Farming Change

growing more food with a changing resource base

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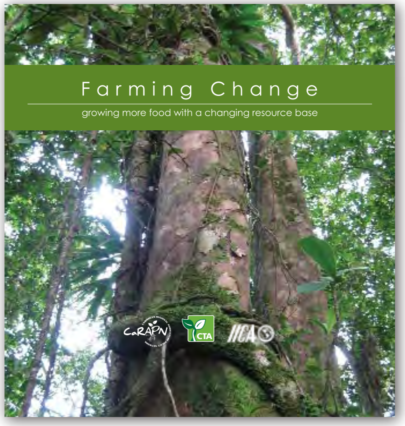
Cover Photo: Dr. Jenny Daltry of Flora and Fauna International (FFI) taken in the rainforest at Mount Troumassee, Saint Lucia during the forest inventory.

Critical Issues Perspectives and Options (CIPO)

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

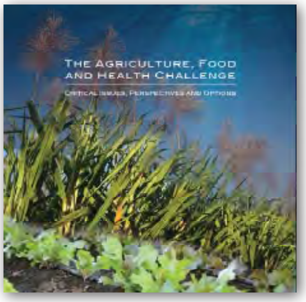


This third issue on 'Farming Change, growing more food with a changing resource base' comprises three inter-related papers, which explore the topics from a Caribbean situation and perspective.

i. Soil Loss: growing food crops without soil;
ii. Forest Cover: securing ecosystem services for sustainable farming;
iii. Species under Siege: combating the IAS threat

These topics should be of strategic interest to Caribbean countries, individually and as a region, as they seek to address the myriad and inter-connected challenges of sustainable agricultural development and food and nutrition security.

The previous issue 'The Agriculture, Food and Health Challenge' 2009, discussed topics of 'Agriculture – linking Food and Health', 'Agriculture for Food or Fuel or Both' and 'Food from the Sea'. A conclusion common in all papers is that countries cannot act alone in addressing existing and emerging challenges. All three authors called for greater regional collaboration (beyond just the usual public-private sector partnership) to include consumers and civil society.



Acronyms and Abbreviations

ACLP	Alternative Community Livelihoods Programme
AOSIS	Alliance of Small Island States
APHIS	Agricultural Plant Health Inspection Service
BLI	Bird Life International
CABI	CAB INternational
CANARI	Caribbean Natural Resources Institute
CARICAD	Caribbean Centre for Development Administration
CARICOM	Caribbean Community
COTED	Caribbean Community Council for Trade and Economic Development
CBD	Convention on Biodiversity
CBO	Community Based Organisation
CCCC	Caribbean Community Climate Change Centre
CEHI	Caribbean Environmental Health Institute
CEP	Caribbean Environmental Programme
CFF	Carambola Fruit Fly
CGD	Citrus Greening Disease
CIDA	Canadian International Development Agency
CIMH	Caribbean Institute for Meteorology and Hydrology
CIPO	Critical Issues Perspectives and Options
C&I	Criteria and Indicators
CITES	Convention on International Trade in Endangered Species
CO_2	Carbon dioxide
COP	Conference of the Parties
CWSA	Central Water and Sewerage Authority
DFID	United Kingdom department for International Development
ECIAF	Eastern Caribbean Institute of Agriculture and Forestry
EEZ	Exclusive Economic Zones
ENSO	El Niño Southern Oscillation
FACRP	Fondes Amandes Community Reforestation Project
FAO	Food and Agricultural Organisation of the United Nations
FCPF	Forest Carbon Partnership Facility
FEE	Foundation for Environmental Education
FNS	Food and Nutrition Security
FUG	Forest Users Group
GAP	Good Agricultural Practices
GCMs	Global Climate Models
GCR	Greater Caribbean Region
GDP	Gross Domestic Product

GEF	Global Environment Facility
GOSL	Government of Saint Lucia
GoSVG	Government of Saint Vincent & the Grenadines
IAS	Invasive Alien Species
IFAS	Institute of Food and Agricultural Sciences
IFMDP	Integrated Forest Management and Development Programme
IICA	Inter American Institute for Cooperation on Agriculture
IPCC	Intergovernmental Panel on Climate Change
IPPC	International Plant Protection Convention
ISPM15	International Standards for Phytosanitary Measures No.15
ITTO	International Tropical Timber Organization
IUCN	World Conservation Union
IWCAM	Integrating Watershed and Coastal Area Management
LFMC	Local Forest Management Committees
LPG	Liquid petroleum gas
LWM	Land and Water Management
LWR	Land and Water Resources
MALFF	Ministry of Agriculture, Lands, Forestry & Fisheries
MAFF	Ministry of Agriculture, Forestry and Fisheries (Japan)
MCM	Million Cubic Metres
MDGs	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
METI	Ministry of Economy, Trade and Industry (Japan)
MRV	measuring, reporting and verification
NASA	North American Space Agency
NGO	Non Government Organisation
NTFPs	Non Timber Forest Products
NRMU	Natural Resource Management Unit
NWC	National Water Commission
NWFP	Non-Wood Forest Products
O_2	Oxygen
OECS	Organisation of Eastern Caribbean States
PES	Payment for Environmental Services
PFE	Permanent Forest Estate
PHMB	Pink Hibiscus Mealy Bug
PM	Propagative Material
PMU	Programme Management Unit
QM	Quarantine Material
REDD	Reducing Emissions from Deforestation and Forest Degradation
SBSTA	Subsidiary Body Scientific and Technological Advice

SFM	Sustainable Forest Management
SIDS	Small Island Developing States
SPH	Stems per Hectare
TBT	Tropical Bont Tick
TTABA	Trinidad and Tobago Agribusiness Association
TWCG	Talvern Water Catchment Group
UK	United Kingdom
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNFCCC	United Nations framework Convention on Climate Change
UNWTO	United Nations World Tourism Organization
USA	United States of America
USDA	United Stated Department of Agriculture
USGS	United States Geological Survey
UTT	University of Trinidad and Tobago
UWI	University of the West Indies
VINLEC	St. Vincent Electricity Services Ltd.
WCR	Wider Caribbean Region
WPM	Wood Packaging Material
WSSD	World Summit on Sustainable Development
WTTC	World Travel and Tourism Council

GLOSSARY

Word/Term	**Meaning, explanation**
Aggrade	To build up a land surface or streambed through the natural deposition of material
Agricultural biodiversity	The diversity of crops and their wild relatives, trees, animals, microbes and other species contributing to food production (Emile Frison, Director General of Biodiversity International)
Amendments	A soil amendment is any material added to a soil to improve its physical properties, such as water retention, permeability, water infiltration, drainage, aeration and structure. The goal is to provide a better environment for roots. To do its work, an amendment must be thoroughly mixed into the soil. Amending a soil is not the same thing as mulching, although many mulches also are used as amendments. (www.ext.colostate.edu/pubs/garden/07235.html)
Bio-augmentation	A technique to improve the degradative capacity of contaminated areas by introducing specific competent strains or consortia of microorganisms to increasing the activity of bacteria that decompose pollutants
Biota	The types of plant and animal life found in specific regions at specific times. All the plant and animal life of a particular region. The organisms that occupy an ecological niche or ecosystem. (http://www.biology-online.org)
Biodiverse / biodiversity	The degree of variation of life forms within a given ecosystem, biome, or an entire planet. Biodiversity is a measure of the health of ecosystems. Greater biodiversity implies greater health. Biodiversity is in part a function of climate. In terrestrial habitats, tropical regions are typically rich, whereas polar regions support fewer species. (http://en.wikipedia.org/wiki/Biodiversity)
Bio-geographical	The study of the distribution of species (biology) spatially (geography) and temporally (history). Biogeography aims to reveal where organisms live, at what abundance, and why they are (or are not) found in a certain geographical area
Bio-remediation	is a natural biological process which relies on bacteria, fungi, and plants to degrade, break down, transform, and/or essentially remove contaminants or impairments of quality from soil and water. (http://waterquality.montana.edu/docs/methane/Donlan.shtml).
Biosphere	The part of the earth and its atmosphere in which living organisms exist or that is capable of supporting life. It is the planet's life support system

Word/Term	**Meaning, explanation**
Biopores	Small (≤1cm) soil-sediment pores produced by biota. (https://netfiles.uiuc.edu/jdomier/www/temp/drift_glossary.html)
Bio-stimulation	The addition of nutrients (primarily nitrogen and phosphorus sources) and other substances to soil to support microbial growth (to catalyze natural biological processes that degrade, break down, transform, and/or essentially remove contaminants or impairments of quality from soil and water) (http://waterquality.montana.edu/docs/methane/Donlan.shtml).
Cation	A positively charged ion, i.e., one that would be attracted to the cathode (negative electrode) in electrolysis. (www.thefreedictionary.com/cation)
Ecozone	The largest scale biogeographic division of the Earth's land surfaces, based on the historic and evolutionary distribution patterns of terrestrial plants and animals. (http://en.wikipedia.org/wiki/Biogeographical)
Endemic species/ endemism	Species that are unique to the specific geographic location
Eutrophication	The process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates. These typically promote excessive growth of algae. As the algae die and decompose, high levels of organic matter and the decomposing organisms deplete the water of available oxygen, causing the death of other organisms, such as fish. Eutrophication is a natural, slow-aging process for a water body, but human activity greatly speeds up the process. (http://toxics.usgs.gov/definitions/eutrophication.html).
Global Climate Models (GCMs)	mathematical models widely applied for weather forecasting, understanding the climate, and projecting climate change.(http://en.wikipedia.org/wiki/Global_climate_model)
Igneous rock	Rocks formed by the cooling and solidifying of molten materials, beneath the Earth's surface, or at its surface, as lava. (http://dictionary.reference.com/browse/igneous+rock)
Leaching	loss of soluble substances and colloids (tiny particles of soil), from the top layer of soil by percolating precipitation. The materials lost are carried downward (eluviated) and are generally redeposited (illuviated) in a lower layer. This transport results in a porous and open top layer and a dense, compact lower layer. The rate of leaching increases with the amount of rainfall, high temperatures, and the removal of protective vegetation. (http://www.britannica.com/EBchecked/topic/333492/leaching)
Organic carbon	Tissues from dead plants and animals. Products produced as these decompose and the soil microbial biomass

Word/Term	**Meaning, explanation**
Metamorphic rock	Metamorphic rocks arise from the transformation of existing rock types, in a process called metamorphism, which means "change in form". The original rock (protolith) is subjected to heat and pressure, (temperatures greater than 150 to 200 °C and pressures of 1500 bars) causing profound physical and/or chemical change. The protolith may be sedimentary rock, igneous rock or another older metamorphic rock.
Natural attenuation	a variety of physical, chemical or biological processes that, under favourable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. (www.nicole.org/training/naturalatten/copenhagenoverviewfinaldraft.PDF)
Neo-tropics	The Neotropic or Neotropical zone is one of the world's eight terrestrial ecozones. This ecozone includes South and Central America, the Mexican lowlands, the Caribbean islands, and southern Florida, because these regions share a large number of plant and animal groups. (http://en.wikipedia.org/wiki/Neotropics)
El Niño Southern Oscillation (ENSO)	A quasiperiodic climate pattern that occurs across the tropical Pacific Ocean with on average five year intervals. It is characterized by variations in the temperature of the surface of the tropical eastern Pacific Ocean, warming or cooling known as *El Niño* and *La Niña* respectively. ENSO causes extreme weather (e.g. floods and droughts) in many regions of the world. (http://en.wikipedia.org/wiki/El_Ni%C3%B1o-Southern_Oscillation)
Non Timber Forest Products (NTFPs)	Considered as any commodity obtained from the forest that does not necessitate harvesting trees. It includes game animals, fur-bearers, nuts and seeds, berries, mushrooms, oils, foliage, medicinal plants, peat, fuel wood, forage, etc.(http://en.wikipedia.org/wiki/Non-timber_forest_products)
Payment for Environmental Services (PES)	Broadly defined, is the practice of offering incentives to farmers or landowners in exchange for managing their land to provide some sort of ecological service. These programmes promote the conservation of natural resources in the marketplace. (http://en.wikipedia.org/wiki/Payment_for_ecosystem_services)
Permanent Forest Estate (PFE)	Consists of legally established forest reserves, protected forests and communal forests
pH	A measure of the acidity or alkalinity of an aqueous solution

Word/Term	**Meaning, explanation**
predation	A form of symbiotic relationship between two organisms of unlike species in which one of them acts as predator that captures and feeds on the other organism that serves as the prey.
'Protected agriculture'	Agricultural production systems that are characterized by the use of plastic-house technology, amongst others, in providing an environment for crop growth that is protected from weather-based hazards
rhizosphere	The part of the soil that is in the vicinity of plant roots
Sustainable Forest Management (SFM)	Forest management according to sustainable development principles. SFM uses very broad social, economic and environmental goals as initially outlined in the "Forest Principles" adopted at The United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992. It captured the general international understanding of sustainable forest management at that time. (http://en.wikipedia.org/wiki/Sustainable_forest_management)

Contents

The Wider Caribbean Region

Location

The Wider Caribbean Region (WCR) comprises the marine environment of the Gulf of Mexico, the Caribbean Sea and the surrounding areas of the Atlantic Ocean.[1] (Fig.1) Also known as the neotropics, the WCR includes all countries bordering the Caribbean Sea, from the U.S. Gulf States (Florida, Alabama, Mississippi, Louisiana, and Texas) in the north to French Guiana, on the North Coast of South America, in the south and east.

The Caribbean is more than sun, sea and sand. It comprises multi-ethnic, multiracial, multilingual societies that have demonstrated resilience since the pre-Columbian era. This resourceful ability to survive has always depended on the ingenuity of its people to adapt to their circumstances, their environment and to make skilful use of natural resources, including soil, forests and biodiversity. Such resourcefulness will be even more critical to meet/adjust to 21st century development challenges.

1 is defined in Article 2.1 of the Cartagena Convention

Figure 1: The Wider Caribbean Region

Note #1: Characteristics Common to SIDS

http://www.unep.org/PDF/SIDS/SIDS-Booklel-4March.pdf

Except for Belize, Guyana and Suriname, the Caribbean is among the three regions of the world dominated by Small Island Developing States (SIDS). SIDS share certain common vulnerabilities. Problems of environmental degradation, increasing frequency and intensity of natural disasters, habitat destruction and depletion of natural resources. These issues are all addressed in the 2005–2015 United Nations Mauritius Strategy for sustainable development of SIDS. It calls for urgent attention to the current state of SIDS natural resource base - soils, land, forests, fresh water and marine resources - within a sustainable development agenda.

SIDS are economically vulnerable because of their geographic dispersion, small domestic markets, low economic diversification, high dependence on traditional primary exports, and inability to capture economies of scale in industry, education, health, public utilities, public administration, and other infrastructure.

They are environmentally vulnerable because of their extremely fragile natural ecosystems that include coral reefs, wetlands, freshwater, coastal and marine areas, and forest and soil resources. They are socially vulnerable when external forces bring stresses and hazards, with which they have less capacity to respond.

The interdependence between economic activities and ecology is evident throughout these Island States.

Tourism is by far the fastest-growing economic sector in all SIDS regions. Earnings from tourism as a proportion of total exports exceeded 20% in 19 SIDS, 30% in 13, and 40% in 8. In Antigua the proportion is 86%, in Bahamas 84%, St Lucia 75%, Maldives 70%, Barbados 59% and St Kitts and Nevis 52%. Yet tourism as currently developed often spoils the very environment on which it depends. Development destroys mangroves and wetlands, yachts and divers damage coral reefs and hotels and cruise ships may discharge raw sewage into the sea.

Where agriculture is the dominant economic activity, its present and future productivity will be determined by soil quality and freshwater resources. In one out of every four SIDS, agriculture contributes more than 20% of the gross domestic product (GDP). Agriculture ranges from plantations of sugarcane and banana to subsistence crops of roots and tubers. It is the major source of income and export earnings. Now, indiscriminate trade liberalization is threatening the future of these traditionally important export crops.

Where tourism and fisheries are the major industries, the States must use their marine and coastal environments intensively. It is therefore clear that further tourism, agricultural or fisheries development without the necessary environmental and social safeguards will be destabilizing. Already, high population densities in many SIDS have increased pressure on land resources and wildlife; intensified demand for facilities to deal with waste on both land and sea; contributed to coastal areas being degraded, adversely affecting beaches, mangroves and coral reefs; and unsustainably used scarce freshwater resources.

Resources of the Caribbean - A Snapshot

SOILS

Soil, described as the planet's life support system, is indispensable to food crop production. For a small total land mass, the Caribbean region is exceptional for the wide range of variability of its soils derived from a wide range of soil parent materials and variability in other soil forming factors. The current land forms resulted from a series of metamorphic, igneous, volcanic and sedimentary processes and activities which gave rise to the potential for many different kinds of soils. In general, the soils of the region are not typical of tropical soils because many of them are developed on nutrient rich parent materials. Fortunately, they have not been exposed long enough for exhaustive leaching of plant nutrients to occur.

FORESTS

Forests, referred to as the 'lungs of the world', cover roughly one-third of Earth and are host to 80% of terrestrial biological diversity. The Caribbean is located within an ecozone that supports warm, moist climate and tropical forests, including rainforests. In relation to its size and geographical make-up, the current range of natural forests occurring in the Caribbean is characterized by rich heterogeneity and diversity typical of the tropics. Estimated total forest cover in the wider Caribbean stands at 38,091 ha., or 61% of total land area, most of which are found in Suriname and Guyana. There are at least nine distinct categories of forests occurring in the Caribbean region, each playing a vital role in maintaining socio-economic activity and biodiversity.

