the Caribbean region is critical given the dual challenges related to declining fish stocks and threats to regional food security. Such management is supported by participation in most, if not all of the international agreements that seek to assist in the sustainable management of marine resources. CARICOM also participates in a number of regional, sub-regional and international bodies whose activities impact on the fisheries within the Caribbean region, usually represented by the Caribbean Regional Fisheries Mechanism (CRFM) which was established in 2002 as the regional fisheries management organisation.

In terms of the emerging interpretation of foods from the sea, the author explores innovative and emerging scientific issues in agriculture, fisheries and forestry being undertaken in various parts of the world with some marked degrees of success. Among the emerging ones include efforts to make saline agriculture both scientifically feasible and economically viable. This is in response to both the shortage of water and arable land, leading to the shortage of food and as well as a possible mitigation strategy to rising sea levels.

The perspective concludes by emphasising that the more immediate concern for the Caribbean is that of increased demand for food from the sea in the context of depleted natural marine

populations. The author opines that the region has not reached an adequate level of agricultural productivity, nor made significant investment in process and agro-related industries. Given this situation and the threats to both agriculture and food security, it is critical that the region invests in the development of new ideas and technologies that can be commercialised for the efficient and sustainable use and management of the vast ocean resources for food security.

While it may not be immediately obvious, the issues raised in all three perspectives are inter-related and have far-reaching implications for how CARICOM policy-makers and other stakeholders treat with the issue of agriculture, food and health. Consideration to these three inter-related perspectives will place the region on a more firm footing to deal with any emerging issues and future challenges to diet-related health problems and agricultural development. Critical to such considerations is the issue of small-holder production, which still dominates the crop, livestock and fisheries activity and which has been the major limiting factor to investment in agro bio-energy in any large scale in the CARICOM.



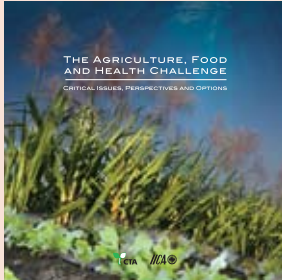
Here students of the Kuru Kuru Cooperative College in Guyana participating in a hydroponics project. With a renewed interest in appropriate sustainable development methods, hydroponics was reintroduced to Guyana, through technical cooperation assistance from IICA



Agriculture – Linking Food to Health

Gillian Goddard





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By approaching the agriculture, food and health interrelationships from the nutrition and health component, Goddard makes a strong case in her paper, for collaboration among the various sectors in developing policies and programmes in the context of overall development.

About the Author

Gillian Goddard, a national of Trinidad and Tobago, has been working in the field of health and behavioural change for the past 12 years. Although she is trained as a medical doctor, she chose to structure her career with a focus on preventative practice including the role of food in staying healthy. In 2006 she opened the first organic business in Trinidad and Tobago. The shop, now a member-owned cooperative, continues to offer organic vegan meals, fresh organic produce and organic dry goods and has always worked as an informal clearinghouse for information and guidance on nutritional therapies and natural treatment options. Ms. Goddard maintains several blogs including one focused on the activities of the shop, the environment and organic agriculture. She sends out a weekly newsletter on these topics that is widely read both locally and internationally. She writes for several national publications on topics as wide ranging as health, natural parenting and the environment.

Agriculture - Linking Food to Health

Introduction

The issue of 'health' linked to nutrition, has been a priority for CARICOM Governments since the 1960s. The Regional Food and Nutrition Strategy (RFNS) of 1981 was an attempt to bring the issues together and provide a framework and management approach within which the major economic and health problems experienced in many CARICOM countries could be addressed. The agriculture, food and health inter-relationship links are of critical importance to the resolution of these problems. In CARICOM, there is need to make a strategic shift in the approach to health and wellness through the food system in partnership with environmental, economic and community development. This shift is already well underway in developed countries and should provide food for thought for Caribbean policy makers.

The perspective on agriculture linking food and health must be placed in the context of the scientifically proven, yet often overlooked role of nutrition. While there have been numerous scientific studies and a plethora of information linking nutrition and health, there has yet to be a marked shift in consumer demands and in the types of 'food' that dominate the processing and distribution segments of the agriculture and food industry in CARICOM. Despite some progress, the development of the food and agriculture sector in CARICOM has proceeded largely separate from the issues of nutrition and health, with limited influence on food imports.

If it is accepted that nutrition must be placed at the centre of the agriculture, food and health inter-relationships, then a discussion of what constitutes 'food' becomes a logical continuation. The paper continues by exploring the notion of food. In today's society, 'food' in of itself, means different things to different people. The source of 'food' is also a subject of much discussion. This is because even with extensive promotion of developing value-chains that link farm output to food processing industries, there continues to be an artificial divide and disconnect between the farm activity (often referred to as agriculture) and the 'food and beverage' industry (captured under manufacturing and processing). With the increased challenges to maintaining health and well-being, it is strongly argued that the issue of food must be defined more from a nutritional than a market-led perspective.

Now that it is established that nutrition is derived from the types of food consumed, the paper continues with a discussion on the role of agriculture and its role in linking food and health. In the current situation, where consumption of certain classes of 'foods' has been linked to the recent sharp increases in public health challenges, the agriculture and food industry has come under more intense scrutiny and responsibility. As a consequence, there is now a growing appreciation that there also exists an artificial

divide between the public perception of the raw material of food (farm output) and of food (products from food and beverage processing industries). This divide is one aspect of the continuing difficulties experienced in linking agriculture, and particularly, local food production to health and wellness in the Caribbean. For most Caribbean countries, the challenge of producing foods that provide health benefits to national and regional consumers and to the national landscape has become more acute.

The most critical issue to be drawn from the discussions is that development in the health and agriculture sectors, inconceivable as this may be, continue to be addressed using a largely disconnected sectoral approach. Industrialised countries are already witnessing the drawbacks of such an approach and are increasingly designing alternative farm and food policies, with explicit public health goals. This approach is seen to hold great promise as a strategy for more effectively meeting the challenge of most, if not all, diet-related public health issues.

In this context, three issues that should occupy decision makers are the need for: (1) reframing of the understanding of the economic and social roles of agriculture and agricultural products in the region; (2) revolutionising the way of thinking on what is to be encouraged in terms of agricultural products and agricultural sector activities; and (3) redirecting or changing human behaviour patterns with respect to food consumption choices. Consideration to these three inter-related issues will position the region on a more firm footing to deal with any emerging issues and future challenges associated with diet-related health problems, food requirements and agricultural development.



Herbs such as Basil have a traditional culinary appeal which makes it a normal consumption choice.

1. Health and Nutrition: Issues and Perspectives

Long gone are the days when Caribbean countries faced challenges with under-nourishment from a caloric perspective. Now the challenge of obesity is one that is much more common.

Goddard (2008)

The importance of diet and food intake has long been recognised as a critical factor in ensuring health and well-being. More recently, it has been increasingly linked to food security, as rising food prices from 2007 threatened the nutritional status of vulnerable populations in the region.

Dealing with Food and Nutrition Security in CARICOM

In 2005, the CARICOM Secretariat emphasised that “*food security is not only an important issue because of the need to ensure that there are sufficient food supplies to meet the consumption needs of the population; it is critical also that the Region be in a position to support its tourism industry with its food requirements for the approximately five million visitors each year who contribute in excess of US\$3 billion to the annual income.*” Implicit in that statement was that the ‘food supplies’ were required to assure safety and health to locals as well as tourists. However, the role of nutrition appeared to be muted. The need to ensure food and nutrition security and even food sovereignty is being strongly advocated by all the leaders in the region, not only to reduce the high and rising food import bill, but importantly, from a preventive health care and cost perspective. This has placed agriculture and its various industries under increasing pressure to provide for and sustain an acceptable level of food security for the countries of the region.

The 2006 World Food Summit (WFS) defined the concept of food security as when “*all people at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life.*” Embodied in this definition is that food security is a continuous process of nutrition and health development that depends on a mix of availability, household access, nutritional adequacy (consumption/biological utilisation and care practices) and stability of the three components (Jacque et al, 2009).

By late 2006, issues of health and the role of nutrition in a healthy diet assumed greater urgency. In 2007, CARICOM Heads of Government reiterated the direct link between diets and health, recognising that unhealthy diets was a major causal factor in the region's health challenge, particularly the rising incidence of Chronic Non-Communicable Diseases (CNCDs) which made the region the worst affected in the Americas. This led to the Port of Spain Declaration Uniting to stop the Epidemic of Chronic Non-

Communicable Diseases (CNCDs) on 15 September 2007. In that declaration, the Heads of Governments re-emphasised the 2001 Nassau Declaration that “*the health of the Region is the wealth of Region*”.

The Heads of Government fully acknowledged the ‘*critical role of health in the economic development of our people*’ and appreciated the prospect that ‘*our current health problems*’... ‘*may impede such development through the devastation of our human capital*’. Changes in consumption patterns have had an adverse effect on the health of the Caribbean population. With respect to the epidemiological transition, nutrition related chronic non-communicable diseases, such diabetes, high blood pressure, stroke, heart diseases, and cancer have replaced malnutrition and infectious diseases as major public health problems.

In proposing strategies to combat CNCDs through diet, the Heads endorsed and supported efforts aimed at securing supplies of wholesome foods from both local/regional sources and extra-regional imports. These included support to the efforts of the CFNI, Caribbean Agricultural Research and Development Institute (CARDI) and the regional inter-governmental agencies to enhance food security and support the elimination of trans-fats from the diet of citizens. It also emphasised the need for the Caribbean Regional Negotiating Machinery (CRNM) to pursue fair trade policies in all international trade negotiations thereby promoting greater use of indigenous agricultural products and foods and reducing the negative effects of globalisation on the region’s food supply. The Heads also supported mandatory labelling of foods or other necessary measures to indicate their nutritional content through the establishment of the appropriate regional capability.

Recognising the severity of the CNCD problem and building on the Port of Spain declaration, CARICOM and representatives of the Caribbean civil society convened what was then described as a ground-breaking summit on CNCDs. By the middle of 2008, it was already becoming clear that the toll that these illnesses were taking - both on an economic and on a social scale - had become staggering. The outcome was a ‘Healthy Caribbean 2008 and Beyond – Declaration’ signed in October 2008. Among the commitments to “Tackling the Caribbean Epidemic of Chronic Diseases”, the civil society alliance called for the promotion of healthier diets by encouraging the availability of affordable and nutritious foods, preferably locally grown, banning trans fats, reducing salt, harmful fats and sugar in Caribbean diets, establishing regional standards for food labelling and services, encouraging breast feeding, and protecting children and society’s other vulnerable groups, through legislative, educational, health promotional and other measures.

Despite the growing regional and global recognition of the importance of health to development, it has been observed that ‘*the realms of public health and sustainable agriculture are fundamentally disconnected from one another*’ (Hamm, 2007). While this observation was based on the American population, it also applies fully to the Caribbean context. In fact, Hamm noted that ‘*a simple investigation*

of farm policy and dietary guidelines quickly illustrates this reality with domestic agricultural production currently incapable of providing a diet to all Americans that is in line with current dietary guidelines. Agricultural production is becoming increasingly consolidated with a loss of mid-scale agriculture just as consumers are seeking locally grown foods in the marketplace.'

The Spreading Westernisation of CARICOM Diets and Nutrition

On a global level, the relationship between diet and health is now well established. In the last 25 years there has been a large body of research which clearly shows the important impact of dietary response, i.e., nutrition, to serious diseases, such as, diabetes and heart disease. The issue of nutrition has also been subject to a growing body of research over time, increasingly so, as the association between illness and diet choices is becoming more direct and clear. Further, the importance of nutrition is increasingly being acknowledged as the incidence of chronic diet-related non-communicable diseases spreads among a relatively larger percentage of the global population, and in particular, among the youth and infants.

In its simplest terms, nutrition is about eating healthily: consuming an adequate and balanced supply of vitamins, proteins, carbohydrates, fibre, minerals, fats and water daily. There are several global pioneers on nutrition, such as, Dean Ornish, Gabriel Cousens and Adelle Davis. Initial studies conducted by Ornish (1998), a Western-trained medical doctor, focussed on the potential for lifestyle changes to result in significant reductions in cardiovascular disease. Two of these studies, the Lifestyle Heart Trial and the Multicenter Lifestyle Demonstration Project, had such dramatic results that they resulted in insurance companies covering Ornish's lifestyle programme for their patients. A more recent study linked to a pilot project, showed that three months of lifestyle change based on low fat, whole foods, plant based diet, moderate exercise, and relaxation programme in 30 men with low risk prostate cancer led to decreased low-density lipoprotein (LDLs) and increased telomere length. These findings are significant because telomeres are the ends of chromosomes and are significant in maintaining chromosomal stability and are related to many changes in disease risk.

Gabriel Cousens is also a Western-trained medical doctor and qualified Ayurvedic Medical Practitioner whose career spans almost 4 decades. His work related to diabetes holds the greatest significance to the Caribbean region. This work is being spearheaded at his Tree of Life Centre where Dr. Cousens focuses entirely on uncooked foods as a treatment for diabetic clients. For most clients, after four days on the vegan, enzyme-rich raw food programme espoused by Cousens, they are able to withdraw safely from all diabetes-related medication.

Adelle Davis, another pioneer, has advocated whole unprocessed foods, criticised food additives and claimed that dietary supplements and other nutrients play a dominant role maintaining health, preventing disease, and restoring health after the onset of disease. Her research showed that diseases of almost

every variety usually result from an under-supply of various combinations of nutrients. Consequently, they can be corrected when all nutrients are supplied, provided irreparable damage has not already been done and, in some instances, these diseases can be prevented. At the time, Adelle Davis' information was contradicted and criticised by many in the health care sector. However, recent and detailed analyses of her work have demonstrated the solidity of many of her theories.

The work of these global pioneers, despite spanning 40 plus years, is barely known in the Caribbean. Ornish's work has not had a significant impact on Caribbean Health or Food Policy. His name is not well-known in the region despite the fact that most Caribbean individuals or nations can ill-afford the astronomical health care costs associated with the recent increase in CNCs. The results of this research and information can have a potentially significant impact on food policy, health expenditure and re-orientation of priorities in the Caribbean.

Although the phrase 'you are what you eat' is bandied about, it does not seem to provide fundamental guiding principles for Caribbean diet and lifestyle. In just a few decades the everyday diet has become inundated with highly-processed foods, rich in fats and protein and containing artificial ingredients, but low in fresh fruits and vegetables. Vegetables and fruits, which were farmed, in general, using sustainable principles and no artificial amendments in the mid-20th century are now heavily treated with chemical fertilizers and pesticides, ripening agents and fungicides. As both dietary and production practices have changed substantially, so too has the health profile. There is increasing evidence of changes in the major causes of morbidity and mortality. Cardiovascular disease, hypertension, diabetes and cancer now top the list, all diseases that are closely linked to the high consumption of unhealthy foods and the low consumption of the healthy ones.

Table 2 highlights the main characteristics of the 'Western Diet' that are associated with the increasing incidence of CNCs. Unfortunately, the understanding of diet from a Western perspective has never incorporated information from cultures who have studied the human needs for food and nutrition for thousands of years. The paradigm used in the Western health system does not include several of the perspectives found throughout most of the other systems – the tactile qualities of the food, the influence of taste on health, the attitude towards eating food that was prepared and stored. In the Ayurvedic health system out of India, the Traditional Chinese Medical system and in other traditional ways of examining food and eating, these concepts were central. But Western perspectives tended to focus on traits that were measurable with the machines that were available.

Table 2: Some characteristics of the 'Western Diet' associated with the increasing incidence of CNCs	
Common Trends Associated with the Modern Diet	Comments
The use of refined grain and flour in place of whole grain	Refined grains lack the germ and bran that form part of the whole grain. Compared to whole grain, refined products contain less fibre, fewer minerals, fewer vitamins and fewer photochemical (with their antioxidant properties).
The use of processed foods instead of natural ones	Industrial processing of foods such as canned or preserved foods tends to: <ul style="list-style-type: none"> - Eliminate part of the beneficial natural ingredients. - Add new ingredients such as additives, many of which are potentially dangerous. - Altering some natural ingredients to improve the appearance of the product, thus forming substances that are detrimental to health. For example, this occurs when unsaturated fatty acids are hydrogenated to make margarine. This process forms harmful trans-fatty acids.
Excessive use of sugar	Although the harmfulness of sugar has possibly been exaggerated, attributing numerous ills to it, there is evidence that excessive sugar consumption promotes dental caries, increase triglycerides, obesity and hyperactivity. It is also associated with gallstones, Crohn's disease, brittle bones, and cancer of the stomach and colon.
Excessive use of additives	Additives are non-nutritive substances that are intentionally added to food products, usually in very small amounts to modify or improve its appearance, flavour, consistency or storage properties. Although some are of natural origin, most are synthesized chemically.
Excessive use of animal fat and cholesterol	Animal fat, especially from meat, milk and egg yolk have characteristics that make them harmful to health. Most notable of these are: <ul style="list-style-type: none"> - Predominance of saturated fatty acids, which promote the synthesis of cholesterol in the liver and its deposit within the arteries. - Presence of cholesterol which also promotes arteriosclerosis - Lack of antioxidant substances such as vitamin E.
Source: IADPA 2002	

In the United States of America (USA) and most Western countries, diet-related chronic diseases represent the single largest cause of morbidity and mortality. These diseases are epidemic in contemporary Westernized populations and typically afflict 50–65% of the adult population, yet they are rare or nonexistent in hunter-gatherers and other less Westernized people. However, the ultimate factor underlying diseases of civilization is the collision of our ancient genome with the new conditions of life in affluent nations, including the nutritional qualities of recently introduced foods (Cordain, et al, 2005).

The main regional body addressing issues relating to nutrition and health is the CFNI. The CFNI, a specialised Centre of the Pan American Health Organisation/World Health Organisation (PAHO/WHO), was established in 1967 to forge a regional approach to solving the nutrition problems of the Caribbean. It serves a total population of about six (6) million. Working with member states, the institute aims to attain food security and achieve optimal nutritional health for all peoples of the Caribbean. The CFNI continues to research and promote the importance of nutrition in a healthy daily diet. Even more importantly, is that this nutrition research is built around foods that can be produced in the region. Partly as a consequence of such promotion, there has been growing media attention, particularly in recent times, promoting the links between food choices and health. There is also further evidence of a wider appreciation for nutrition in good health, seen in the rise in the number of establishments in the Caribbean now offering nutrition-based weight-loss and health-related services and counselling. However, and unfortunately, promotion of locally grown fresh fruits and vegetables, still contrasts unfavourable with that for temperate based foods. Hence, while there may be a theoretical understanding of the relationship between food and health, there appears to be limited public understanding about the relationship between food and health and agriculture, especially locally produced fresh produce.



Food nutrition choices impact on the choice of crops grown by farmers. Communicating the nutritional benefits of local crops provides a win-win situation for food and nutrition security.

2. Food Consumption and Nutrition

What people choose to eat depends largely on culture and economics. People can choose freely from available foods only if they can afford them; without an adequate income, food choices are limited.

Breslow (2006)

In today's society, 'food' in of itself, means different things to different people. The source of 'food' is also a subject of discussion. Even with extensive promotion of developing value-chains that link farm output to food processing industries, there continues to be a divide and disconnect between the farm activity and the 'food and beverage' industry.

The evolution of food and diets

Breslow (2006) offers a good starting point for this particular issue. He noted that humans have evolved to depend on a continuous supply of energy (calories) and nutrients from edible plants and animals. While the precise number of foods eaten by humans is uncertain, scientists estimate that at least twenty thousand plants have edible parts. To these must be added fungi and algae, as well as foods derived from mammals, fish, seafood, birds, eggs, milk, and exotic animals. Among food plants, about 150 have been domesticated and are cultivated on a large scale, but only about twenty constitute principal energy sources, and just three -wheat, corn and rice- dominate world markets. Breslow (2006) also recognised the influence of economics and culture on food consumption habits, such as, the predominance of rice and noodles in Asian diets, and bread in Mediterranean diets. Religious prohibitions such as, those against consuming beef, pork, or alcoholic beverages, also exert considerable influence among certain ethnic groups.

Another point made by Breslow (2006) is the fact that as recently as the mid-twentieth century, most foods were produced and eaten locally. As transportation improved, production became increasingly centralised and foods were processed to permit transport and storage. About 80 percent of every food dollar is spent for processing beyond the food itself, including transportation, packaging and advertising. Processing removed essential vitamins, minerals, and other nutritious components and added preservatives, texturisers, flavours, and colours. However, some vitamins and minerals are added to processed foods as replacement or fortification. Food companies introduce more than twelve thousand new food products—many of them candy, snacks, soft drinks and desserts—into the American food supply each year. Increasingly, these manufactured foods find their way onto supermarket shelves even in the most remote of rural areas in the Caribbean. In the United States of America (USA), a typical supermarket stocks more than thirty thousand different food items and manufacturers market them with about \$30 billion worth of annual advertising. Marketing affects dietary choices. Thus, the changing

food supply favours consumption of processed foods higher in energy and relatively lower in nutritional value than the basic foods from which they were derived.

These points raised by Breslow (2006) have relevance for the Caribbean. For example, it is being increasingly acknowledged that 'food' and hence nutrition in the Caribbean is largely based on a few basic products - wheat, corn, potatoes, rice. Brathwaite (2009) re-emphasised this point, noting that of the 270,000 species of plants in this world, the food and hence nutritional base of the Caribbean depends on a very narrow base of genetic material. Of importance is that virtually all of this 'food' is being grown and developed outside of the region. The high and rising food import bill in the Caribbean since the 1980s is evidence of this fact. This also reinforces the previous point of dependence on a very narrow basket of foods for nutrition. This does not auger well for an optimal diet, or for efforts to forge strong linkages between local agriculture and food production in the Caribbean.

Breslow (2006) described an optimal diet as one that maximises health and longevity, prevents nutrient deficiencies, reduces risks for diet-related chronic diseases and is obtained from foods that are available, affordable, safe and palatable. At issue is how to select a health-promoting diet from the array of possible choices. When the leading causes of illness and death were infectious diseases made worse by inadequate diets, health officials advised people to eat more foods from specific groups such as dairy, meat, fruits and vegetables, and grains. As diseases, such as, coronary heart disease, certain cancers, diabetes and stroke overtook infectious diseases as the leading causes of death, new recommendations were needed to address these chronic conditions. A large body of biochemical, animal, epidemiologic and clinical research indicated that diets high in energy, saturated fat, cholesterol, sugar, salt, and alcohol raise risks for multiple chronic diseases, whereas diets high in fruits, vegetables, and whole grains reduce chronic-disease risk: factors such as obesity, high blood cholesterol, and high blood pressure. This evidence established the basis for new dietary recommendations.

The observations of Breslow above on the link between an optimal diet and health and wellness are not dissimilar from those raised in the Caribbean in response to rising concerns over the increase in CNCD associated with diet and food consumption. Despite the mounting scientific evidence linking health to diet and the flood of diet and health information and intense promotions of healthy food products, the majority of consumers in the Caribbean have not substantially modified their food choices. This is well borne out by the evolution of eating habits based on Caribbean anthropology and sociology. Throughout the Caribbean region, there are certain foods that have become staples during the colonial period, mainly wheat and wheat products, rice, salted and canned fish, canned meats and warm beverages, such as, Ovaltine, Milo and leaf teas. Across the globe, ex-colonies have in common the items on their grocery shelves and spin-offs of these items. Many ex-colonials report a wave of nostalgia on seeing a can of Golden Syrup or one of KLIM – a dried milk powder.

The examination of colonial ideas and colonial economics that took place in the post-colonial period did not translate heavily into an examination of the colonially-developed food sector. Unquestioned eating of many of these foods continued - with Guyana under the Burnham regime being a notable exception.

Food Consumption Patterns in CARICOM

In most Caribbean countries salted fish and salted pork, developed appropriately by Europeans to allow for preservation of a protein source while travelling long distances, continue to be staple and well-liked meals. This includes stewed codfish and dumplings, ackee and salt fish, buljol for salted codfish, and breadfruit with pigtail souse. Each country has its own version of preparation. But many of these foods, in the quantities and frequency in which they are currently consumed, have been found to have a deleterious effect on health. Products, such as, corned beef, eaten occasionally and in small amounts during the colonial period, may not have had a noticeable impact on cholesterol levels and high blood pressure. However, even the most cursory examination of nutritional status contains a percentage of fat and salt to make it quite a challenge to maintenance of good health.

It is quite common and ironically so, on one hand, to attend meetings or seminars on agriculture on topics, such as, creating consumer demand for local products, incentives for farmers etc., with the snacks and/or lunch generally dominated by wheat-derived products filled with imported fillings. On the other hand, it is also common to observe that on the agendas of such meetings, there is some tendency, albeit hesitant, to use 'nutrition breaks' to underscore the need to increasingly offer fruit and other healthy foods for mid-morning breaks. The offerings of fresh tropical fruits or vegetables are usually limited and often, specifically requested. This 'consumption-driven' reality increases the level of difficulties in both creating and implementing the enabling policies and strategies required to firmly link agricultural production to consumption and nutrition.

It is important to reiterate that quality of life, which includes nutritious food, is a human right. Further, the role of nutrition in health and wellness is inextricably linked to food production, preparation and consumption. Agricultural produce is the primary source of food nutrients. However, it is a well documented fact that since the mid-1980s, food production has undergone a radical shift in response to changing consumer demands that go beyond and in several instances, disregard nutrition-based choices. The main drivers of consumer demands have been convenience, in terms of location of food outlets, size of offerings and speed of delivery, and as well novelty. Foods are now mostly processed, highly refined and fortified with essential nutrients that may have been compromised during the processing operations. Such processed foods are closely linked with the non-communicable, diet-related illnesses and diseases. This leads to a central issue, that the definition of food should be based largely, if not solely on its nutritional content as

that relates to daily required intake for health and wellness. The need to explicitly define these nutritional guidelines has been the subject of much debate and revision.

In promoting healthy food choices, the Caribbean uses the dietary guidelines recommended by the CFNI. These guidelines are developed based on the recommended levels of nutrients required for a healthy daily diet and their main food sources. The determination of the nutritional properties of foods is based on the nutrients contained in them. The main nutrients are carbohydrates, fats, proteins, vitamins and minerals. These are briefly explained below.