BIODIVERSITY

Genetic diversity, the planetary gene pool, is crucial for resilience of all life on Earth. The WCR has been designated as one of the world's biodiversity hotspots and spans 4.31 million km^2 of ocean and 0.26 million km^2 of land.[2] The Caribbean also borders the Mesoamerica biodiversity hotspot[3] and a number of near-shore and offshore islands in the Caribbean Sea are biologically important for their endemic species (i.e. the species are unique to the specific geographic location) and as nesting areas for seabirds. The WCR supports extremely diverse marine (sea-based), freshwater and terrestrial (land-based) ecosystems of global ecological and economic importance. The marine ecosystems surrounding the Caribbean islands, comprise a major share of the world's important biodiversity, designated as a Special Area by the United Nations (UN) in 2002. The region's rich source of diversity in flora, fauna, microbes and in particular the high levels of endemic species, may be the most abundant resource, second to human capital, for sustainable development of the Caribbean.

2 http://www.biodiversityhotspots.org/xp/Hotspots/caribbean/
3 http://www.biodiversityhotspots.org/xp/Hotspots/mesoamerica/


(Photo: CARDI)

Farming Change

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About the Theme

From colonialisation, through early independence, during the transition from preferences to free markets and in the contemporary period, agriculture in Caribbean countries has been synonymous with the farm sector, or primary production. The farm sector, dominated by crop production, attracted multiple descriptors, depending on the area of interest and perspective. The terms 'Industry' and 'large scale farming' were used to describe the traditional, monoculture export crops, mainly banana, rice, sugarcane, cocoa, coffee, nutmeg and citrus. These crops were allocated the best lands and 'benefitted' from continuous use of agrochemicals. The term 'food crop sector' was relegated to a range of small scale, short term crops, dominated by roots and tubers, vegetables and plantain among others. With the 'best' lands under traditional crops, forest or non-agriculture use, food crop production occurred largely on 'marginal lands' usually on steep slopes. This crop farming profile changed little over the decades.

This farming crop profile has demonstrated 'resilience' in the face of natural hazards, mainly hurricanes, periodic droughts and the occasional 'exotic' pest and disease. Farming systems have also exhibited 'resistance' to changing international trade policies, consumer demands and new technologies that demanded a shift from commodity-based to market-led operations and deep structural change. However, the 21st century presents one significant and indisputable force that will irreversibly alter the context for farming climate change!

The region is extremely vulnerable to climate variability. Unless critical actions are taken now, the impacts on the environment, economy and society are projected to be severe. As emphasised by Governments of the Caribbean Community at the Thirtieth Meeting of the Conference in Liliendaal, Guyana in July 2009, *"...dangerous climate change is already occurring in all Small Islands and Low-lying Coastal Developing States including the Caribbean and many SIDS will cease to exist without urgent, ambitious and decisive action by the international community to reduce global greenhouse gas emissions significantly and to support SIDS in their efforts to adapt to the adverse impacts of climate change".*

Already food production is being affected by (a) the steady and continuous loss of top soil and reduction of resources for food crop production; (b) the looming threat of water scarcity and implications for food production and desertification and (c) the increased vulnerabilities of a weakened environmental system to invasive alien species and consequently, the threat of biodiversity loss. These issues are inextricably linked and in an era of climate change, their cumulative impacts would be disastrous for Caribbean countries.

The theme of this CIPO – Farming Change – was chosen to provoke thought from two perspectives: i.e., whether farming in the Caribbean has changed over time, and especially now, in response to food and nutrition security imperatives; and whether agriculture and the farm sector in particular, are poised to take advantage of the dynamics of the changing natural environment in a manner that provides sustainable environmental, social and economic benefits for the economies, societies, and communities in the Caribbean. This CIPO focuses largely on the second perspective, i.e., the changing situations in the agriculture natural resource base and the implications for sustainable farming and food production.

This CIPO edition begins with a discussion on 'Soil'. In a paper titled 'Soil loss – growing food crops without soil' Professor Nazeer Ahmad points out that 'naturally occurring' soils in the Caribbean are facing dire circumstances, a situation that goes largely unnoticed and underappreciated.

Professor Ahmad is convinced that soil will continue to be the base for life on Earth, the foundation of forests and eco-systems and the platform for food production. Ahmad establishes up front, exactly what soils are and their critical functions. With a better understanding of the resource itself, Ahmad attempts to explain the origins and types of soils of the Caribbean, and their suitability to a range of uses, including food production. The author is quick to emphasise however that over time, poor land use and management practices have undermined soils and reduced their fertility and productivity, thus compromising food production.

This sets the stage for the discussion on soil loss, specifically, the main causes of land degradation. It is well understood that farming is part of both the problem and the solution. Given the scale of resource degradation globally and rising concerns over food and nutrition security, soilless food production technologies are emerging as an integral part of a solution. However, Ahmad notes that despite advancing soilless technologies, several Caribbean countries may not have the capacity to maintain the levels of investment required to sustain food production on soilless cultures and at the same time, secure affordable food supplies. As a way forward, Ahmad offers some options for Caribbean countries to preserve and rebuild the remaining soil resources of the Caribbean through a combination of enabling policies, good practices and appropriate knowledge and technologies.

While soil loss is indeed a critical issue for the region, it is one that can be addressed and reversed through effective policies and concerted actions. So too, can issues related to forest destruction, through policies, practices and importantly, enhancing awareness and appreciation of the vital functions and roles of these critical resources. This is the subject of the second paper, 'Forest Cover – securing ecosystem services for sustainable farming', which brings attention to the importance of, and threats to, forests in the Caribbean. This discussion is timely, since countries around the world are building climate change adaptation and mitigation strategies around their forests.

According to Cecil Lyndon John, tropical forests are important in balancing eco-systems and supporting the physical and biodiversity base for farming. In promoting understanding of the resource, John describes the types of forests in the Caribbean and their ecosystem functions and services. This leads into discussion on the main ways in which forest resources are utilised in development, including provision of water supply and soil protection to sectors such as agriculture, tourism and housing.

Despite its importance and with periodic disturbance by natural events, such as hurricanes, forests in the Caribbean are being continuously felled for fuel wood (charcoal), food production (farming) and other economic activities (e.g. tourism). In emphasising soil formation, retention and nutrient cycling as core and basic functions of forest ecosystems, John singles out crop production on hillsides as one of culprits of deforestation and land degradation. This reiterates the point made by Ahmad that agriculture is also a main factor in land degradation and soil loss.

John places serious emphasis on the link between intact forests, weakened natural systems and vulnerability to climate change impacts. By 2050, climate change projections suggest an overall warming of between 1 and 5ºC or greater (depending on the scenario used). This warming far exceeds natural variability. By now it is well appreciated that the state of the region's forests resources will play a key role in determining countries' capacity to adapt and mitigate climate change impacts. In this regard, John urges Caribbean countries to follow and engage in the global discourse on adaptation/mitigation strategies, particularly the Reducing Emissions from Deforestation and Forest Degradation (REDD and REDD+), which seeks to conserve tropical forests found mainly in developing countries, including in the Caribbean.

John concludes by reiterating that tropical forests and their ecosystem functions and services, are under threat mainly from indiscriminate and destructive human activity. A likely outcome from continuation of such activities is that tropical forests in the region can expect to lose ecosystem diversity. To avert this likelihood countries will need to adopt a new approach to forest management policy and planning that is fully integrated into national development planning. John agrees with Ahmad's conclusions that the issue of effective planning is perhaps the most immediate and important need to ensure sustainable forest management and preserve the functions of forests.

Poor practices and climate change are not the only threat to the Region's natural resources and biodiversity. Caribbean countries have, for sometime now, been confronting an insidious and never-ending threat to its biodiversity:- invasive alien species (IAS). Like a rapidly growing cancer, invasive plant and animal alien species have the potential to exacerbate the problems of soil degradation and to do significant damage to the agriculture potential in the region.

Naitram Ramnanan, a CAB International specialist, tackles the issue of biodiversity destruction, including the impacts on economically important crop and animal species for food production, by focussing on the IAS threat. 'Exotic pests and diseases' are not an unknown factor in Caribbean agriculture. However, within the broader category of IAS, their potential to transform biodiversity and the implications for agriculture and the wider economy are only now being documented, studied and understood.

"Species under Siege: combating the IAS threat", Ramnanan reemphasises the importance of the region's biodiversity in balancing eco-systems and supporting the physical resource base for food production, provision of basic utilities, tourism services and industry. Next to human capital, biodiversity is the most valuable resource in the Caribbean. It is well understood that human activity is a major threat to, and key factor in the destruction of the Region's vast and unique wealth of biodiversity. Indeed, Ramnanan warns that some unique species are under siege and at risk of being altered and in some cases lost on account of the introduction of IAS.

Ramnanan pays special attention to explaining what an IAS is, how they are introduced to the Caribbean and the type of threats they present. It is now widely agreed that IAS have adverse, broad environmental, public health, social and economic impacts and is a major threat to agriculture and food production. Early detection and preventative measures are invaluable to combating the IAS threat and preserving agricultural biodiversity. The author uses past and recent experiences in response to IAS introductions in the Caribbean to emphasise the importance of a continuous and integrated prevention, control and management programme of which surveillance is essential. The author concludes with the main areas requiring attention and offers what could be considered pre-requisites for addressing the IAS threat in agriculture specifically and in the Caribbean in general.

The separate yet inter-related discussions on soils, forests and biodiversity, converge towards a critical conclusion – that while they are all essential to sustainable food production, these natural resources are under threat from human activity. For the resource-scarce and vulnerable Caribbean, saving soils, forests and species and promoting efficient and sustainable use of these resources can offer tremendous scope for future development and resilience in an era of climate change and economic volatility. These three topics are presented together to underscore their critical connections and emphasise the need for integrated assessments, policy formulation and development interventions at both national and regional levels.

"The nation that destroys its soil, destroys itself."

Franklin D. Roosevelt

(Photo: IICA Guyana)

Soil Loss:
Growing food crops without soil

Professor Nazeer Ahmad
Professor Emeritus of Soil Science,
The University of the West Indies,
St. Augustine, Trinidad and Tobago

Introduction

growing food crops without soil

Introduction

In late 2007, global food prices started to soar. In response, Caribbean countries re-emphasised the need to 'grow more food' promoting roots, tubers and vegetables, among others. Between 2010 and 2011, Jamaica took steps to expand white potato production and along with Trinidad and Tobago reintroduced rice production for domestic consumption. Belize also entered into partnership with Jamaica to grow and export corn for poultry and other livestock feeds.

The growing competition for land resources encouraged more intensive farming, i.e., increasing yields and output on the same amount of land. Efforts were also made to improve production systems and enhance efficiency of agro-chemical use. In countries with access to under-utilised and/or unallocated lands, farming areas were extended to meet the objective of growing more food. However, in some instances, these 'new' lands included substantial parts of forests. The drive to 'grow more food' also sparked renewed interest in improving farming systems, mainly 'protected agriculture systems', as a measure to reduce the myriad risks associated with open-field crop production.

Inspite of a growing interest in protected agriculture and other efforts to modernise and transform agriculture through the application of technologies, farming in the Caribbean, is still basically, soil-based under open field conditions. The quality of soils, therefore, remains a key determining factor in the ability to 'grow more food'.

Growing enough food is now a common global concern, even in countries with a limited agriculture tradition and/or limited physical capacity to grow food. Soil, described as the planet's life support system, is indispensable to food crop production- at least it used to be! However, scientists have and continue to explore all possible options to grow food without soil. This search is being driven by the global challenge for securing food and nutrition needs of a burgeoning world population with a dwindling pool of natural resources, notably land and water. One example is desert farming. Israel, considered to have low-quality water and terrible soil, has pioneered innovative technologies such as, drip irrigation to grow produce like cherry tomatoes, peppers, asparagus and melon, for export, mostly to Europe.[(4)] In other situations, countries are taking measures to save their remaining soil resources from further land degradation or change of use, to secure food production. With the notable exception of Haiti, which is considered to be severely (estimated at 98%) deforested, the latter situation is more reflective of Caribbean countries.

4 In the desert, fish farming is a fertile enterprise, by Dina Kraft, published: Wednesday, January 3, 2007 http://www.nytimes.com/2007/01/03/health/03iht-snisrael.html?_r=1

Complementing soil-based farming with soilless technologies could be considered part of a long term solution. However, success of soilless technologies will depend on capacity to produce a wide range of large quantities of basic foods at affordable prices. Given the state of soil resources and the adverse impacts of climate change, growing more food may well become a fragile balance between more efficient use of remaining soil resources and cost-effective soilless systems.

This paper raises awareness of the role of soil in the region's socio-economic development. It brings attention to both the state of soils for food production and trends and scope of soilless technologies for growing more food.

- Part 1 places soils in context positioning top soil, in particular, as a strategic resource that has supported crop and livestock industries in the Caribbean for over four decades.
- Part 2 discusses soils of the Caribbean, their main properties and suitability for a range of economic activities with a focus on farming. This is based on a more comprehensive publication on Soils of the Caribbean.[5]
- Part 3 addresses changing land use patterns and the resulting impacts on soils. Intensive agriculture in relatively small areas, progressive forest felling and acute deforestation as well as for housing, especially construction on slopes and arable lands are among the chief culprits of land pollution, significant run-off and soil erosion. These produce deleterious downstream effects in water ways and coastal marine eco-systems. If left unchecked, farming, available water resources and capacity to adapt to changing climates, among others, will all be compromised.
- Part 4 explores available soilless options for growing more food amidst rapid resource depletion. Such technologies, especially those that emphasise soil and water saving, are also rapidly transforming farming systems and practices. Some of the growing inventory of such technologies are profiled and discussed in terms of their 'suitability' and 'capability' for expanding food production in a Caribbean context.
- Part 5 summarises and concludes with an acknowledgment that in the immediate and short-term, soil-based farming systems will continue to present the most viable options for growing food. The need to save both the quantum and quality of soil resources in the region cannot be understated. The arguments for exploring opportunities and scope for adopting soilless/soil-saving farming technologies are valid, particularly where such technologies are appropriate and complementary to farming systems in the Caribbean. However, caution is still advised with respect to land use and management with the ultimate long term goal being to preserve remaining soils. The time is now ripe to give due consideration to approaching sustainable management of soils regionally, through more effective and collective institutional support for enforcement of land use legislation.

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5 Soils of the Caribbean, Professor Nazeer Ahmad, Ian Randle Publishers, Jamaica, 2011.

1. What on Earth is Soil?

1.1 Soil

Soil, is a thin layer of life covering much of the terrestrial surface. It acts much like a giant recycling system, providing food, feed, fibre[6] and increasingly, energy through crop production for biofuel. Soil makes up the outermost layer of the Earth's land surface, which can range anywhere from a few centimetres to hundreds of feet. This process of soil development yields a series of layers or horizons, each with distinctive characteristics or properties (Fig. 2).

Figure 2: General Soil Profile

An average soil sample is 45% minerals, 25% water, 25% air and 5% organic matter[1]

1. Litter Layer: an organic layer above the mineral soil consisting of fresh or partially decomposed organic material.
2. Top soil: is the mineral soil surface layer and consists of highly decomposed organic matter. It is the horizon most impacted by biological and human activity.
3. Sand and Silt: this layer has lost most of its nutrients to leaching and is light brown in colour.
4. Clay and Carbonates: sometimes referred to as the zone of accumulation due to settling of nutrients leached in the third layer.
5. Large Rocks and Parent Material: represents the weathered parent material.
6. Bedrock: is a deep accumulation of materials deposited over time – generally from geological activity.

Several soil-forming factors, including climate, relief, soil parent material, time and biological elements influence the formation, occurrence and distribution of soils. This occurs over a very extended process of decomposition of rock material, through weathering and erosion, weak acids (such as carbonic acid) in the atmosphere and the effects of man, vegetation and many other organisms living on or in the soil.[7]

This therefore, makes soil a non-renewable resource – meaning that its loss cannot be easily replaced.

6 Noorallah Juma, PhD, PAg, Global Soil Science Educators & Knowledge Managers www.pedosphere.com
7 'Soil and Water Management Module '1, Basic soil properties, (2010) by Ann McCauley, Soil Scientist, Clain Jones, Extension Soil Fertility Specialist and Jeff Jacobsen, Soil Scientist. http://landresources.montana.edu/SWM/PDF/Final_proof_SW1.pdf

SOIL SCIENCE 101

Soil has physical, chemical and biological properties and characteristics. The basic physical properties are permeability (the rate at which water moves through the soil), porosity (fraction of pore space in the soil which influences permeability), texture (the grains and mineral particle sizes in the soil) and structure (the way in which soil granules clump/aggregate). These properties affect the ability of air and water to move through the soil and thus its ability to support biota[8]. Texture is often considered the most important physical property that influences soil's other properties.

The chemical properties influence the exchange of nutrients within the soil and the plant's ability to utilize them. These properties are soil pH (concentration of hydrogen ions that determine the acidity or alkalinity of the soil); salinity of electrical conductivity (level of soluble salts); cation exchange capacity (capacity of the soil to hold cation nutrients important for both plant and microbial nutrition); organic matter content (decomposing plant and animal material that supply nutrients and aid aggregation); and the carbon to nitrogen ratio (the relative proportion of carbon and nitrogen which impact the rate at which organic matter decomposes).

Soil is the most biologically active element of the biosphere, In fact, soil is host to the largest pool of biodiversity of all bio-spheres.[9] Soil biota performs functions that contribute to its development, structure and productivity. Plants, in turn, support soil structure and porosity and supply organic matter through their shoot and root residue, providing soil micro-organisms with food. Soil fauna work as soil engineers, initiating the breakdown of dead plant and animal material, ingesting and processing large amounts of soil, burrowing 'biopores' for water and air movement, mixing soil layers and increasing aggregation. Soil micro-organisms represent its most diverse biotic group, with an estimated one million to one billion micro-organisms per one gram of agricultural top soil (Tugel and Lewandowski 1999.[10] The rhizosphere (the narrow zone of soil directly surrounding plant roots) is the most biologically active region of the soil.

8 The types of plant and animal life found in specific regions at specific times. www.biology-online.org

9 the part of the earth and its atmosphere in which living organisms exist or that is capable of supporting life

10 McCauley, Jones and Jacobsen et al. J. 2010. (ibid)

1.2 Benefits of Fully Functioning Soil

The concept of fully functioning soil may seem odd. However, it is an appropriate use of the term to underscore the importance of soil as a system and a strategic resource.

Soil abounds with life and unique characteristics, performing complex natural functions that are often difficult to observe in their entirety. Through its many types and combination of properties, fully functioning soil is valued either for its life-giving functions or as a life-less base or surface for construction/industrial activities. There are also a number of environmental services that soil contributes to through a soil-plant-environment (ecosystem) interaction, making it the most dynamic of biospheres on Earth. The life-giving role of soil derives from the natural functions of soil biology – often with no supplemental actions which substantially reduces the economic burden associated with functioning of modern economic activities.

Farming and food production are among the industries that use soil. Crop growth depends on maintaining the natural balance among the differently-sized mineral particles (which give soil its texture), water (held within pore spaces), air (primarily oxygen, carbon dioxide and nitrogen in similar location and around roots), nutrients (macro and micro) and trace minerals (contained within and supplied by organic and inorganic matter). In this way, soil is essential to large-scale farming since it acts as a reservoir and supplier of nutrients and water and a supportive medium for crop growth.

Soil supports human life by providing environment-maintenance functions, without which large-scale human interventions would be required to sustain life on the Earth's surface. Fully functioning soil also reduces the risk of floods and protects underground water supplies by neutralizing or filtering out potential pollutants[11].Waste-disposal/recycling at landfills, an essential necessity in burgeoning cities and urban centres, also make use of the soil's naturally-occurring micro and macro-organisms (e.g. bacteria and earthworms) for efficient operations.

Quite apart from using the soil itself as a resource, soil is increasingly being used as an inert substrate (base) in construction (residential, commercial, transportation infrastructure). In such uses, soil is generally not differentiated from land. It is perceived simply as the physical space/platform on which the respective physical structure can be built on or grounded. Hence in construction, it is its physical characteristics, i.e, bulk density and water-holding capacity not its biological properties that are of greatest value.

11 soilquality.org (Ibid)

In recent times, the biodiversity of soil has become a headline issue given the newly discovered avenues for use of soil-borne bacteria and fungi in the treatment of diseases such as cancer(12). Soils are also receiving heightened global attention in terms of their potential role in mitigating the effects of elevated atmospheric CO_2 (carbon dioxide) a prime factor in global warming. This is because soil represents the Earth's largest terrestrial stock of organic carbon.(13) Carbon (C), the active element of photosynthesis and the key structural component of all living matter(14), is essential to healthy crop production.

Land use and management practices designed to sequester (retain) C in soils can have additional environmental benefits, such as, reduced erosion, increased water holding capacity and increased below-ground biodiversity. Many therefore, view C sequestration in soils as a win-win strategy. However, attention has also been drawn to the fact that the amount of C that can be stored in soils is finite and can be reversed by a change back to previous land management practices or a change in climate.

Soil quality is defined as 'the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation.'

UDSA, Natural Resource Conservation Service - NSSH Part 624, Soil Quality, Definition and Purpose (624.00), http://soils.usda.gov/technical/handbook/contents/part624.html

12 BBC News. 2011. "Soil bacterium helps kill cancers". http://www.bbc.co.uk/news/health-14761417

13 Eleanor Milne, Soil organic carbon, (Dec. 21, 2009), http://www.eoearth.org/article/Soil_organic_carbon

14 Cutler J. Cleveland, Carbon (Nov18, 2008) Encyclopedia of Earth www.eoearth.org/article/Carbon?topic=49557

2 Soils of the Caribbean

The region has examples of the oldest geological (Precambrian) formations in the world, as in Guyana and Suriname, to the most recent, as in the volcanic islands of Dominica and Saint Lucia. Moreover, the number of soil types in the Caribbean space is very high for its small actual land area. This is the result of the combination of parent materials and climatic factors that influence micro-ecosystems and thus soil formation and type. Generally, soils in the Caribbean are either Derived or Residual.

Derived soils are from:

- recent marine and fresh water deposits, such as, the coastal soils of Guyana, Suriname and Belize and the peripheries of the swamps of Trinidad. With appropriate reclamation and water management, they can be productive for sugarcane, rice and even tree crops.
- pre Quaternary, marine and fresh water sediments, such as, the riverain soils of Guyana and Suriname and alluvial soils of Trinidad, Jamaica, Belize, Cuba and the Dominican Republic. These are among the region's most resilient soils, suitable for a wide range of crops. Unfortunately without adequate reclamation measures, they are subject to periodic flooding.
- older sediments such as the Coropina soils of Guyana and Suriname, low Pine Ridge soils of Belize, and similar soils in Cuba and the Dominican Republic. They are not suitable for agriculture as they are infertile and unproductive.
- calcareous materials, ranging from those on hard pure limestone to soft impure marly rock. These are productive and adaptable soils, except for those on hard pure limestone which are normally shallow. This group also includes the bauxite producing soils of Jamaica and the Dominican Republic. For these soils, an adequate fertilizer management must be based on a proper nitrogen fertilization and the control of phosphorous and potassium levels.
- volcanic materials: Most of the volcanic rocks in the region (e.g. Dominica and Saint Lucia) are fragmentary and not lava-like and are also cation rich. They give rise to fertile, resilient soils which resist erosion and are among the best soils for agriculture regionally.

Residual soils:

These soils range in texture from sand to clay and occur chiefly, but not only in the larger territories on steep slopes. They are fragile with limited fertility and are easily erodible. Much of the soils are covered with tropical rainforest and in some cases have potential for new crops such as oil palm and rubber. Table 1 offers a basic guide to understanding the major groupings of soil types in the region. Generally, soils of the region are not typical of tropical soils because many of them were developed on nutrient-rich parent materials. Fortunately, they have not been exposed for a very long time for exhaustive leaching of plant nutrients to occur.

Table 1: Profile of Major Soil Types in the Caribbean		
Soil Type	**Location & Properties**	**Suitability**
Derived from recent marine and fresh water sediments *(Entisols, Inceptisols, Vertisols)*	- Occur in low-lying terrain with flat relief, found in Guyana, Trinidad and Jamaica; - High activity, very fine textured clay soils, well supplied with plant nutrients.	Suitable to food crops, pasture and commercial agriculture commodities.
Derived from pre-Quaternary marine and fresh water sediments *Inceptisols, Entisols)*	- Occur in relatively flat topography, ranging from loams to clays. - Among the best soils in the Region	Have considerable capabilities for wide range of crop and farming systems.
Derived from older fresh-water sediments *(Ultisols, Alfisols)*	- Occur in low-lying areas on flat or nearly flat topography and in situations with high rainfall. - Relatively light texture surface layer dominated by silt & fine sand, very dense & compact sub-surface horizon.	Generally unsuitable for agriculture but used in Jamaica where they tend to be more fertile; More suitable for housing and infrastructural development.
Derived from soft, impure calcareous parent materials *(Oxisols, Alfisols, Mollisols, Vertisols, Inceptisols, Entisols)*	- Occur on gently rolling to steeply sloping landscapes. - Widely distributed throughout Region except for Guyana.	More appropriate for pasture and perennial crop production.
Derived from indurated calcareous rocks *(Oxisols, Alfisols, Mollisols, Vertisols, Inceptisols, Entisols)*	- Associated topography ranges from nearly flat to hilly.	More appropriate for pasture and perennial crop production.
Derived from volcanic materials *(Inceptisols, Mollisols, Vertisols, Alfisols, Andisols)*	- Occur in the Windward Islands high rainfall conditions and to some extent in the Leewards. - Very good physical properties (especially Andisols), but can be leached.	Good for a range of crops including root crops as soil physical properties facilitate harvesting with little or no implement use.
Residual soils derived from sedimentary, igneous and metamorphic basic to acidic rocks *(Alfisols, Ultisols, Inceptisols and Entisols)*	- Occupy over 70% of Guyana, 30% of Trinidad & Tobago and Belize, and in central mountainous regions of Jamaica. - Widely distributed in the Region	Little agricultural potential (permanent crops e.g. cocoa, citrus and timber). Best left to biodiversity conservation, water catchment and generation of forest products.

Problem soils:
The region also has, what can be called, 'Problem soils', meaning soils that are highly vulnerable and should be given due consideration in terms of land use. These soils are usually the acid sulphate soils of Guyana, Suriname and Trinidad, peats of Guyana and Suriname, sands of Guyana, Belize, Cuba and Dominican Republic and petroleum polluted soils of Trinidad and Barbados. While such soils can be utilized for economic benefit, choice of activity should seek to limit removal of soil cover or land-alteration as much as possible. The latter is normally described as low impact site preparation to preserve a site's natural hydrological and biological characteristics [15], such as, tourism development activities. Compared to other soil types, problem soils are poorly suited to agriculture, but with special extensive and continuous treatment, are being used to some extent. The costs of such treatments may, however, be prohibitive to competitive agriculture.

The best soils for agriculture are those derived from pre-Quaternary marine and fresh water sediments. These soils situated on flat topography that facilitates a range of farming systems inclusive of mechanisation and scaled production. They also demonstrate significant resilience to rapid degradation. Unfortunately, these soils are under great pressure for settlement and infrastructural development. This means that farming may have to expand into areas where it may not be suitable or where it may be very difficult to do well (e.g. soils derived from older fresh-water sediments). While soils derived from recent marine and fresh water sediments and from indurated [16] calcareous rocks are generally suitable for a range of production systems, they will require different management regimes to retain their productivity levels; i.e., soil fertility management and soil protection against erosion, respectively.

Note #2
Soil Capability and Suitability

Soil capability refers to the natural capacity of the soil to perform at a given level for a particular use, including but not limited to farming. Soil suitability is the adaptability of a given area for a specific kind of land use. The soil capability and suitability concepts are especially important to farming where the right conditions are essential to crop productivity. Since soil is continuously being altered by both naturally occurring phenomena and human activity, continuous determination of its capability and suitability is required.

Soil capability is determined by a number of factors undertaken through detailed land evaluation that combines land systems information (such as topography and distance from human settlements) with climatic, agronomic and forestry data. This process can also be used to determine soil suitability. Capability and suitability soil assessments can determine the most appropriate form of land use, i.e., whether the soils in a particular area is more suited to farming or road construction.

Sources: (a) Dent, G. and Young, A. 1981. Soil Survey and Land Evaluation, George Allen and Unwin London; (b) Land suitability and capability, www.fao.org/docrep; (c) www.ijesd.org/papers/85-D490.pdf

15 http://buildgreen.ufl.edu/Fact_sheet_Low_Impact_Site_Preparation.pdf
16 to make hard; harden, as rock

In the Caribbean, the most resilient soils are those formed on non-indurated and fragmentary rocks (such as volcanic ash) or sedimentary materials (such as shales and marly materials (Table 2)). These soils have very good structure, are stable and resistant to erosion. In many instances, the parent material can be incorporated into the surface and subsoil layers, thus increasing the effective rooting depth for crops. Water and nutrient retaining capacities are high, making soils of good quality for supporting crop development. Soil degradation is slow but can be exacerbated by irresponsible use and management activities.

Table 2: Level of Resilience of Major Soil Types in the Caribbean

Soil Type	**Resilience**
Derived from volcanic materials *(Inceptisols, Mollisols, Vertisols, Alfisols, Andisols)*	High; soils have high aggregate stability and resistance to erosion
Derived from pre-Quaternary marine and fresh water sediments *(Inceptisols, Entisols)*	High; have deep profiles, fair aggregate stability and good nutrient and water retention
Derived from recent marine and fresh water sediments *(Entisols, Inceptisols, Vertisols)*	Moderate; deep profiles, good nutrient and water retention but subject to flooding
Derived from older fresh-water sediments *(Ultisols, Alfisols)*	Moderate: Susceptible to erosion.
Derived from indurated calcareous rocks *(Oxisols, Alfisols, Mollisols, Vertisols, Inceptisols, Entisols)*	Low: shallow profiles resilient to degradation and fertility depletion.
Derived from soft, impure calcareous parent materials *(Oxisols, Alfisols, Mollisols, Vertisols, Inceptisols, Entisols)*	Low - Moderate: Susceptible to erosion and nutrient imbalance.
Residual soils derived from sedimentary, igneous and metamorphic basic to acidic rocks *(Alfisols, Ultisols, Inceptisols and Entisols)*	Low: much of these soils are already degraded.
Problem Soils Problem soils *(mostly Entisols, Inceptisols and Sp*	Low: much of these soils are already degraded.

Soils from basic igneous and volcanic rocks or calcareous materials are also stable and resistant to erosion but have suffered some degradation because of their location on steep slopes in high-intensity rainfall areas. However, they can be rehabilitated through appropriate management even if the parent rock is hardened and the contact between the soil and the rock is abrupt. These soils have good water and nutrient retention capacities and are suitable to the production of a wide range of crops. Fortunately, soils with these qualities are the most common in the region.

The least resilient soils are those formed from non-calcareous parent materials such as sandstone, schists, phyllites, granites, grano-diorites, diorites and granitic gneisses. These soils occur throughout the Caribbean. They have weak structures which are easily destroyed by tillage. Their soil material is also readily eroded in run-off water during high rainfall. Based on the extent of soil loss, the land can become completely degraded with loss of the top soil and resulting shallow soils with rock outcrops. In such situations the original vegetation will not re-establish. Because of the hardened under-lying rock, the effective rooting depth ends at the abrupt rock/soil interface. Also, because of the shallow soil depth and low inherent water and nutrient retaining properties, the soils become droughty and can only support stunted vegetation, often with no economic value. Though proportionally less, these landscapes are becoming more common.

Tropical soils are notoriously fragile due to rapid disintegration of rock by high temperatures and rapid leaching of the released nutrient elements as a result of high rainfall, common to tropical regions. This eventually leaves a highly resistant residue, poor in plant nutrients, from which the soils develop. The resulting soils are considered fragile since the small amount of plant nutrients contained is mostly concentrated on the soil surface and can be easily lost by soil erosion or depletion by intensive cropping. This predisposes the soil to rapid and severe degradation. Moreover, whereas fallow periods were traditionally used to help stabilize soils and restore their fertility, the practice has become progressively shorter due to pressure on the land use from an ever increasing population and demand for food.

3. Soil-loss and Crop Production

3.1 Understanding Soil Loss

> **Note #3:**
> **From Fertile to Barren**
>
> A review of the literature shows that Iraq, which is part of the Fertile Crescent where agriculture started some 10,000 years ago, was once the wealthiest, most innovative and most advanced country in the world. However, Iraq today is plagued by soil problems, such as salinisation, erosion and the consequences of rapid deforestation.

Whereas it can take several centuries to form good soil, this can be undone in a comparatively short amount of time. Soil loss is a result of land degradation. Degradation is usually described as the lowering or loss of the current and/or future capacity of the soil to produce goods and services (inclusive of, but not limited to agriculture). The degradation process is characterized by the harming/destruction of one or more of the potential ecological functions of the soil – namely bio-mass production (nutrient, air, water supply and root support for plants), filtering, buffering, storage and transformation (e.g. water, nutrients, pollutants) and biological habitat and gene reserve.[17]

Erosion is often the end-result of the degradation process and thus a symptom of soil degradation rather than the cause. However, erosion and decomposition of bed-rock/parent material are natural and continuous processes that are beneficial for the formation of good soils. Some form of degradation must occur to facilitate the erosion process. In its natural state, this process is progressive and occurs over a long period of time. In fact, natural processes can take more than 500 years to form just two centimetres of top soil.[18] This is not necessarily a bad thing. The concern and issue arise from disruptions and particularly accelerations to these natural processes due to human activity, which in turn, affect the scale, extent and rate at which degradation occurs.

Land degradation and soil loss result from natural hazards and/or unsuitable and inappropriate land use management practices. Natural factors include land topography and climatic factors such as steep slopes, frequent floods, high wind and rains, strong leaching in humid regions and drought conditions in dry regions.[19] The Caribbean receives a significant amount of rainfall each year, especially during the annual hurricane season (June–November) which causes major landslides and erosion of coastlines and coastal roads. Extreme and virulent weather associated with climate change such as drought, also affects soil structure and composition.

Soil degradation is categorised according to three types: (i) displacement of soil material (i.e. erosion); (ii) *in situ* (in natural environment) chemical deterioration; and (iii) *in situ* physical deterioration, each with specific sub-types. (Table 3).