- Carbohydrates: provide heat and energy and in some foods, also supply roughage, or fibre, which supports healthy digestion. Most foods, except meat, fish, poultry and cheese, contain some carbohydrates in the form of either starch or sugar.
- Fats: are essential to the diet as it is the main source of energy and is one of the components from which all body cells are made. It also helps carry vitamins through the bloodstream. Of the three main types of fats – saturated (in butter, meat), monosaturated (in olive oil) and polyunsaturated (in avocado, nuts, fish) – saturated fats should be the least consumed.
- Proteins: are needed for growth, to build and repair body tissue and to protect from disease. They also supply heat and energy. Good sources of protein are from animal products, vegetable fats, rice, nuts, legumes and other pulses.
- Vitamins: the word 'vita' means life. However, while the human body needs only small amounts of vitamins, an inadequate supply leads to stunted growth, low resistance to infection, nervous diseases, skin problems, anaemia and weakened bones and teeth.
- Minerals: such as calcium, phosphorus, iron, sodium, potassium, iodine, magnesium, zinc, copper and selenium are found in most foods and are essential to a healthy diet, protecting against anaemia and weak bones and teeth.

Fibre is not a nutrient, but is important to human health through its role in helping the digestive system to work properly and getting rid of body wastes. Fibre can be either soluble (as found in beans and legumes) or insoluble (as found in citrus fruits). Similarly, water is not a nutrient, but it aids the digestive process, the regulation of body temperature and the elimination of waste products from the body.

Products of low or negligible nutritional value, that pose a potential risk to health and wellness and consumed for reasons other than nutrition, such as taste, novelty, and experience, should be definitively differentiated from 'food'. The basis for such a differentiation already exists in efforts by countries to define nutritional guidelines and food baskets for a healthy and secure daily diet.

The CFNI has specified six Food Groups based on their concentration of the different nutrients. The foods recommended in the CFNI's "Guide to Meal Planning for Healthy Eating" are also all based on the

production capacity of Caribbean countries as well as cultural influences on eating preferences (Figure 1). These six food groups are Staples, Foods from Animals, Legumes, Vegetables, Fruits and Fats and Oils. The CFNI's guidelines are presented in a 'pie-chart' relationship that guides the user in terms of the relative quantities of each food group that is required for a healthy daily diet.

Figure 1:
Food – Categorised into Six Nutrition-based Groups



Source: CFNI

The CFNI Food Groups, developed on the basis of nutrition, is being promoted as food for the Caribbean that is essential for a healthy lifestyle. Notwithstanding and appreciating the role of culture and religion in consumption choices, there are some emerging uses or alternative uses of food, and consumption habits evident in the Caribbean. Despite a mainstream Caribbean style of eating that is driven, in large part, by recent cultural food choices, intense marketing by the fast-food sector, price concerns, food subsidies and other more external factors, there has been a definite increase in philosophy-driven eating choices.

The evolving food consumption choices

There are now several increasingly popular approaches to food consumption driven by nutrition and health concerns. Despite lack of attention in the Western-styled health sector, these approaches are getting increasing attention from a human groundswell. These are briefly profiled below.

Vegetarianism and Protein Reduction Diets: Vegetarianism is the most mainstream of the dietary alternatives and is most strongly connected to religious philosophies, including the significant numbers of Hindus, Rastafarians and Seventh-Day Adventists. The number of vegetarians, pesco-vegetarians and vegans is increasing rapidly in the Caribbean, reflecting the possibilities of making choices that are dramatically different from the surrounding culture or family traditions. Most Rastafarians converts in the region would have grown up eating mainstream diets. However, conversion required a shift to diets with low animal content. The same goes for Seventh-Day Adventists.

It is uncommon to find any Caribbean territory in which a vegetarian restaurant does not exist; and indeed, the spread of the 'vegetarian' diet to varying degrees, is increasingly transcending Rastafarianism and entering 'mainstream' food service establishments. Perhaps a major driver of the mainstreaming of 'vegetarianism' has been the proven link to health. Extensive studies across the globe have shown vegetarian diets to be associated with a lower risk for cancer, heart disease and many other illnesses. While the movement may remain small relative to mainstream and conventional diets, it is possible and even desirable to promote an increase in the number of vegetarian meals consumed. Related to this aspect, is also the need to support the inclusion of vegetarian options in both public and private eating situations.

Organic eating and Organic agriculture: Almost every Caribbean country now has an organic movement. This movement has exploded for a variety of reasons. Chief among these is the rise in health consciousness around the globe. The Caribbean has not been isolated from this trend. This has been driven by concerns over food safety and the impact of chemical residues on health and as well, greater awareness of the environmental impact of intensive agriculture and agro-processing. Some of the strongest organic movements in the Caribbean are in Jamaica - the Jamaica Organic Agriculture Movement (JOAM) and in Dominica - the Dominica Organic Agriculture Movement (DOAM). The Dominican Republic, however, is the leading producer and exporter of organic agricultural products from the Caribbean. While in CARICOM, the scale of organic agriculture is relatively small compared to conventional agriculture, it is possible to find some outlet or farmer that sells organic foods.

Live Enzyme or Raw Foods Diet: As the name suggest, these diets are built around uncooked or minimally cooked foods that are, most often, plant based. There are several guiding principles in a raw foods diet, including that food should be prepared to preserve or increase the quantity of available food enzymes.

That is, no heating above 118 degrees Fahrenheit, and that fermentation should be encouraged whenever possible. Also, produce should not be chemically treated, with a preference for organic foods. Further, produce should be fresh since reduction in the vital energy found in food occurs almost immediately after harvesting. The principles of food combining – as derived from Ayurvedic tradition – are often observed.

Several of the larger Caribbean countries – Barbados, Jamaica, Trinidad and Tobago - now have places that offer raw-food cuisine. And most countries have at least one fresh fruit and vegetable juice bar. There is a growing demand for fresh, non-pasteurised juices and freshly picked fruits and vegetables, not only from local populations, but increasingly, from the more health-conscious tourists. National and regional efforts should ensure that support is provided to increase the capacity of supply in a manner that reinforced food safety principles.

Gluten Avoidance: The available data show that sensitivity to wheat – one of the leading sources of foods in the world - is becoming a measurable problem. One in 100 people in the United Kingdom (UK) are estimated to have gluten intolerance and 15 percent of the US population. Increasingly, foods labelled 'gluten free' are finding their way onto shelves in most of the leading supermarket chains in the Caribbean. The growing array of 'weight loss' services, particularly in Trinidad and Tobago have singled out wheat and wheat-based products as a leading cause of obesity and other diet-related diseases. There is a growing tendency for some to reduce and eventually remove wheat-based products in their diet. For example, products of the bakery industry are very popular food items and the extent of promotions undertaken for bread, biscuits, breakfast cereals and cakes presents a formidable challenge to reducing consumption of wheat-based products. Ironically, wheat and its derived products have remained in the top three imported food products in the Caribbean since the 1970s.

The importance of acknowledging these evolving 'movements', as they are becoming is based on the fact that in many instances, they are adopted as a response to the health challenge and the 'bastardisation' of food due to the dominance of the mass-produced, factory-type food products. They are changing the notion of 'food', with a preference for consumption of high levels of fresh produce, that embody sustainable principles in their production. The encouragement of these food choices can have major impact on the perception and status of the agricultural sector. They can positively influence shifts in agricultural production choices and practices.

In the Caribbean, the CFNI is linking the notion of 'food' to nutrition through its well-defined, and critically familiar and available foods in its six Food Groups. The CFNI's representation of its food guide differs from the globally promoted, hierarchical food guide pyramid developed by the United States Department of Agriculture (USDA), with the assistance of the United States Department of Health and Human Service (USDHHS). However, the message is the same since it also encourages consumption of specified daily

servings of certain food groups, particularly those that form the base of the pyramid - the plant food groups. The USDA food guide pyramid also places emphasis on “eating less” in order to prevent chronic diseases.

There is international policy consensus on the importance of issuing dietary guidelines that link diet to health. However, as the CFNI has indicated, the discussion is still ongoing, particularly for the Caribbean given the differences in the nutritional content of tropical fruits and other foods on which the Caribbean Guide is built. Variyam (2002) noted that dietary guidelines are generally based on research that is uncertain, incomplete, sometimes contradictory and endlessly debated, due, in part, to the fact that scientific arguments usually focus on the role of single nutrients, such as fat, specific fatty acids, cholesterol, fibre, sugar, or sodium. Further, it is also noted that individuals do not eat single nutrients; they eat food! In today's societies, with most meals increasingly consumed outside the home, some politically unpopular changes in food patterns are occurring.

Variyam (2002) concluded that, from the standpoint of health, while dietary guidelines make sense, the challenge is to find ways to make the recommendations easier to follow. This is an issue both for agricultural development, in terms of ensuring that consumers have access to the recommended foods, and as well, education in terms of providing information and training on the variety and novel ways of how to use recommended foods. With respect to the latter, hotels and restaurants are beginning to play a key role in offering variety in local dishes without sacrificing nutrition. This is being facilitated by a growing thrust towards ‘agri-tourism’ where local farm products are becoming more integrated into the cuisine of leading hotels and restaurants. This trend offers new opportunities to more directly link agriculture to food and health.



Making the right consumption choices is the key to a healthy diet.

3. Agriculture - Linking Food to Health

..we still have the breadfruit, we still have the pineapple; but we much prefer corn, soybean, rice and the other things that we don't grow. And therein lay a big chunk of our food security problem.

Binger (2008)

Notwithstanding an increased awareness of the food, diet and health link in the Caribbean, the critical issues and the inter-relationships between them are still not well appreciated, or even pro-actively enabled. The most critical issue remains how best to link and develop agriculture, nutrition and health in an integrated manner. This also includes issues relating to decisions taken to improve production of low cost, high quality foods and considerations of how agricultural interventions limit or enhance the nutritional profile.

Dependence on non-indigenous foods

In terms of historical background, during the colonial period, the Caribbean was positioned as a region in which raw agricultural materials were grown and harvested but in which minimal processing would take place. Any raw materials would be sent to the colonising nation where the full processing and value adding would take place. For example, in European locales, cotton would be converted to cloth, cocoa beans to chocolate and citrus fruits into luxury marmalade. It is important to realise that from a planning, policy and economic perspective, local agriculture had minimal connection to the fulfilment of local needs. The intended market (primarily overseas) was disconnected from production. This legacy was aptly summarised by Binger (2008) below:

“When I started looking at the issue of food security in the Caribbean on the internet, it took me right back to the “mutiny on the bounty”. This was our first attempt at food security in the Caribbean. It was supposed to have brought pineapples, breadfruit etc from the Pacific to feed our forefathers who were working very hard but not seeing much return. Well we still have the breadfruit, we still have the pineapple; but we much prefer corn, soybean, rice and the other things that we don't grow. And therein lay a big chunk of our food security problem.

Our second part of the food security problem is that we have never been a culture of food producers. We have been a culture of export commodity producers, cash crops. And the logic has always been that we grow what we grow best or for which there is a market. We sell and we import. Question is - is that paradigm still valid or do we need to change the paradigm. This is how I see the challenge - nine out of every ten meals that we eat in this region is imported. It costs us somewhere in the vicinity, according to CARICOM, from about US \$3 billion dollars a year in food imports. To afford that (level

of) food imports we export some agricultural commodities; some bananas, some spice, some sugar and what we get from tourism.

We are the most dependent region in the world on tourism, which makes for a very vulnerable economy. So we are 90 percent plus dependent on imported energy for our energy services and we are more than 90 percent dependent on imported food for our nutrition. That does not spell a future full of promise; that is a very worrisome premise".

The post colonial period ushered in a desire to interrupt that historic and colonising strategy of ignoring local needs; self-sufficiency became the buzz-word! In an attempt to re-position the agricultural sector and to begin 'adding value' to agricultural products, most governments in the region supported local food processing. In most countries, a negative list was enforced to allow fledgling processors to develop under protection from competing imports. There were also incentives regimes built on tax exemptions and other concessions to help enhance the profitability and competitiveness of food processing industries. However, several important questions remained largely unaddressed. Among these were: (1) are the foods being produced beneficial to national and regional consumers and to the national landscape?; (2) are all the costs of these products through their supply chains as well as their health, environmental and social effects being considered?; and (3) is a holistic strategy adopted to facilitate collaboration between agricultural producers and processors to ensure a smooth chain of supply and fair prices for the raw materials?

On closer examination of the first question the results are mixed. On the one hand, packaged and frozen foods (cassava, pigeon pea and mango) are available for the busy consumer to have certain local produce with minimal preparation time. On the other hand, grocery shelves throughout the region are overflowing with packaged goods that, while produced in the region under the title of food, are of questionable nutritional benefit and in some cases have been shown to promote ill health. These include nitrate processed meats; snack foods with high salt, trans-fat and preservatives; carbonated beverages with little other than sugar, water and artificial flavours and colours. While these have fuelled growth and expansion of the 'food and beverage' sector in the Caribbean, and most notably, in Trinidad and Tobago, it is difficult to determine how these products, when used with any regularity, enhance the health profile of the consumer.

With reference to the costs of these processed products and their supply chains, the verdict is clearer. The regional health data all point to worsening health markers - increasing prevalence of obesity, heart disease, diabetes and cancers. High consumption of processed agricultural products – sugar, tobacco, alcohol, deep-fat fried root vegetable chips - is associated with this worsening state of health. Without closer examination, it is difficult to ascertain whether the economic cost of unhealthy processed foods outweighs the economic benefit of greater employment and higher tax revenues. However, there are

ways to create employment and national income that may not incur this high social and economic cost. On a social level there has not been great care paid to ensure that the control of processing of products has not simply switched from an overseas colonial elite to a local elite. In several islands, there has developed a version of the multinational corporation with products from Jamaica and Trinidad and Tobago, in particular, filling the shelves of all the other islands with repackaged snack foods, breakfast cereals and canned goods.

With respect to the latter point, use of a holistic strategy is a far cry from the current situation of a sharp division between the agricultural production community and the food and beverage industry. The region has not succeeded in developing a level playing field for agricultural producers and food and beverage processors. Prices of raw materials have remained low and the status of those working in the agricultural sector continues to be among the lowest level choice for available employment. These two factors have resulted in an aging farming population across the region. In countries such as Trinidad and Tobago, where agricultural production cannot meet consumer needs and can definitely not provide a consistent supply of raw materials to be used in processing, the content of the industry is built primarily on imported raw materials - thus further increasing the food import bill.

Be that as it may, the current position of agriculture limits the potential of its impact in the food, diet and health challenge. Agriculture is still generally interpreted as 'farming and livestock rearing'. Food production is also synonymous with produce: that is, root crops, other staples and vegetables. Most fruits are grown for the export market. Further, the limited livestock rearing that exists in most countries, except for mainland territories of Belize, Guyana and Suriname, is for home and domestic consumption. However, the label of 'food' is also assigned to products of the value-adding and processing-based 'Food and Beverage' industries, as distinct from agriculture.

Agricultural development, the food industry and nutrition

As noted earlier processed 'foods' have overtaken the food market and while some may have desirable nutritional properties, several types add to the diet-related health burden. This situation has often crowded-out positive influences that policies for agriculture can have on farm and factory production decisions, consumption choices and preventive health care. The production of livestock is also important to discuss. While high consumption levels of food from animals that goes against both international and regional recommended food guidelines, it is still valuable to promote good practices that will ensure that livestock is reared in as healthy a manner as possible. Grass fed cattle and the use of livestock and poultry feeds developed locally could improve the quality of meat in the diet.

The influence of agriculture is also limited by an artificial divide between the public perception of raw materials for food – the agricultural produce – and for prepared food. The general attraction towards

farming is poor, whereas food businesses and service establishments are booming across the region. The infrastructure for prepared foods has exploded as rapidly as the growth in these food-based businesses and much of what is needed can be easily found – packaging, appliances, processed ingredients, etc. The same cannot be said for farming, livestock and fisheries. Government interventions continue to be the norm and are assumed to be necessary if agriculture, that is primary production, is to continue to have a central role in Caribbean economies. In most parts of the Caribbean there are agriculturally-oriented banks to ensure that financing for primary agriculture is made available. The concept of the ‘agripreneur’ (agricultural entrepreneur) is not yet widely understood and many farmers or other growers do not function with the standard business mindset found in other self-employed entrepreneurs.

In the health sector, agriculture is not given a pivotal role. There are some hopeful signs that food can begin to take its rightful place in discussions on health economics and addressing the CNCD challenge and its accompanying illnesses. One such sign that is being aggressively promoted in the Caribbean and that is also directly linked to the health and food security issue is that of household food production (also termed backyard gardening). The CFNI has emphasised that food and nutrition security, while a development issue requiring macro-level response, is essentially, an individual or household responsibility. The development of household agriculture must form part of the strategy to position agriculture directly in the path of health. Growing an increasing proportion of what is consumed within the household was always part of a traditional Caribbean behaviour. Even within the context of slavery, there was usually the opportunity for the enslaved Africans and their descendants to grow certain crops outside of the purview of the plantation structure, and to sell the excess in community markets. It is only within the past decade, that the kitchen garden has become increasingly rare. On the smaller islands and in rural areas backyard gardens are a lot more common. Even then, the backyard gardens are giving way to decorative plants and occasionally, fruit trees, similar to urban practices.

With the evolving context for agriculture, diet choices, health challenges, and importantly, environmental considerations, the new household agriculture would have to be different than the traditional operation. Using principles of permaculture and looking closely at nutritional needs and time constraints, the backyard garden should no longer be restricted to the external area of a home but would incorporate the interior and any balcony spaces. Essential components would include: sprouting, herbs and seasonings, fruit trees, aquaculture and animals. The issue of sprouting is sufficiently important to warrant some discussion. Sprouting takes place by soaking seeds and then rinsing in water to keep them moist until they germinate. In traditional Caribbean cooking, prior to the accessibility of canned leguminous products, many regional dishes were prepared by beginning the sprouting process prior to cooking.

Sprouting is increasingly being associated with lifestyle changes towards healthy eating habits. Sprouts are some of the most nutritious food substances that can be found on this planet. Chavan and Kadam (1989) concluded that *“the desirable nutritional changes that occur during sprouting are mainly due to*

the breakdown of complex compounds into a more simple form, transformation into essential constituents and breakdown of nutritionally undesirable constituents....."

Sprouting is also especially important in times of agricultural crisis such as flooding, hurricanes and disasters from other natural phenomena. The environment in which to sprout is much less vulnerable to climatic change and global warming. Developing a focus on sprouting sends a clear signal to the need for an emphasis on seed production. It is not sustainable or cost effective on a long term basis to import all the seeds required for sprouting. Mung bean sprouts are one of the most common sprouts used even now in the Caribbean in Chinese foods. And while the traditional use of mung in dhal has been replaced with split peas, the tradition and hence the market remains available. However, uses of mung go much further and require further investigation, particularly if there is a genuine interest in adjusting agricultural production to emphasise the health imperative.

Generally, the benefits of household agriculture are many and span the range from health to wealth issues. But the more obvious ones include eating freshly, home-prepared foods and supplementation of income. The nutritional benefits with freshly prepared foods that have been picked shortly prior to eating are multiple, in addition to which the risk of bacterial contamination is greatly reduced. Further, with home-prepared foods, the control over the ingredient input is high. The addition of flavour-enhancers, artificial ingredients, low-quality inputs and other deleterious ingredients becomes minimal when food preparation remains in the hands of families or community groups. Finally, 'income' is a defined component of food security in as far as it enables access to vital food supplies. Hence the impact of backyard gardening on supplementation of income through sale/trade of any excess is critical to rural families. Further, money is saved on purchase, on time required for purchasing, and made from selling.

To expect this household agriculture to develop and flourish without leadership is naïve. The current interest in larger businesses to keep increasing their markets does not leave uninformed consumers moving easily into planting. Resources must be made available; information on permaculture, gardening and sprouting can be brought more easily to the consumer so that they can flow relatively painlessly into the new activity. Other issues should include provision of free seeds, subsidised soil, free or subsidised classes and a massive publicity campaign. The issue of leadership in agriculture must and directly relate to the youth.

Special attention is in order, regarding the issue of youth, food and health in the Caribbean. Several especially relevant topics such as, youth obesity, the dietary connection to Attention-Deficit Hyperactivity Disorder (ADHD) and Type 2 diabetes in children, must form part of this debate. Wallinga (2007) noted the link between Americans' excess consumption of added sweeteners and added fats and farm policies encouraging production of the commodity crops later made into these sweeteners and fats. Sufficient evidence was found to show that industrialisation has had some important negative impacts

on certain indicators of public health, including the epidemic of childhood obesity and related disease, such as type II diabetes, and antimicrobial resistance. It was felt that designing alternative farm and food policies, with explicit public health goals, holds some promise as a strategy for more effectively meeting the challenge of childhood obesity, antimicrobial resistance, lack of access to fresh produce and other public health needs.

The food industry in the Caribbean is very loosely regulated outside of issues of microbial contamination. There are few stringent regulations in place determining what is or is not healthy eating. Hence it is not uncommon to see publicity for milk products as the healthy alternative in a population in which many individuals are lactose intolerant, sweetened drinks with artificial colours and flavours being deemed sports/health drinks, and specific targeting of the youth and teen populations by fast food suppliers. Perhaps if there were some balance, then the potential influence of these products would not be as high. The budget for the farming community to publicise the desirable health effects of fresh foods, high-fibre foods and organic eating falls far short of what a fast food company can afford.

It is difficult to conclude that there is a deep seriousness within the health sector about the health of the youth of the region when such a large imbalance exists and there is little indication of a well-thought out regional strategy on a consistent, detailed, well-funded basis. This leads, therefore to a continued lack of understanding of the role of locally produced agriculture and food products in the fight against ill-health.



The health of young people in the region requires closer attention to balanced diets - fruits included!

4. Food for Thought: Conclusion

Let food be your medicine

(Hippocrates)

It seems inconceivable that in the mainstream, the serious issues of health and food production continue to be addressed using a sectoral approach. If the agricultural and health management policy sectors were to take a central role in the discussions of food and health there would be three main areas that would need addressing.

Firstly, and of necessity, there would be a reframing of the understanding of the economic and social role of agriculture and agricultural products in the region. As part of this reframing, it would be important to address two main issues: (1) the cultural definition of food being viewed as the processed products of agriculturally derived products and (2) the idea that value-added products are of more financial and economic value than fresh products. This understanding should be turned on its head. From the moment of harvesting, most foods begin to lose their nutritional value. If nutrition was at the basis of agricultural and food production decisions, then in practice, this understanding would mean that people would pay premium prices and give great value to consumption on or close to the farm as opposed to only giving value to food after processing. With a global population that increasingly enjoys tropically derived agricultural products, this positioning would mean that just as vineyards in Sonoma, California or the Loire Valley, France can draw crowds to sample products at the source, so too can the Caribbean attract local and foreign visitors to citrus orchards, mango and avocado estates.

The true costs of the main CNDCs should be understood in the context of the preventability and the treatability of these diseases through lifestyle changes, especially diet and nutrition. If the resources that are currently being used for medical and surgical treatment were shifted into prevention and lifestyle treatment options, then the budget available for agriculture, agricultural production and marketing of the health-inducing agricultural products would yield more substantial and sustained returns to health, the environment and quality of life.

Secondly, and following from the first aspect, there would have to be a revolutionising of the way of thinking on what is to be encouraged in terms of agricultural products, agricultural sector activity and the development of consumer tastes. As it now stands, agriculture development is based on: (1) tradition, that is the history of food production and food consumption; (2) profits, that is, what earns highest income, usually in export markets; and (3) consumer convenience, that is satisfying the demands of the consumer regardless of the cost to the farmer or farming system. A revolutionising of this way of thinking would result in some major changes in practices along the entire farm to market value chain. The value would be placed on promoting and ensuring food nutrition and health, and in this regard, on ensuring good and sustainable agricultural practices.

Some positive and sustained changes that could result would include expanded activity in aquaculture of seaweed and other, non-animal, edible plant life. This has been an elusive goal in the Caribbean since, at least, the mid-1980s. The benefits to aquaculture development would transcend the health aspect to economic, social and environmental benefits. Also, capacity for seed production could be substantially expanded to supply a wide variety of seedlings and planting material for food production as well as seeds for sprouting. This would also revive the waning interest in backyard/household gardening, community farms, food forests and even the planting of food trees in all publicly owned and accessible lands since the key input – planting material – would be more readily available and accessible. The benefits of developing and sustaining such capacity would almost immediately and far outweigh any initial financial investment costs associated with same, particularly, rapid resuscitation of productive capacity in the aftermath of hurricanes and other such disasters.

A logical extension to developing capacity for seed production, would be promoting interest in developing similar capacity for animal feed production; also an elusive objective in CARICOM. It is unlikely that consumption of food from animals will be reduced in any appreciable proportion in the medium to long term. What is expected is that food from animals will continue to experience growth. However, such growth has and will continue to be fed largely from imports, in spite of the advances made in the livestock industries, notably poultry in the Caribbean. However, such growth can be easily destabilised by periodic trade disruptions since virtually all the key inputs for the livestock industries are imported from developed countries. Developing capacity in this area would truly require a revolutionising of the way of thinking on what is to be encouraged and how investment resources are utilised. This could both accelerate and organise the ad hoc efforts at developing locally produced feeds and training farmers in sustainable pasture management for livestock and poultry.

Thirdly, and not the least of importance, there would also have to be a redirecting or changing of human behaviour patterns with respect to food consumption choices. Perhaps it is in this area that the benefits of change would be most evident with noticeable impact. The recommendations effecting such change represent significant departures from past and current patterns of behaviour in the region. This essentially speaks to the field of 'change management' a growing area in development, organisational and management theory and practice.

In a broad sense there are two major ways to get humans to change. One is to implement external change so that there is no or reduced access to opportunities for continuing to make old choices while simultaneously increasing access to new choices. The other is to implement processes that help support an internal change of assumptions and goals that then lead to new choices being voluntarily made on a frequent basis. In the ideal situation there will mainly be an impetus towards the latter option whereby through a successfully planned strategy, individuals will re-evaluate old ideas about food, agriculture and health and this will result in a smooth transition towards healthier eating habits, rational policy and

planning in governmental employees and shifts in farming culture. Unfortunately it is usually necessary to use a combination of externally imposed change to drive and support the internal change process.

In the area of food, health and agriculture the external changes can lead to several results. These include a reduction in availability and access to foods that are associated with unhealthy lifestyles. Measures that would contribute to that result include removal of invisible subsidies from processed foods, and introduction of measures, such as, disposal tax for packaging and bottle tax for soft drinks. Indeed, in the UK, soft drink machines and junk food machines have been removed from school compounds. Such measures could be further complemented by placing limits on the excessive advertising and messaging of 'popular' foods that are largely associated with unhealthy lifestyles.

Other response options could also include actions that increase access to desirable foods and food choices, particularly where the farmers' are linked more directly into mainstream distribution channels. This latter aspect would be further enhanced by providing farmers with access to information to make good decisions and services/materials to help make the structural shift. While there have been numerous efforts aimed at raising awareness among the farming community, this should not be equated with giving information. Raising awareness assumes that there is an internal change where someone now sees and notices something in a way that is different from before.

In the final analysis, ensuring food and nutrition security in the Caribbean requires that the inter-connections between agriculture, food and health are enabled, forged and sustained. It further demands that collaborative relationships among the key stakeholders in these sectors must similarly be enabled, forged and sustained for long-term commitment to common objectives. The reorientation of agricultural development with a focus on nutrition as a prerequisite for good health, must take some critical issues into consideration. Of importance must be a focus on the one factor that differentiates fresh produce from processed foods – 'freshness'. Since it has been shown that from the moment of harvest, the nutritional quality of food begins to deteriorate, healthy eating then depends, in part, on proximity of food sources to the consumer. As noted previously, traditionally, food production was close to the main consumption centres. However, with the advances in transportation technologies, and the spread of cities, towns and other similar centres, a significant share of the foods consumed travel miles to get to the consumer. This reality has given rise to the concept of 'food miles' as an unintended, albeit adverse impact of globalisation on the agriculture and food industry.

Also, and notwithstanding the novel innovations in Japan with 'plant factories', farming in the Caribbean will generally remain dependent on soil resources, hence the issue of food, agriculture and health must also address the 'nutritional' composition of the soil. While the issue of productivity has been largely linked to 'yields' and soil fertility, increasingly, such soil fertility issues are beginning to go beyond traditional measures of agro-chemical usage, particularly, chemical fertilisers. Just as human nutrition is a factor

of a variety of nutrients similarly obtained from consumption of a variety of foods, so too must the issue of the nutritional composition of soils be approached from a similar perspective. This has implications for the development of new types of soil enhancing techniques and inputs based on the principles of sustainability. This in turn has implications for further innovation in farming production systems.



Like the growth of these plants, food and nutrition security goals require inter-connections that are enabled, forged and sustained.

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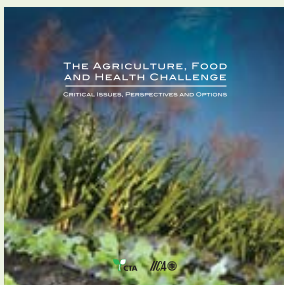
Food Security poster promoted under the project "Enhancing Information and Communications for Food Security in Trinidad and Tobago", funded and implemented by IICA and CARDI in 2009.



Agriculture for Food or Fuel or Both

Al Binger, PhD.





Agriculture for Food or Fuel or Both

Al Binger, PhD.

Al Binger took on the agriculture system geared to food production versus that for fuel debate and rightly argued that the potential for greater food and fuel security could be enhanced by adopting policies that make more efficient use of the land and sea resources in the region.

About the Author

Al Binger's recent work with the Caribbean Community Climate Change Centre (CCCCC), IICA and the UNDP as Energy Advisor, Biofuel development and Renewable Energy and Sustainable Development, respectively, among others provides the context for Prof. Binger's wealth of perspectives on the topic of Agriculture for food or fuel or both.

Albert H. Binger, a Jamaican national, obtained his PhD Agronomy, from the University of Georgia, School of Agriculture, Georgia, USA, in 1980. Prior to his Ph.D., he completed Post Graduate Studies Biophysics at the University of California, Los Angeles, USA, in 1975 and a BS Chemical Engineering at the University of California, Los Angeles, in 1974. Professor Binger has and continues to build a distinguished career history in the fields of Renewable Energy, Agriculture, the Environment and Sustainable Development.

Prof. Binger's paper was reduced for the purposes of this publication. The original paper is available in electronic format on www.carapn.net

Agriculture for Food or Fuel or Both

Introduction

The Regional Development Context

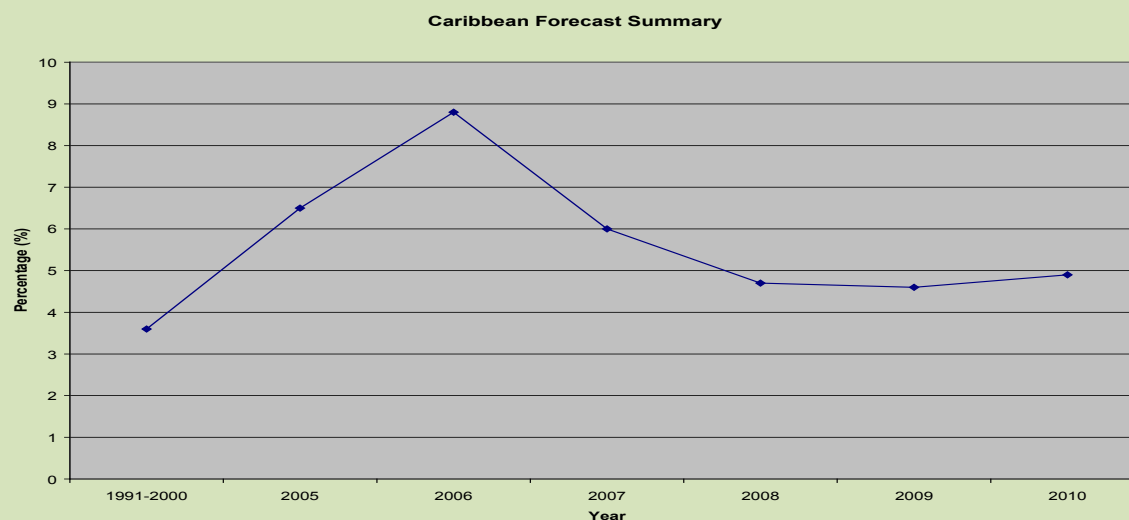
“Our biggest problem in the agricultural sector is how to cut down on the imports of food from outside the region. Meat and other livestock products illustrate the problem it is often cheaper in foreign exchange to import the meat than to import the feed...”

(Sir Arthur Lewis, 1971)

It is argued that the Caribbean region has the potential, in the short- and long-term, to implement policies and programmes that could lead to both better food and energy security across the region. This assertion takes fully into consideration the region's land frontier which has available arable lands in countries like Guyana, Belize, Suriname and Jamaica, and against the background of a declining sugarcane industry and increasing high food and fuel prices. This is also in the context of the current situation in regional economies, and as well, two of the most critical sectors for its development needs- agriculture and energy. Achieving these twin objectives, however, takes full cognisance of the region's development challenges, the obstacles common to both food and energy security and its vulnerability to disasters from natural hazards and climate change.

Among the region's development challenges is the economic vulnerability of its leading sectors to external shocks. Tourism, financial services, mining and mineral extraction and agriculture, have all been impacted by the global financial crisis. This is, perhaps, the most severe the region has faced since the post-independence period. Regional growth in Latin America and the Caribbean (LAC) has slowed markedly as the global slowdown and tightening financial conditions take hold, while external current accounts are set to weaken (IMF, 2008). Most of the regional development agencies and banks have projected that the region will experience a downturn in economic activity in 2009, with the tourism sector, a major foreign exchange earner and fuel consumer, being negatively impacted (Figure 2).

Figure 2: Caribbean Forecast Summary – Growth Rates (1991-2010)
Source: World Bank, 2009. Global Development Finance 2008



The financial sector, which accounts for 45 per cent of the region's gross domestic product (GDP), was severely impacted by the collapse of the regional conglomerate, CL Financial Group (CLICO). So too was the adverse impacts on a number of Member States, of contraction in British American Insurance, and collapse of *ponzi* scheme-like operations of the Sanford Group. The impacts of the latter were more severe in Antigua and Barbuda and St. Vincent and the Grenadines (CARICOM, 2009). These impacts are expected to worsen with the United States of America (USA) recent clampdown on tax havens.

Tourism, the region's economic mainstay, saw declines in the first quarter of 2009, the worst since the tourism slump that followed the September 11, 2001 attacks in the US, a major source of tourists to the region. At least five Caribbean countries have suffered double-digit drops in tourist visits this year as the global economic slowdown wreaks havoc on the region's top industry – thousands have lost their jobs. The tourism industry has traditionally relied on imported food due to lack of regular and high quality supply, among other factors. An estimated 40-45 percent of agricultural imports are concentrated in the tourism sector (AgriFood Trade Service, 2009). Considering that food represents approximately one-third of all tourist expenditures, the level of imports can significantly affect the economic and social impacts of tourism (Donovan et al, 2008).

1. Agriculture and Food Security

...the Caribbean has the arable land to increase food production....the combined area of the two largest countries -Guyana and Suriname- is more than double the combined area of all the other Caribbean countries

Over the past centuries, the climate and land resources of the Caribbean region have proved suitable for agricultural commodities and the production of sugar, bananas, coffee and spices have been the mainstay of the sector for a majority of the countries. During that time, commodity crop production was allocated the prime agricultural lands. Lands that were considered marginal or became marginal were used for the production of food crops usually root or tree crops, vegetables and livestock, or left with vegetation to provide environmental services.

The economic context of agriculture

The contribution of primary agriculture to the Caribbean's GDP varies widely across the region, from highs of 32 and 30 percent in Guyana and Haiti, respectively, to as low as 2 percent in Trinidad and Tobago, respectively. However, based on the proportion of the population in agriculture, Haiti is the most agrarian with 62 percent. Today, primary agriculture accounts for less than 10 percent of the region's GDP and for approximately 30 percent of regional employment. Although the sector has experienced disappointing results over the last decade, it is still a significant export earner and means of livelihood in several countries.

In fact, the high share of agricultural production that is exported, most often comprising one or two commodities that go mainly to one market, demonstrates the high dependence on external trade. The European Union (EU) and the USA markets alone account for more than two-thirds of Caribbean agricultural exports, with less than 15 percent of exports going to 'other' destinations. While in 2007, agriculture exports exceeded more than US\$ 3 billion, since July 2008, the major commodity exporters of CARICOM - Belize, Guyana, Jamaica, Suriname and Trinidad and Tobago - have experienced the repercussions of the deterioration of commodity prices. World commodity prices driven by high energy prices soared to unprecedented levels in July 2008 and then fell dramatically. Other commodity prices exhibited a similar pattern. (UWI, St. Augustine, 2009)

The decline in export earnings would have significant impacts on the food situation in the Caribbean to support food imports. The major crops grown for domestic consumption include fruits and vegetables, tubers (potatoes, cassava, yam, taro, and sweet potatoes), cereals (corn, sorghum and millet), groundnuts and pulses. Over the last three decades, in addition to declines in traditional export crops, domestic food production has generally, also been declining. This has made it very difficult to close the gap between domestic consumption and domestic production and highlights the region's dependence on imported food commodities.

Food accounts for up to 20 percent of total imports in some Caribbean countries. By the late 1970s, most Caribbean countries experienced a negative food trade balance that has risen, in some cases, to as much as 10 percent of GDP (CARICOM Secretariat, 2008). Annual food imports averaged over 350,000 tonnes of vegetables; 380,000 tonnes of fruits; 480,000 tonnes of meat; 1.3 million tonnes of milk; 2.4 million tonnes of oil crops, and 6.4 million tonnes of cereals. Consequently, the region is a net food importer (except for Guyana and Belize) with imports dominated by food from animals and cereal based products (wheat, corn, rice, soybeans and oats). In terms of food from animals, CARICOM imports 35 percent of broiler consumption and on a percentage basis, is one of the largest importers of poultry products in the world. Between 1997 and 2006, intra-CARICOM food imports rose by about 24 percent, with food imports from outside the region rising by as much as 50 percent (CDB, 2008). In contrast, agriculture production remained virtually constant in absolute market prices between 1997 and 2006. In 2007, the region spent in excess of US\$ 3.5 billion on food imports. The cereals import bill alone, increased by 13 percent between 2006 and 2007, equivalent to an extra cost of US\$ 94 million (FAO, 2008).

The high level of food imports places the region in a vulnerable situation with respect to food security. Further, research carried out by the Caribbean Food and Nutrition Institute (CFNI) indicates that a great proportion of the imported foods consumed in the Caribbean indeed contribute to the many illnesses and diseases affecting the people and development. Recently, CARICOM Ministers of Agriculture set a target that 25 per cent of food should be grown within the region. The Caribbean does have arable land to increase food production (Table 3) unlike regions, such as, Asia, where land scarcity has become acute in most countries and rapid urbanisation is reducing the area available for agriculture (WDR, 2007).

Table 3: Land Use and Agriculture in the Caribbean ⁽¹⁾ : Total area, arable land and land under permanent crops							
Year	Total Area	Arable Land	Land Under Permanent Crops	Arable Land Over Total Area	Total Area	Arable Land	Land under Permanent Crops
	(Million ha)			(percent)	Share in Total World (percent)		
1980	23	4.9	1.7	20.8	0.2	0.4	1.7
1990	23	5.4	1.8	23.2	0.2	0.4	1.6
2002	23	4.9	2.2	21.0	0.2	0.4	1.7

(1) The Caribbean is based on FAO Country Group Composition that includes all of CARICOM plus Anguilla, Aruba, British Virgin Islands, Cayman Islands, Cuba, Dominican Republic, Guadeloupe, Martinique, Netherlands Antilles, Puerto Rico, Turks and Caicos Islands, US Virgin Islands

Source: FAO: Summary of World Food and Agriculture Statistics 2004, Rome, 2004

The combined area of the two largest countries (Guyana and Suriname) is more than double the combined area of all the other Caribbean countries. Suriname has been rated as one of the top 20 countries with the most natural resources. More than 80 percent of Guyana's surface area is rainforest the size of England. Additionally, Guyana and Belize were identified in the Group of Experts Report on CARICOM in the 1980s as the potential 'bread baskets' of CARICOM. The combined area of the seven smallest countries (Dominica, Saint Lucia, Antigua and Barbuda, Barbados, St. Vincent and the Grenadines, Grenada and St. Kitts and Nevis), at 3,228 km sq, is seven times smaller than the land area of Belize – the smallest of the mainland countries. Guyana, Belize and Suriname in particular with their specific land and labour endowments can influence the region's food prices and availability.

There is the view that the region can make significant cuts in its food import bill. According to the Caribbean Agricultural Research and Development Institute (CARDI), substitutes for cereals could be found in cassava; alternatives in meat include small ruminants, poultry and fish, while sweet potatoes could be substituted for Irish potatoes. Solutions to the shortage of rice could take the form of the expansion of the production of rice in Belize, Guyana and Suriname.

Grain – Rice and Corn

In the Caribbean, rice is a widely consumed food product. It is grown extensively in Belize, Cuba and Guyana. In Belize, rice production increased from 18 million pounds in 2003, to 20 million pounds in 2007, due largely to use of more sophisticated equipment and improved seeds and technology. In 2008, rice production in Guyana increased by 10.5 percent to 329,574 tonnes, the highest annual production in five years, of which an average of 80 percent is exported. Cuba produces just a fourth of the 800,000 million tonnes its 11 million people consume annually. The country hopes to replace 29 percent of rice imports in 2009, with expectations of increasing that figure to 56 percent in 2013 (Carib Daily, 2008). The Government of Jamaica and a private company have collaborated in a 25-acre experimental rice field as Government strives to reduce the country's annual rice import by 25 per cent in five years (Jamaica Observer (2009). The Government announced that marginal cane lands, more than 20,000 acres now idle, were available and suitable for rice production. Jamaica spent in excess of US\$ 700 million on food imports in 2008 and imports approximately 100,000 tonnes of rice annually from the USA and Guyana, at a cost of US\$ 63 million per year.

Poultry and Eggs

Chicken is by far the most popular meat intake in the region and the poultry industry is among the largest agro-industry in the region. The Caribbean Poultry Association (CPA) estimated that more than 70 percent of consumption is local, with a 2004 per capita consumption of chicken at 46 kg per annum, on par with the USA (for chicken only) and above the average of industrialised countries at 24 kg per capita, and developing countries at 9.00 kg per capita. Poultry comprises 86 percent of the region's meat consumption compared to 40-60 percent for most industrialised countries.

The CPA, one of the largest agribusiness associations in CARICOM, comprises 18 members, 15 poultry companies and 3 national associations from nine CARICOM countries which altogether account for over 70 percent of the region's production. In 2006, poultry production in the region was estimated at US\$ 500 million, employing approximately 100,000 people, 30,000 of them in rural areas (CPA, 2008). The largest producers of poultry are Barbados, Belize, Guyana, Jamaica, The Bahamas and Trinidad and Tobago, where in 2003 some 200,000 metric tonnes of poultry products were produced. Belize has doubled production between 2003 and 2008 reflecting the trend of increasing production.

The poultry industry has important linkages to other agro-industries as it utilises the corn grown in Belize, rice and coconut grown in Guyana and Suriname, soya bean meal produced in Trinidad and Tobago and Barbados, and spent fast food fat in Jamaica. Poultry offal meal produced by most poultry processors across the region provides protein material for animal feed. These linkages provide economies of scale for the production of feeds. Jamaica Broilers, a member of the CPA, indicates that the industry is a major supplier of quality fresh chicken to the quick service restaurant sector.

With respect to eggs, in 2007, 43 million dozen eggs valued at US\$ 58 million was produced by the Caribbean egg industry. The region has about 2,825 producers - 425 commercial and the rest referred to as small and backyard farmers. Jamaica's egg industry does 11 million dozen eggs per year, valued at US\$ 13.2 million, with local producers supplying 100 per cent of the table-egg market. Jamaica represents 26 percent of regional production and 22 percent of value. As part of the focus on supplying the tourism industry, Jamaica has built a liquefied egg-processing plant at a cost of JA\$30 million, which began operation in December 2008. The plant has the capacity to liquefy up to 18,000 eggs per hour, but will begin operation at 10,000 eggs per hour or 56 percent capacity. Jamaican poultry farmers now sell 20 per cent of their table egg stock to the hospitality sector, but because of food safety issues, hotels have been moving toward the use of processed, liquid eggs (Jamaica Gleaner, 2006). In Belize, egg production was up by 7 percent, from 2.7 million dozens in 2004 to 2.9 million dozen eggs in 2007. Dominica's poultry production forms a significant part of the sub-sector and local production meets the domestic demand for eggs. Within recent times the broiler production has increased significantly and is estimated to meet 11 per cent of the domestic demand (FAO, 2007). While capacity has increased, seasonal demand, particularly in December, must be met by imports, mainly from the USA.

While food production capacity has improved, such improvements have not been sufficient to offset the high reliance on imports. Hence, the net-food import situation is likely to remain so. Only the three mainland countries could have capacity for viable production of soybeans, rice and corn- the base of the regional food basket. However, Caribbean countries face another challenge. That is, the use of crops, including soybean and corn for the production of fuel, i.e., bio-fuels in an effort to provide for the region's energy security.

2. The Energy Situation in the Caribbean

The Caribbean is predominantly a net fuel importing region, with imports accounting for more than 90 percent of commercial energy consumption.

Annually the Caribbean region spends a significant portion of scarce foreign exchange to import liquid petroleum fuels to provide energy services. With the exception of Trinidad and Tobago, the Caribbean is predominantly a net fuel importing region, with imports accounting for more than 90 percent of commercial energy consumption. Total petroleum imports, inclusive of electricity and gasoline, was more than 163 million barrels during the same period – electricity consumption accounted for 18 percent of total consumption (Table 4). Gasoline and diesel fuel represents 37 percent of petroleum imports in the region and the fastest growing type of imported fuel.

Table 4: Regional Fuel Imports (2000-2004)					
	2000	2001	2002	2003	2004
Gasoline	15,754.1	15,753.0	17,508.2	24,859.5	26,279.4
Diesel	24,851.4	25,236.6	28,089.1	33,771.8	34,511.8
Total Gasoline & Diesel (000 bbl)	40,605.5	40,989.6	45,597.3	42,989.7	44,550.7
Total Cost, USD Gasoline/Diesel	3,731,042.21	3,258,426.17	3,851,725.25	5,432,383.62	6,501,131.93
Source: CEIS					

All transportation fuels and an estimated 85 percent of all electric power in the Caribbean are generated with liquid petroleum fuel (CARILEC, 2008). Hence, meeting the increasing demand for reliable and cost effective electricity supplies is a major challenge for the future economic development of the region. Electricity prices are high in the region and among the highest in the world, primarily a result of the very high cost of transportation, associated with the relatively small quantities of fuel delivered to the various countries, as well as the high level of liquid petroleum fuel use in the power matrix, and low efficiency of the relatively small power grids (UWICED).

The energy sector of the Caribbean is dominated by liquid petroleum fuels (LNG). Trinidad and Tobago is the largest supplier of LNG to the US and one of the largest LNG exporters in the world. In 2007, Trinidad and Tobago exported 451 billion cubic feet of natural gas to the US, about 60 percent of total US LNG net imports and about 2 percent of total US natural gas supply. Oil reserves are not renewable and without any further new field discoveries, Trinidad and Tobago's proven reserves (both oil and gas) are estimated to be exhausted by the year 2025. This sector is responsible for almost eighty percent 80

percent of Trinidad and Tobago's foreign revenue (Ryder Scott Company, 2008). In addition to Trinidad and Tobago, Barbados, Belize, Cuba, and Suriname produce varying amounts of crude and small amounts of oil to help reduce the cost of imports (Table 5). It is also estimated that Barbados's proven reserves, both oil and gas, will be exhausted within the next five to fifteen years.

Table 5: Proven Reserves and Production of Oil and Natural Gas in the Caribbean				
	Proven Reserves		Production	
	Crude Oil	Natural Gas	Crude Oil	Natural Gas
Units	Billion Barrels	Billion M ³	000' bbl/day	Billion M ³
Barbados	0.002	6.0	1.1	0
Belize	0.007	0	3.51	0
Cuba	0.124	2,500.0	51.80	0.351
Suriname	0.088	0	15.27	4.2
Trinidad & Tobago	0.728	18,770.0	168.0	1,377.0
Total	0.95	21,276.0	239.68	1,381.55

Source: Energy Information Administration (EIA) Country Analysis Briefs, Caribbean,

Overall, across the region, approximately 85 percent of the population has access to electricity. However, it is estimated that the region wastes a significant amount of the energy. Two major contributors to the poor energy efficiency are the relatively high percentage of private automobiles that consume significant amounts of fuel due to traffic congestion and poor vehicle maintenance and the significant losses in generation, transmission and end use of electricity. This makes for a very high energy per unit of GDP value. With the exception of The Bahamas, Barbados, Guyana, Jamaica, Trinidad and Tobago and Suriname (where there are national oil companies that are primarily responsible for imports of petroleum fuels), the rest of the countries' petroleum fuels imports are controlled by international companies.

The energy situations across the region are characterised by a national electric utility that is sometimes privately owned, sometimes public and sometimes a combination of the two. These power companies use either bunker or diesel fuel to produce power. The cost of electricity is, on average, among the highest in the world, primarily a result of the very high cost of transportation, associated with the relatively small quantities of fuel delivered to the various countries (UWICED). For example, electricity prices in the Caribbean ranged from 0.197 US dollar/kWh in Barbados, to 0.188 US dollar/kWh in Grenada. Meanwhile, in Trinidad and Tobago, the only oil producer in the region, prices were 0.037 US dollar/kWh. The rising cost of fuel imports has aggravated the situation and has been negatively impacting the Caribbean economies.

Fertilizer and chemicals inputs and the cost of transportation have all increased significantly over the past two years partly as a result of the increasing cost of energy built on fossil fuels. So far in the early

stages of the 21st century, energy and food have become inter-linked. Projections are that this linkage will likely strengthen until a relatively cheap source of energy is available to substitute for fossil fuels.

One option for meeting future demand for fuel is by development of the region's vast renewable energy resources in combination with increasing energy efficiency. These resources are solar, wind, geothermal, biomass, and the ocean. With respect to the latter, the Caribbean Sea represents a major source of thermal energy which can be converted into electricity thereby contributing to energy security. The total area of the Exclusive Economic Zone (EEZ) is 2,205,470 km² compared to the region's total land area of 484,716 km² (CTA, 2007). Ocean resources can be developed with available technology to directly and in-directly address both food and energy security. Exploration of coastal waters and the EEZ using highly sophisticated technologies have so far provided encouraging results and new resources are anticipated. However, their availability will be based on the cost of extraction and quality of the crude or natural gas. Beyond the conventional approach of searching for oil, the region's major prospects for significant liquid fuel production is from the agricultural sector.

In the search for such a 'cheap' source of energy and/or substitute for fossil fuel, agriculture has become a sector of interest. Caribbean governments and private sector have been exploring the use of agricultural crops for fuel generation. Recent studies have shown that conversion of cropland to biomass production can provide a long-term alternative fuel source by using locally produced feedstock grown on former sugarcane lands, as well as available lands in Guyana, Suriname, Belize and Jamaica. This can be done at relatively constant cost that in many cases is already cheaper than the fossil fuels.



Opportunities to use sugar cane fields for bio-fuel production are being explored.

3. Fuel from Agricultural Crops

Beyond the conventional approach of searching for oil, the region's major prospects for significant liquid fuel production is from the agricultural sector.

Several studies by international institutions indicate that bio-energy will play a much larger role in energy supplies during the 21st century. The principal physical determinants of the potential of biofuels in any country are availability of land resources, labour force, and climatic conditions. The principal economic determinant of feasibility is the technological package (from production to processing), while the principal determinant of economic viability is government policy. Identifying the potential agro-industry begins with assessment of the land resources.

In response to high prices for petroleum fuels, starting in the late 1970s, and lasting into the 1980s, there were a number of efforts across the region at developing renewable energy resources. Sugarcane has long been recognised as one of the world's most efficient crops in converting solar energy to chemical energy, as exemplified in the Brazilian ethanol/sugar programme started in the early 1980s, and which is the largest in the world. Over the last few decades, Brazil has served as an example of the associated cost and benefits of biofuel.