17 http://www.unescap.org/stat/envstat/stwes-04.pdf
18 http://www.cep.unep.org/publications-and-resources/technical-reports/tr32en.pdf
19 Soil Degradation, prepared by Dominic Ballayan from FAO

Table 3: Soil Degradation Types and Effects on Ecological Functions and Land-use Systems		
Class	***Sub-types***	***Main effects on Land-use systems***
TYPE 1: DISPLACEMENT OF SOIL MATERIAL		
W	Water erosion	This type is sub-divided between effects of water and wind erosion and degradation associated with both. Water supply and quality are greatly compromised. Agriculture is severely compromised by excess/ absence of water supply and top soil removal.
Wt	Loss of topsoil	
Wd	Terrain deformation/mass movement	
Wo	Off-site effects & reservoir sedimentation	
Wof	Flooding	
Woc	Coral reef and seaweed destruction	
E	Wind erosion	
Et	Loss of topsoil	
Ed	Terrain deformation	
Eo	Over-blowing	
TYPE 2: IN SITU CHEMICAL DETERIORATION		
C	Chemical deterioration	Soil pH is outside of tolerable limits for most crops. High concentrations of nutrients (eutrophication) and pollutants are leached, contributing to water pollution and destruction of down-stream aquatic habitats (eutrophication).
Cn	Loss of nutrients and/or organic matters	
Cs	Salination	
Ca	Acidification	
Cp	Pollution	
Ct	Acid sulphate soils	
Ce	Eutrification	
Type 3: IN SITU PHYSICAL DETERIORATION		
P	Physical deterioration	Land/soil capability severely diminished. Possibility of rehabilitating the land for alternative use is low.
Pc	Compaction, sealing and crusting	
Pw	Water-logging	
Pa	Lowering of water table	
Ps	Subsidence of organic soils	
Po	Other physical activities (mining & urbanisation)	
Source: Ballayan 2004, adapted from FAO (1994) and adapted from FAO/RAPA (1992)		

Table 3 emphasizes that issues of soil loss are not only confined to physical removal of soil material but also relate to the soil's inability to fully function as 'the planet's life support system'. The information also reveals dynamism between and among the types of degradation, where a single event can also bring about multiple consequences impacting multiple land-use systems. Systemic impacts are magnified through the soil-plant-atmosphere interactions which, incidentally, are the same mechanisms through which ecosystem/environmental services are supplied. This includes the cycles for producing oxygen and sequestering carbon dioxide and nitrogen. The effects of soil degradation, similarly, affect the plant and atmosphere (environment).

A particularly critical issue in land degradation and soil loss is inappropriate land use and soil management practices. Unsuitable land use contributes significantly to soil deterioration and loss, as has occurred in Jamaica and Suriname as a result of mining activities. It also increases the costs of such use since it may require mitigation/counter measures to enhance suitability.

Of all land use changes, construction activities have the greatest potential to produce massive, short-term increases in erosion and sediment.[20] Constructing housing on farm lands will require greater compaction and bulk density in the soil, more than that available through naturally occurring processes. As a result of the alteration, soil water infiltration and storage capacity are drastically reduced, leading to flooding and terrain deformation. Mitigation measures must be introduced, increasing the financial and economic costs of construction. In recent times, a large portion of erosion in the Caribbean has been caused by poor road alignment and improper control of drainage and runoff from roads.

In the late 1970s and 80s, Country Development Atlas were prepared for most, if not all Caribbean countries. These included a series of Geology, Land Capability, Land Use and Vegetation and Land Distribution and Tenure maps.[21] However decisions with respect to land use have generally not been aligned with capability and suitability assessments. The result has been widespread use of arable lands for housing and other domestic and physical infrastructure.

With independence, economic development and population expansion, pressures on the land for other uses, mainly housing, industrial sites, transportation and other infrastructure have increased. Such pressures have worsened attitudes to land as an inert substrate base, rather than a living resource for productive use.[22] Already, there is evidence of further intensification and diversification of land use to meet multiple and often conflicting socio-economic and environmental objectives.

Any form of human activity will require some form of alteration of the natural environment. In the absence of countervailing measures, the potential negative effects of degradation are exacerbated. Fortunately, the overall status of soil degradation in the Caribbean is not yet as bad as for the rest of the tropical world; the operative word being yet! This is largely because of the type of soils in the Caribbean and the types of crops being grown. Parent rocks (i.e., the underlying original layer of bedrock) in the region are relatively young, geologically and hence weathering, leaching and soil formation are not very advanced (in general).

20 http://www.cep.unep.org/publications-and-resources/technical-reports/tr32en.pdf
21 Done under an Organisation of American State Economic and Social Affairs initiative
22 www.forestrynepal.org/wiki/149

3.2 Agriculture – a Problem and Solution

Although 99% of the world's food comes from the soil,[23] the rate of soil loss is greater today than it has ever been. In fact, an increasing number of scientists are starting to emphasize the extent to which soil – even more than petroleum, water or air – is a limited and fragile resource.[24] (Note #4). This fragility derives from the fact that natural soil formation processes occur over centuries and soil functions and the scale at which they are provided, cannot be easily replicated using existing technology.

Note #4:
Soil's Startling Statistics

- For each pound of food eaten in the United States, approximately 5.51 lbs of soil are lost to wind and water erosion, resulting from agricultural practices.
- Twelve pounds of farmable soil are similarly lost in developing countries, with 3.70 lbs of farmable soil lost in China for every pound of food eaten.
- Approximately 213,000 people are added to the planet daily, requiring about 34,000 more farmable acres each day to feed them—acreage which does not exist.
- Due to all of the above, by 2014 only about 64% of the world's population is likely to have an adequate diet.

Source:www.greenschool.org/community/green-farm/bio-intensive-soil-vs-common-gardening-soil/

Current estimates suggest that 10–20% of global terrestrial area has degraded soils and there are indications that this area is extending.[25] Back in June, 2004, the United Nations observed that the world's land was turning to desert at an alarming speed - at twice the rate that was occurring in 1970.[26] A contributing factor was that conventional agriculture viewed soil as simply another commodity, an inert medium for growing. Consequently, soils were inundated with chemicals to provide high yields and kill plant pests and diseases. In the process, once-fertile soils have become severely depleted of organic matter, nutrients and micro-organisms, the army of invisible, beneficial workers in the soil.

Depleted soils are in danger of being blown away by wind or washed away by rain. Consequently, 30% of the world's cropland has been abandoned in the last 40 years due to severe erosion, and as little as 40 years of farmable soil remain globally. Comparative estimates on the state of degraded soils in the Caribbean are either not readily available or are outdated. However, the well documented experience of Haiti provides a living laboratory and evidence of the possible outcomes from unabated and unwarranted destruction of land and the consequent impacts on soil loss (Note #5). In the Caribbean, Haiti is indeed a special and oft-cited case, in which all the soil resources are highly eroded and important areas salinised.

23 http://www.guardian.co.uk/world/2004/feb/14/science.environment
24 http://www.boston.com/bostonglobe/ideas/articles/2008/04/27/the_future_of_dirt/
25 Land Use System Analysis. http://www.alterra.wur.nl/UK/research/Specialisation+Soil+Science/LU/LSA/
26 Source: Bio-Intensive Soil vs Common Gardening Soil from www.greenschool.org/community/green-farm/bio-intensive-soil-vs-common-gardening-soil/

Note #5:
Soilless Haiti

Substantial soil loss was a problem in Haiti since the colonial period. Mountain forests were cleared for coffee production and plantation crops (cotton, indigo, tobacco) were clean cultivated (scraping weeds between plants and pre-till field burning). Due to excessive erosion, coffee plantations were difficult to re-establish after the first generation and indigo crops were only productive for three years (Paskett and Phylocete 1990).

After the revolution, peasants combined remembered horticultural practices of Africa with learned agriculture and plantation cultivation methods. This produced a mixed system where Haitian farmers would clean cultivate agricultural crops (i.e., removal of bush cover), burn crop stubble prior to tilling and periodically leave annually cropped parcels fallow for an extended period. Tree gardens were also established around family compounds. However, with increasing population and resulting pressures on the limited arable lands, the fallow practice was increasingly precluded, tree gardens were diminished in size, and peasants were forced to move to less desirable mountain lands for annual crop culture and settlement.

The increased practice of clean cultivation together with more intensive farming resulted in substantial degradation of the chemical and physical properties of the soil, making erosion all the more frequent. As crop performance fell and lands that had become infertile were abandoned, farming and settlement expanded into the mountain slopes where the disastrous effects experienced in the plains were magnified in the absence of management guidelines for regulating where and how land could be used.

Source: Paskett, C. and Phylocete, C. 1990. Journal of Soil and Water Conservation 45(4): 457 – 459. http://epat.wisc.edu/.forest/.soil-cons/.format/.history.html

The Haiti situation reflects the several significant threats facing other Caribbean countries in particular, the SIDS. Intensive farming systems are, by nature, very exploitive of soil use and over-dependent on agro-chemicals to maintain crop productivity and control of pests and diseases. The urge to continually till the soil and to keep the land free from weeds weakens soil structure and in periods of intense high rainfall and winds, the soil becomes loose and vulnerable to erosion. Similarly, crop production on soils unsuited to farming increases the need for enhancement and mitigation measures which increase costs.

As indicted by the Haiti outcome, poor agricultural practices, combined with land deterioration and soil loss contribute significantly to unsuitable land use. The agriculture problem stems, in large part, from unsustainable patterns of land use.[27] Decades of monoculture, slash and burn and other poor farming practices were closely tied to the plantation cropping systems, European land law and official land tenure regimes.[28] For agriculture, the best available lands were allocated to concentrations of sugarcane, citrus, cotton, coconuts, cacao, tobacco and indigo. Food crop cultivation was relegated to the marginal lands, usually on hillsides, the genesis of the shifting, slash and burn substance small scale farming. Intensive farming and other forms of agriculture therefore may be the most liable contributors to inappropriate soil/land use/management and land/soil degradation.

Among the several and significant threats to the state of soil in the Caribbean, associated with the agriculture industry, that further aggravate the degradation process include:

- the sub-division of agricultural estates into small plots under independent ownership and control. This policy has exacerbated problems associated with dependency and fragmentation and also placed limits on options for addressing environmental issues,

- land use changes, particularly the loss of arable lands to non-agricultural land use, and

- soil pollution as a result of inappropriate disposal, including solid waste and mis-use of agro-chemicals.

The issue of soil pollution is of particular interest. Pollution is a sub-type of *in-situ* chemical deterioration that is particularly destructive on soils (Table 3). Chemical misuse and improper waste disposal of farm materials, such as plastic banana sleeves, agrochemical containers, and over use of agro-chemicals which leach into soils, are major sources of agriculture-related pollutants. This adds to the growing and general problem of pollutants accumulated in land-fills across the region, strained by population growth and increased waste from homes, which are a source of heavy metal contaminants. The impacts on long-term soil fertility, water pollution and eutrophication[29] and sedimentation on coral and aquatic vegetation are disastrous.

While loss of soil and degradation are taking a significant toll on the Caribbean environment and economy, the situation has not yet received the attention that it deserves. Should this situation of land degradation and soil loss be left unchecked, agriculture and water resources be adversely impacted

27 Land use is the way in which land is allocated and used for a particular purpose. Use is closely linked to soil capability and suitability and is a decisive factor in the ability of soil to resist degradation.

28 Besson, J. 2003. Land in the Caribbean: Proceedings of a Workshop on Land Policy, Administration and Management in the English-speaking Caribbean; March 19–21, 2003, Port of Spain, Trinidad & Tobago.

29 Eutrophication is the process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates which typically promote excessive growth of algae.

but so too will capacity to adapt to climate change and eventually, quality of human life. Farming and food production, especially in SIDS, are already compromised by the impacts of climate change, such as sea level rise and the effect of salinisation on soils and water. This fact alone should raise the proverbial 'red flag', and hence the level of urgency with which the region should respond to the soil-loss situation.

The physical quantity of soil/land and fresh water resources is not expected to increase and consequently, the state and future of the natural resources upon which food production systems will depend must feature in this response. However, thus far, Food and Nutrition Security dialogue and interventions are somewhat muted with respect to an explicit recognition of the seriousness of the soil loss situation and definitive actions aimed at mitigating the problem. This appears to be a monumental oversight of modern agriculture and other productive sectors. Such oversight and inaction, amidst increasing loss of arable land, and climate change effects which contribute to desertification, are tantamount to 'shooting oneself in the foot' i.e., compromising food and nutrition security and human life.

An eroded cliff face in Dominica. Climate change interventions are needed to limit this scale of erosion which both affects agriculture and endangers lives.

(Photo: Brent Theophile)

3.3 Soil Degradation and Sustainable Farming

Extreme soil loss poses a considerable threat to farming and hence food and nutrition security. Soil-loss also presents a threat to biodiversity and thus support for endemic fauna and flora. Specifically, this can also present avenues for the introduction and establishment of invasive alien species (IAS) which are a considerable threat to the natural environment.

Given the need and urgency to expand food production, poor practices will undoubtedly continue to occur, leading to even more soil loss. An important part of the global response has been the search for sustainable farming techniques and methods that preserve the remaining soil resources. These methods seek to rehabilitate/aggrade depleted and depleting soils, enhance efficiency of use and conserve soil to maintain current cropping volumes, whilst minimising the potentially damaging effects of intensive farming.

Optimum conditions for plant health usually means a balance among the air (oxygen and carbon dioxide), moisture (water) and nutrients (including carbon, nitrogen and phosphorus). In traditional soil-based farming under natural conditions (*in situ*), there are challenges in maintaining and balancing these requirements. In some locations and at different times of the year, the moisture content of soil may vary from excess (flood) to insufficient (drought). Variations in topography, soil type and soil conditions also affect the availability of nutrients and capacity of the plant to absorb them. The function of the soil is to: (a) secure the requirements for crop production, and (b) provide a medium to physically support the plant as it grows.

In food crop production, the ultimate objective is to provide/ensure/maintain the three essential requirements for optimum plant growth. With growing concerns over the state of natural resources, crop production methods are increasingly favouring complementarity- i.e., using natural soil as the base, but enhancing its properties so that conditions for plant growth are as optimal as physically possible. There are two general groups of such farming methods, (a) soil-saving practices and (b) soil rehabilitation methods. The main ones are profiled below.

3.3.1 Soil Saving Practices

Practices that conserve and/or save soil can offer interesting and productive options for farming systems in the Caribbean. These approaches also have the advantage that they can be utilised over an extended period of time without undermining soil and water resources. Further, such practices tend to be low cost, non energy-intensive and do not require specialised and usually costly amendments or additional inputs. Many existing soil-saving practices have easy and direct application to small farming systems and some are already being practiced in the region, albeit, on a limited scale. Some of the more common ones are profiled below.

- ***Use of Organic matter***

Decades of chemical use from the 'green revolution', in particular chemical fertiliser resulted in salt accumulation and disruptions in activity of soil biota. This has contributed to a gradual decline in soil quality and productivity. The highly soluble nature of many chemical fertilisers has also resulted in leaching and groundwater contamination. Over time, while food crops have become less and less responsive to chemical inputs, pests and diseases have thrived. The increasing unresponsiveness of plants to chemical inputs has encouraged increased and over-use of such inputs, worsening the problem.

Greater use of organic matter is promoted as a method of maintaining healthy soil biota and stimulating biological activity, thereby improving soil fertility, particularly of top soil, the most vulnerable layer. Use of organic matter also aids in improving soil physical properties, i.e., tilth, aggregation, water holding capacity and resistance to erosion. In comparative tests with chemical fertilisers, long-term additions of organic manure were shown to have the most beneficial effects on crop yield and soil quality.[30] Use of organic matter is a beneficial soil-saving technique for sustainable food crop production appropriate for the numerous small farmers in the Caribbean.

However, the use of organic matter should not be equated to organic farming. Organic farming is an ecological production management system that optimises "the health and productivity of interdependent communities of soil life, plants, animals and people. The principal guidelines for organic production are to use materials and practices that enhance the ecological balance of natural systems and that integrate the parts of the farming system into an ecological whole. Organic agriculture practices cannot ensure that products are completely free of residues; however, methods are used to minimise pollution from air, soil and water."[31] While several small farming systems in the Caribbean may practice 'chemical free', 'low chemical' and/or 'natural farming', due to the stringent certification requirements, they may not meet the qualifications of 'organic' farming.

Making compost to support transitioning to Organic Horticulture in Suriname

(Photo: Maureen Silos)

30 Liu, E. et al. 2010. Long-term effect of chemical fertilizer, straw and manure on soil chemical and biological properties in North-west China. Institute of Environment and Sustainable Development in Agriculture. Chinese Academy of Agricultural Sciences. Beijing.

31 USDA National Organic Standards Board (NOSB) definition, April 1995

- ***Permaculture***

The term permaculture (permanent agriculture), was created in the 1970s by Australians Bill Mollison, David Holmgren and their associates in the 1970s. It refers to the conscious design and maintenance of agriculturally productive ecosystems that have the diversity, stability and resilience of natural ecosystems [32]. Permaculture is considered to be a more holistic farming system, modelled after natural ecosystems that balance food production with the plants, animals, their nutrient cycles, climatic factors and weather cycles. Permaculture is appropriate to food production and sustainable land and water management. It is also applicable to community design in urban, semi-urban and rural settings (Note #6). However, the fact that multi-level interventions may crowd and complicate the farming system could be a disadvantage.

Note #6: Wa Samaki Ecosystems, Trinidad

Application of Permaculture principles empower producers and their communities to design landscapesforfoodsecurity,sustainability,biodiversity and wildlife conservation, to create polyculture food systems and forests, to find and read landscapes to reduce erosion, and to rehabilitate degraded lands and increase water retention. Among other benefits, permaculture will protect and grow our soils. Tropical soils are thin; most nutrients are held in the vegetation. Mulches, rotations, biodiversity of crops and polycultures all trap and recycle nutrients in a system, just like a forest.

There is a number of practising permaculture sites in the Caribbean that also teach Permaculture Design Courses (PDC). Among them is Wa Samaki Ecosystems/Caribbean Permaculture Consultants Ltd (Trinidad and Tobago).