In the area of fuel for transportation, the renewable sources are limited to biomass and particularly sugarcane as its juice can be made into a substitute fuel or extender for use in spark ignition engines. Biomass provides an efficient and cost-effective way to collect and store solar energy in a solid form. It can be burned to release the stored energy as heat, or it can be thermally, chemically or bio-chemically processed to convert it into liquid and gaseous fuels, or into other solid fuels. The optimal energy conversion process is determined primarily by the form in which the plant stores its energy (sugar, starch, cellulose, lignin), as well as the physical and chemical properties of the biomass. The contribution from biomass in the long-term given in these studies vary from 100 to 300 exajoules (EJ)¹ per year towards the total world energy consumption, which is projected to rise to nearly 500 EJ per year in 2025, and 700 EJ per year by 2100 (Binger, 2006). In a United Nations Development Programme (UNDP) study on "Modernised Biomass Energy for Sustainable Development," Kartha and Larson (2000) estimate that residues from sugarcane (bagasse, leaves and tops) have the potential to generate more than half the electricity consumption in the Caribbean by 2025.

It appears that the most economic option for a renewable energy that is likely to be competitive in a number of Caribbean countries is biomass as liquid fuel for transportation. It also provides significant by-products for electricity generation. This is not a new conclusion and it was the basis of the Brazilian

¹ One Exajoule is equivalent to the energy content of 177,000 barrels of crude oil

decision to develop the ethanol programme. The by-product left over from ethanol is now a major source of fuel for process heat as well as power generation. Thus, there is both market and production synergy in developing biofuel with sugarcane as the lead crop (Binger, 2006). For sugar-producing countries there is a unique opportunity to diversify away from the sweetener market into the energy services market given the relative ease at which sugarcane feedstock can be used for energy (Table 6).

Table 6: Sugarcane yields, production and area cultivated in 2004				
Country	Sugarcane Yield	Sugarcane Production	Potential Ethanol Production	Area Cultivated
	Tons/Hectare	Tons/Year	Barrels	Hectares
The Bahamas	24.7	55,500	28	2,250
Barbados	53.8	430,000	216	8,000
Belize	48.1	1,149,475	578	23,887
Cuba	31.3	12,500,000	6,289	400,000
Dominica	20.0	4,400	2	220
Dominican Republic	38.1	4,950,000	2,491	130,000
Grenada	45.0	7,200	4	160
Guyana	61.2	3,000,000	1,509	49,000
Haiti	60.0	1,080,000	543	18,000
Jamaica	47.5	1,900,000	956	40,000
St. Kitts & Nevis	55.6	100,000	50	1,800
St. Vincent & Grenadines	25.0	20,000	-	800
Suriname	40.0	120,000	60	3,000
Trinidad & Tobago	51.2	665,000	335	13,000
Average/Total	42.9	25,981,575	13,062	604,927
Source: IICA, Al Binger (2006)				

Ever since the decision by the EU to end the preferential price for sugar imports, Caribbean sugar producing countries have argued that such a move would have very negative consequences on their development prospects. The discontinuation of sugarcane production and processing would likely result in significant negative social, economic and environment consequences, arising from loss of employment particularly in the rural areas. The production of biofuel represents a proven option that has the potential to more than offset the loss of the preferential price. For example, the thirty three (33) million tons of sugarcane produced by the region in 2004, to make an estimated 3.3 million tons of sugar, at a world price of US\$ 250 per ton, would have an estimated value of about US\$ 800 million. If the 33 million tons of sugarcane were used as feedstock to produce ethanol and electricity, using proven technology, some 3.3 billion kilowatt hours of electricity and an estimated 2.6 billion litres of ethanol could be produced for national and regional consumption. The estimated value of the ethanol and electricity based on US\$ 70 per barrel for crude oil would be in excess of US\$ 3.0 billion.

Coconut is also among a number of crops whose production could also be expanded to provide feedstock for the production of biodiesel. The average production during 2003-05 from 14 Caribbean states of 600,000 tons per annum could have produced enough coconut oil to substitute 109 million litres of diesel and enough residues (shells & husk) to substitute 132 million litres of diesel. The foreign exchange savings from the diesel substituted by the coconut oil and residues is estimated at US\$ 160 million at a crude oil price of US\$ 70 per barrel and US\$ 229 million at US\$ 100 per barrel.

Unlike sugarcane, that has very specific land characteristics for growth, crops that produce seeds grow under a wider range of soil conditions and climate. In countries where hilly and steep slopes dominate the landscape, and where there is ongoing environmental degradation due to soil erosion, the production of oil seeds using hardy crops such as *Jatropha* and *Castor* along with grasses to control soil erosion would make significant contribution to sustainable development in a number of ways. In addition to sugar cane, coconut and oil seeds, Table 7 provides an indication of other potential crops in selected Caribbean countries. The development of biodiesel production would yield significant direct environmental benefits in countries like Haiti, Jamaica, Dominica, Saint Lucia, and Grenada, where protection of upland watershed is critical to long-term water resources, quality of the coastal environment and soil fertility.



The mighty coconut - among a number of crops whose production could be expanded to provide feedstock for biodiesel.

Table 7: Potential of Selected Caribbean Countries as Biofuels Producers and Crop(s)

Excellent Potential	Lead Crop(s)	Biofuels Market	2004 Imported Petroleum Products (US\$000's)- {Potential Biofuels Market}
Belize	Sugarcane, Oil Seeds and Fast growing trees and grasses	Transportation Fuels Power Generation	73,185
Guyana	Sugarcane, Oil Seeds and Fast growing trees and grasses	Transportation Fuels Power Generation	169,004
Cuba	Sugarcane, Oil Seeds and Fast growing trees and grasses	Transportation Fuels Power Generation	1,449,014
Dominican Republic	Sugarcane, Oil Seeds and Fast growing trees and grasses	Transportation Fuels Power Generation	1,712,591
Good Potential			
Barbados	Sugarcane	Transportation Fuels Power Generation	209,451.3
Jamaica	Sugarcane, Oil Seeds and Fast growing trees and grasses	Transportation Fuels Power Generation	928,646.2
Trinidad & Tobago	Sugarcane	Transportation Fuels	1,258,352.8
Suriname	Sugarcane, Oil Seeds and Fast growing trees and grasses	Transportation Fuels Power Generation	162,381.4
Some Potential			
St. Kitts and Nevis	Sugarcane, Oil Seeds and Fast growing trees and grasses	Transportation Fuels Power Generation	26,668.7
Saint Lucia	Sugarcane, Oil Seeds and Fast growing trees and grasses	Transport Fuel - Diesel; Power Generation	82,884.9
Dominica	Sugarcane, Oil Seeds and Fast growing trees and grasses	Transport Fuel - Diesel; Power Generation	14,686.4
Haiti	Sugarcane, Oil Seeds and Fast growing trees and grasses	Transportation Fuels Power Generation	-
Grenada	Oil Seeds and Fast growing trees and grasses	Transport Fuel - Diesel; Power Generation	29,282.7
Antigua & Barbuda	Oil Seeds and Fast growing trees and grasses	Transport Fuel - Diesel; Power Generation	75,088.2
St. Vincent & Grenadines	Oil Seeds and Fast growing trees and grasses	Transport Fuel - Diesel; Power Generation	23,136.8
Limited Potential			
Montserrat	Fast growing trees and grasses	Power generation	3,154
Source: Al Binger (2006) IICA			

There are several challenges to the development of an agro-energy industry for the production of biofuels to replace imported petroleum fuel in the region. These include the development of the institutional relationships between a number of state, private and community actors; ownership at the national and local levels; sustainable production of feedstock/raw material and its effective transportation; institutional capacity; supportive policies and legislation, and; decision making processes. Despite these challenges, research shows that agro-energy industries increases income generation opportunities at all stages of feedstock production, transportation and plant operation.

The benefits to be derived from investments to include fuel production as part of an agriculture diversification strategy can be grouped into economic benefits, sustainability and social advancement. The Brazilian biofuel programme has been deservedly credited with many successes; improving the energy security, increasing farming household income and reducing the quantum of foreign exchange leaving the country. The Brazilian ethanol programme came about as the result of escalation in the international oil prices in the latter 1970s and 1980s. It may be described as a value added sugar production enterprise in which sugarcane is grown and processed partly for sweetener and ethanol.

In addition to Brazil, a number of other countries are benefiting from national programmes that diversify the agricultural sector into the production of both liquid and solid biofuel to substitute for liquid petroleum.

- The USA produced some 9.2 billion litres of ethanol in 2008. On average, the US ethanol industry produced 668,000 barrels per day, mostly from corn. (Dinneen, 2009) This policy has been blamed, along with speculative investment in energy, for the increases in food and fuel prices in 2008.
- The EU is also a major producer of biodiesel, producing some 5.7 Mt of biodiesel in 2007 to substitute for diesel as part of its policy of reducing greenhouse emissions (EBB, 2009).
- Colombia, a major producer of both ethanol and biodiesel. also uses sugarcane as the feedstock for ethanol, but uses African palm as the crops to provide the feedstock for biodiesel.
- Australia and India are also major producers of biofuel, producing solid fuel from crops like fast growing legumes and eucalypts, ethanol from sugarcane and biodiesel from *Jatropha curcas*, to substitute for imported petroleum.

Economic Benefits: Pioneering biofuel research work at the Centre for Environment and Energy Research (CEER) University of Puerto Rico during the 1970s and 80s developed new varieties to help address the energy needs of the island, emphasising not only fermentable sugars, but large biomass production (Alexander, 1986). The goal was to tap into the energy market to improve the economic viability of the declining sugar industry. The work done by CEER led to the concept of a sugarcane energy system, which was different from sugarcane for sucrose system. In the production of energy the goal is to cultivate sugarcane that will, at maturity, produce a very high level of fermentable sugars and large amount of biomass. The variety developed by CEER produced 300 percent more *fermentable sugars* and biomass per acre than the sucrose variety. Additionally, the harvest periods for energy cane are year round; while the sugarcane for sucrose crop is usually harvested once a year.

The scientific work done by CEER showed clearly the advantages of the energy cane concept in an island economy dependent on imported petroleum fuels versus a conventional sugar production for export. Alex Alexander's work failed to convince the political decision makers and the sugar industry went into the history books. Antigua and Barbuda, Puerto Rico, St. Kitts, and Trinidad and Tobago, are islands that once had a sugar industry that was once a major pillar of the economy. Alex Alexander's research showed that the industry could be diversified to produce energy and make even greater contribution to economic development than the production of sucrose.

In many sugarcane growing countries it is now common practice for the combined production of sugar and electricity. A very successful example of this is Mauritius which despite being a relatively small producer of sugar is able to be competitive in the international market primarily due to having electricity as a co-product. During the sugarcane processing season the industry can supply as much as 40 percent of the island power needs. Mauritius is now exploring the production of ethanol and a third product from sugarcane to help increase its energy security.

Higher economic benefits resulting from the production of biofuel provides increased opportunities for increases in employment and or wages in the rural population, as it is a relatively labour-intensive activity in many developing countries. An increase in disposable income of households usually leads to higher household spending which positively impacts household food security and the rural economy.

Sustainability: The key criterion for sustainable development is the sustainability of the agricultural system. If the agricultural system does not use the land resources in a sustainable manner then serious ecological damages can result. The importance of a sustainable system is now even more important than in the past as a result of the changes that will occur due to the global phenomena described as global warming. These changes will include changes in rainfall periodicity and intensity, day and night temperatures, relative humidity, wind intensity, increased pest and disease problems - all key factors in crop production. The agriculture of the future will have to prosper in a much more adverse environment than in the past, and some agronomic systems will no longer be viable as they lack the resilience to combat these changes.

An example of this is illustrated by the Government of Jamaica's decision to end its centuries-old banana export industry (Lancashire, 1997) as a result of storms and hurricanes which devastated banana plantations almost annually for the last three years. The banana crop with long recovery periods of up to a year was considered no longer economically viable. Most of these lands, according to reports, will go into sugarcane, a crop that did not have as favourable a return under good climatic conditions as bananas. Sugarcane as a crop grown for sugar has significantly less economic value per acre per year than bananas. In the case of Jamaica, the ratio appears to be more 1:2.5 if natural disasters are not considered.

It is interesting to note that, beginning in 1981, the Jamaican Government's agricultural development programme *Agro 21*, funded by the government and the US Agency for International Development (USAID), converted significant amount of lands from sugarcane to bananas. In retrospect, if the Government of the day had chosen the alternate recommendation of diversifying the sugar industry into an energy industry along the lines of what was recommended for Puerto Rico or followed the examples of Brazil or Mauritius, the present situation with both bananas and sugarcane could have been much different. Sugarcane has been grown in Jamaica and the region for hundreds of years; bananas slightly over a hundred. Sugarcane is more suited to the climatic conditions than banana; it resists drought, fires, flood and wind; it may be burned but re-grows; it gets blown down but recovers. Like many other current or previous sugar producing countries, the industry has not returned a profit in many a decades and depends on its role as a provider of rural employment and a generator of foreign exchange as the basis for its survival.

This dependence on political factors for survival rather than economic viability could be positively impacted by integrating the energy and agriculture sector, with the goal of minimising the outflow of foreign exchange for food and fuel (greater than 90 percent dependency in both cases). Sugarcane, while still a major crop in some countries, is but one example of a crop and an agro-energy system in which the economic value in its traditional application accrues less economic benefits than it would have in an energy application.

Social Advancement: The quality of life of a society is partly determined by the availability of energy and the efficiency at which it generates goods and services. For the millions of households that depend primarily on agriculture for their livelihoods, improving quality of life is very dependent on the future growth and sustainability of the sector. The production and export of agricultural commodities is a major source of employment of labour and the ongoing decline is increasing hardships for households dependent on crops such as sugar and bananas. Improving the fortunes of the sector is a major goal of regional governments, who now seek substitute crops for those which no longer have sustainable market opportunities, or are unable to cope with changing climatic conditions.

Various governments, independently, are seeking answers to help the sector return to growth. Answers to key questions such as which crops, for which products, for which market, produced how, and having sufficient financial benefits to the farmers are determinants. Essential to social advancement of the farming households and the rural sector in particular, is developing a sustainable market with a predictable price. In this context agro-fuels production may provide answers to the key questions.

The key requirements for biofuels production begins with clear, identifiable and quantifiable markets; the availability of land resources which would not bring about competition with domestic food production; appropriate weather and climate regime; proven experience with the production of the crop(s) by local farmers; conversion and end use, at least at commercial demonstration scale; commitment on

the part of government to enact and enforce requisite policies and associated laws to ensure that the market is developed for biofuels. Based on the requirements, not all countries in the region are currently positioned to pursue biofuels industries.



***Arundo donax* or Giant Cane offers a biodiesel alternative that does not conflict with food-providing agriculture.**

While sugar cane is a potential source of energy it is not as productive an energy crop under similar conditions as fast growing grasses such as *Arundo donax*. In an agro-energy assessment done for the Government of St. Kitts and Nevis to identify potential crops for energy production, it was found that *Arundo donax* grown on 4,000 acres of former sugarcane land would generate significantly more economic value compared to either sugarcane production for sucrose or fuel. High economic value crops like *Arundo donax*, very resilient to changing climatic conditions and cultivatable on wider range of soils represent new opportunities for the agriculture sector where on average about 20 percent of the population ranging from a low of 3 percent in the Bahamas and 60 percent for Haiti derive their livelihood.

As the biofuel industry develops, increased usage of residues from food crops can help to improve the food security of a region or country. The complementarities in the production of crops that produce biomass for fuel and food crops hold significant promise for improved efficiency and sustainability in the way land is used. Marginal and degraded lands could become more viable for sustained agricultural production through the production of biomass feedstock. Other socio-economic benefits include support of traditional industries, rural economic diversification and the economic development of rural communities.

4. Common Challenges to Food and Fuel Security

The region is a net food and oil importer and rising food and oil prices are hitting the Caribbean more than any other region in the Western Hemisphere, with the effects of high oil prices generally exceeding those related to food

Impact of Rising Prices

Rising food and oil prices are impacting the Caribbean more than any other region in the Western Hemisphere and analyses shows that the effects of high oil prices exceed those related to food in most of the Caribbean (IDB, 2008). It is estimated that the average negative net impact of high oil and food prices on the trade balance for Caribbean countries (except Guyana and Trinidad and Tobago), is 5.4 percent of GDP, compared to 4 percent of GDP in Central American countries (IMF, 2008).

Oil prices rose by 44 per cent between January and June 2008 to reach a monthly average of US\$133.93 per barrel; then collapsed to a monthly average of US\$ 39.15 per barrel by February 2009, close to the level of the first quarter of 2004. Since March 2009, oil has traded near US\$ 50 a barrel, and surged to almost US\$ 57 a barrel in early-May. In the Caribbean, the cost of fuel imports jumped from US\$ 6.5 billion in 2004, to US\$ 12 billion in 2007, representing 16 percent and 21 percent of GDP, respectively.

The dramatic increases in food prices are not a temporary phenomenon but a trend that is likely to persist in the medium-term. The trend is due to several factors including demand in developing countries, higher fuel costs, droughts in Australia and low crop output in Europe, the use of crops for biofuels and speculation on global commodity markets (IICA, 2008). Some aid officials and food experts have pointed to a more fundamental reason why prices are rising: a world grown accustomed to plenty is increasingly unable to produce enough food to sustain itself, and where generous agricultural subsidies and trade barriers to USA and EU agricultural industries have skewed the real price of food on international markets and stunted farming in poorer countries (Times, 2008). Based on current dietary preferences, it is expected that the majority of the countries in the region will continue to be dependent on food imports. Generating the necessary foreign exchange to pay for imports will therefore be a major determinant of food security in the various countries.

The food crisis has been causing concerns about the food and nutrition status of CARICOM residents, especially vulnerable groups of poor families who comprise approximately 38 percent of the total population. In CARICOM, expenditures on food are estimated to account for 20 percent of total household expenditures and for as much as 35-40 percent among poor households. It is argued that the problem is not one of food shortage, but rather a situation where people cannot keep up with the rate of price increases. This prompted the CARICOM Heads of Government at the 12th Special Meeting of the Conference of Heads of Government of the Caribbean Community, in December 2007

(CARICOM Secretariat 2007), to take immediate action. Among these actions was the agreement to several measures, such as, wage increases and reductions in tariffs, including the Common External Tariff (CET). These measures were meant to be instituted immediately to cushion the impact of rising food prices and ensure the adequate supply and distribution of food intra-regionally. They were also meant to address challenges of food deprivation and under-nourishment that has plagued CARICOM countries since the early 1990s (Table 8).

Table 8: CARICOM - Food Deprivation/Under-nutrition						
Country	1990-92		1995-97		2001-03	
	percent	(000)	percent	(000)	percent	(000)
Bahamas	9	22.7	14	39.2	7	21.3
Barbados	<2.5	Na	3	8.7	<2.5	Na
Belize	7	12.7	6	12.1	5	11.4
Dominica	4	2.9	7	4.9	8	5.9
Dominican Republic	27	1.9 ¹	26	2.0 ¹	27	2.3 ¹
Grenada	9	7.3	7	5.8	7	5.9
Guyana	21	253.1	12	89.9	9	69.3
Haiti	65	4.6 ¹	59	4.5 ¹	47	3.8 ¹
Jamaica	14	338.7	11	281.3	10	255.7
St. Kitts/Nevis	13	5.5	19	8.2	11	4.5
Saint Lucia	8	10.5	7	9.9	5	7.5
St. Vincent & Grenadines	22	24.3	27	30.7	12	14.2
Suriname	13	54.2	10	41.8	10	42.1
Trinidad and Tobago	13	161.4	15	187.3	11	145.2
Total (Million)		7.296		7.220		6.686
¹ million						
Source: CFNI (2007)						

Several international agencies, including IICA, the UN and the World Bank predict that food prices will remain high for years to come. In fact, IDB and World Bank estimates suggest that the recent surge in food prices may have erased the gains in poverty reduction of the last decade in many countries (IMF, 2007). Before the upsurge in food prices, FAO estimates for 2003-05 showed that all four developing regions were making progress in reducing the prevalence of hunger. However, progress has been reversed in every region, resulting in increased hunger prevalence for the entire developing world for the first time since the World Food Summit (WFS) (FAO, 2008).

Achieving the WFS goal of reducing the absolute number of hungry people from about 800 million to 400 million will prove more challenging, as the total number of undernourished people in the world reached 963 million in 2008, nearly 15 per cent of the world's population (FAO, 2008). This situation is compounded by estimates that indicate that global food demand will double by 2030 as the world's population increases by an additional two billion people.

The food import figure was projected to double in 2009, due largely to increased biofuel production, higher energy prices, climate change and increased food consumption in emerging markets (IMF, 2008). Weather-related events have also had devastating effects on the global and regional agricultural production, and were also key factors in the food crisis. Climate change, in particular, if not effectively addressed, will adversely affect agricultural production and further threaten food security in the Caribbean region.

Impact of Changing Climate

Food security and energy security are both inextricably linked to climate change. Climate change is a predominantly energy-related issue, as an estimated 80 percent of Greenhouse Gases (GHG) is generated by the energy sector, primarily from combustion of fossil fuels. Agriculture is estimated as contributing between 10 and 15 percent of greenhouse emissions, coming from rice paddies, livestock and waste decomposition.

Climate change is really “the dark side of fossil fuel” and the world, especially Caribbean islands, are facing very serious problems, with an estimated 80 percent of greenhouse emissions generated by the energy sector. Agriculture is also a factor in global warming, contributing roughly 15 percent of greenhouse emissions. At the UN Climate Change Conference in Poznan, Poland, Germanwatch launched its *2009 Global Climate Risk Index* (Germanwatch, 2008), which ranked at least six Caribbean islands - Haiti, Dominican Republic, Dominica, Jamaica, Martinique and Saint Lucia - in the top forty countries (out of 150) experiencing extreme weather impacts, with Haiti in the top five.

Based on the latest report from the Intergovernmental Panel on Climate Change (IPCC) the scientific body established by the United Nations to monitor and assess climate change, the Caribbean region can expect to experience, for the foreseeable future, many changes in the climatic conditions that once characterised the region. Caribbean islands are among the group of developing countries that have contributed the least to the emission of greenhouse gases. However, while the potential impacts of global warming are still being assessed, they are regarded as among the most vulnerable countries to the effects of climate change, with the least capacity to adapt to these changes (IPCC, 2007). Some of the most adverse effects of climate change- include sea-level and global sea water temperature increases and increase in the frequency and intensity of extreme droughts, floods and hurricanes, causing major disasters. Studies have shown that the potential economic cost of climate change could be as much as 14 percent of the Caribbean's GDP by 2025.

The frequency and socio-economic impacts of severe natural events continue to undermine Caribbean development objectives and losses generated by these extreme natural events pose a major threat to the region's progress towards meeting MDG goals. A particular striking example of the vulnerability of

small island states to natural hazards was in 2004, when Hurricane Ivan, the strongest hurricane for the 2004 hurricane season and the most powerful to hit the Caribbean region in 10 years, hit Grenada. This caused the death of 39 people, destruction of 90 percent of homes and decimated the island's well-known nutmeg industry (which represents 80 per cent of agricultural exports) wiping out the island's competitive advantage in the world nutmeg market. Damage to the economy of US\$ 815 million was in excess of 200 percent of the country's GDP. The economy, which was expected to grow at 4.7 percent before Ivan struck, actually contracted by 3 percent (ECLAC).

A key factor influencing the region's vulnerability to the impacts of extreme weather events is that most island countries have fragile agriculture-based economies and depend heavily on their natural environment for their livelihoods and well-being. Such total loss is not unusual, as more than half of the region depend on a single commodity for their total revenues from merchandise exports. In 2007, Hurricane Dean destroyed all of Jamaica's major export crops, and the growing areas of the southern part of the island suffered major dislocation. Haiti lost major portions of its banana, bean, and yam crops to wind and salt water on its southern coast, and there was extensive damage to the agriculture sectors in Dominica and Saint Lucia. Many of the short-term crops (corn, pigeon peas, sweet potatoes and vegetables) are seasonal and any significant shifts in climatic conditions such as increased temperatures, more frequent or more intense droughts, and any changes in mean rainfall, could have adverse effects on production and food supply. This type of farming is also particularly vulnerable to droughts, pests and diseases.

Changes in climate could also create more frequent drought situations and increase the incidence of losses by pests and diseases. Extreme natural events will continue to divert significant resources from investment in agriculture and developing the infrastructure and the human resources which underpin the sector. Recent UNEP studies and reports conclude that climate change is likely to cause an estimated 4 to 5 percent decline in the potential for agricultural output across the world by 2018. The Middle East and North Africa are expected to see declines of about 10 percent while in Latin America and the Caribbean, it is going to be in the region of 13 per cent. There are concerns that growing competition between crops for food and fuel could exacerbate these climate change challenges to agricultural production. While some of these concerns may be appreciated, it must be understood that in the context of climate change, biofuel production, as a renewable energy source, could help mitigate climate change and offer large new markets for Caribbean agricultural producers, thus offering both food and fuel security.

5. Conclusion: Integrating Food and Fuel Security

The global debate on food versus fuel in the case of the Caribbean is better framed as a double-dilemma and not an either or proposition.

There are few direct linkages between the agriculture and energy sectors in the Caribbean. With a more urgent need to diversify the region's economy, the two sectors have been thrown together, and are being pitted one against the other in the food versus fuel debate. In this regard, the Caribbean region must define a set of options for use of its natural resources, that can address both food and energy security. This is a critical issue since the majority of countries depend on imports for more than 90 percent of food and energy. In some cases, energy imports are more than 100 percent of exports.

Energy security and food security are interwoven since funds not exported to buy oil are available, either to buy food or develop local food production and distribution capacity and infrastructure. The region has always been dependent on exports to earn foreign exchange to buy food. Removal of one link in this chain will increase economic benefits in the long term. Land resources and climatic conditions are not always best suited to food production in comparison to other uses, such as, for non-food production (i.e., livestock and poultry feeds, spices, fibre, fuel and essential oils). If the region wants to reduce its food and energy insecurity and position its member states on a sustainable development path, it has to, as a priority, integrate the agricultural and energy sectors and establish policies that promote sustainable use of land and ocean resources not just nationally, but regionally.

Traditionally, the agricultural and energy sectors have existed in the Caribbean as separate entities with no real institutional linkages. Historically, the main focus of agriculture can be characterised as a sector in the business of maximising exports to earn foreign exchange. Similarly, the energy sector is in the business of managing the import of petroleum fuel and the generation and distribution of reliable electric power. As a consequence, there have been missed opportunities both to increase local food production and to diversify local agricultural production to produce fuels as substitutes for imported petroleum. The result has been a growing food and energy dependence. Experiences from countries that have exploited these opportunities show that the benefits – economic, social and environmental – are significant in contributing to sustainable development.

Integration of the food and energy sectors is necessary in order to address a number of sustainable development issues. These include:

1. Environmental sustainability – the island states of the region are highly dependent on environmental resources for the livelihood of the majority of their populations. It is therefore critical that the management systems used to tap the resource base do not degrade its long-term ability to provide

the necessary environmental services to support production and livelihoods.

2. Economic growth – efficient and effective utilisation of the environmental resources is required to maximise economic benefits from land and marine resources.
3. Social improvements – to make sure that the resource base is used in such a manner where households have prospects for improved quality of life over time.
4. Governance and accountability – in some countries the existence of Coastal Zone Management Units, provides for the management of the coastal zone as a whole area which helps ensure proper management. However, political constituencies are demarcated in such a way that it is very difficult to achieve the same kind of long-term sustained governance of the natural resources, in particular, land, forest and water as political constituencies should be demarcated along watershed unit so that elected officials can be held responsible.

The recommended path of socio-economic growth for Small Islands Developing States (SIDS) by the international community is sustainable development, as articulated in the UN-sponsored meetings on sustainable development of SIDS held in Barbados in 1994 as a follow-up to the UN Conference on Environment and Development (UNCED) in 1992. These meetings produced the Barbados Programme of Action (BPOA). Central to the BPOA is environmental sustainability, so that the land and marine based natural resources are not destroyed or become too degraded during the process of generating financial resources. The fundamental principle of sustainability derived from biology is maximum synergy. Caribbean SIDS have so far made little progress in getting synergy between sectors opting to continue the silo structure of large countries, consequently the agriculture and energy sector remain separated.

The limited integration of the agriculture and energy sectors is therefore not a consequence of knowledge gaps by decision makers. Unfortunately, in too many countries across the region, environmental sustainability is under threat and in a growing number of countries significant degradation is already occurring to land- and ocean-based resources, ranging from biodiversity, water quality, forest, and fertility of soils. Based on the information from countries where linkages between the two sectors exist, integration requires a set of national and regional policies that establish and direct the market for energy products generated by the agricultural sector, support mechanisms, such as attractive financing and technology transfer assistance and legal frameworks that provide security. Currently, there is no shared legislation and no shared policy and few shared programmes.

In response to global supply and demand forces, the relative economic values of agricultural commodities versus crude oil continue a declining trend. Currently, the price of sugar ranges from US\$250 per ton and the proceeds from the sale of a ton will buy less than five barrels of crude oil, representing a monumental change in the relative value of the two commodities. This change makes it more economically beneficial for countries like Barbados, Belize and Jamaica to produce petroleum substitute from sugarcane rather than sugar, and countries like Cuba, Dominican Republic, and Guyana to add electricity and ethanol as co-products in sugar production.

The Caribbean Sea is also a major source of food for the region. It is also a very large solar energy collector, and is the region's largest natural resource. However, as a result of absent policies to integrate agriculture and energy, it remains an underutilised resource as both the agricultural and energy sectors regard it as a source of livelihood for artisanal fisherfolk. Seen in its full context, the energy resources of the Caribbean Sea can produce more energy than the world currently derives annually from petroleum.

National and regional development of agro-fuel enterprises requires the development of regional and national agro-energy policies to connect the two sectors. There are a few programmes and projects, for example, biodiesel from used cooking oils and fats and biogas from animal waste, which tend to be on the small-scale but make significant contributions to meeting energy needs as well as environmental protection. Integrating the agricultural and energy sectors for the commercial production of substitute petroleum fuels requires that important policy and programme linkages be established.

A number of the precedents and experiences necessary to integrate the two sectors are already in place at the regional level. Examples include:

1. Caribbean Court of Justice (CCJ); which deals with the settlement of disputes and provides a sense of safety for private sector entities that have traditionally invested nationally to invest regionally.
2. Caribbean Development Bank (CDB), a credible financial institution that can facilitate increased access to funding for investment in agro-energy, including promoting interregional investments.
3. CARICOM Single Market and Economy (CSME) under which regional agricultural and energy policy can be integrated so as to provide for establishment of a: (i) regional biofuel market in one or two countries. For example, Barbados and Antigua and Barbuda, which have significant demand for diesel fuel for power generation and limited land area, can agree to buy biofuels from other CSME countries at predetermined cost that are linked to petroleum prices. Properly designed, such a policy would establish standards for biofuel and address issues of warranty on power generating equipment; and (ii) Facility within the CDB or the Caribbean Private Sector Organization that would provide technical assistance to CSME parties who wish to invest in the production of biofuel.
4. Human and Institutional Capacity - although the agricultural and energy sectors are organised as silos with regard to each other, the energy sector has significant human resources in many of the countries that could effectively and efficiently coordinate the growth and development of an agro-energy sector across the region.

Institutionalising these regional instruments and extending them to the agriculture and energy sectors would make investment in agro-fuel less risky and more attractive propositions than they now are. The potential benefits from a regional approach to better address food and energy security are significant and represent a unique contribution to regional sustainable development through employment generation, improved energy and food security, reduced trade deficits, foreign exchange savings and reduced vulnerability to climate change and more ecologically sound use of land resources.

6. Achieving Both Food and Fuel Security – Critical Considerations

... there have been missed opportunities to increase local food production as well as to diversify local agricultural production to produce fuels as substitutes for imported petroleum.

Agro-energy must be integrated in the baseline for efficient decision making in the determination of the most beneficial use of agricultural resources. Investing in energy without evaluating and promoting synergy with the agriculture option can no longer be allowed to continue. Similarly, investing in agricultural commodities for export without giving due consideration to possible energy opportunities is also not a viable option for promoting synergy. Critically, investments in either may foreclose very beneficial options for extended periods.

The challenges faced in achieving acceptable levels of food and energy security provide the basis for the recommendations with respect to developing and balancing the capacity for both food and fuel production from agricultural crops.

1. Supportive policies and legislation

Agriculture industries for food and fuel need supportive and integrated national agriculture, energy and environment policies that view food and oil imports for agro-industry, consumption, land transportation or electricity generation as a loss of income to farmers.

The agriculture policy environment should enable a paradigm shift in the investment focus from traditional commodities, such as, sugar and bananas to strategic and innovative commodities, such as, livestock feeds, organic fertilizer, medicinal and herbal plants, hydroponics and greenhouse production, carbon sinks and biofuel.

The energy policy should support, as first priority, maximum energy from biofuel in the transportation, electricity generation and domestic sectors. Private sector participation in electricity generation will require policies to promote power purchase agreements between the utilities and the producers of biomass-based power. A regulatory framework has to be put in place that can determine and implement a pricing system for biofuel based on the energy value of the raw material and linked to the international price of oil. Agreements will be needed for pricing mechanisms for both the purchase of feedstock and the sale of energy.

National investment policies should be formulated to encourage industry workers to be shareholders. Policy and legislation actions will be necessary to establish raw material prices, linked to certified land use to ensure environmental sustainability. Land utilisation policies should give priority to identifying and zoning lands for sustainable food and biofuels production. Where such lands are not in managed production, they should be made available to interested private sector parties.

Vehicle import policy will be a major determinant of the success of biofuel for transportation fuel, and tariff instruments have to be used to favour the importation of bio-fuelled vehicles. Product standards need to be developed and enforcement procedures need to be incorporated in the legal framework of the country.

2. Identification and development of regional based industries

This speaks to those industries that are, or can be, developed in more than four countries and which could be made more viable by increasing regional production of inputs and export of finished products. This will require an analysis of the critical inputs, including land resources, suitable crops and available technology for efficiently converting these crops into food, feed and/or fuel. Technology exists that can convert forms of biomass, such as, grasses or fast growing trees into food, feed (forage production) or fuel which also represents an agriculture that is more resilient to climate change. A good template is the regional poultry industry. For example, The Bahamas has plans to explore the use of leguminous fast growing trees and grasses, supplemented with imports of grain, as needed, as the basis for developing a more economical source of feed to support the local poultry industry. The Bahamas has demonstrated it can produce poultry competitively, via the College of The Bahamas chicken farm.

3. Technical Capacity development

R&D capacity across the region needs to be rationalised and restructured to provide the kind of leadership that is required to revitalise agriculture. Research on the potential of these new areas, already being conducted against the background of the region's biodiversity, should be commercialised, where appropriate and expanded to give priority focus to building capacities in crop varieties with a high biomass yield. These include "energy cane," higher copra producing coconut varieties, fast growing trees and grasses. This has implications for CARDI, whose work programme should incorporate research on the new ideas for investments, e.g., in animal feed production, fuel production, and cosmoceuticals from herbal and medicinal plants, among others. The need for investments in demonstration is to effectively transfer agricultural systems in these new areas is also critical.

There are a number of critical technical skills that are essential for the implementation of a successful food and biofuels programme in agriculture. Trained technical personnel are required for:

- i. Breeding high-yielding, disease-resistant varieties for particular agronomic environments and the development of environmentally benign pest management technologies;
- ii. Strengthening research and extension services to monitor the performance of selected varieties under field and processing conditions, to enable pests and diseases to be identified and controlled before they become a serious problem, and to inform the plant breeders and farmers;
- iii. Operating, maintaining and managing a modern, sophisticated ethanol plant optimally;
- iv. Designing and implementing environmental best practices to protect the environment and for the long-term sustainability of the industry;
- v. Developing downstream activities including transport, storage, blending and distribution; and

- vi. Improving the coordination and management of other activities associated with biofuels production such as infrastructure, logistics, land use, plant configurations, the use of co-products, and disposal of wastes.

Capacity development is also needed on the part of governments to be able to have the requisite planning capacity to put in place policies and the legal framework necessary to support the industry development. In many cases, based on existing agreements on the sale of fuels and/or electricity, new legislation may be required, such as, power purchase agreements that provide the macro-economic framework to catalyse non-traditional investment in electricity generation.

4. Institutional Development and linkages between state, private and community actors

National, inter-sectoral policies that create linkages between the agriculture and energy sectors are imperatives. In the case of forging energy linkages with agriculture, this would entail the amount of land resources that would be allocated for energy purposes. It would require policies to facilitate the use of the energy produced, i.e., whether electricity or liquid fuel for transportation. National energy and agriculture policies that assign priority to agro-energy production in the countries, where there is potential, will also be imperative to drive and support the R&D agenda.

5. National and local ownership

Wide public dialogue and demonstration for education and outreach are important to achieve widest possible public understanding about the costs and benefits of biofuel and the inter-relationships to other agricultural pursuits, especially food production. National ownership will help make the political environment more conducive to the effective zoning and use of appropriate lands for biofuels and food production. National dialogue will also provide baseline information to help in the formulation of policies on land use for biofuel and food production, the kinds of incentives and disincentives that will be necessary to ensure that land use is sustainable and that there is maximum use of suitable land.

6. Financing

New investments in “new agriculture” are primarily limited to few areas, e.g., aquaculture and ornamental fish. Agro-energy could be considered the newest of these new investment areas. However, the investment climate for agriculture in the region is not structured to facilitate investment, much less, new and innovative propositions. Three basic things are necessary to attract financing and investments: economic viability/markets, human resource capacity and technology. These are particularly critical for investing in building the capacity of agriculture to produce both food and fuel.

Additional sources of financing and new implementation mechanisms are needed. Governments will have to explore more innovatively, various non-traditional sources, such as, like retirement funds, and reinsurance underwriting premiums to finance agriculture. For example, the insurance cost would be a part of the right to conduct insurance underwriting. The increasing interest in the trade of carbon

emissions represents another potential mechanism for additional financing for the development of agriculture's food and fuel industries. In this regard, the region should take steps to capitalise on monies available from carbon sequestration, by having the United Nations Framework Convention on Climate Change (UNFCCC) provide for payment for protected areas through the collaborative programme of the United Nations-Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD), as well as carbon emission reductions that will result as use of biofuels. This could serve as a first step to farmers getting financial rewards for sound land use. Such rewards would provide additional incentive to get farmers who grow short-term cash crops on very fragile lands, to produce biofuel feedstock as an alternative.

7. Raw Material Production and Transportation

Key requirements for sustainable and reliable production of raw material are technology, R&D coupled to good extension, financial benefits linked to a secure market, and adequate land resources. Labour issues and transportation management are key challenges that will have to be addressed through public dialogue. Incentives to encourage good worker attitude and productivity need to be devised to ensure adequate supply of raw material to the biofuels industry. Biofuels production requires significant transportation of raw material to the production facilities and economic and reliable transportation systems.

Actions that can be taken in the short-term, to inform the development of policies and programmes to give effect to the above recommendations should focus on:

- a) The conduct of studies to determine the costs and benefits of a Regional Biofuel Programme aimed at 100 percent substitution of liquid fuels for power generation and maritime transportation. Current estimates show the Caribbean uses in excess of 60 million barrels of diesel and heavy fuel for power generation and maritime transportation. This should also include a process of identifying the requirement for the establishment of a regional market for biofuel. This can be spearheaded by the CDB and CARICOM Secretariat, Council for Trade and Economic Development (COTED).
- b) Assessment of the make and type of engines used in the power sector to determine warranty conditions and the associated specification of biofuel that would fulfil warranty requirements, undertaken in collaboration with the CDB and the Caribbean Association of Electric Utilities (CARILEC).
- c) Development of an investment project to provide necessary technical support a comprehensive R&D programme for the production of biofuel for power generation and maritime transportation in The Bahamas. This is based on the fact that agricultural contribution to GDP is the lowest in the region and that the Government plans to develop 30,000 acres in Grand Bahama, 50,000 acres in Abaco and about 150,000 acres in Andros. Through this project, The Bahamas will have an opportunity to pursue a non conventional approach to the development of its agriculture sector to reduce its economic vulnerability and lessen dependence on tourism. It can also be used to transfer the experiences to the rest of the Caribbean.

- d) Assessment to determine the amount of land and best crops in the region considered suitable for the production of food and feedstock for biofuel production. On that basis, an R&D scheme would need to be developed to support the process. This could be undertaken through CARDI-Ministries of Agriculture cooperation.
- e) Studies on the sugar industries in Jamaica, Barbados, Belize, the Dominican Republic to determine their comparative profitability as an energy industry and the corresponding level of investment and cost benefit.

In the document titled *Towards a Single Economy and a Single Development Vision*, adopted by Heads of Government of CARICOM (July 2007) as the framework for achieving the CSME, agriculture has been identified as one of the engines of growth for the region. The CSME is intended to improve export opportunities and attract foreign investment by creating a single market among participating member states.

However, the current focus of Caribbean agriculture, measured by the relative development of existing institutional capacity, is neither on food nor energy, but rather traditional agricultural commodities. Caribbean agriculture faces a dilemma in adapting to changing global economic and environmental conditions and deteriorating social conditions for its estimated millions of farmers' households. The future of regional agriculture in the face of global challenges will depend on the policy and planning response from both national governments and the region as a whole.


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An underwater photograph showing sunlight filtering through the water's surface, creating a shimmering, dappled light effect. The water is a deep blue color, and the light rays are visible as bright, vertical streaks. The overall scene is serene and natural.

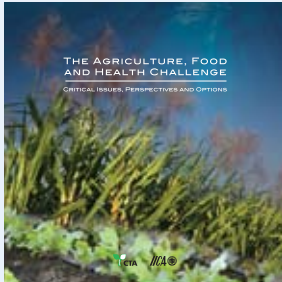
The Caribbean Sea represents a major source of thermal energy which can be converted into electricity, desalinated water, and medium for mari-culture addressing both energy and food security. The availability of less costly electricity at predictable prices and potable water from the ocean would provide critical inputs for intensive agriculture systems such as aquaculture, mari-culture, greenhouse production, irrigation and hydroponics. These technologically advanced systems are significantly less vulnerable to climatic factors such as droughts and floods than current systems. Given the vast quantities of energy and food available from the ocean directly and indirectly the region can address a significant degree of its energy and food security through development of ocean resources.

(Al Binger, 2009)

Food from the Sea

Marcia Creary





Food from the Sea

Marcia Creary

The author explores water-based food production systems, which are particularly applicable given the foreboding influence of climate change on rising sea levels. The beneficial effects of some seafood on health provide additional support for such ventures.

About the Author

Ms. Creary's training, work experience and long list of technical papers, articles and other information products on a range of subjects related to environmental issues, coastal management and climate change provides the backdrop for her perspectives on the topic of Food from the Sea.

Jamaican national Marcia Marilyn Chevannes Creary's qualifications include MPhil, Marine Sciences, University of the West Indies (UWI, 2000), a Postgraduate Diploma, Management Studies (UWI, 1990) and a BSc (Upper Second Honours) Zoology (UWI, 1980). From April 2005, Ms Creary assumed the position of 'Environmental Data Manager' at the Caribbean Coastal Data Centre, in the Centre for Marine Sciences (CMS), UWI, Jamaica, a position she currently holds today. As part of her duties, Ms. Creary negotiates and supervises the implementation of projects and memoranda of understanding (MoUs) undertaken by CMS and liaises with personnel in local, regional and international institutions for the execution of projects and the acquisition of data. She also lectures and conducts training in coastal management and coral reef monitoring.

Introduction

Obtaining food from the sea has been a fundamental source of livelihood for coastal societies that predates land-based agricultural activity. Today capture fishing is an important source of employment for many rural communities and key to ensuring food security as it ranks as a significant component of the global economy. However, the nature of fishing activities has undergone radical changes in the last century. The increase in the world's population has led to the rapid expansion of commercial fishing which has developed the ability to exploit fish stocks worldwide under an open access regime. The development of new fishing technology and practices was accompanied by the ability to target specific fish stocks with great accuracy resulting in the rapid depletion of key species. At the same time as the oceans stocks are declining the practice of aquaculture is increasing to fill the gap and to meet the nutritional and income needs of these communities. As a result of developments over the last hundred years, obtaining food from the sea is now a complex industry, involving both large scale commercial entities and small-scale community-based fisheries involved in the global seafood trade and production for local subsistence consumption (Kura et al; 2004).

Food from the sea can be interpreted in two ways: the traditional interpretation of “seafood” and the emerging concept of using seawater for saline agriculture. “Seafood” is the term generally used to describe the aquatic plants and animals consumed by humans, regardless of the source. So, as well as seafood captured from the oceans (capture fisheries), seafood is also produced through aquaculture and mariculture (farm raised fish, shellfish and seaweed). Capture fisheries and aquaculture supplied the world with about 110 million tonnes of food fish in 2006 and of this total, aquaculture accounted for 47 percent (FAO, 2009a). Food from the sea is an important component of human diet and some countries rely heavily on this as their primary source of animal protein. Finfish, molluscs, crustaceans and seaweed make up the bulk of the human food that comes from the sea. Additionally, wild and cultured marine organisms are a source of biomedical compounds, pharmaceutical products and industrial goods and services.

Seafood is under serious threat. Scientists now strongly believe that global fish stocks have been over-exploited and are a fraction of what they used to be a century ago. Populations of some popular species have plummeted while others are considered to be commercially extinct. Poorly regulated fishing activities have decimated fish stocks on the world's continental shelves, severely impacting many subsistence fishing communities. At the regional level, environmental issues such as sea level rise and warmer seas, as a result of global warming, further compound the existing problems of over-fishing, land based sources of pollution and invasive marine and freshwater species. In terms of seafood security the consensus now is that the focus for regional fisheries should be turned to management and conservation, along the chain from harvest to the market place, rather than on development only (CERMES, 2009).

An increasing demand for seafood products, coupled with a decrease in supply from capture fisheries has fuelled the search for additional areas to develop this source of food, including expanding the fishing industry. Further, with the recognition of the potential inherent in sea water, the prognosis for food from the sea is very optimistic since the emerging field of mariculture is increasingly based on applied science and innovative technology.

With respect to the second interpretation, the principles of agriculture can be applied to under-utilised coastal lands that have the potential to support species of commercial value to produce animal feed, human food and raw material for industry. The use of sea-water to grow crops holds promise for food and nutrition security as new technology is being developed to cultivate existing crops and to domesticate crops from wild varieties. There has been experimentation involving the use of sea water for irrigation which could provide a feasible solution to both rising sea levels, the scarcity of fresh water and competition for arable land.

The purpose of this paper is to explore the issues associated with “food from the sea”, to provide an overview of the current status of the fisheries resources, the Caribbean context and emerging and innovative trends which may offer possibilities for the Caribbean, with particular reference to sustainable use and development of their vast ocean resources.



Fish for food is just the beginning of the benefits of the sea for food and nutrition security.

1. The Ocean's Seafood Resources

Seafood is an important component of human diet and some countries rely heavily on this as the primary source of animal protein.

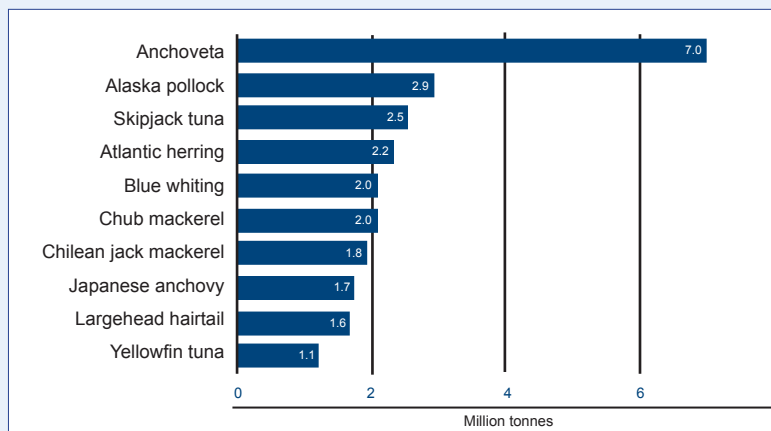
The oceans cover approximately two-thirds of the Earth's surface and provide a number of functions including generating oxygen, absorbing carbon dioxide, regulating the climate in addition to providing food and nutrients. The oceans are also economically important to many countries that rely on it for food, tourism, fishing and other marine resources. Seafood, generally describes aquatic plants and animals consumed by humans, regardless of their source. This includes both food harvested from the oceans (capture fisheries) and aquaculture (fish farming and mariculture). Included in the definition of "seafood" are finfish, molluscs (including octopus and squid), crustaceans, seaweeds, reptiles, and marine mammals: the first four categories make up the bulk of the human food that comes from the waters of the world (Stickney, 2003).

Fish Stocks

Marine stock:

Globally, fishable resources include fin fish and whales, crustaceans (lobster, crabs and shrimp) molluscs (bivalves, gastropods and cephalopods) and minor products like sponges, sea weed and other invertebrates both for food and non-food applications like pharmaceutical products and industrial goods and services. Ten species dominated the global catches and they represent more than 30 percent of the total marine catch (Figure 3). There are five small pelagic species (anchoveta, Atlantic herring, chub and Chilean jack mackerels, and Japanese anchovy), two tunas (skipjack and yellow fin), two low-value gadiformes (Alaska pollock and blue whiting) that are mostly marketed in processed forms, and the largehead hairtail, a benthic-pelagic species.

Figure 3: Top ten species in Marine capture fisheries production (2006)



Source: FAO

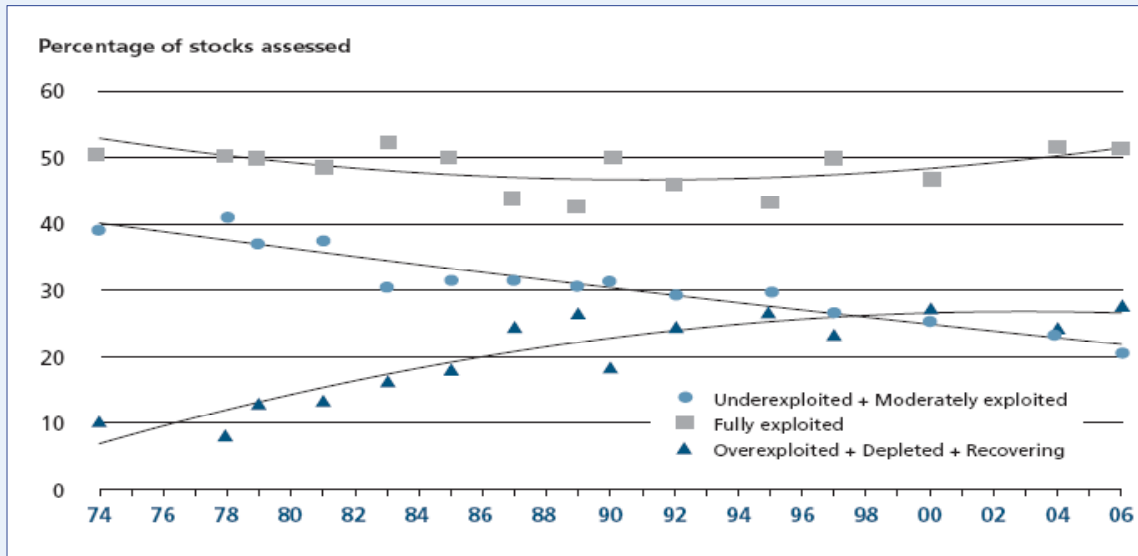
Most of the stocks of the top ten species, which account for about 30 percent of the world marine capture fisheries production are fully exploited or overexploited and, therefore, cannot be expected to produce major increases in catches (Table 9). This indicates that the maximum wild capture fisheries potential from the world's oceans has probably been reached.

Species	Status
Anchoveta (<i>Engraulis ringens</i>)	Two main stocks in the Southeast Pacific fully exploited and overexploited;
Alaska pollock (<i>Theragra chalcogramma</i>)	Fully exploited in the North Pacific
Blue whiting (<i>Micromesistius poutassou</i>)	Fully exploited in the Northeast Atlantic
Atlantic herring (<i>Clupea harengus</i>)	Several stocks fully exploited, some depleted and some under-exploited because of market conditions
Japanese anchovy (<i>Engraulis japonicus</i>)	Fully exploited in the Northeast Pacific
Chilean jack mackerel (<i>Trachurus murphyi</i>)	Fully exploited and overexploited in the Southeast Pacific;
Yellow fin tuna (<i>Thunnus albacares</i>)	Fully exploited in the Atlantic and Pacific Oceans and probably moderately to fully exploited in the Indian Ocean.
Skipjack tuna (<i>Katsuwonus pelamis</i>)	Some stocks fully exploited while some reported as moderately exploited particularly in the Pacific and Indian Oceans where they could offer some limited possibilities for further expansion of fisheries production
Chub mackerel (<i>Scomber japonicus</i>),	Some limited possibilities for expansion are also offered by a few stocks which are moderately exploited in the Eastern Pacific, while other stocks are already fully exploited.
Largehead hairtail (<i>Trichiurus lepturus</i>)	Overexploited in the main fishing area in the Northwest Pacific, but its state of exploitation is unknown elsewhere

Source: Adapted from FAO, 2009a

It is worth noting that the Northeast Atlantic, the Western Indian Ocean and the Northwest Pacific have the highest proportions of fully exploited stocks, while overexploited, depleted and recovering stocks are between 20-25 percent in all areas except the Northwest Pacific, Central Pacific and the Eastern and Western Central Pacific; where, they are 10 percent or less. While 20 percent or more of under-exploited or moderately exploited stocks are found in the Eastern Indian Ocean, Western and Eastern Central Pacific Ocean, and South Western Pacific Ocean and the Southern Ocean. The worst depleted stocks globally include the Atlantic cod, the haddock, the salmon and the Argentine hake. Of the nearly 600, marine stocks monitored by the FAO, 3 percent are under-exploited, 20 percent moderately exploited, 52 percent fully exploited, 15 percent over exploited, 7 percent depleted and 1 percent recovering from depletion (FAO, 2009a) (Figure 4).