Source: www.wasamakipermaculture.org

32 http://www.wasamakipermaculture.org/#!vstc17=page-1

- ***Polyculture***

Polyculture is the opposite of monoculture and includes crop rotation (alternating growing of crops), multi-cropping (growing two or more crops simultaneously such as in intercropping, companion planting and row/alley cropping), and growing of beneficial weeds (e.g. acting as trap crops). Such systems reduce the likelihood of pest and disease populations exceeding tolerable threshold levels, promote diversity of crops to reduce susceptibility to pest and disease and enhance more efficient use of limited/scarce farm lands. However, such systems can be relatively labour-intensive and if not managed properly, can contribute to lower soil fertility.

- ***Conservation tillage***

Tillage is a necessary part of land preparation, particularly in short term food crop farming. Conservation tillage is any crop-farming system that leaves about one third of the soil covered after planting. This includes zero-till, strip-till, ridge-till and mulch-till practices. In all of these, some of the residue from the previous year's crop is left on the field as a form of protection against wind and water erosion, as well as a source of organic matter to improve soil nutrient content and structure. This practice also helps maintain soil moisture and helps minimize the loss of nutrients due to leaching and soil amendments. Some key advantages include substantial reduction in soil erosion (as much as 90% using no-till vs an intensive tillage system).[33] It also contributes to reduced soil compaction, saves time and energy in land preparation and conserves water. However a main disadvantage to be overcome is that crop residue may harbour/encourage pests and diseases.

- ***Windbreaks***

Conservation buffers, or as commonly called 'wind breaks', are small areas or strips of land planted in permanent vegetation as a perennial soil cover and means of soil stabilization. While buffers are usually a type of grass and/or legume (e.g. alfalfa), trees and shrubs may also be used.[34] Some common types of windbreaks include field borders (buffers at the edge of the field using either forest trees or fruit trees, such as mango), filter strips (to slow run-off from the field), grassed waterways (in areas where water naturally runs or is concentrated) and riparian buffers (planting trees, shrubs and grasses on the edge of rivers/streams). Windbreaks support reduction in windborne pollutants, sedimentation and leaching of nutrients, and amendments into watercourse. It has been observed that the existence of windbreaks can reduce up to 75% of sediment and 50% of plant nutrients from reaching surface water. However, such buffers do use up part of the already limited space of small land-holders and may also harbour/ encourage pests and diseases if not effectively managed.

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33 Conservation Tillage, 2002 "Core 4 Program, Conservation Technology Information Center, Iowa

34 http://www.agaware.org/soilconservation.pdf

By their very nature, these soil-saving techniques profiled above, tend to be labour intensive. The chronic labour shortage in agriculture acts as a disincentive to adopt and maintain these techniques over time. While some, especially land preparation, may be a one-time cost, others, such as weed control, will be recurrent. As a result several small farmers may experience difficulties in sustaining such soil-saving techniques and increasingly opt for more contemporary agro-chemical solutions. However, supporting the practice and pursuit of alternative soil-saving farming systems may also trigger innovation through the design and/or adaptation of existing equipment suitable to sustain small farms. As with all technologies, the cost-benefits of such innovation must be fully determined and communicated to convince farmers to adjust or make the switch.

3.3.2 Soil Rehabilitation

Soil rehabilitation cannot replicate natural soil-building processes or the means by which nature creates soil structures that provide environmental services and support crop development. However, soil rehabilitation aims to restore conditions under which biological activity can be resumed (where disrupted) and sustained. In short, soil rehabilitation seeks to re-build and restore soil productivity through the soil-plant-environment interactions.

Such techniques usually deal with 'curative' or 'restorative' treatments for degraded, polluted or otherwise difficult soils. Such treatments are commonly associated with post-mining or other heavy earth extraction methods and may or may not be utilised within any of the soil-saving systems profiled above. However, soil rehabilitation explicitly recognizes that human activities (even restorative) alter the natural environment and that even well-intentioned rehabilitation interventions may have some undesired effects. Consequently, among the guiding principles for using soil rehabilitation measures are good knowledge of the zone/area for rehabilitation, risk and impact assessment and risk and impact management.

The broad category of soil rehabilitation options can be categorized into: (a) physical (b) chemical and (c) biological, based on the specifics of the soil property that is degraded or lost.

- ***Physical Rehabilitation***

Physical rehabilitation focuses on restoring the physical components of the soil which support its productive capacity, such as, texture and structure. The primary treatments for restoring good physical structure of the soil are (a) topsoil-handling, (b) tillage and (c) drainage.

- Topsoil handling is an operation used to establish productive nutrient cycles on rehabilitated sites by conserving and re-spreading topsoil. Excavators are normally employed to spread existing topsoil within the area to be rehabilitated or topsoil obtained from another area. With respect to the latter, it is important to note the potential of introducing invasive alien or indigenous weeds and other organisms.

- Tillage, or de-compacting, is undertaken to facilitate aeration and disaggregation of clods and hardpans. This allows for finer texture (i.e. smaller soil particles), improved porosity (i.e. larger pore size), better infiltration of water (as a result of larger pore size) and reduced run-off as the soil is better able to hold water. Tillage may be integrated with topsoil handling, using simple tools, such as a fork and shovel for small acreages; small hand-held and diesel-powered rotavators/tillers; ploughing (e.g. using disk ploughs which break down surface soil clods) and sub-soiling (e.g. using winged sub-soilers which focus on breaking up clods in the subsoil). As far as possible, tilling should be avoided under wet and extremely dry conditions and on steep slopes. Tillage depth should also be limited to avoid creating deep-profile compaction.

- Drainage: Improving soil drainage generally involves some form of tillage, where the aim is to remove water-logging and so improve the supply of oxygen for soil microorganisms as well as plant roots. Soil drainage is not the same as soil water-holding capacity, which basically addresses the ability of soil to retain water for plant use. Water-logging leads to delays in seeding and germination, increased crop disease and maturity-related problems, soil compaction, and higher equipment operating costs.[35]

Note #7

Winged sub-soiler used for de-compacting.

Tillage is often done in association with introduction of organic matter which improves structure and water-holding capacity, especially in sandy soils. The operation loosens the soil, breaks massive soil materials into small clods and encourages the formation of more porous aggregates. In addition, it creates an open structure in the soil that allows excess water to drain away while enabling oxygen flow to respiring plant roots. The long-term stability of aggregates and pore spaces depends on soil texture, soil organic matter and soil biological activity.

Source: García et al 2004

With all of the above, restoring plant cover/vegetation (a common measure) needs to be established in conjunction with or immediately after, to limit erosion.

- ***Chemical Treatments:***

Chemical treatments or soil rehabilitative measures seek to correct imbalances in soil pH, salinity and nutrient absorption. Many of these imbalances lead to progressive loss of organic matter (depletion from intensive farming), moisture (extreme evaporation as in uncovered soils) and nutrients (particularly leaching as a result of high precipitation). The imbalances also result from extensive use of acid-forming inorganic fertilizers (e.g. ammonium nitrate or diammonium phosphate). The following describes some important and common corrective chemical treatments to enhance soil quality.

35 García et al 2004 complete reference

Liming: by mixing limestone thoroughly into the soil before planting the crop in order to:

i. reduce toxic levels of soluble aluminium and manganese, which are present in more soluble form in strongly acidic soils and can be present in toxic amounts around plant roots;
ii. increase the efficiency of applied fertilizers, which is reduced in such acidic soils;
iii. encourage the activity of soil bacteria which is drastically limited in acidic soils, thus improving the release of valuable nutrients;
iv. stabilize soil aggregates and render the soil more resistant to erosion;
v. supply calcium and magnesium for crops. Adding calcium in a soluble form, such as, gypsum or in some cases, calcium chloride helps to correct soil salinity. After the treatment, the sodium can then be leached through the soil along with other soluble salts.

When salts accumulate, the soil becomes less permeable and the salt damages or kills the plant. Saline soils cannot be reclaimed by chemical amendments, conditioners or fertilisers. A field can only be reclaimed by removing salts from the plant root zone. The main non-chemical methods of managing saline soils are by improving drainage (a temporary measure to improve the infiltration of water in the soil), reducing evaporation (by applying mulch), and or by leaching (by adding low-salt water to the surface to carry the dissolved salt deeper into the soil profile and away from the root zone). Leaching works well on saline soils that have good structure and internal drainage.

Agricultural lime, or Aglime, is a fine limestone material commonly used to reduce soil toxic levels and encourage soil bacteria activity.

(Photo: CARDI)

- ***Biological Rehabilitation:***

'Bio-remediation is the use of biological processes to degrade, break down, transform and/or remove contaminants and other pollutants from soil and water.[36] This treatment offers a major advantage since it is a natural process (environmentally-friendly) that harnesses the normal functioning of bacteria, fungi and plants which use contaminants as a source of food/energy. Processes, such as, natural attenuation[37], bio-stimulation[38] and bio-augmentation[39] break down contaminants into harmless or less toxic states. These techniques can also be used in varying forms from simple/small-scale to commercial systems. However, the cost of its commercial development may also be prohibitive.

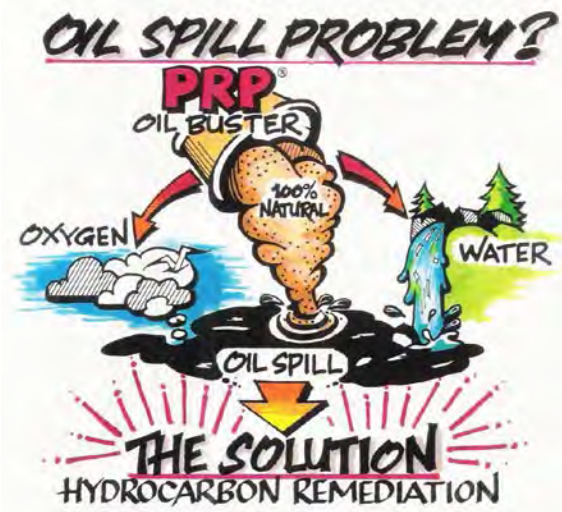

Illustration:
Bio-remediation for treating oil-spills

Source: www.alibaba.com/product-free/101494123/Bioremediation_Process_Chart/showimage.html

Common types of bio-remediation treatments include:

- Phyto-remediation, to remove bio-accumulable heavy metals from mining soild and areas subjected to heavy metal leaching.
- Bio-leaching, to extract specific metals from their ores through the use of living organisms. This treatment is usually applied in cases of heavy metal contamination of the soil.
- Bio-venting, to use micro-organisms to biodegrade organic constituents adsorbed on soils in the unsaturated zone. It also improves the activity of indigenous bacteria and stimulates the natural and *in situ* biodegradation of hydrocarbons in soil by inducing air flow.[40]
- Land-farming, to degrade, transform and immobilise contaminants using microbiological processes and oxidation. This treatment mixes contaminated soils with soil amendments, such as soil bulking agents and nutrients, which are then tilled periodically for aeration.[41]
- Bio-augmentation, to treat contaminated soil or water by introducing a group of natural microbial strains or a genetically engineered variant.

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36 http://waterquality.montana.edu/docs/methane/Donlan.shtml

37 Natural attenuation relies on natural conditions and behaviour of soil microorganisms that are indigenous to soil.

38 http://www.science-dictionary.com defines bio-stimulation as the addition of nutrients to polluted waste or ground in order to enhance the remedial activity of microorganisms.

39 Bio-augmentation consists of adding nutrients and other substances exogenous to the soil environment to catalyze natural attenuation processes.

40 http://www.cpeo.org/techtree/ttdescript/bioven.htm

41 http://www.cpeo.org/techtree/ttdescript/lanfarm.htm

- Bio-stimulation, to enhance the remedial activity of microorganisms, by adding nutrients to polluted waste or ground, which modifies the environment to stimulate existing bacteria capable of bioremediation.
- Bio-fertiliser, to promote soil biological activity in association with plants for their mutual benefit using beneficial microbes (bacteria or fungi), such as, Rhizobium, which naturally form nodules on the roots of legumes and aids in fixing nitrogen in the soil.

Soil-saving approaches are particularly recommended for small farmers, in the subsistence to semi-commercial range in both farming and backyard gardens in residential areas. Such practices may be used/applied with minimal guidance and appropriate legislature/incentive by Government (e.g. reduction in home/land tax for adoption of soil-saving practice).

Generally, soil rehabilitation treatments feature restoration of plant cover as a basic factor in returning the soil to some semblance of functionality. This, in itself, underscores the unbreakable connections between saving-our-soils (*the life support system of Earth*) and sustaining-our-forests (*the lungs of the world*), the next paper in this CIPO edition. Offering incentives to adopt soil-saving and soil rehabilitation techniques in farming would serve to limit destructive practices (agriculture and non-agriculture) that increase the need for acquiring additional lands, thus saving/expanding the productive capacity of lands already under agriculture. It also has possible applications beyond farming, such as, positive externalities for minimising land degradation from other economic uses - especially residential and other construction.

Contour farming - an effort to control soil erosion in the watershed hillside near an area called Thiotte in Haiti. Farmers there mostly grow vegetables (such as cabbage). This culture also helps to cover farmers' cost of production.

(Photo: Alain Thermil, IICA Haiti)

4. Growing food crops without soil

4.1 Soilless technologies

Crops can still be grown without naturally-occurring soil, as long as the basic requirements for optimal plant growth – air, moisture and nutrients – are provided. Growing soilless is based largely on the soil replacement concept. Soilless food production technologies essentially revolve around 'wasting' less, i.e., making more efficient use of soil resources to grow the same or more food. It could also mean using no soil at all to grow food crops. The latter is the subject of this section.

Soilless technologies were developed with the purpose of securing food production in areas/climates where traditional soil-based production was either not possible, considered a significant threat to the sustainability of the soil and natural environment, or incapable of meeting production needs. Soilless cultures are developed to manage, in varying degrees, the nutrition and atmospheric conditions for plant growth. Nutrients are transformed into a form that plants can readily absorb via the root or leaf systems, for optimal growth, under controlled conditions (*ex situ*). Consequently, essential requirements for crop development, such as, water, oxygen, carbon-dioxide, light and nutrients are all regulated.

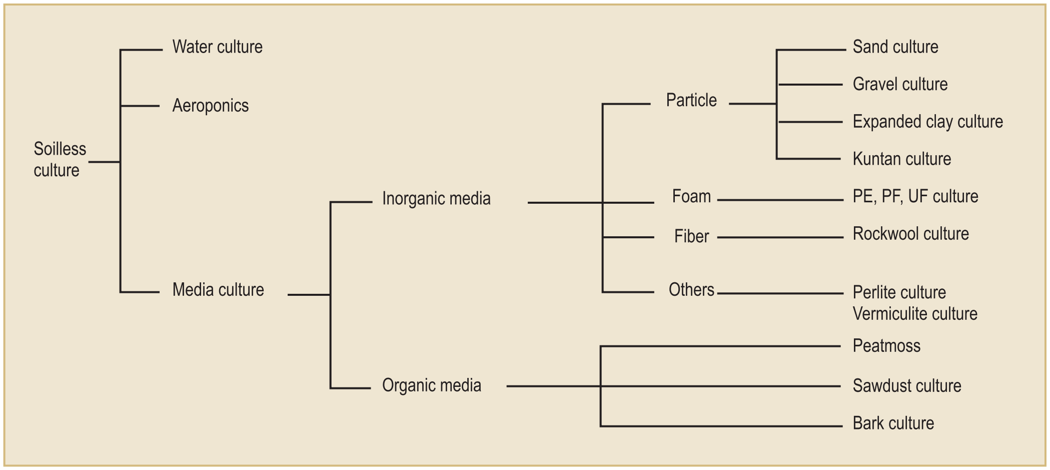
The main types of soilless technologies for food production currently practiced are hydroponics (water culture using an oxygenated and nutrient-enriched liquid as medium for supplying plant nutrition), aeroponics (where nutrients for uptake are supplied through the surrounding atmosphere) and/or media culture (Fig. 3).[42]

One of the main types of soilless technologies for food production is media culture where soil is replaced with a range of substitute inorganic and organic material, including foam, fibre, sand, gravel peatmoss, sawdust, bark and rice hulls.

(Photo: IICA Guyana)

42 Soilless Culture in Japan, by Hideo Ikeda, Member of the International Society for Soilless Culture, College of Agriculture, University of Osaka Prefecture http://www.hydrofarm.com/articles/soilless_japan.php

Figure 3: Various Systems of Soilless Agri-Culture



http://www.hydrofarm.com/articles/japan_fig1.jpg

4. 1.1 Hydroponics

Hydroponics is a subset of controlled environment or 'Protected' agriculture that substitutes soil for water, and provides shelter from the natural environment. Instead of the traditional farming practice of growing in soil and dispersing a lot of water in the soil and having the plant root search for the nutrition, through hydroponics, plants are fed nutrients directly to the root base. The elements of the nutrition are the same as for plants grown in soil, i.e., nitrogen, phosphorus, potassium, as inorganic ions in solution. In this manner, the nutrient solution replaces the soil as a reservoir of mineral nutrients. The plant roots may be in the mineral solution only or in an inert medium such as perlite, gravel, mineral wool or coconut husk. Media are usually utilized in early stages for germination or initial establishment of the crop.