Figure 4
 Status of Marine Fish Stocks - Global Trends in the state of the world fish stocks since 1974



(FAO 2009)

Aquaculture

World aquaculture -fish, crustacean, molluscs and other aquatic animals- has grown dramatically in the last 50 years and continues to do so more rapidly than other animal food-producing sectors. While capture fisheries production stopped growing in around mid-1980, the aquaculture sector has maintained an average annual growth rate of 8.7 percent worldwide. In 2006 Aquaculture accounted for 47 percent of the world's fish food supply. Countries in Asia and the Pacific were responsible for 89 percent of this production with China contributing 67 percent of the world's aquaculture supply of cultured aquatic animals and 72 percent of its supply of aquatic plants. Table 10 lists the top ten producers in world by quantity and growth (FAO, 2009a).

Table 10
Top ten aquaculture producers of food fish supply: quantity and growth

Top ten producers in terms of quantity, 2006				Top ten producers in terms of growth, 2004-2006 ¹			
2004		2006		2004		2006	
Country	(Tonnes)	Average annual growth rate (%)		Country	(Tonnes)	Average annual growth rate (%)	
China	30 614 968	34 429 122	+ 6.05 %	Uganda	5 539	32 392	+ 141.83 %
India	2 794 636	3 123 135	+ 5.71 %	Guatemala	4 908	16 293	+ 82.20 %
Viet Nam	1 198 617	1 657 727	+ 17.60 %	Mozambique	446	1 174	+ 62.24 %
Thailand	1 259 983	1 385 801	+ 4.87 %	Malawi	733	1 500	+ 43.05 %
Indonesia	1 045 051	1 292 899	+ 11.23 %	Togo	1 525	3 020	+ 40.72 %
Bangladesh	914 752	892 049	- 1.25 %	Nigeria	43 950	84 578	+ 38.72 %
Chile	665 421	802 410	+ 9.81 %	Cambodia	20 675	34 200	+ 28.61 %
Japan	776 421	733 891	- 2.78 %	Pakistan	76 653	121 825	+ 26.07 %
Norway	636 802	708 780	+ 5.50 %	Singapore	5 406	8 573	+ 25.93 %
Phillipines	12 220	623 369	+ 10.32 %	Mexico	104 354	158 642	+ 23.30 %

Notes: Data exclude aquatic plants. APR refers to the average annual percentage growth rate for 2004-2006.

¹ For top countries in terms of growth, only countries with more than 1 000 tonnes production in 2006 were taken into account.

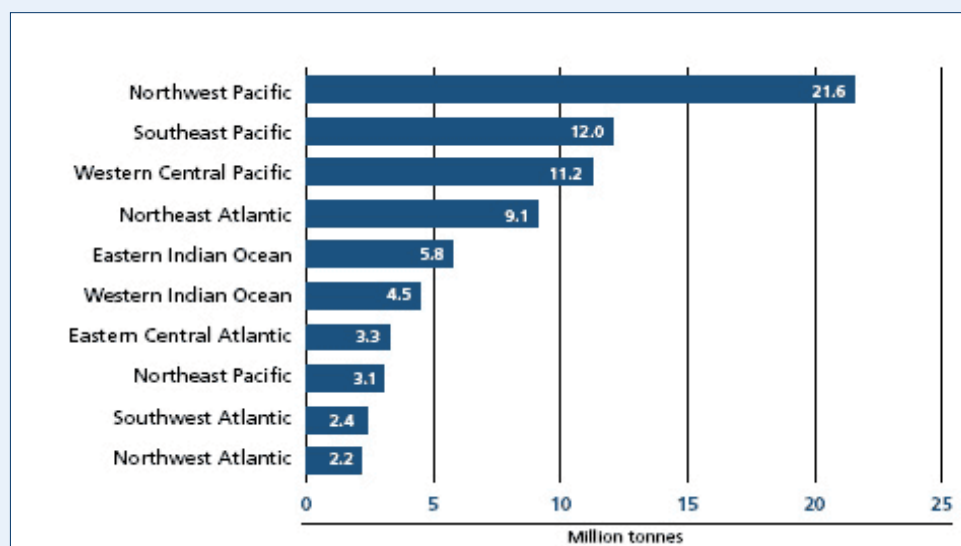
Source: FAO, 2009a

Most aquaculture production of fish crustaceans and molluscs come from inland fisheries (61 percent by quantity and 53 percent by value) and occur in freshwater environments. Aquaculture in the marine environment contribute 34 percent of production representing 36 percent of total value and this mainly involves the production of high value finfish but also consists of large amounts of low-priced mussels and oysters. High value finfish and crustaceans are also grown in brackish waters. Most of the cultured marine species are of relatively high commercial value, thought to be due to the decline in wild stocks. While the overall share of farmed fish in marine finfish production has stayed quite low, for the species that are farmed, aquaculture frequently dominates the market and is often substantially higher than the past highest catch recorded by capture fisheries (FAO, 2009a).

Main Fishery Suppliers

The global fishery is dominated by Pacific Ocean states, (Figure 4) accounting for 89 percent of production and 77 percent in terms of value. This region produces 98 percent of the carp, 95 percent of the oyster and 88 percent of the shrimp and prawns utilised globally (FAO, 2009a). Following the increase in demand, fish catch has increased 500 percent between 1950 and 2000. However, after passing the 100 million tonnes mark in 1990, fish production would have fallen if not for aquaculture.

Figure 4:
Capture fisheries production: principal marine fishing areas in 2006



FAO, 2009b

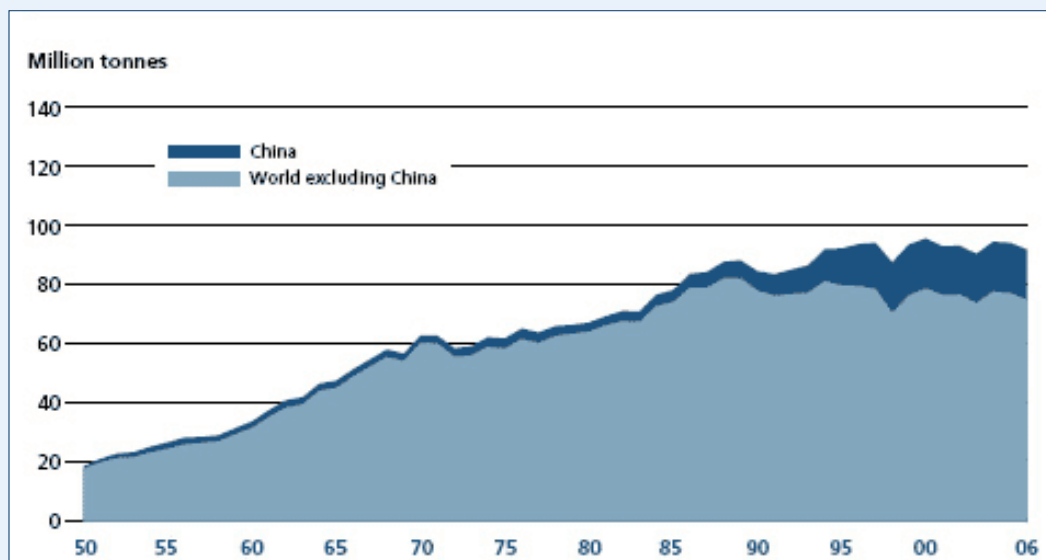
Fleets from about ten fishing countries land 65 percent of the total marine catch worldwide (Table 11).

	Country/Region	Marine Capture (metric tons)	Share of total percent
1	China	14,379,457	17.2
2	Peru	7,950,450	9.5
3	European Union	6,031,308	7.2
4	USA	4,915,128	5.9
5	Japan	4,659,716	5.6
6	Indonesia	3,898,271	4.7
7	Chile	3,797,143	4.5
8	Russian Federation	3,422,117	4.1
9	India	2,787,940	3.3
10	Norway	2,686,733	3.2
	Others	29,153,771	34.8
	Total	83,682,034	100

Source: (Kura, et al., 2004)

China was by far the largest producer of fishery products accounting for 51.5 million tonnes in 2006. This was largely due to aquaculture production of 34.4 million tonnes which accounted for 67 percent of the quantity and 49 percent of the value of aquaculture in the global fishery (FAO, 2009a) (Figure 5). Indications are however, that production figures for China were not as high as reported and are likely to be revised and reflected in subsequent reports.

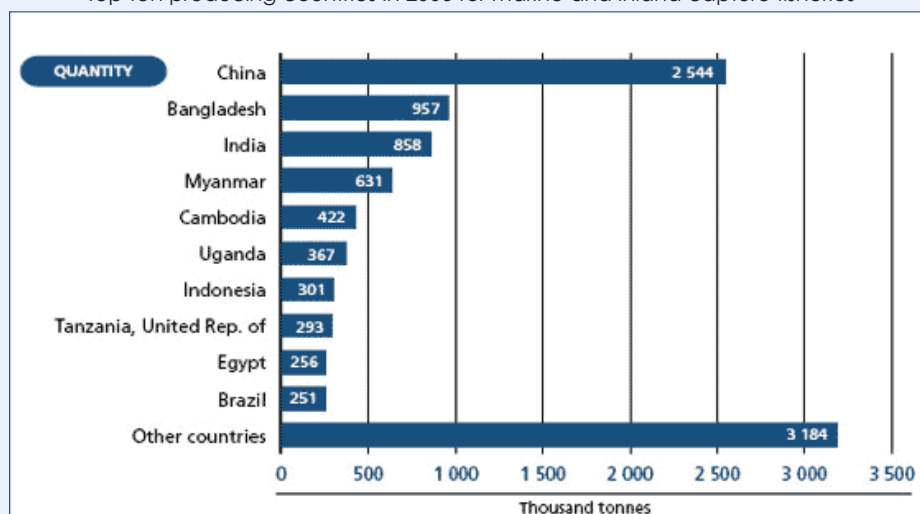
Figure 5:
Comparison of Global fisheries with China- World capture and aquaculture production.



Source: (FAO, 2009)

Because of importance of China to the production statistics it is often discussed separately Preliminary estimates for 2007, based on reporting by some major fishing countries, indicate that world fishery production excluding China is 96 million tonnes, representing approximately a 3 percent increase for capture production and a 7 percent increase for aquaculture production compared with 2006. World capture fisheries production has been relatively stable in the past decade with the exception of marked fluctuations driven by catches of anchoveta – a species extremely susceptible to oceanographic conditions determined by the El Niño Southern Oscillation in the Southeast Pacific. Peru and the United States of America (USA) were also among the top producing countries (Figure 6). Asian countries accounted for 52 percent of the global capture production.

Figure 6:
Top ten producing countries in 2006 for marine and inland capture fisheries



Source: FAO

In 2006, capture fisheries and aquaculture together supplied 110 million tonnes of food fish, up from 100.7 million tonnes in 2000. That is a per capita supply of 16.7 kg; providing, 2.9 million people with 15 percent of their average per capita animal protein intake. In the Asia and the Pacific region, aquaculture production from China, South Asia and most of Southeast Asia consists primarily of cyprinids, while production from the rest of East Asia consists of high-value marine fish. In Latin America and the Caribbean (LAC), in the last decade, salmonids have overtaken shrimp as the top aquaculture species group. In North America, channel catfish is the top aquaculture species in the United USA, while Atlantic and Pacific salmon dominate in Canada. In Sub-Saharan Africa production is low despite its natural potential. On the other hand, in North Africa, Egypt is the dominant country in terms of production (99 percent of the regional total) and, is now the second largest producer of tilapia after China and the world's top producer of mullets. In the Near East, the Islamic Republic of Iran and Turkey are the two leading producers of trout, carp and the Indian white prawn. Aquatic plants produced by aquaculture, was 15.1 million tonnes, a value of US\$7.2 billion in 2006. This sector had a growth rate of 8.0 percent since 1970, and represented 93 percent of global supply; 72 percent of this originated in China (10.9 million tonnes). Virtually all the remaining production came from Asia (the Philippines, Indonesia, Republic of Korea and Japan) (FAO, 2009a).

Table 12 illustrates the growth of the marine and aquaculture fisheries industry from 2000 to 2006.

Aquaculture continues to be the fastest growing animal food producing sector with a per capita supply increasing from 0.7 kg in 1970 to 7.8 kg in 2006 with an average annual growth rate over the 36-year period of 6.9 percent. This is a direct result of the level of exploitation and hence reduced supply capacity of the capture fishery.

Table 12: World fisheries and aquaculture production					
Million tonnes	2002	2003	2004	2005	2006
<u>Inland Total</u>	<u>32.7</u>	<u>34.4</u>	<u>36.7</u>	<u>39.3</u>	<u>41.7</u>
Capture	8.7	9.0	8.9	9.7	10.1
Aquaculture	24.0	25.5	27.8	29.6	31.6
<u>Marine total</u>	<u>100.9</u>	<u>98.7</u>	<u>103.8</u>	<u>103.4</u>	<u>102</u>
Capture	84.5	81.5	85.7	84.5	81.9
Aquaculture	16.4	17.2	18.1	18.9	20.1
<u>Total capture</u>	<u>93.2</u>	<u>90.5</u>	<u>94.6</u>	<u>94.2</u>	<u>92</u>
<u>Total aquaculture</u>	<u>40.4</u>	<u>42.7</u>	<u>45.9</u>	<u>48.5</u>	<u>51.7</u>
<u>Total world fisheries</u>	<u>133.6</u>	<u>133.2</u>	<u>140.5</u>	<u>142.7</u>	<u>143.6</u>

Note: Excluding aquatic plants.
Source: (FAO 2009a)

Seafood Demand and Utilisation

Fish and fishery products are the most internationally traded foodstuffs in the world. About 38 percent of the fish by live weight is traded internationally. In value terms, about 50 percent of the trade originates in developing countries, while almost 80 percent of fish is exported to the USA, EU and Japan markets (Elamin, 2005). The world population has increased steadily from 6.3 billion people, in 2002, to 6.6 billion people in 2006, and the demand for fishable products increased with world population from 16 kg per capita to 16.7 kg per capita. In Asia alone more than 1 billion persons depend on food from the sea for their main protein source and globally 2.9 billion people get most of their dietary protein from seafood (FAO, 2009a).

Seafood is a source of top-quality protein and is an important component of a healthy diet especially for growing children and the elderly. The importance of seafood in the human diet varies greatly around the world. The consumption of seafood in the USA is approximately 7 kilograms per person annually while Japan and China consume about five times that amount. Terrestrial animals, such as beef and pork, are more expensive than seafood in Japan. The consumption of seafood has become increasingly popular in recent years as it is regarded as a health promoting food source. Medical researchers indicate that seafood contains the type of fat (omega 3) that is regarded as healthy (Stickney, 2003). The proposed health benefits of seafood rich in Omega 3 fatty acids are listed in Box 3.

Box 3 Health Benefits of Seafood Rich in Omega 3 Fatty Acids

- √ positive effect on heart rhythm
- √ reduced the incidence of a stroke
- √ reduced risk of macular degeneration
- √ decreased risk of Alzheimer's disease
- √ reduced chest pains and the need for nitroglycerin to treat Angina.
- √ lowered risk of developing asthma and improvement in asthma symptoms in children
- √ favourable changes in various atherosclerosis risk
- √ treatment of depression also specially for bipolar patients where fish oil is taken in conjunction with conventional medicines.
- √ favourable changes in people suffering from bronchitis
- √ positive benefits in patients with cancers of the mouth, throat, stomach, colon, rectum, pancreas, lung, breast and prostate.
- √ beneficial in many other chronic non-communicable diseases such as
 - Crohn's disease,
 - chronic obstructive pulmonary disease (COPD),
 - dysmenorrhea, eczema,
 - endometriosis,
 - fibrocystic breast disease,
 - gestational hypertension,
 - halitosis,
 - high cholesterol,
 - high triglycerides,
 - insulin resistance iron deficiency anaemia.

Source: (VitaminLore, 2002).

In addition, seafood is also low in sodium, an excellent source of minerals and vitamins, such as calcium, phosphorous, iodine (essential for the thyroid gland), iron, (for red cell formation), zinc (for wound healing), Niacin (healthy skin and release of energy) and vitamin b complex (metabolic processes) (Health Benefits of Water, 2006).

In the Caribbean and Latin America chronic diseases are the leading cause of premature mortality accounting for two out of three deaths of people below 70 years old. These chronic non-communicable diseases which include cardiovascular disease (heart attack and stroke), cancer, hypertension, diabetes, obesity, chronic respiratory diseases as well as high cholesterol contribute to approximately 50 percent of disability adjusted life years lost in the region. In this decade, it is projected that cardiovascular disease will claim 20.7 million lives and will triple in the next 20 years, the societal costs of diabetes in the region was estimated at US\$ 65 billion in 2000 (CARICOM, 2009). As a result, food based dietary guidelines have been established for a number of countries in the Caribbean (e.g. St Vincent and the Grenadine, Saint Lucia, Grenada and Guyana) to promote the adoption of healthy diets and lifestyles, primarily to combat the increasing incidence of obesity, cardiovascular disease and diabetes. Seafood

is considered an excellent component of this healthy diet and a good substitute for red meat. (Albert et al., 2007)

Seaweeds (marine algae) are consumed directly as human food and are used in a variety of food and household products. Brown and red seaweed constitute most of the production, with much lesser amounts from green seaweed. Other aquatic plants include watercress, water chestnuts, and various other edible species (Stickney, 2003). There are a number of seaweeds that are used as vegetables and can form part of a healthy diet as all the minerals found in sea water are also found in these plants (Box 4).

Box 4

Commonly consumed seaweed species, often referred to as sea vegetables

- Dulce (*Palmaria palmata*)
- Sea lettuce (*Ulva lactuca*)
- Laver or Nori (*Porphyra*)
- Irish Moss (*Chondrus crispus*)
- Kelp or hollow-stem kelp (*Alaria esculenta*)
- Rock Weed or Knotted Wrack (*Ascophyllum nodosum*)
- Rock Weed or Bladder Wrack (*Fucus* spp.)
- Spirulina (*Arthrospira platensis* and *Arthrospira maxima*)
- Ognori (*Gracilaria* spp)

Source: <http://www.grandmanannb.com/index.htm>

Dulse (Figure 7) is an edible alga commonly found in the frigid zones of the Atlantic and Pacific and has been harvested as food for thousands of years. It is a good source of iron and other trace metals and it also contains iodine and manganese, which activate enzyme systems and is excellent in salads. In addition to being eaten as a source of food, dulse and other seaweeds are processed for inclusion in various package foods as thickeners and stretchers (Natural Ways to Health, 2009).

Figure 7:
Dulse, an edible seaweed that is also processed for inclusion in various packaged foods.



Spirulina, commonly used seaweed, (Figure 8) is four times easier to digest than beef and contains 50 different minerals and trace minerals.

Figure 8:
Spirulina is a blue - green alga which has been developed because of its ability to synthesise high-quality concentrated food.

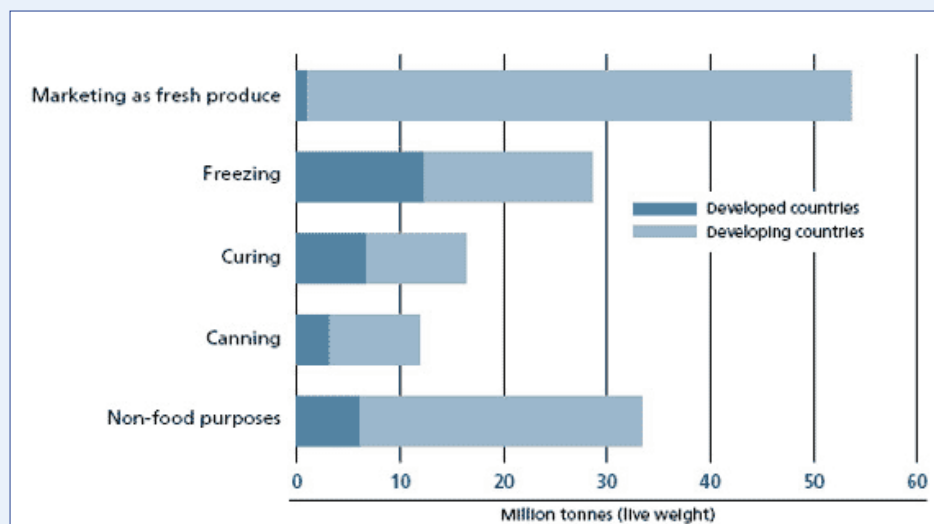


In 2006, 77 percent of world fish production was utilised directly for human consumption, the remaining 23 percent (roughly 33 million tonnes) was used indirectly or for non food products, fish meal and fish oil (FAO, 2009a) (Table 13).

Table 13: World fisheries and aquaculture production and utilisation					
Million tonnes	2002	2003	2004	2005	2006
<u>Total world fisheries</u>	<u>133.6</u>	<u>133.2</u>	<u>140.5</u>	<u>142.7</u>	<u>143.6</u>
Utilization					
Human consumption	100.7	103.4	104.5	107.1	110.4
Non-food uses	32.9	29.8	36	35.6	33.3
Population (billions)	6.3	6.4	6.4	6.5	6.6
Per capita food fish supply (kg)	16.0	16.3	16.2	16.4	16.7
Note: Excluding aquatic plants. Source: (FAO 2009a)					

Fish for direct consumption is processed in a number of ways. In 2006, 48.5 percent of fish used directly was live and fresh, and the remaining 51 percent processed, of which 50 percent was frozen, 29 percent was prepared and preserved and 21 percent was cured (FAO, 2009a). How the fish is processed or utilised depends largely on the market. In most developing countries, like the Caribbean region, ambient temperatures, quality deterioration, post harvest losses, poor infrastructure at local markets limit marketing perishable goods. Fish is usually marketed live and fresh or smoked/fermented; but frozen fish products have increased steadily. In developed countries more frozen fish products are marketed as seen in Figure 9.

Figure 9:
Utilisation of world fisheries production (breakdown by quantity), 2006



Source: FAO

Fish meal, which consists of commercial product made from both whole fish, bones and offal of processed fish, is a high-protein supplement used for livestock and aquaculture. The fish is first pressed to remove the fish oil and the remaining matter converted to a brown powder or cake which is mainly used as a high protein supplement in aquaculture feed. Countries which produce fish meal include Peru, China, Thailand, Chile, USA, Japan and Denmark. The production of fish meal is closely linked to key species of low value pelagics, like anchoveta. These fish catches have been largely irregular and account for the decline in fishmeal production from 30 million tonnes in 1994 to 20.2 million tonnes in 2006.

Other non-food uses of fish include the pharmaceutical industry; where bioactive molecules from fish, crustaceans and other marine organisms are utilised. Chitin and chitosan from shelled fish, like crab and shrimp are used for water treatment, cosmetics, toiletries, food and beverages, agrochemicals and pharmaceuticals. Japan is the largest market for these products, using some 20,000 tonnes for chitin derived products. Biomedical products are also generated from waste products, like fins, bones and skin. 2,500 tonnes of gelatin was made from fish skin in 2006. Fish collagen has advantages over bovine collagen and carotenoids and astaxanthins are pigments extracted from crustacean wastes. Anticancer molecules are initially extracted from sponges, bryozoans, and cnidarians, then later chemically synthesised for reasons of sustainability (FAO, 2009a).

With the rise in demand for seafood, certain popular species can be contaminated with toxic polychlorinated biphenyls (PCBs) and heavy metals such as mercury and some contain toxins, whether from harmful dinoflagellates or synthesised by the animal. Information about potential seafood contamination and status of fish stocks is not readily available to the consumer to allow for informed choices (Alseomo, 2007). Due to bioaccumulation in larger fish species and shellfish, pregnant mothers and children are advised against consuming excessive quantities of shark, swordfish, king mackerel, tilefish and barracuda. Cases of ciguatera poisoning, which is associated with tropical fish species usually those found in reefs waters, and other seafood poisoning also occur in the region (Brunette et al., 2009). Integrated aquaculture, organic aquaculture and the use of genetically modified organisms (GMOs) are also on the rise and research is required to ensure that the fish produced do not present a risk to consumers (FAO, 2009a).

Generally, seafood is purchased by the consumer with little knowledge of the health of the fish stocks, how they are harvested and the impact on the wider marine environment. There is still plenty of fish and other seafood available in the markets and restaurants, although the types may have changed and the prices might be higher. In the USA approximately 50 percent of the seafood is purchased at the grocery store and these sales are increasing annually. However, in many stores there is no information provided to the consumer on fish species and how they are caught. There are even instances where seafood is deliberately mislabelled as “organic” or “eco-friendly”. This makes it very difficult for consumers to make informed choices.

Greenpeace has developed a Red List of seafood that is derived from fishing and aquaculture practices that are most damaging and in need of immediate attention (Box 5). The six species at the top of the list, based on the criteria established by Greenpeace, are in the greatest danger and they propose that the sale of these should be stopped immediately (Wilson, 2008).

Box 5: Greenpeace Seafood Red List

The following Red List of seafood come from fisheries or farming practices that is among the most damaging and need immediate attention. The six species at the top of the list are in such urgent peril that their sale should stop immediately.