Among the benefits of hydroponics are that it helps eliminate the possibility of soil-borne diseases (such as E-coli) and promotes Integrated Pest Management (IPM) or biological controls. There are no weeds to pull and no soil to till. It is ideal for tomatoes, lettuce, leafy vegetables, cucumbers, beans, herbs and all kinds of flowers. Because nutrients to the plant are controlled, plant growth is faster and yields are higher.[(43)]

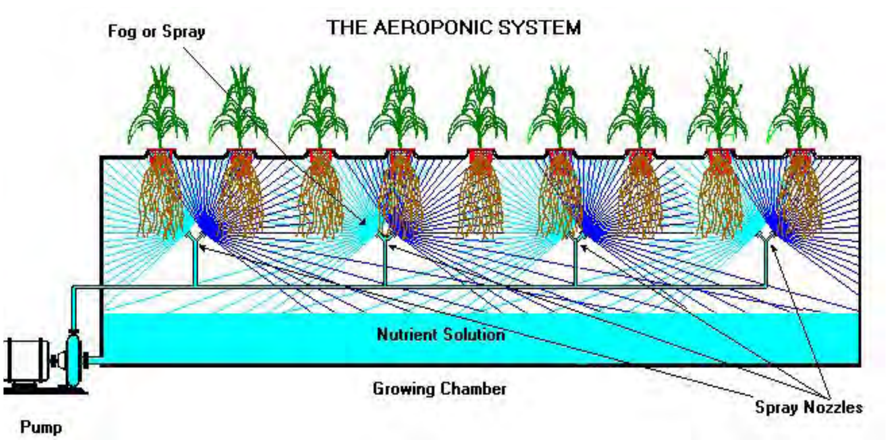
43 http://hydroharvestfarms.com/allabouthydroponics.html

Japanese 'plant factories' are an excellent example of a soilless technology which primarily depends on hydroponic culture.[44] The experiences to date point to other benefits in terms of greatly enhanced capability to grow food under harsh conditions, such as, in non-farmland areas and areas suffering from extreme soil degradation and soil loss. Plant factories are also promoted for urban food production and as 'comfortable work' settings for the elderly and disabled. However, some significant challenges are also noted, including high energy costs and facility installation costs; cultivation technology yet to be established; lack of human resources with both cultivation skills and facility management skills; and limited types and varieties of crops available for production. Despite these challenges, the Japanese Ministry of Economy, Trade and Industry (METI) has indicated that in cooperation with the Ministry of Agriculture, Forestry and Fisheries (MAFF), the aim is to triple the number of Plant Factories in Japan over the next three years and develop and expand this agri-industry in other countries, such as, in the Middle East region.[45]

4.1.2 Aeroponics

This is in some ways a type of hydroponics, which grows plants without soil or another medium. Plants are kept in a moist greenhouse-type environment where a nutrient solution, containing inorganic plant nutrients in soluble form, is applied continuously or intermittently directly to the roots of plants in the form of mist or aerosol. The supply of nutrients can be done by hand or using a computer-operated spraying system of positioned nozzles (Fig. 4 and 5).

Figure 4: Illustration of an Aeroponic System



Source: http://growaeroponics.com/

44 see feature in previous CIPO Issue – the Agriculture, Food and Health Challenge (2009)

45 http://www.meti.go.jp/english/policy/sme_chiiki/plantfactory/about.html

Figure 5 Aeroponic production of cabbage[46]

As with hydroponics, aeroponics has an advantage in that it enables farming where soil is not suitable. The controlled plant nourishment means that plant growth and hence crop development is consistent and noticeably faster. It also allows for more efficient use of water, control of weeds and disease, and for space efficiency. This alone alleviates, to some degree, the pressures on agriculture to acquire additional land for food crop production. It is also applicable to small-scale production systems in both urban and semi-urban settings. As with most technologies, the main disadvantages are associated with the high cost in preparing growing systems, relatively limited scope for commercial horticulture food production (fruits and vegetables) and its relative energy intensiveness. However, some developing countries, including Kenya are actively exploring this technology to drive rapid increases in productivity.(47)

4.1.3 Media culture

This is a system in which crops are planted on solid substrate rather than on soil and a nutrient solution is applied to the media. Both inorganic and organic media are used. Inorganic media are classified according to their shape into particles, foam, fibre and others. Particle media culture includes sand culture, gravel culture, expanded clay culture and Kuntan culture. Organic solid media include peatmoss, sawdust, bark and rice hulls. Media culture, also dubbed 'dirtless' gardening is essentially what is referred to in the Caribbean as hydroponics, as the experience in Guyana suggests (Note #8).

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46 Rosebud, 2011. How Hydroponics Systems work for you, Part 2: Aeroponics and Nutrients. http://www.rosebudmag.com/gardening/how-hydroponics-systems-work-for-you-part-2-aeroponics-nutrients

47 See "Kenya to adopt soilless, mid-air potato-breeding technology' in African Agriculture, 30 December 2010 extracted from http://knowledge.cta.int/en/Dossiers/CTA-and-S-T/Developments

Note #8: ***Students of the Kuru Kuru Cooperative College, Guyana learning 'Hydroponics'***

(Photos: IICA Guyana)

With a renewed interest in appropriate sustainable development methods, hydroponics was reintroduced to Guyana through technical cooperation assistance from IICA. The late Dr. Héctor Muñoz, a Mexican agronomist and IICA Emeritus Professional, introduced this improved farming method to youth in Guyana through a Secondary School Hydroponics Competition in September 2007. The initiative was seen as more than a competition; a foundation to guide the participants to choose a right career. It was also seen as a promoting a different image of agriculture among youth, as it moves away from traditional practices of forking and ploughing. This alternative method of agriculture allows crop production despite adverse and unpredictable environmental conditions. Three steps are taken in preparing the hydroponics gardens:

1. preparation of the substrate,
2. transplanting of the seedlings, and
3. maintaining the hydroponics garden from initial transplanting to harvesting of crops.

Crops planted include tomatoes, celery, spinach, lettuce and patchoi .

4.2 Suitability of Soilless Techniques

Important considerations in growing 'soilless'

Sustainable agriculture and food production is a global consensus. The recently approved Regional Food and Nutrition Security Policy (RFNSP, October 2010), its accompanyingAction Plan (October 2011) and the CARICOM Community Agriculture Policy (CAP, 2011) have in common the objective of securing sustainable food supplies. While farmers are being urged to embrace organic and other forms of soil-based sustainable farming, given the state of the region's resources, there may well be need to at least explore some of the available and appropriate options for meeting food and nutrition needs by growing soilless. There are several issues which will need to be considered in arriving at a decision on the full or partial adoption of soilless techniques among these issues include:

- ***Capacity to meet growing demands for food***

The food crops currently prioritised under regional agriculture and FNS policy are rice, roots and tubers, legumes and a range of vegetables. There is an observation that the major soilless technologies - hydroponics, aeroponics and media culture – may only be suitable for some vegetables. Given the narrow range of food crops that such soilless production currently supports and the general absence of systems agriculture in the region, it is unlikely that soilless food production systems can effectively meet growing demands for food in the Caribbean. Further, although soilless systems may have a more inherent capacity to advance and assure food safety, such foods need to be produced through a system that also enhances affordability and nutritional attributes. In the current Caribbean situation, the proportion of food needs that soilless technologies can satisfy appears to be relatively low compared to soil-based systems.

- ***Technical capacity***

The soilless technologies profiled above are not exhaustive and are intended to underscore that while the Caribbean is still confronting low and declining productivity in contemporary farming, the rest of the World is advancing in soilless ways to produce food crops. Even if soilless technologies could offer benefits for Caribbean farming systems and expanded food production, the state of technological advancement in farming in Caribbean countries is woefully inadequate to deal with basic production challenges, let alone replicate the key functions provided by soil and at the scale at which they are naturally provided. Generally, the capacity among Caribbean farmers for adopting technology and innovation is reportedly low. Soilless technologies which are designed to replace soil, in situations of severe and irreversible land degradation and/or competing land use pressures, may, at this point in time, be either too far advanced or not yet a feasible or reasonable option for most Caribbean countries.

- ***Environmental Implications***

Soil-based food production systems are predisposed and vulnerable to natural and man-made hazards. Vulnerability reduction seeks to limit exposure to hazards and to develop 'climate smart' farming. For Caribbean countries, the capacity of soilless technologies to significantly reduce physical vulnerability of open-field farming systems to hurricanes and other natural phenomena and as well the need to fast track recovery in post-disaster situations offer attractive options. That is, provided that they can be efficiently operated and can generate income and wealth. The threat of climate change impacts provides further fuel to exploring the advantages of soilless food production which compare more favourably than with conventional systems. Further, soilless food production systems would have to demonstrate capacity to reduce the expansionary pressures/competition for land and other resources (e.g. water, energy and labour).

- ***Energy Requirements***

Energy cost is of particular relevance and is becoming an increasingly sensitive factor in food price volatility as oil prices rise and fluctuate. Hence, unless cost-saving and clean energy alternatives are developed, energy-intensive food production systems may incur long-run costs making them prohibitive to all Caribbean countries, with the possible exception of Trinidad and Tobago. Generally, Caribbean farming and food production systems incur high energy costs - a major factor impacting on choice of production system and competitiveness. Soilless technologies are very energy intensive, so too are soil-rehabilitation treatments. In contrast, the soil-saving and bio-remediation activities have an advantage since they essentially rely on naturally occurring processes.

- ***Investment Costs and Financial Viability***

Soilless technologies are an innovation that has yielded remarkable benefits to a few countries in the world. However, such technology would need to (among others) demonstrate financial viability as an option for food production in the Caribbean. While it would be expected that some government support would be required to establish soilless systems for food production, success will depend on whether such systems can be weaned off government support and managed commercially. Several Caribbean countries may not have the capacity to maintain the levels of investment required to support both large-scale soilless technologies and secure affordable food supplies from conventional forms of farming. Hence from a cost-effective perspective, heavy investment in soilless technologies for food production may not be as sustainable an option as preserving the current stock of soil resources in the region as a whole. Generally, soil-saving and soilless food production systems should not be seen as mutually exclusive. The issue is based on a combination of political and technical choices, each with economic implications, that is: (a) whether remaining soil resources will be used largely in their natural state (open field production), or under protected conditions; (b) whether soilless systems will be developed for a subset of strategic food crops "freeing up" conventional farming for other food production; or (c) a mix of both options.

5. Conclusions and options forward

5.1 Conclusions

Soil is the planet's life support system!

Soil is described as a thin layer of life covering much of the terrestrial surface, and acting much like a giant recycling system, providing food, feed, fibre and increasingly, energy through crop production for biofuel. Soil also provides important ecosystem services, including provisions of fresh and clean water, food and flood regulation, essential for human life and carbon storage in an era of climate change. An estimated 99% of the world's food comes from the soil. The life-giving role of soil derives from the natural functions of soil biology. Healthy soil has most, if not all the properties needed for healthy plant life. Therefore, soil has been indispensable to food crop production.

Land use and soil management have continued largely unchanged!

Countries of the region are pursuing all available and appropriate options for growing more food on a dwindling pool of natural resources, including access to fertile arable land. Amidst the global expansion in number, size and levels of sophistication of farming technologies, the Caribbean has been seriously lagging, particularly with respect to soil-saving practices and land rehabilitation treatments for degraded lands. Even with the urgency of FNS concerns and the emerging development challenges, sustainable and integrated resource management systems in the Caribbean are still generally weak. Left unchecked, this will further increase production costs of the farm sector and jeopardize the region's ability to meet FNS objectives.

The future of food production through soil-based farming is at risk!

Extensive and long-term use of agro-chemicals, mainly fertilisers to increase crop yields, has had detrimental impacts on soil quality and fertility, with adverse and long-lasting implications for food production. Also over time, construction of domestic and economic infrastructure, including expansive international airports, sporting venues and tourism facilities, have also been uncompromising in demand for land space, with similarly deleterious impacts on soil resources. Changing land use patterns, changing technologies and changing climate have and are combining to also change the structure and composition of soil resources in a manner that undermines its capacity to carry out its critical functions. Among such functions is that of supporting optimal plant growth. Given the region's limited physical endowments, especially the small island states and the increasing pressure on finite land resources, the capacity to sustain FNS is compromised.

Soil is a strategic resource that is under appreciated and under threat!

Globally, it is estimated that the rate of soil loss is greater today than it has ever been, with an increasing number of scientists emphasizing the limited and fragile nature of soil as a resource, even more so than petroleum, water or air. In the Caribbean, long-term mis-use and improper land management, growing population and other socio-economic pressures have over-ridden imperatives and requirements for preserving the health and productivity of the soil as an essential resource. This, coupled with the vagaries of tropical weather (heavy rainfall and high winds) has resulted in a steady loss of top soil. In many instances, even the sub-soil and parent materials have been eroded leading to steadily diminishing levels of soil fertility and in turn, productivity of Caribbean soils. This has contributed to declining yields of several crops of economic significance, increased cost of production and eventual abandonment of large cultivated areas.

Soilless technologies are influencing the scope and scale of food production

With acute natural resource challenges, other parts of the world are pioneering options in soilless techniques, such as hydroponics, with increasing wide-scale application. More significantly, these technologies have opened up opportunities for urban and sub-urban food production and enhanced household FNS options. In the Caribbean, soilless food crop production techniques still have very limited applications. Protected agriculture in its various formulations, mainly greenhouse production, is currently a major policy thrust in several, if not all Caribbean countries, promoting a relatively narrow range of short-term crops, particularly vegetables. However, protected agriculture, whether of a soil-saving or soilless orientation, is largely a response to the vagaries of tropical weather and the adverse impacts on farm productivity and crop loss.

Use of other soil-less/saving technologies, such as hydro/aquaponics is far less common. Water-based farming methods may have improved the supply situation of a few products, and mitigated to some extent, the water for agriculture problem. However, the cost of such production methods can be high, further contributing to rising food prices and cost of living. This underscores the importance of soil-based agriculture for food production and hence the need to conserve, at all costs, the remaining soil resources in the region. Further, the inherent limitation of these soilless systems remain in the range of foods that may be economically Produced. Whereas a fair range of vegetable, legume and fruit crops can be grown well in these systems, some of the other important food items - primarily sources of protein and carbohydrates - remain reliant on traditional soil-based farming.

How countries of the region respond, individually and collectively, to the current state of soil resources still appears to be an under-appreciated issue in the food and nutrition security dialogue. With so much of the agricultural lands already abandoned or in the course of being abandoned, the opportunity presents itself to rethink the basis for land use planning and enforcement and as well, to put both policies and programmes in place for sustainable soil management practices. This is essential to promote and manage rational land use throughout the region as well as to build resilience to climate change impacts.

5.2 Options Forward

Knowledge of appropriate land use is becoming more important today as countries strategise to address the causes and redress the impacts of land degradation and soil loss.[48] There are some critical areas in which the Caribbean stakeholders can take immediate actions to secure the base for food crop production in the short-to-medium term. Among these, strong and effective governance structures, that provide the foundational elements for sustainable natural resource management is a top priority.

In this regard, there is urgent need for:

(1) updated capability and suitability assessments, and land and water resource management databases

The existing data-base for the soils of the region is about 40-50 years old and it is incomplete. A new data base should be established with the soils mapped and described to Series and Phases. Research must be intensified to find improved ways of managing soil for increased productivity and preservation. An essential element of such databases must be updated land capability classifications and suitability assessments, with specifications of appropriate treatment in the interest of soil conservation. The classification should be based on local soil and environmental conditions and should allow for all legitimate use of the land. Establishing a reliable advisory service for soil management is also important. This service must facilitate farmer registration and regular soil sampling and be tested as the basis for dispensing technical advice as part of national farmer support initiatives. Such a database and technical advisory service will be critical in the process for formulating evidence-based and equitable policies for land and water resource management.

(2) developing and practising integrated and harmonised policy, planning and management systems.

Preserving the remaining soil resources of the Caribbean must be an urgent and top priority for all farming systems and sustainable food production. Policies and actions need to consider an expanded role for forestry, agro-forestry and permanent tree crops of adaptable fruits, both local and introduced, particularly now as the region attempts to develop 'climate smart' agriculture. In this regard, the region confronts a tri-fold challenge to:

1. preserve the utility of remaining soils through adoption of soil-protecting techniques;
2. rebuild degraded soils for economic use and environmental stability; and
3. renew focus on improving management of arable lands through appropriate regulatory and legislative measures.

48 http://landcover.usgs.gov/pdf/anderson.pdf

The need to re-institute and strictly enforce land zoning policies for each Caribbean country, administered by an independent authority with binding decision-making powers should also be seen as an important and immediate action.

There is a general consensus on the need to aggressively pursue an integrated systems approach to soil, land and water resource management within a broader sustainable resource management regime. Effective governance mechanisms to manage human welfare objectives, resource allocations as well as conflicts and disputes arising from resource use will be central to success. As long as there are alternative uses for the land and soil resource, there will be conflict, especially in the processes that seek to establish functional governance and management structures. A harmonised planning and management regime will enhance capacity to cater to the needs and priorities of stakeholders and users, and ensure full participation and involvement at multiple levels (e.g. community, provincial and institutional). This will ensure positive outcomes with respect to policy and legislative formulation processes as well as encourage responsible resource use by stakeholders (e.g. farmers, tour operators) and support sustainable practices based on education and empowerment.

(3) modern legislation and enforcement capacity that give effect to sustainable resource management principles and provide the scope for policy implementation

Land and water use policy lack the 'teeth' to be effective in enforcing appropriate behaviour. Particular attention should be given to zoning of land and water resources (LWRs) to ensure that protocols meet specific needs. These include better cost management and preventative measures against government usurpation of protocol to validate destructive building practices, especially in construction and housing.