- 1) Atlantic Halibut, *Hippoglossus hippoglossus*
 - 2) Bluefin Tuna, *Thunnus thynnus*, *Thunnus maccoyii*, *Thunnus orientalis*
 - 3) Chilean Sea Bass, (Patagonian Toothfish) *Dissostichus eleginoides*
 - 4) Hoki, (Blue Grenadier) *Macruronus novaezelandiae*
 - 5) Orange Roughy, *Hoplostethus atlanticus*
 - 6) Sharks (including shark fins), superorder Selachimorpha
 - 7) Alaska Pollock, *Theragra halogramma*
 - 8) Atlantic Cod or Scrod, *Gadus morhua*
 - 9) Atlantic Salmon, *Salmo salar*
 - 10) Atlantic Sea Scallop, *Placopecten magellanicus* (Georges Bank and mid-Atlantic stocks)
 - 11) Greenland Halibut, *Reinhardtius hippoglossoides*
 - 12) Grouper, (imported) *Epinephelus morio*
 - 13) Monkfish, *Lophius americanus*
 - 14) Ocean Quahog, *Arctica islandica*
 - 15) Red Snapper (Gulf of Mexico), *Lutjanus campechanus*
 - 16) Redfish (Ocean Perch), *Sebastes mentells*, *Sebastes marinus*, *Sebastes fasciatus*
 - 17) Skates and Rays, superorder Batoidea
 - 18) Swordfish (North and South Atlantic) *Xiphias gladius*
 - 19) Tropical Shrimp (farmed and wild), *Penaeus spp.*, *Metapenaeus monoceros*, *Pandalus jordani* and *Pandalus borealis*
 - 20) Tuna - Albacore (South Atlantic), *Thunnus alalunga*
 - 21) Tuna – Bigeye, *Thunnus obesus*
 - 22) Tuna – Yellowfin, *Thunnus albacores*
- Source: (Wilson, 2008)

There is a gradual trend in consumer's preference for sustainable, organic and natural products and the supermarkets and wholesalers are trying to capitalize on this trend. Some supermarkets are now establishing seafood policies committed to sustainability. These include such criteria as sourcing fish from less depleted stocks and buying from suppliers who utilise less destructive fishing methods. The FAO has developed guidelines for certification of seafood from capture and aquaculture sources but as demand for seafood grows there is more pressure on the stores to source simpler, faster and cheaper "certified" fish (Wilson, 2008).

4. Innovative Uses of the Oceans Resources for Food

The increase in global populations, the concurrent increase in demand for food and fuel and the challenges of climate change, have turned attention to the relatively unexplored potential of the sea.

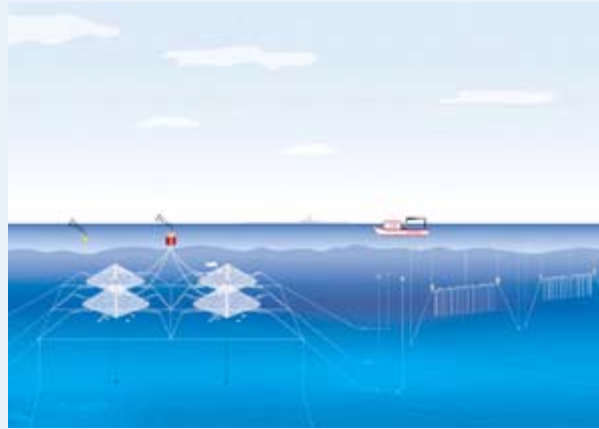
An increasing demand for seafood products, coupled with a decrease in supply from capture fisheries has fuelled the search for additional areas to develop the sea as a source of food, including expanding the fishing industry. Innovation in aquaculture and Use of sea-water to grow crops is already being experimented on in some arid regions of the world, may offer possible solutions to food and nutrition security.

Aquaculture and Mariculture

Aquaculture, the farming of fish, shrimp, seaweed and other aquatic organisms is a key component to the success of Global Seawater Inc. (GSI's) Integrated Agriculture vision. In 2007 more than half of the seafood consumed globally was produced by aquaculture. Industrial aquaculture, as efficient as it is, has negative impacts on the planet: the release of large quantities of effluent back into the seas cause environmental degradation. This "negative" is a huge positive to GSI's operations. The effluent is carbon rich and acts as fertilizer for halophytic plant crops. By partnering with existing seawater aquaculture industries, local investors can lower their aquaculture farm costs related to pumping seawater out of adjacent oceans; thereby significantly reducing energy costs and related carbon emissions- a "win-win" scenario. Fifty seawater farms, each of 500,000 hectares, will have the capability to permanently remove from the sea enough seawater to stop sea level rise. The seawater farms will continuously pump and permanently remove seawater from the oceans at a rate greater than the rate at which oceans are rising due to ice melt, thermal expansion, the flow of a fraction of pumped groundwater that makes its way into the sea, and other causes. Established and potential aquaculture operations will play a key role in determining the best locations for our projected 50 large-scale Integrated Seawater Farms around the plane (GSI).

The USA, through National Oceanic and Atmospheric Administration (NOAA) is pursuing the development of mariculture or offshore aquaculture as an effective means of reducing their growing dependence on seafood imports, providing jobs for economically depressed coastal communities and increasing food supply and security. These operations will be located in the open ocean between three and 200 nautical miles (within their EEZ) offshore (NOAA, 2006) (Figure 10).

Figure 10:
Diagrammatic representation of a potential offshore aquaculture operation



(NOAA, 2006)

Presently, aquaculture operations, both freshwater and marine, are either coastal or land-based; but with the competition for space and the decline in water quality suitable for aquaculture, interest in going offshore has increased. The presence of less competition for space, deeper water, stronger current flow and superior water quality makes going offshore an appealing option. Although the concept of offshore aquaculture has been around for some time technological advances that now make it possible have only been developed within the last 10 years. This technology is being tested and refined in four locations (two operations in Hawaii, one in Puerto Rico and one in New Hampshire). Also taken into considerations are the environmental challenges which include the potential interaction with wild stocks, the management of wastes and potential aquatic animal health issues.

Developing countries produce more than 70 percent of the fish consumed by humans and are taking an increasing interest in aquaculture – seen by many as a way to meet future demand for fish and mitigate the overexploitation of wild fish stocks. Fish farming has boomed in the past three decades and now supplies some 40 percent of the world's total food fish supply. But there is concern that aquaculture is poorly regulated and is not the ultimate answer to the fish crisis.

Saline Agriculture

Water with salt content up to and even exceeding that of seawater is being used for irrigation of various food, fuel and fodder crops. Oilseeds, grass, fodder, fuel wood and pharmaceuticals and other products have been produced using highly saline water (National Research Council, 1990). In saline agriculture, an alternative is to allow the environment to select the crops, thereby matching salt-tolerant plants with desirable characteristics to the available saline resources. Halophytes such as *Zostera marina* (sea grass)

and Palmer's salt grass (*Distichlis palmeri*) have been used by Native Americans to make flour from which bread is made. *Salicornia* spp. has been evaluated as a source of vegetable oil and field trials have been conducted in the United Arab Emirates (UAE) and Egypt to determine its potential for growth on unusable land (Figure 11). Tradition crops such as tomatoes, onions, melons and asparagus have all been grown using brackish water irrigation.

Figure 11:

Salicornia fields in Eritrea (East Africa) planted and maintained



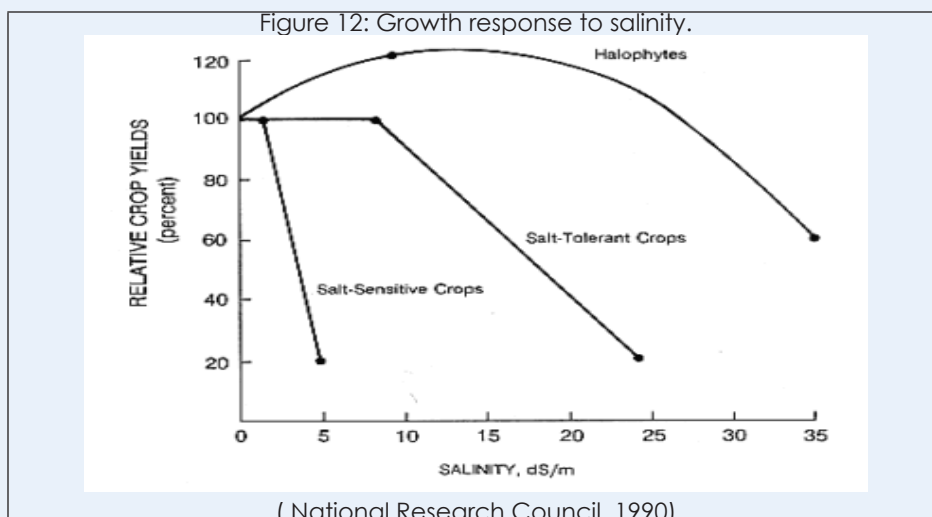
An integrated, forest of *Salicornia* and mangroves in Eritrea (East Africa)



Hodges, 2004.

Many halophytes, such as *Suaeda maritima*, have increased yields at low salinity levels. Salt-tolerant crops, such as barley, maintain yields at low salinity levels but decrease as salt levels exceed a certain limit. Yields of salt-sensitive crops, such as beans, decrease sharply even in the presence of low levels of salt (National Research Council, 1990). (Figure 12)

Figure 12: Growth response to salinity.



(National Research Council, 1990)

In 2006 production of crops by aquaculture was 15.1 million tonnes valued at US\$7.2 billion. This sector has a growth rate of 8.0 percent since 1970, and represented 93 percent of global supply; 72 percent of this originated in China (10.9 million tonnes) (FAO 2009). Feed meal for poultry, swine and aquaculture species is also produced using finfish, like herring, sardine and anchovy; while, cod, hake and haddock are commonly used to make artificial crab, shrimp and other more expensive seafood (Stickney).



Seaweed Plantation in Bali, Indonesia

Using the life work of Dr. M. Murray of Ambrosia Technology has engineered a product called sea-crop. This formulation is a concentrate soil and plant stimulant containing over 80 natural source minerals and active organic substances from deep sea Pacific Ocean water. This concentrate has been tested and passed for use in organic agriculture and purports an improved nutrient and water uptake root growth, plant growth and yield as well as reduced transplant shock, drought stress and the ability to control parasitic nematodes. It even promises an improved flavour. It has been tested on both plants and animals, where it increases stamina and animals prefer to eat forage grown with sea-crop rather than regular fertilizer alone (Figure 13).

Figure 13:
Plums on the left treated with sea crop weighed 172.1 grams, while those on the right not treated with sea-crop weighed 68.9 grams



(Ambrosia Technology LLC 2008)

Countries with saline agriculture projects include China, Mexico, Eritrea, India, Pakistan, Israel, Libya, Jordan, Tunisia, Egypt, Iran, Morocco, United States, Saudi Arabia, Syria United Arab Emirates, Kuwait, Australia and Sudan. The shortage of water and arable land, leading to the shortage of food is one of the major societal problems and saline agriculture could lessen this shortage of food and water (Bushnell, 2009). Of the over 100,000 naturally occurring halophyte plants about 250 of these have the potential to be staple crops and over 100 of these are now in trials for applications (Bushnell, 2008).

The oceans cover more than 70 percent of the earth's surface and less than one percent of water on the earth comes in exploitable forms – like lakes, rivers and groundwater. Saltwater, when used to irrigate crops inland will ruin the land unaccustomed to high salinity. However, used on coastal deserts seawater has great potential. Integrated farming systems in Eritrea utilise seawater pumped inland to sustain shrimp, fish and plants as well as irrigate wetlands and mangrove forests; thus foresting previously arid lands and combining agriculture, aquaculture and conservation (Muhawi, 2003).

Salicornia is a halophytic, 'wild' plant, which provides a gourmet vegetable from its young shoots, as well as edible oil and high protein meal from the mature plant. The large amount of biomass generated, can be utilised as animal fodder, particle board and firebricks (Muhawi 2003). *Salicornia* yields 2 tonnes/hectare of seed which contains 28 percent oil and 31 percent protein (Glenn, 1999) This is similar to soya bean in yield and seed quantity (Glenn, 1999) and can therefore replace seeds like sunflower. Saltwater is pumped inland to irrigate *Salicornia bigelovii* fields, and flow through shrimp tanks and fish lakes, before returning to the sea via restored mangals. The mangroves provides habitat for hundreds of fauna as well as sequestering atmospheric carbon and reducing atmospheric pollution. The waste is removed from the fish and shrimp ponds in water and used to fertilize the *Salicornia* fields and irrigate the re-established wetlands (Muhawi, 2003)

Other potential halophytes with potential for domestication are *Suaeda fruticosa*, *Haloxylon stocksii*, *Arthrocnemum indicum*, *Cressa cretica* and *Halopyrum mucronatum*. They have an oil quantity between 22 percent to 25 percent and 65-74 percent of the fatty acid content of the lipids in the seed is unsaturated (Weber, 2007).

Biomass and Energy Security

Biomass production is limited by arable land and freshwater. These are the same factors that restrict traditional agricultural production. Desert and arid regions of the world now become potential candidates for biomass production (Bushnell, 2009). Marine crustaceans as a whole totalled 5.7 million tonnes in 2006, with the crab and lobster groups at the highest level ever, and shrimps only slightly lower than the peak reached in 2004. Harvests of bivalves (scallops, clams, oysters and mussels) and gastropods decreased for most species groups in 2005, but they showed signs of recovery in 2006. Catches of the "sharks, rays and chimaeras" group have declined (FAO, 2009a).

Biomass production has a number of advantages in that it is renewable, carbon neutral and relatively inexpensive. However, production capacity is limited by the availability of fresh water and arable land. Bushnell believes that biomass grown in the Sahara could supply the worlds' energy requirements. He feels that deserts generally receive abundant sunlight; have brackish or saline ground water; are often near or on the coast; and thus have the potential to be utilised for saline agriculture for biomass, fuel and food. This idea goes against the conventional thought that seawater and saline intrusion are detrimental to agriculture; but this could represent a viable alternative to conventional traditional agriculture in certain regions. The marginal coastal or near coastal land could be utilised for food and fodder, reclaimed by desalination techniques or used for full-fledged seawater cultivation. Seawater is widely available as 97 percent of all water is seawater. Sea water also contains a variety of minerals (magnesium, bromide, phosphorites, and metallic sulphides) and nutrients important for agriculture. Increased vegetative cover in these arid areas could influence atmospheric water content and rainfall.

The most likely source to emerge above the other alternatives is photosynthesis and the magic word it coined: biofuel. This means cultivating grasses, trees and algae to provide ethanol, biodiesel, and biomass. The trick is to develop new crops and not use those needed for human food. The worst-case example is America's subsidized disaster with corn-based ethanol, escalating food prices everywhere (GSI). The system has the following benefits:

- Uses a potentially infinite source of seawater and does not compete for limited freshwater supplies;
- Is capable of making coastal lands highly productive;
- Can be integrated with aquaculture and biomass production;
- Does not compete with existing need for rain-fed or freshwater-irrigated agricultural lands used for conventional animal and human food production;
- Has the potential to create new jobs and alternatives to traditional fishing and farming;
- Represents a form of adaptation to sea level rise and in some case removes cost of dislocation and the building of sea walls; and
- Removes more Co2 from the atmosphere that it produces, and therefore acts as a carbon sink; thus contributing to the alleviation of the impacts of global warming.

Global Seawater Inc. and the Seawater Foundation are two organizations that have developed various techniques for integrating saline aquaculture, saline agriculture and biomass production. Seawater is channelled inland to raise aquatic animals and to irrigate halophytic plants and trees. The cost is shared across the integrated systems and does not compete with freshwater or traditional agricultural lands. Also, the renewable biomass sequestered a significant amount of carbon from the atmosphere. The integrated systems creates employment in otherwise economically marginalized coastal communities.



Where fishing is not an option, saline-water agriculture might prove beneficial to ensuring livelihoods in marginalised coastal communities.

5. Threats to the Oceans Resources for Food and Fuel

The vitality of the world's oceans is being seriously impacted by human activity that has resulted in severe impacts on the biological production of the world's oceans and the services they provide to billions of people today.

Vulnerable marine ecosystems, such as, coral reefs and important fisheries are being adversely affected by decades of over-harvesting, destructive fishing practices, marine and pollution (mainly coastal) and the more recent phenomena of alien species invasions and climate change. The main issues related to these factors are summarised below.

Over-harvesting and Destructive Fishing Practices- Over-harvesting occurs when the amount of fish caught exceeds the amount of fish needed to sustain fish stocks in a given region. Put simply, there are too many boats, especially large-scale, industrial vessels such as factory trawlers, with too much capacity for devastating fish stocks. As a result of over-fishing, fish populations decline and formerly productive fisheries may be forced to close. The long-term costs of over-fishing can also include social dislocation due to loss of jobs, loss of biological diversity and ecosystem collapse.

The failure of global fisheries management can largely be attributed to the practices of open access fisheries. This “democratic” fisheries practice essentially means that anyone who has a boat can fish anywhere and take as much fish as they wish. The unsustainable nature of this practice was eventually recognized and led to the negotiations of international agreements to manage these marine resources. Government subsidies have traditionally encouraged fishing beyond sustainable levels with flawed Maximum Sustainable Yield (MSY) estimation by managers and under-reporting by fishers resulting in greater exploitation than was being recorded. Over-fishing was also facilitated by over-capitalisation of fishing fleets, poor enforcement and the low priority of fisheries in the national economies. In addition, poaching, the use of illegal



Sustainability of fishing depends on partnerships with fishers in management of the resource.

gear and wastage of catch (like discarding fish by shrimpers) are mechanisms which also led to the downfall of the world's fisheries. These threats are now being exacerbated by global warming and other anthropogenic factors. Since 1970, the world's fishing fleet has expanded twice as fast as world catches. The fishing fleet in China, the world's leading fish producer, is now around six times the size it was in 1979. As a result, excess fishing capacity has reached alarming proportions. There are about 3.5 million vessels/boats currently fishing in the world's oceans. Intense competition between countries and rival fleets over access to fishing grounds has sparked numerous international disputes over fishing rights in recent years (Greenpeace, 2008).

Destructive and wasteful fishing practices are responsible for the capture of approximately 27 million tonnes of unwanted fish annually that are discarded, usually dead or dying, back to the sea. The widespread use of unselective fishing gear is deadly for certain animals in some situations. The use of long-line fishing boats kill tens of thousands of albatross each year; while driftnets indiscriminately kill millions of marine creatures, even though they target just one or two commercially valuable species. Marine mammals are often killed in trawls, set nets and purse seine nets. In addition, there is severe damage caused by fishing operations that use destructive gear and fishing practices, like bottom trawling which physically disturbs marine habitats such as the ocean floor, sea grass beds and coral reefs. Up until now most of the fisheries management decisions have been designed to achieve economic and sometimes political objectives and have not paid much attention to the protection of the marine environment or conservation of the fish populations.

Marine Pollution

Land-based sources, oil spills, untreated sewage, heavy siltation, eutrophication (nutrient enrichment), invasive species, persistent organic pollutants (POPs), heavy metals from mine tailings and other sources, acidification, radioactive substances, marine litter and ship borne waste results in a range of threats. Many of these can be attributed to the rapid increase in coastal development and discharge of untreated sewage into the near-shore waters, resulting in enormous amounts of nutrients spreading into the sea and coastal zones. In Latin America and the Caribbean about 85 percent of the wastewater discharged into the marine environment is untreated. In addition, agricultural run-off loaded with nitrates and phosphates reach the marine environment and enrich the coastal waters causing eutrophication. With coastal development has come the conversion of coastal wetland and mangrove forest to urban, industrial and aquaculture use. This has resulted in the loss of their natural purification functions (Nellemann et al., 2008).

Invasive Species

Exotic and invasive species have been identified by scientists and policy-makers as a major threat to marine ecosystems. The infestation of invasive species, that is species purposefully or accidentally introduced in non-native environments, is growing. Invasions of marine habitats are now occurring at an alarming rate, with dramatic effects on biodiversity, biological productivity, habitat structure and

fisheries. Some habitats are more readily invaded than others due to physical or biological characteristics that facilitate or prevent the success of exotic species. Those ecosystems that have been heavily destabilised by human activities such as pollution and over-fishing are more susceptible to invasion. Most introductions of exotic and invasive species result from anthropogenic dispersal primarily as a result of the worldwide movement of ships with organisms carried in their ballast water or as fouling organisms. The patterns of dispersal are strongly correlated with major shipping routes, while their establishment globally appears to be strongly related to the intensity of fisheries, bottom trawling, pollution and other stressors (Nellemann et al., 2008).

Climate change

According to the Inter-governmental Panel on Climate Change (IPCC) global warming which leads to climate change, is evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (IPCC, 2007). Impacts from climate change will be both positive and negative as they relate to production and marketing costs, changes in the prices for fishery and aquaculture products, and increased risks of damage to or loss of infrastructure, tools and housing. Increased sea temperatures, variations in sea surface temperature (SST), sea-level rise and ocean acidification caused by climate change pose a serious threat to marine life, coastal and island communities and national economies. The distribution of marine and fresh water species is already being impacted by climate change with warmer water species moving closer to the poles because of changing habitat size and productivity resulting from increasing temperatures. Biological processes are also being impacted negatively and have serious consequences for fish production.

The global fishery is very vulnerable to climate change and variability, especially those of the small island developing states (SIDS). Communities that rely heavily on fishing for their income are vulnerable and will face varying challenges based on their level of sensitivity, exposure and adaptive capacity. Of particular concern will be those regions with low adaptive capacity to change, including the SIDS in the Caribbean. Vulnerable communities may be faced with less stable livelihoods, decreasing availability and quality as well as quantity of fish for food and health risks related to fishing under harsh weather conditions or farther from home. Therefore, as temperatures increase and the natural ecosystems degrade, fish landings are expected to decrease and the cost of fishing increase. This has severe implications for rural community dwellers in the Caribbean who depend directly or indirectly on the fishing sector for income and food source.

Management Issues

The immense capacity of the oceans resources for food, fuel and sustainable livelihoods cannot be understated. In recognition of the still relatively untapped nature of these resources and the severity of current and emerging threats, management of the ocean's resources, including fish stocks, became a global issue. To date, such management issues have emphasised international cooperation for the

management of the ocean's fish stocks. Over the past 30 years, with the decline of the once abundant fish stocks, a number of international agreements have been negotiated to assist in the sustainable management of these marine resources (Kura et al., 2004).

The 1982 United Nations Convention on the Law of the Sea (UNCLOS) is the primary international legal instrument governing high seas fishing (among other things). It sets out a framework of rights, obligations and duties with respect to high seas fishing – most importantly, the freedom to fish on the high seas, balanced with the responsibility of individual States to control the activities of its nationals and vessels (Hedley, 2003). Under UNCLOS countries had the right to claim complete sovereignty over the marine resources within 200 nautical miles of their coast, an area established as the Exclusive Economic Zone (EEZ). Prior to this countries territorial zone extend only 12 nautical miles from the coast. The establishment of the EEZ allowed the rich resources of coastal waters, where 90 percent of the commercial fish are harvested, to be controlled by national governments, placing the responsibility for sustainable management in the control of coastal nations (Kura et al., 2004). UNCLOS did not become law until 1994 and presently 159 countries are party to this Convention with 75 percent of these being coastal states (Hedley, 2003). Despite the intent of UNCLOS, not all countries have instituted adequate fisheries management plans and laws and for those who have, implementation and enforcement is still a problem.

The 1995 UN Fish Stocks Agreement (UNFSA) built on the provisions of UNCLOS, sets out the framework for cooperation with other countries to conserve and manage highly migratory fish stocks such as tuna and stocks that straddle both the high seas and a State's EEZ (Hedley, 2003). Although the agreement was adopted in 1995 it could be not entered into force until 2001 when, 36 of 59 signatories had ratified it. This Agreement lacks the participation of the major players as a number of important fishing nations have not yet accepted the treaty. Of the top 10 fishing countries only India, Norway, Russia, and the USA have ratified this agreement. China, Indonesia, and Japan have signed but not ratified the treaty. Chile, Peru, and Thailand have not signed the treaty at all (Kura et al., 2004).

The FAO has managed the only repository of global fisheries data and regularly collects and analyses statistics on the capture fisheries, aquaculture and commodities (FAO, 2008). One of its major roles is to promote key principles of sustainable fisheries management and to help nations implement these principles within their EEZ. The FAO's Code of Conduct for Responsible Fisheries introduced in 1995 contains recommendations and guidelines to assist national policy-makers and fisheries managers. The Code recognizes the nutritional, economic and social environment and cultural importance of fisheries and the interest of all those concerned in the fishery sector. More than 150 countries have adopted this voluntary Code which is consistent with the principles outlined in the UNFSA. A number of technical guidelines for responsible fisheries that cover certain important topics in greater detail have been produced to supplement the general provisions of this Code, including guidelines on applying the precautionary principle, integrating fisheries management into coastal area management, developing aquaculture responsibly and applying an "ecosystem approach" to fisheries, among other topics (Kura et al., 2004).

International Guidelines for the Management of Deep Sea Fisheries in the High Seas to assist states and fisheries management organizations in the sustainable management of these resources is a more recent addition. These guidelines are intended to identify vulnerable marine ecosystems in areas beyond national jurisdictions and the potential impacts of fishing activities on those ecosystems and to facilitate the adoption and implementation of conservation and management measures. The guidelines also include special arrangements for developing countries that give consideration to providing financial and technical assistance, technology transfer, training and scientific cooperation (FAO, 2009b).

However, the presence of these agreements, codes and guidelines does not guarantee adherence as there are, in many instances, no legal sanctions or enforcement is very difficult or near impossible outside those imposed by the participating nations. In addition, many developing countries do not have the resources or capacity to implement the guidelines. The provisions of the codes and guidelines have had some effect on fisheries management with the development of fisheries management plans tailored to different stocks or geographic regions. However, the existence of the management plans does not always translate into effective protection of the fish stocks.



Staking an interest in management of the fishery resource ensures that benefits are shared equitably to those whose livelihoods depend on the resource.

6. Developing the Caribbean's Marine Resources

The Caribbean Sea represents the major renewable resource and a major source of thermal energy which can be converted into electricity, desalinated water, and provide critical inputs for intensive agriculture systems such as aquaculture, mariculture, greenhouse production, irrigation and hydroponics.

(Binger, 2009)

The vast ocean resources of the Caribbean Sea estimated at 80 times the land resources represent the major renewable resource for addressing food and energy security (Binger, 2009). However, the potential of and threats to the oceans' resources have significant implications for the Caribbean region to develop, on a sustainable manner, both the food and non-food products of its largest and most renewable resources. To understand the global issues in a Caribbean context, it is important to understand the nature of the use of the vast resources of the Caribbean Sea.