While most Caribbean countries have land use legislation that also governs zoning, lack of enforcement has rendered these laws virtually ineffective. This has exacerbated the land loss for agriculture with both public state agencies and private sector interests culpable. In fact, the FAO[49] concluded that while a standard system of characterizing land use does not exist for the Caribbean, a rudimentary one can be based around traditional systems, such as, rural and urban settlement, industrial infrastructure development (e.g. roads, airports, and businesses), open-field agriculture, intensive/industrial agriculture, forest cover, watershed and water-catchment areas, and protected areas. All these systems, with the exception of watersheds and water-catchments, impose expansionary pressures on available land. The unavoidable conclusion is that there is a tendency for land use in Caribbean countries to be ad hoc and unregulated.

49 The FAO has a more detailed categorization system for land use that comprises some 40 categories. See: http://www.fao.org/nr/lada/index.php?option=com_content&view=article&id=154&Itemid=184&lang=en

As of 2011, no comprehensive bodies of laws which address systems for ownership and implementation in the agriculture sector were found to exist.[50] It is proposed that one particular body of law which needs to be created and developed is agricultural real property. As countries determine how to utilise, take, grant and cultivate agricultural lands, real guidelines need to be in place to assist this process. While existing laws in Jamaica and Trinidad and Tobago provide some guidance, legislation should ideally cover five distinct areas:

i. Possession: methods used to possess or take agricultural land whether by private individuals or by the public sector.

ii. Land use: each country needs a nationwide legal framework delineating how agricultural lands are to be developed, zoned, and dedicated for agricultural use (which should also incorporate the development of non-traditional agriculture).

iii. Management: this correlates to the possession methods and land use strategy; each country can have specific guidelines on how they intend to manage the transfer and development of agricultural lands, public as well as privately owned. Additionally, each country can and should have a Register of all agricultural lands in the area.

iv. Land security: laws related to this category would assure private individuals that they need not worry about unlawful takings of land, or personal property, produce or chattel on said lands. In the event of such an occurrence, specific agricultural land laws would have penalties prescribed for offenders which would be strictly enforced.

v. Development strategy: should be specifically enacted into a body of law particularly addressing agricultural lands, and not necessarily be some initiative drafted by a particular Ministry. This strategy can and should be revised frequently to account for new developments, feedback, and changes in other related laws.

(4) building more inter-institutional arrangements for better cooperation on management issues.

The discussion suggests that it is the approach, or lack thereof, of proper land use management and critically, land use policy enforcement that has contributed to the state of soilless in the Caribbean. This includes issues related to haphazard, uncontrolled development and the consequent deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands and loss of fish and wildlife habitat.[51]

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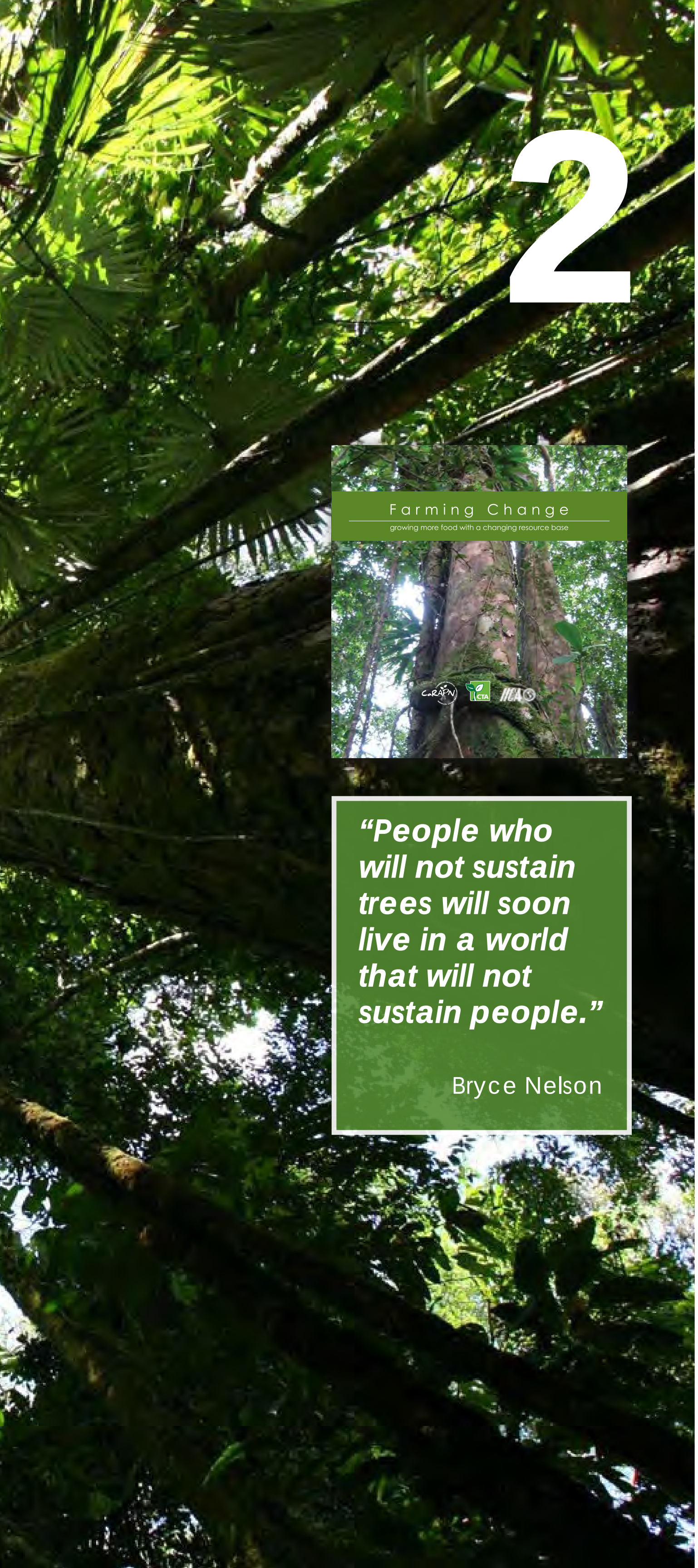
50 Developing An Action Plan For Promotion Of A Regional Agribusiness Sector And Targeted Commodity Enterprises, EuropeAid/127806/D/SER/GY Landell Mills Development Consultants, Final Report, Executive Summary/Working Document. February 2011
51 http://landcover.usgs.gov/pdf/anderson.pdf

Management provides the essential policy space and environment in which more fundamental changes can be made at the resource-use level to improve the quality of the soil – particularly the resilience of soil ecosystem services by preserving biological activity. This is not something that synthetic approaches can replicate on the scale necessary to sustain life. It also identifies outstanding areas, such as, research and data acquisition, human resource and institutional development, and financial backing to initiate large-scale interventions. A regional agricultural modernisation fund would be critical in this regard.

Partnering with the Caribbean Centre for Development Administration (CARICAD) may be valuable in building inter-institutional arrangements for better cooperation on management issues. CARICAD is a regional intergovernmental organisation specialising in transforming and modernising the public sector of Caribbean states. Specifically, the organisation has already contributed to improved institutional governance in several CARICOM countries and has both experience and strategic positioning for supporting improved resource governance structures to support economic development.

Taking from the CARICAD example, there are several institutions that would be instrumental in helping at both the national and regional levels to improve the scope for planning and implementation of national activities which are the immediate concern. These institutions are also considerable repositories of information and knowledge that can expand the level of thinking (as well as reduce the time and cost needed) by national authorities in finding feasible solutions. What is most needed here are improved communication channels and formal mechanisms for cooperation which can be facilitated either through CARICOM Secretariat or by being a member/signatory to the conventions under which the organizations tend to work and mobilize resources.

While the benefits of soil-saving systems for food production and environmental preservation are understood, the value of soilless systems is yet to be ascertained and accepted. Soilless technologies however, do offer tremendous scope for ‘pulling’ youth in agriculture. For the forseable future, the Caribbean will continue to rely on soil-based food production. Hence priority must be placed on building sustainable farming systems through adherence to, and application of, natural resource management principles and practices.



2

"People who will not sustain trees will soon live in a world that will not sustain people."

Bryce Nelson

Forest Cover:
Securing ecosystem services for sustainable farming

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securing ecosystem services for sustainable farming

Introduction

Forests, generally referred to as the 'lungs of the world', quietly go about their business of filtering air, producing oxygen and water and cycling nutrients in soils. Forests cover roughly one-third of Earth, are also host to 80% of terrestrial biological diversity and provide the base for socio-economic activity for some 1.6 billion people. Other forest ecosystem functions and services include watershed protection, water flow regulation, slope stabilisation, rainfall generation and local climate cooling.

The importance of forests was well recognized by the United Nations (UN) which declared the year 2011as the "International Year of Forests" in a global celebration of forests and the contribution they make to sustaining life on this planet. Part I establishes exactly what forests are and the different types that can be found in the Caribbean. This sets the context for an appreciation that forests are not synonymous with 'rain forests' or lush green vegetation or just "bush", but include also grasslands, shrublands and mangroves, each with its own ecosystem functions and services.

With a better understanding of what constitutes forests, Part II describes the functions of forests globally and specifically in Caribbean countries. Located within an ecozone that supports a warm, moist climate, Caribbean countries host rich and diverse tropical forests, the bulk of which occurs in Suriname and Guyana. The value and strategic role of forests of the region in socio-economic development, including mitigating impacts of climate change is well illustrated. The discussion also reiterates the importance of forest resources for livelihoods and establishes the links between the state of forests and functioning of ecosystem services, including climate change mitigation.

As will be shown, the most critical and pressing issue for forests is that of deforestation, which, over time has compromised its effective functioning. This constitutes the focus of Part III. The UN Food and Agriculture Organisation (FAO)'s 'State of the World's Forests 2005[1] noted that "*although deforestation appears to have slowed in the past decade, the average annual rate is still high in many SIDS*". Growing and competing pressures on land use, including expanding farming, are among the major contributors to forest destruction and loss of their ecosystems services. This aspect of the discussion brings out more directly, the link between forests and farming.

Unfortunately, it is observed that historically, the forest-farming relationship has been one of competition and conflict. Despite the lack of empirical evidence, it is generally understood that typically, the destruction of forests across the region has occurred when agriculture was at its peak.

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1 FAO (2007) State of the World's Forests 2005, Rome. www.fao.org/docrep/007/y5574e/y5574e00.htm

Hence, there is some relationship between the destruction of forests and the changing landscape and capacity for sustainable farming and food production in the Caribbean. This recognition is important from the perspective that despite its own challenges, farming and forestry both support a wide range of inter-related activities upon which large segments of the region's population and economies depend on and survive.

The unfolding impacts of climate change have thrust the state of forests and the environment onto the global agenda. This provides the opening for a detailed discussion in Part IV, on the threat and impacts of climate change, recognized as the most significant environmental challenge of the 21st century and beyond.(2) Conservation, sustainable forest management and enhancement of forest carbon stocks in developing countries are central aspects of the solution. The global initiative on Reducing Emissions from Deforestation and Forest Degradation (REDD or REDD+) remains the most substantive multilateral global investment which seeks to conserve tropical forests, largely found in developing countries. This global initiative is of particular relevance for the Caribbean SIDS and stakeholders are urged to follow and engage in dialogue on the state and preservation of forest resources globally, and more particularly, the remaining forests in the Caribbean. Meaningful engagement will require deeper understanding of the function and actual contribution of forest and ecosystem services to the region's sustainable development, climate change threat and options to reduce vulnerability.

An assertion that forests are sentinels for regional well being and that effective forest management is in the interest of all actors in all sectors. A strong call is made for the region to regard the protection of forests as a means of protecting the resources that sustain socio-economic well-being and all sectors that depend on healthy forests and their ecosystem services. It is recognised and fully acknowledged that there is a need for more inclusive and participatory approaches to forest management that embraces non-traditional partners (e.g. agricultural Community Based Organizations (CBO), Non Government Organizations (NGOs) and the private sector.

2 Secretariat of the Convention on Biological Diversity. 2009. Biodiversity and Livelihoods: REDD benefits. Deutsche gesellschaft fur Technische Zusammenaebeit (GTZ) GmbH

1. Forests

FAO defines forest as "*land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10% or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use*." The definition adds the following explanatory notes:[3]

i. forest is determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 metres *in situ*. Areas under reforestation, (that which have not yet reached but are expected to reach a canopy cover of 10% and tree height of 5 metres) are included, as are temporarily unstocked areas resulting from human intervention or natural causes, which are expected to regenerate.
ii. forest includes areas with bamboo and palms provided that height and canopy cover criteria are met, as well as windbreaks, shelterbelts and corridors of trees with an area of more than 0.5 hectares and width of more than 20 metres.
iii. forest includes forest roads, firebreaks and other small open areas; such as those of specific scientific, historical, cultural or spiritual interest.
iv. forests includes plantations primarily used for forestry or protection purposes, such as rubber wood plantations and cork oak stands,
v. forests excludes tree stands in agricultural production systems, for example in fruit plantations and agro forestry systems. The term also excludes trees in urban parks and gardens.

Globally, forests cover approximately 31% of the Earth, host 80% of terrestrial biodiversity[4] and support livelihoods of some 1.6 billion people.[5] (Fig.1) Tropical rainforests typically occur between 28° north and south of the equator. (Fig.2) The Caribbean, South and Central America, the Mexican lowlands and southern Florida are included in this ecozone. This ecozone receives a minimum normal annual rainfall between 175 cm (69 in) and 200 cm (79 in) and mean monthly temperatures that exceed 18 °C (64 °F) during all months of the year. These conditions have fostered tropical rainforests into one of the most productive, biodiverse and complex ecosystems alive today. Tropical rainforests are home to half of all the living animals and plant species on the planet[6] and are considered to be an endangered ecosystem. These regions share a large number of plant and animal groups.[7]

3 http://www.fao.org/docrep/009/j9345e/j9345e05.htm
4 http://www.un.org/en/events/iyof2011/
5 http://en.wikipedia.org/wiki/Tropical_rainforests
6 http://en.wikipedia.org/wiki/Tropical_rainforests
7 http://en.wikipedia.org/wiki/Neotropic_ecozone

Figure 1: The World's Forests

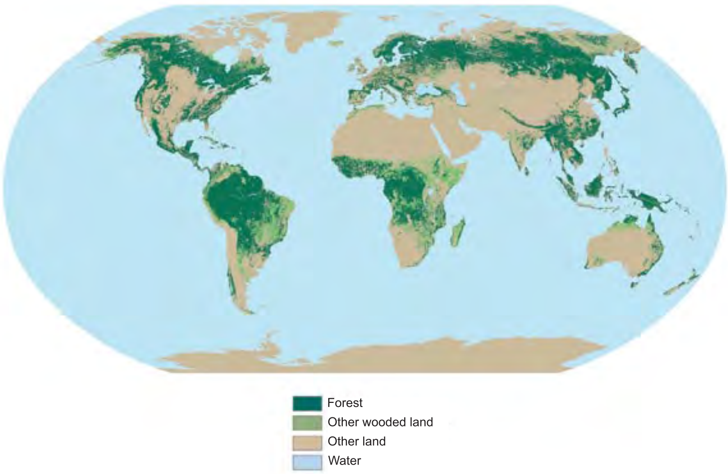
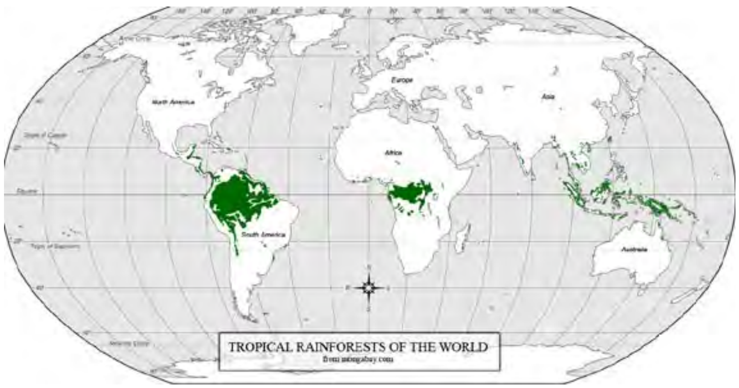


Figure 2: Tropical Rainforests of the World



In relation to its size and geographical make-up, the current range of natural forests occurring in the Caribbean is characterized by rich heterogeneity and diversity typical of the tropics. The Caribbean is located within an ecozone that supports warm, moist climate and tropical forests, including rainforests. Estimated total forest cover in the wider Caribbean stands at 38,091 ha., or 61% of total land area, the bulk of which covers mainland countries of Suriname and Guyana. There are at least nine distinct categories of forests occurring in the Caribbean region, each playing a vital role in maintaining socio-economic activity and biodiversity of the countries individually, and the region as a whole.

1.1 Forests of the Caribbean

The current state and health of the region's forests ranges from country to country (Table 1). Suriname tops the region for forest cover with approximately 90% of land area under forest cover. At the other extreme is Haiti, with the lowest forest cover in the Caribbean. Caribbean forests range from the extensive, verdant, biodiverse rainforest-covered Amazon regions of Guyana, Belize and Suriname to the coastal dry forests and rainforest covered mountains of the islands in the insular Caribbean (Table 2).