Role of the Caribbean Sea

The Caribbean Sea's resources play an important social and economic role as a source of food, employment and foreign exchange earnings (UNEP, 2005). Capture fisheries is by far, the dominant economic use of the marine resources. Other important economic activities include whale watching, water sports and other related services linked to the tourism industry. This activity is not as widespread as capture fisheries and hence the focus of the paper is on seafood, i.e., capture fisheries and aquaculture.

Sea food

Marine fisheries - mainly capture fisheries – is the main economic activity, providing livelihoods for more than 130,000 persons in the Caribbean, earning over US\$ 150 million per year from exports, saving the region at least three times as much in foreign exchange, as volume of production is four times the volume of export (CRFM, 2002).

Capture fisheries is primarily small scale and is undertaken within the shallow protected coastal waters. The artisanal fishing vessels are generally open canoes made from reinforced fibreglass, ranging from, 3.5 to 9 m in length and powered by outboard engine. There are also oar propelled boats made from wood or a mixture of wood and fibreglass. Decked vessels, generally made from steel with length ranging from 15 to 20 m, are used primarily for fishing offshore and capture a range of species according to the seasonality and the geography of the stocks. A wide variety of gear such as gill nets, beach seine, cast nets, hook and line, rod and reels, spear guns, lobster and fish traps and shrimp trawlers are utilised. Included in the capture fishery are lobster, conch, marine shrimp, finfish and also aquarium species, crabs and squids (Table 14). Industrial fishing operators tend to catch and export conch, lobster and quality finfish (Uwe et al., 2006).

Table 14:
Review of some important fisheries resources in the region of Western Central Atlantic Fishery Commission.

RESOURCE TYPE	STATUS	IMPORTANCE	SHARED DISTRIBUTION
SPINY LOBSTER	Fully exploited or overexploited	High value for export and tourism	Throughout region (except the Guyanas- Brazil)
QUEEN CONCH	Fully exploited or overexploited. Highly vulnerable to overexploitation and stock collapse. Listed in CITES, Appendix 2	High value for export and tourism	Throughout region (except the Guyanas- Brazil and the Gulf of Mexico)
LARGE COASTAL PELAGICS (for example, dolphinfish, black fin tuna, mackerels)	Unknown but fishery expanding rapidly	Domestic and tourism consumption, recreational	Broadly distributed and highly migratory
LARGE OCEANIC PELAGICS (yellowfin tuna, billfishes, swordfish)	Generally fully exploited to overexploited	High value for export, tourism and recreational	Broadly distributed and highly migratory
LARGER PELAGICS (coastal and ocean sharks)	Potential for severe overexploitation as by-catch. Biodiversity concern due to vulnerability	Food (domestic)	Broadly distributed and highly migratory
SOFT BOTTOM DEMERSALS (for example, snappers, groupers)	Heavily exploited as by-catch and directed fishery	Domestic importance for food, export	Widely distributed on the continental shelves. Locally migratory
DEEP SLOPE DEMERSALS (for example snappers, groupers)	Fully exploited to overexploited	High value for export, domestic and tourism consumption	Widely distributed on the continental shelves. Locally migratory
SHALLOW REEF FISH (for example, snappers, groupers, parrotfish, grunts, surgeonfish)	Fully exploited to overexploited. Fishing is affecting reef ecosystem health and productivity. 13 species in 5 families on IUCN Red List	Domestically important food, high value for export, tourism aesthetics	Widely distributed in coral reef habitats. Some species migratory on shared shelves
FLYINGFISH	Unknown but fishery expanding slowly after rapid expansion in High-value export 1980s	Domestically important food fish	Distributed and migratory throughout southeastern Caribbean
SHRIMP	Fully exploited to overexploited	High-value export	Widely distributed and migratory within sub-regions
OTHER (octopus, squid, seaweed, sea urchins, corals and so on)	Various	Locally important	Nationally to widely distributed
TURTLES AND MARINE MAMMALS	Some populations endangered	Of concern regarding biodiversity. Nationally important for tourism, aesthetic purposes	Nationally to widely distributed

Source: UNEP, 2005

The Belize fishery is focused on the capture of spiny lobster and queen conch. Finfish species include groupers, snappers, hogfish, king mackerel, barracuda and jack which are all targeted for export. Grunts, snook, mullets, porgies, triggerfish and tarpon are caught for local consumption. Shrimp is caught by both artisanal and industrial trawl fishers. Other marine organisms such as sharks and crabs are captured to a lesser extent (FAO, 2005a).

The coral reef fishery dominates the artisanal fishing on the island shelves and account for the largest category of fish capture in Jamaica. The group is comprised of a large number of species, many of which have their juvenile stages associated with coastal mangroves and seaweed beds. This group is already overexploited and the groupers and barracudas are considered the most vulnerable to over-fishing. The large groupers are found on the deep slopes and banks. Unfortunately, their large size and high quality makes them highly prized and very susceptible to fishing pressure. The coastal pelagic are comprised of a number of different species which include jacks, herrings, anchovies and mojaras and are caught for local consumption. The four important groups that make up the offshore pelagics (found in open waters) are mackerel, dolphin-fish, tunas (including billfish and swordfish) and sharks. Most of these species are highly migratory with ranges extending throughout the wider Caribbean. The Caribbean spiny lobster is the most valuable lobster species in the western Atlantic with the fisheries extending from North Carolina in the USA to Rio de Janeiro in Brazil. The lobster fishery has both an artisanal and industrial sector and is considered to be over exploited. Several species of shrimp are also captured (CFRAMP, 2000).

Jamaica is the world's largest producer of the Queen Conch (*Strombus gigas*) making this its most valuable fishery. At present the stocks are abundant and productive, but because it is listed as an "at risk" species under Convention on International Trade in Endangered Species (CITES) a strict export quota systems has been implemented to comply with the provision of that convention (STATIN & NEPA, 2001).

Many of the fishing communities in the countries of the region are rural poor. Fishers are engaged in either full-time or part-time fishing and many have limited formal education. Many of these artisanal fishers earn incomes below the poverty level and often supplement their income with alternative employment or practise subsistence farming. Associated with the fishers are a large number of persons engaged to varying degrees in processing and marketing.

Despite the existence of a fisheries sector some countries such as Jamaica continue to be a net importer of fish and fish products, importing up to 60 percent of their demand annually. The fisheries sub-sector is becoming a leading export sector for many countries but concerns exist about depletion of fish stocks due to over-exploitation of the resources and damage to the ecosystem. The Western Central Atlantic Ocean, where the Caribbean is found, has experienced a decline of more than 10 percent in capture production since 2000 (CERMES 2009). This fishery is dominated by small scale/artisanal fishers and as

such has the potential to play an important role in key development issues like poverty alleviation and food security (CERMES, 2009). Table 15 shows the fish landings of various Caribbean states.

Table 15: Fish Landings of Caribbean State (CARICOM, 2004).								
Country	Year	Fish landing by type				Fish landing x boat days		
		Fish	Crustaceans	Molluscs	Other	Quantity (Tonnes)	No. of Boat Days Spent	Total Catch
Barbados	1990	1,340	1,935	335	---	3,610	12,333	1,334
	1995	1,271	2,636	589	---	4,496	16,534	1,146
	1998	1,610	2,621	670	---	4,902	17,818	1,814
	1999	1,439	2,783	472	---	4,694	13,505	1,530
	2000	1,332	3,050	668	---	5,050	12,838	1,390
	2001	1,534	2,282	658	---	4,473	13,940	1,530
	2002	1,597	3,422	523	---	5,542	13,354	1,474
	2003	1,604	3,508	620	---	5,731	14,501	1,568
	2004	1,397	3,079	580	---	5,055	10,930	954
Belize	1995	325	2,035	302	---	2,662	---	---
	1998	244	4,819	14	---	5,077	---	---
	1999	222	8,018	16	---	8,256	---	---
	2000	138	9,221	9	---	9,368	---	---
	2001	123	10,446	580	---	11,149	---	---
	2002	613	1,754	462	---	2,830	---	---
Dominica	2000	---	---	---	---	495	---	495
	2001	297	---	---	---	525	---	525
	2002	338	---	---	---	641	---	641
	2003	196	---	---	---	404	---	404
	2004	250	---	---	---	403	---	403
Guyana	1997	37,600	123,818	---	---	---	---	---
	1998	39,541	30,143	---	---	---	---	---
	1999	35,257	14,386	---	---	---	---	---
	2000	30,277	19,328	---	---	---	---	---
	2001	26,892	25,250	---	---	---	---	---
	2002	25,186	22,058	---	---	---	---	---
	2003	33,724	22,584	---	---	---	---	---
Jamaica	1997	2,292	---	1,805	---	7,747	---	---
Saint Lucia	1990	457	4	4	97	562	---	562
	1995	576	12	15	407	1,011	---	1,011
	1998	1,159	20	42	304	1,525	---	1,525
	1999	1,295	23	90	421	1,829	---	1,829
	2000	1,443	25	40	352	1,860	---	1,860

Table 15: Fish Landings of Caribbean State (CARICOM, 2004).

Country	Year	Fish landing by type				Fish landing x boat days		
		Fish	Crustaceans	Molluscs	Other	Quantity (Tonnes)	No. of Boat Days Spent	Total Catch
	2001	1,455	36	41	435	1,967	---	1,967
	2002	1,206	58	31	317	1,612	---	1,612
	2003	1,096	23	60	349	1,528	---	1,528
	2004	1,102	11	46	362	1,520	32,041	1,520
Suriname	2000	8,871	1,529	---	---	---	---	---
	2001	12,202	1,700	---	---	---	---	---
	2002	10,937	2,000	---	---	---	---	---
	2003	12,000	1,900	---	---	---	---	---
	2004	18,647	1,530	---	---	---	---	---
Bahamas	1995	440	5	---	48	493	---	446
	1998	406	14	---	65	485	---	420
	1999	403	21	---	43	467	---	424
	2000	331	12	---	45	387	---	343
	2001	292	13	---	23	328	---	305
	2002	361	15	---	46	421	---	376
	2003	31	18	---	44	381	---	337
	2004	347	14	---	41	402	---	361
Turks & Caicos	1990	15	328	424	---	767	8,215	767
	1995	1	284	953	---	1,238	10,097	1,238
	1998	---	315	645	---	941	7,271	941
	1999	1	187	737	---	925	6,714	925
	2000	1	291	817	---	1,109	8,321	1,109
	2001	4	323	725	---	1,052	3,348	1,052
	2002	3	182	655	---	840	7,085	840
	2003	---	278	720	---	998	5,460	998
	2004	---	388	680	---	1,057	8,449	1,057

Source, CARICOM, 2004

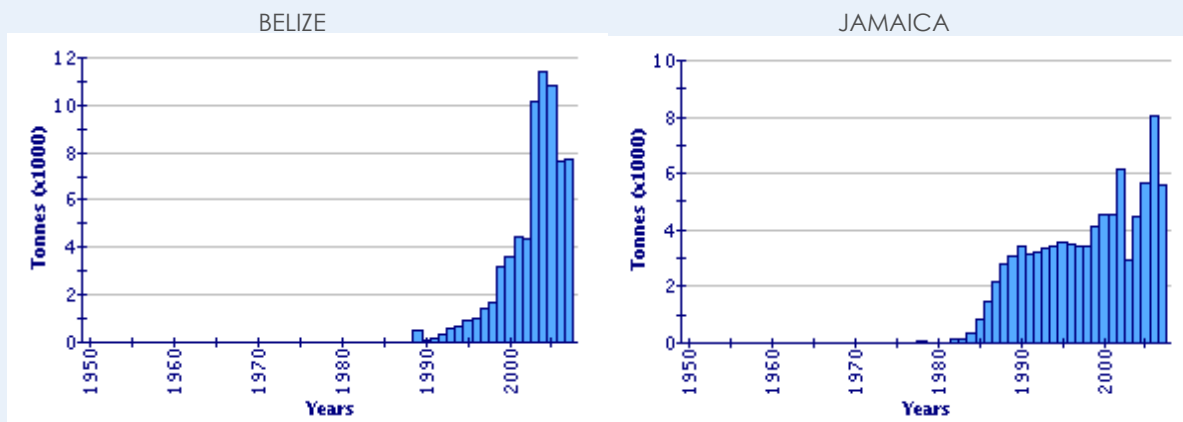
Note that the data are inconsistent; some countries like Jamaica only show data for one year, while others show five or more years of fish landing statistics. This disparity in data collection is a factor in the 'flawed' estimation of the MSY by fishery managers, and is typical of developing countries. Although there seems to be an absence of comprehensive fish data to show the extent of over-fishing; if fishers have to work longer to catch the same quantity of fish, this could mean that fish is less abundant.

Aquaculture and Mariculture

Aquaculture has generally only developed in the larger countries of the region as most of the islands lack suitable land space and fresh water supplies. Belize, Guyana and Jamaica have expanded their

aquaculture production over the past 20 or so years. Aquaculture began in Belize in 1982 with four hectares (ha) of experimental farms and has expanded rapidly and is now a significant contributor to the Belizean economy in terms of foreign exchange earnings, income generation, employment and food security (Figure 14).

Figure 14:
Graphs showing reported aquaculture production for Belize and Jamaica from 1950



Source: FAO Fishery Statistics (FAO, 2005a)

The industry is primarily based on the production of the whiteleg shrimp (*Penaeus vannamei*). Aquaculture has expanded in volume and value more rapidly than the capture fishery, terrestrial livestock and other agro-production. Farmed shrimp production in Belize is expected to remain fairly constant and improvements in farming technology will allow farmers to gradually reduce production costs. There is now the emerging interest to diversify the aquaculture sector to include marine cage farming. The species proposed for culture include the cobia (*Rachycentron canadum*) and the Florida pompano (*Trachinotus carolinus*) (FAO, 2005a).

As indicated above, aquaculture in Jamaica is a growing sector. In 1992 production was recorded at 3,000 tonnes and by 2002 production was estimated at 6,000 tonnes. Aquaculture occurs mostly on the south central plains where currently there are approximately 180 fish farmers on an area of 526 ha with approximately 90 percent of the farms practising semi-intensive aquaculture. The fish produced is marketed both locally and internationally. In 1997, some 283.7 tonnes of fresh tilapia fillets 97.2 tonnes of frozen fillet and one tonne of frozen whole tilapia were exported to the USA. The aquaculture sector in Jamaica is currently dominated by tilapia (FAO, 2005a). There is little mariculture (farming of marine species) in Jamaica. Mariculture projects involving the culture of shrimp and oysters have been introduced but were not sustainable (STATIN & NEPA, 2001).

In Guyana there are two forms of aquaculture: traditional, extensive brackish-water culture, and freshwater pond culture. Brackish-water farms operate as extensive polyculture systems, utilising the existing sluices and dams from the sea defence structures to control water exchange. In most cases, the trapped fish and shrimp grow to marketable size without any additional inputs. Fish and shrimp species grown in the ponds include querman, snook, croaker, bashaw, tilapia, tarpon and indigenous shrimp such as *Penaeus (Litopenaeus) schmitti*, *P. aztecus* and, *P. brasiliensis* and the swamp shrimp (*Misopenaeus tropicalis*). Brackish-water culture occurs mainly in the swamps along the Atlantic Coast. In the freshwater ponds, *Tilapia (Oreochromis mossambicus)*, *T. nilotica* and, to a limited extent, atipa catfish (*Hoplosternum littorale*), are the main species cultured in Guyana. Two commercial farms were recently established to produce fresh water prawn (*Macrobrachium rosebergi*), using imported seed and feed. In 2001, the government established the Mon Repos Freshwater Aquaculture Demonstration Farm and Training Centre, with assistance from FAO and the Canadian International Development Agency (CIDA), with the aim of stimulating and promoting the development of aquaculture through the training of farmers, the provision of start-up seed and technical assistance to farmers, and to conduct adaptive and applied research (FAO, 2005a).

In Dominica there are six farmers on the island involved in the culture of fresh water prawn (*Macrobrachium rosenbergii*) which only supply the local market. Tilapias have also been cultivated alongside the prawns, but they have not been a popular choice of fish by the locals. St Kitts currently has only one aquaculture project which is privately owned and experimenting with the growing of tilapia in ponds near the ocean, using seawater. Antigua and Barbuda produces seamoss (*Gracilaria spp.*) which is used locally primarily to flavour beverages. For Saint Lucia, Trinidad and Tobago, Barbados and Vincent and the Grenadines there are no significant commercial aquaculture operations. In Trinidad and Tobago, the development of this sub-sector is constrained by limited waterways, user conflicts in terms of land use, developmental priorities and general environmental degradation as may be evidenced through pollution of the waterways and habitat degradation, among other factors (FAO, 2005a).

Demand for seafood

The vast majority of the capture fisheries are sold fresh for domestic consumption while lobster tails, conch and valuable fin fish species are exported in a chilled or frozen state (CFRAMP, 2000).

The region supports some 29.6 million people and fish production is roughly 400,000 tonnes per annum. On average the annual fish consumption is 14.1 kg per capita, but there is a large disparity between the Greater Antilles, with 12.7 kg per capita, and the Lesser Antilles, with 23.9 kg per capita. The protein supply is above the daily world average amount per capita, except Haiti and the Dominican Republic, and fish supply varies between 14 percent of total animal protein in Haiti and The Bahamas and about 50 percent in Martinique, Guadeloupe and St. Christopher/Nevis.

In the Lesser Antilles the demersal fishes are the most appreciated, like snappers and groupers as well as imported salted cod. In fact, in Martinique approximately one quarter of total fish consumption is salted cod. On the other hand, in the Greater Antilles both demersal and pelagic fishes are accepted and some freshwater fishes like Tilapia and Carp have become popular. Countries like Jamaica, Cuba, Dominican Republic and Trinidad and Tobago have experienced significant growth and transformations of the productive structure of aquaculture, in particular fish farming, which has had a strong impact on the marketing and consumption of fish. Economic and social factors greatly influence the consumption of fish; for example, salted fish was established during the colonial era and now is a mainstay of the Caribbean diet. Molluscs are not traditionally consumed; but conch and the mangrove oyster are eaten mainly in Cuba and Jamaica. While crustaceans are scarce and seldom consumed locally, they have become valuable as export commodities especially the spiny lobster. Freshwater prawns are farmed extensively in the Greater Antilles for local consumption and the tourist industry. The consumption of imported frozen and smoked fish is also increasing (FAO, 2005a) (Table 15).

Table 15:
Fishery products and the average consumption between the years of 2003 to 2005, Caribbean total and Individual CARICOM Countries

Country/Area	Production	Non-Food Use	Tonnes in live weight		Food Supply	Population Thousands	Per capita supply (kg/year)
			Imports	Exports			
Caribbean Total	182,155	15,162	255,606	37,891	384,094	40,152	9.6
Antigua Barb	12,587	1,000	2,524	581	3,530	82	43.0
Bahamas	11,789	667	4,797	6,482	9,571	319	30.0
Barbados	2,500	15	8,876	272	11,090	291	38.1
Dominica	745	0	1,308	2	2,051	68	30.2
Grenada	2,211	0	2,356	586	3,987	105	38.1
Haiti	8,133	0	17,968	388	25,713	9150	2.8
Jamaica	16,134	0	52,713	1,376	67,471	2,665	25.3
Montserrat	50	0	134	0	184	5	34.5
St Kitts Nevis	445	0	1,170	96	1,519	49	31.2
Saint Lucia	1,461	0	4,331	4	5,787	159	36.3
St Vincent	4,782	4,000	1,085	166	1,701	118	14.4
Trinidad & Tobago	11,123	6	16,285	4,049	22,612	1,319	17.1

Source: FAO, 2008

Threats and Issues

Poor fisheries management, marine pollution and environmental degradation, alien invasive species and climate change are some of the potential threats to the Caribbean fishery. These factors have negative impacts on the production and distribution of fishery resources regionally as well as globally (Haughton et al., 2001).

The countries of CARICOM have a relatively poor record of fisheries management. The major constraint to proper management in the Caribbean is the weak institutional capacity of the responsible agencies. The fisheries management agencies in the region are set up to promote fisheries development, but they are not equipped, organized or empowered to deal with the complex task of fisheries management and the sustainable development of the marine resources. The factors that contribute to poor management include irresponsible fishing practices (Figure 15), inadequate knowledge of the fish stocks, the marine ecosystems and the social and the economic conditions of the fisheries.

Figure 15:
The irresponsible fishing practice of harvesting juvenile fish and shellfish is harmful to the health of the fish stock



Source: FAO, 2009b

There are also inadequate long term policies, inadequate human and institutional capacity for research, planning and decision making. In addition, resource users are not sufficiently included in the planning and decision making process. Monitoring, surveillance and enforcement efforts are insufficient. Also in need of upgrading are the post-harvest handling, process and marketing procedures as well as the port and shore based facilities (Haughton et al., 2001). Caribbean fishers are concerned that they are seeing smaller catches with the fisheries being of smaller size. Also of concern are the lack of awareness of regional development in the sector and lack of information related to overexploitation of particular fishing grounds. Fishers now need a management structure to guide them on how to regulate their fishing and to diversify their sources of income (CARICOM, 2009).

As indicated earlier, an invasive species is one whose establishment and (often rapid) spread threaten ecosystems, habitats or other economic species. Many invasive species are also “alien” meaning that they are non-native, non-indigenous, foreign or exotic, having been deliberately or accidentally introduced to an area from their native range (Kairo et al., 2003). Invasive species represent the second largest threat to biodiversity in the Caribbean marine environment after habitat destruction because of their potentially harmful impact to the ecosystem (UNEP, 2008). There are an estimated 18 marine alien invasive species in the Caribbean, two of which have arrived within the last 20 years. The Asian green mussel (*Perna viridis*), which is native to the tropical Indo-Pacific, first appeared in the western hemisphere in Trinidad and Tobago in 1990 and is now found in Venezuela, Kingston Harbour and Tampa Bay, Florida.

Introduction to the Caribbean is believed to have been from ballast water and subsequent dispersal either by ballast water or the prevailing currents (Ray, 2005). The Asian green mussel compete for space and tends to take over and dominate any hard substrate if settles on. More recently the lionfish (*Pterois volitans*), which is also on Indo-Pacific origin was first sighted in Florida after Hurricane Andrew in 1992 and has since spread to a far east as Trinidad and Tobago and as far south as Columbia. This voracious predator has very few known enemies and has an insatiable appetite for small marine organisms, particularly juvenile fish such as snappers, groupers as well as shrimp, lobster and crabs of commercial importance. The lionfish if left unchecked is likely to put a further strain on declining fish stocks as they target the same fishes as the fishers (Sundaravadanan, 2009).

Management Options and Solutions

The Caribbean Regional Fisherfolk Network (CRFN), established as the regional representative on policy decision-making at the state and regional level, would have to contend with the myriad of concerns of fishers, the remoteness of some of the communities and existing lack of organization in these communities. Through the Network and with the assistance of the Caribbean Regional Fisheries Mechanism (CRFM), it is hoped that capacity will be built in areas required to meet the needs of the fishers and the associated communities.

Community-based management approaches, might lead to restrictions on collection and export of threatened and endangered species with replacement by farm bred species. Establishment of hatcheries can assist in eggs and larval survival as well as the survival of juveniles when released in the wild.

Consumers, in particular those in the developed world, must be active agents for achieving sustainable fishing practices and healthy fish stocks. From a consumer’s point of view – at least in most developed nations – the sad condition of fish stocks is not obvious. There are still plenty of fish available in markets and restaurants, although the types may have changed and the prices may be higher. Commercial

fishing is driven by demand and the authors contend that consumers need to be more conscious of which fish are sustainably harvested.

Further Research -Emerging Issues and Future Challenges

In order to ensure the sustainability of our fishery, both globally and regionally research on areas of interest like; integration and multi-trophic aquaculture, organic aquaculture, as well as genetic modification of cash crops like wheat, rice and tomatoes to develop high yield, salt-tolerant varieties need to be carried out. This should be in tandem with improved enforcement, assessment, analysis, record keeping and communication, especially in the Caribbean.

Ongoing research areas should include enhanced growth rates and enhanced 'salt-loving', reduced water/nutrient requirements, irrigation efficiency improvement, plant/life form tailored for specific bioconversion and processes refining, safe/contained saline/seawater irrigation practices to avoid freshwater aquifer contamination. The suggested seawater agriculture biomass solution mix should include seawater irrigation near dry and flattish coastal area. Saline irrigation where saline aquifers are available at reasonable pumping depths and seawater irrigation inland where economics appear feasible which is likely to enhance rainfall induced irrigation (Bushnell, 2008)

Farmers should be encouraged to be innovators and to share their improved technologies. Farmers tend to be keen to learn from other farmers, to accept innovations observed in the field of other farmers working in similar conditions. Innovators are likely to improve their production and their income as well as expand their resource base. Innovators are likely to influence others.

Partnerships can also be built with researchers for programmes that are farmer driven rather than researcher driven; the government needs to also find out what is happening in the field. Researchers need to communicate with the farmers as equals and be willing to listen and learn from them. Building on farmer innovation represents a fundamental change in the role of extension officers. The researchers should also be able to facilitate knowledge exchange among farmers as well as between farmers and extension officers.

The creativity of farmers is a major untapped resource that can be used in realizing the potential of agriculture and rural development and represents an opportunity for policy makers and scientists to embrace farmer innovation as a valuable tool in agricultural transformation (Reij et al., 1992).

The attainment of food security in the region will remain elusive because the region has not reached an adequate level of agricultural productivity nor made significant investment in process and agro-related industries.

Research needs for saline agriculture (National Research Council, 1990)

- The development of salt tolerant cultivars of existing crop species;
- Exploration of new species to identify candidates for economic development;
- In vitro selection of genotypes tolerant to high salinity levels to improve adaptability of conventional crops;
- Improved dialogue and cooperation between plant ecologists, plant physiologists, plant breeders, soil scientist and agricultural engineers to aid in the development of economic crops; and.
- Development of specialised programmes at regional research institutions to further characterize saline agriculture and to explore the options for the region.

Diversification of products from the sea

Cultivation of invertebrate species for biomedical compounds and pharmaceuticals can lead to the development of innovations in species culture and their products. Ocean management needs to move beyond single-sector management and towards comprehensive ecosystem-based management if it is to be effective at protecting and sustaining ocean health. The study results show that hotspots of cumulative impact are in coastal areas near urban centres and heavily polluted watersheds.



Policy to direct activities around an ecosystem-based management strategy is especially needed for coastal areas near urban centres and heavily populated watersheds.

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