Table 1. Caribbean States Forest Cover

Country	Total Land Area (*'000ha*)	Total Forest (*'000 ha*)	% land area
CARICOM Member States			
Suriname	15,600	14,113	90.5
Guyana	21,498	16,879	78.5
Dominica	75	46	61.3
Belize	2,280	1,348	59.1
Trinidad & Tobago	513	259	50.5
Antigua and Barbuda	44	9	20.5
Jamaica	1,083	325	30.0
Montserrat	11	3	27.3
Saint Vincent & the Grenadines	39	6	15.4
Saint Lucia	61	9	14.8
Grenada	34	5	14.7
Saint Kitts and Nevis	36	4	11.1
Barbados	43	2	4.7
Haiti	2,756	88	3.2
The Bahamas	1,001	842	2.8
CARICOM Associate member States			
Turks and Caicos Islands	43	34	80
Anguilla	9	6	60
Cayman Islands	26	13	50
Bermuda	5	1	20
British Virgin Islands (BVI)	15	3	20
Non CARICOM Caribbean States			
Cuba	10,982	2348	21.4
Dominican Republic	4,838	1376	28.4
Puerto Rico	887	229	25.8
Others(1)	310	143	44.5
TOTAL	**62,189**	**38,091**	**61.3**

(1): (Guadeloupe, Martinique, and United States Virgin Islands

Source: Table compiled from data in FAO. (2007).State of the World's Forests 2005. Rome. http://www.fao.org/docrep/007/y5574e/y5574e00.htm (except where noted in table for specific countries)

Table 2: Forest Types of the Caribbean

Mangrove Forests

… or 'rainforests by the sea'* are evergreen forests of brackish water, independent of direct rainfall found and within the inter-tropical zone. They are among the most biodiverse and productive wetlands on Earth. Mangrove wetlands generate ample goods and services, such as, providing critical habitat for bird, fish and other wildlife, playing key roles in biogeochemical hydrologic cycles, regulating water quality, reducing shoreline erosion, offering flood protection, moderating climate, and supporting numerous economic activities such as hunting, fishing, and recreation.** This well-known vegetation class contains only a few widely distributed, salt-tolerant species. They are common along the coastlines of many Caribbean states e.g. Caroni Swamp, Trinidad and are threatened by development activity, e.g. marinas and ports.

Freshwater Swamp Forests

… are independent of direct rainfall and more dependent on edaphic (soil) water. These forests occur in flat areas close to sea-level, with a permanent or seasonal freshwater flow and no inflow of salt water. Trees are evergreen with a tendency for more or less monotypic (single-species) stands to form. Soil surface becomes muddy since the water table reaches the surface for at least part of the year and is sometimes inundated. Soil water is available even if the surface dries out. This class varies from the permanently muddy and occasionally inundated swamp redwood forest beside rivers with a permanent flow of water, to forest on flat areas behind beaches that rely on seasonal creeks to maintain the water table: e.g. Guyana and Suriname's Paramaribo Swamp Forests. Also found in small locations in Eastern Caribbean islands.

Deciduous Seasonal Forest

… is defined as deciduous because taller trees tend to lose all their leaves in most dry seasons, although smaller trees and shrubs are evergreen. Its overall appearance during a normal dry season is of a more or less leafless canopy. There is no moss or cover of ground ferns. Vines and herbaceous ground cover are present, particularly in the more disturbed areas, where more light passes through canopy during the wet season. Annual rainfall of 800-1300 mm (30-50") and a marked five month-long dry season. Also commonly found along the coastlines of the Eastern Caribbean islands, Hispaniola and Puerto Rico.

* Biodiversity of the Caribbean, A Learning Resource Prepared for the OECS, Part 2 / Section D - Mangrove Swamp Ecosystems, Protecting the Eastern Caribbean Region's Biodiversity Project), February 2009, Prepared by Ekos Communications, Inc. Victoria, British Columbia, Canada, http://www.oecs.org/perb_docs/bc_part2d_mangroves.pdf

** A systematic method for 3D mapping of mangrove forests based on Shuttle Radar Topography Mission elevation data, ICEsat/GLAS waveforms and field data: Application to Ciénaga Grande de Santa Marta, Colombia Marc Simard,!, Victor H. Rivera-Monroy, José Ernesto Mancera-Pineda, Edward Castañeda-Moya, Robert R. Twilley

Table 2: Forest Types of the Caribbean

Semi evergreen Seasonal Forests

.... occupy the zone between Deciduous Seasonal Forest and Lower Montane Rainforest. They are characterized by upper canopy trees with rather thin, often broad, and quite often compound leaves, which may lose some, but not all, of their leaves during a dry spell. There are no, or very few, epiphytes, ground ferns and mosses. Annual rainfall of 1300-1800 mm (50-70") generally a five month-long dry season. Commonly used for agriculture and rural settlement in the Windward Islands and generally found in Martinique, Saint Lucia, St. Vincent, Grenada and Carriacou of the Grenadines.***

Lower Montane Rainforests

... merge with Semi-evergreen Seasonal Forest at lower elevations and with Montane/Cloud Montane Rainforest at higher elevations. Trees are evergreen because there is no water deficit most years in any month. In general, trees of all heights are found, without clear divisions into separate canopy layers. Although there may be a shrub, fern and herbaceous (mainly Anthurium) ground cover, this forest class is easy to walk through (if one ignores the incline) except where the canopy has been destroyed and ferns, vines and shrubs colonize the clearing. This type is common to Jamaica and the Windward Islands.

Montane Rainforests

...feature slopes that are extremely steep. Rainfall is very heavy, there is little wind and landslides are very common. The steepest areas are covered with tree ferns and palms, with canopy height of about 4-6m, with some scattered taller trees on slightly less steep areas. Such forests are found in Blue Mountain forests of Jamaica**** the Northern Range Forests of Trinidad, Grenada, Martinique, Dominica, Saint Lucia.

*** http://www.worldwildlife.org/wildworld/profiles/terrestrial/nt/nt0234_full.html
**** Frank Wardsworth Reference & Jamaica dendrology

Table 2: Forest Types of the Caribbean

Cloud Montane Rainforests

...are found on the high summits at an elevation of 700m. The canopy is about 8m high with occasional much taller trees. Terrestrial ferns, anthuriums, bromeliads, and epiphytes are very common; moss cover is often several centimetres thick. Cloud and mist cover, with heavy rainfall, is predominant, with only occasional and short periods of sunshine. They can be found in Grenada, Martinique, Dominica, Saint Lucia, Guadeloupe, etc.

Grassland forests

...are open areas covered mostly by grasses or sedges, but other herbs and low shrubs are also present. Individual trees or small clumps of trees and taller shrubs may also be present. They tend to occur in lower coastal regions with reduced rainfall and undulating terrain. They are typically converted to agriculture, pasturage or settlement areas.

Elfin Shrubland

...is found in the windiest spots on the ridges and peaks, at an elevation above 700 metres, a shrub-land vegetation class dominates. The canopy is up to 2m tall, but often less. Cloud and mist cover, with heavy rainfall, is predominant with occasional short periods of sunshine. (Grenada, Martinique, Dominica, Saint Lucia)

All photos from Graveson, Roger. 2009. The Classification of the vegetation of Saint Lucia. National forest demarcation and bio-physical resource inventory project Caribbean, Saint Lucia SFA 2003/SLU/BIT-04/0711/EMF/LC.

Many of these forest vegetative zones have been threatened by agricultural and other economic activities in the past and some remain threatened today (e.g. Mangroves and Deciduous Seasonal Forests). Familiar forests in the Caribbean include the Northern Range in Trinidad which falls in the category of Montane forests, Morne Diablotins in Dominica, which contains a mix of Montane forests, Cloud montane and Elfin type forests and Mt. Qua Qua, one of the central mountains of Grenada's interior range, which hosts Elfin mountain forests in the upper slopes. Since most of the islands are actually ridge tops, most of the ridge peaks are actually inland, except for the Sierra Maestra in southern Cuba.

In most instances, the declared Government forest reserves in the Caribbean occur in the inland regions of most states. This is due largely to the historical focus on timber production, hillside slope protection for water catchment purposes and the need for soil and water conservation. Generally, coastal forest reserves including mangroves, were and still are commonly considered to be "bush" and hence of little importance to maintaining water supply. They are also largely marginal agricultural zones and hence considered suitable for alternative development options. This has opened up opportunities for conversion of most coastal forests under private land ownership, with very few government-owned coastal dry forest reserves. Most of coastal forest ecosystems (e.g. tropical dry forests or deciduous seasonal forests, mangroves) and their biodiversity are generally threatened from development pressures associated with expanding tourism and urbanization.

Historical records provide evidence that the early European settlers recognized the importance of forests to economic and social development. They instituted measures to protect them despite the clearance of large tracts of forested areas for the expansion of sugar cane, coffee, rice and citrus plantations. The first such documented measures included the establishment of Gilpin Trace as a protected Crown reserve on April 17, 1776, the first reserve of its kind in the Americas. It is now part of the Tobago Forest Reserve and has remained a protected area ever since.[(8)] Kings Hill Reserve in St. Vincent and the Grenadines was also established as a protected forest through a 1791, Order No. 5. It also has the distinction of a historical legacy that recognized the links between forested hillsides and protection of water resources, making it also one of the oldest forest reserves in the Americas. It was established with the explicit intent of protecting water resources for adjacent landowners. In 1912, all land above 330m in elevation in St. Vincent was designated as Crown land, reserved by law to protect forests in the upper watersheds[(9)].

8 http://www.answers.com/topic/tobago
9 UNEP.1992. http://www.unep-wcmc.org/protected_areas/data/countrysheets/vct.html

Note #1: Flashback: the symbiotic relationship between endemic forest tree species and indigenous peoples

Tabonuco or "Gommye" (Dacryodes excelsa)

Forest tree species endemic to the Caribbean grows to a height of 35 m and can live for over 400 years.
(Photo: R. Graveson. 2009)

Archeological evidence indicates that the earliest settlers in the Caribbean (the Pre-Columbian Mesoindian peoples some 6000 years ago) as well as the early colonial settlers depended on forests for potable water, foods, fuels, medicines, fibre and materials for housing and transport. It is believed that the Greater Antillean maize (corn) may have been introduced to the South Eastern North America around 1200BP when the Taino were expanding into Cuba and Bahamas.

The calabash tree, (Crescentia cujete) and the lightweight, straight grained silk cotton tree (Ceiba pentandra) were important species, the latter for canoe making, used for transportation and trade. The Tainos of Puerto Rico used another species, the Tabonuco or "Gommye" (Dacryodes excelsa) as a source of incense and canoe construction. The practice of canoe construction from this type of tree is still done today by the Kalinago (Carib) community in Dominica

Source: UNESCO Publishing .2003. General history of the Caribbean. Volume 1. Autochthonous societies.

2. Functional Forests

2.1 Ecosystem Goods and Services

Forest ecosystems support a wide spectrum of social and economic activities critical to survival, livelihoods and sustainable development. Forests functions range from products associated with timber and non-timber resources to tangible services, such as ecotourism, and intangible services linked to its environmental and ecosystems roles. These functions have been conveniently grouped into four main categories (Table 3)

- Supporting services, which describes the essential functions for life on Earth, including functions relating to soil health for primary production;
- Provisioning services, which describes the tangible goods and products that can be obtained from use of forest resources;
- Regulating services, which describes the often non-monetised yet essential services and benefits associated with the healthy functioning of an ecosystem;
- Cultural services, which describes the non-monetised contributions to the quality of human life and well being as a result of healthy forest ecosystems.

Table 3: Forest Ecosystem Goods and Services

Supporting Services Provision of habitat Nutrient cycling Soil formation and retention Production of atmospheric oxygen Water cycling Primary production	**Provisioning (Goods)** Food, Fibre and Fuel; Genetic Resources; Biochemicals Fresh Water
	Regulating Services Pest regulation and Invasion resistance; Herbivory Pollination and Seed dispersal; Climate regulation Disease regulation; Natural hazard protection Erosion regulation; Water purification Flood regulation
	Cultural Services Spiritual and religious values Knowledge system Education/inspiration Recreation/aesthetic value

Source: '*The role of forest biodiversity in the sustainable use of ecosystem goods and services in agriculture, agro-forestry, and forestry'*. Ian Thompson (et al.) Canadian Forest Service, Great lakes Forest Research Centre. December, 2010 and the Millennium Ecosystem Assessment (MEA).

Environmental roles and ecosystems services of forests, although intangible, are essential to life on Earth. These services include biodiversity conservation, land protection, such as, slope stabilization and soil nutrient cycling, rainfall generation and watershed services and amelioration of high temperatures and local climate cooling. However, many biodiversity-related ecosystem services are not recognized as important.

The dimensions of such well-being derived from forest ecosystems are: (a) security (personal, secure access to resources and protection from disasters), (b) basic material for good life (access to food, shelter, clothing and livelihoods), (c) health (access to clean air & water, etc), (d) good social relations (social cohesion) and (e) freedom of choice and action; the latter cutting across all the other dimensions.[10] The provisioning function appears to have the strongest intensity in its linkages between ecosystems services and human wellbeing, followed by the regulating services. Some of these relatively less understood environmental and ecosystems services are briefly discussed below.

a) Biodiversity conservation

Forests are essential for human survival and well-being. They harbour two thirds of all terrestrial animal and plant species. They provide food, oxygen, shelter, recreation, and spiritual sustenance, and they are the source for over 5,000 commercially-traded products, ranging from pharmaceuticals to timber and clothing. The biodiversity of forests—that is, the variety of genes, species, and forest ecosystems—underpins these ecological goods and services and is the basis for long-term forest health and stability. The issue of 'resilience' has recently emerged as an important ecosystem property and is a function of biodiversity at many scales: genes, species, and regional diversity among ecosystems.

Functional species play disproportionately important roles in ecosystem services and sustainability, e.g., pollination (from many insects, some birds, some bats), pest reduction (also from many birds, many bats, predatory insects), and decomposition (mainly from insects, fungi, micro-organisms). Thresholds exist where the resilience capacity is overcome and the system moves to a new state that will differ in appearance and services. For example, if a forest becomes dry, it loses species, is subject to increased frequency of fire, and moves to a savannah or grassland state. This new state is stable and will require considerable change to move to another state. Unfortunately, the forest biodiversity has been lost and so have most of the goods and services from the ecosystem.[11] Loss of biodiversity alters ecosystem resilience and can result in reduced goods and services.

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10 'The role of forest biodiversity in the sustainable use of ecosystem goods and services in agriculture, agro-forestry, and forestry'. Ian Thompson (et al.) Canadian Forest Service, Great lakes Forest Research Centre. December, 2010 and the Millennium Ecosystem Assessment (MEA).

11 Thompson, Ian. (et. al.) 2010. 'The role of forest biodiversity in the sustainable use of ecosystem goods and services in agriculture, agro-forestry and forestry'. Canadian Forest Service, Great lakes Forest Research Centre December, 2010

b) Rainfall generation

Agriculture in the Caribbean relies mostly on rain-fed production, evidenced by the devastating impacts of the recent drought from late 2009 to early 2010 on crop and livestock production. The drought of 2009-2010 in the Caribbean impacted severely on all sectors of economic activity including agriculture (Note #2). It was so severe, that it has provided an ominous glimpse into possible worst case future scenarios under a protracted drought for ecosystem and socio-economic impacts.

Given the projections of reduced rainfall and increasing temperatures under climate change, drought could become more persistent in the future. With continued deforestation, the situation could become even more worrisome. Forests therefore play an important role in rainfall generation and subsequently, the state of water resources in the region (Note #3).

Note #2: Water Woes!

In 2009, below-average rainfall in Jamaica led to significant reductions in stream flow, especially in rivers feeding the Kingston and St. Andrew areas. The increased demand for water led to a rapid depletion of storage in the two largest surface water storage systems on the island- the Mona Reservoir (capacity of 3.67 million cubic metres [MCM] or 808.5 million imperial gallons) and Hermitage Dam (capacity of 1.80 MCM or 395 million imperial gallons).

By February 2009, the Mona Reservoir and Hermitage Dam were down to 40% and 34% of capacity, respectively. Water rationing to service areas went into effect. Over 70 small rural systems (springs and run-of-the-river diversions) in the east or the central area of the island either went dry or the flows declined by over 80%.

In August 2009, water restrictions were imposed as the situation worsened. There were demonstrations in some rural areas as the National Water Commission (NWC) and the parish councils tried to truck water to the citizens. Farmers in the agricultural belt along the south coast suffered significant losses of crops.
The economic cost to the NWC to truck water, plus the loss of revenues was estimated to have exceeded US$1 million. An increase in water borne diseases such as gastroenteritis and others due to the lack of water to maintain a high level of sanitation was also reported. There was also the considerable economic cost to the country due to reduced production time at factories, and early closure of businesses and schools.

Source: Adapted from the Working Document for the Twenty-First Inter-Sessional Meeting of the Conference of Heads of Government of the Caribbean Community, Roseau, Dominica, 11-12 March 2010

Note #3: Forest Weather

Researchers studying the dynamics of South America's tropical forest have produced scientific evidence showing with precision for the first time that a forest can return as much as 75% of the moisture it receives to the atmosphere. The finding indicates that the forest plays a much more important role in weather generation than had been previously believed. The pioneering study, conducted in the world's largest forest in the Amazon River Basin, is also the first to show that the amount of water a forest gathers can be returned to the air in large enough amounts to form new rain clouds. The new research also indicated that land covered by trees collected and returned to the air at least 10 times as much moisture as bare deforested land, and twice as much as land where grasses or plants other than trees predominated.

Other data gave evidence that water runoff is greatly increased without the heavy mass of vegetation to break the fall of rain, and that the rate at which water infiltrated the soil was considerably lower in compacted pasture soils than in other types. These two findings mean that most of the runoff from precipitation travels relatively far from the site and is not easily returned to the atmosphere. And the study also showed that removal of trees adjacent to rivers or their tributaries contributed to greater runoff, rising levels of streams and flooding.

These studies are credited with focusing the attention of scientists on the impact forested and non-forested land can have on hydrological cycles and regional climatic patterns. And although few scientists can predict the impact of extensive forest destruction on global climate, Dr. Salati and his colleagues' state in their report that extensive forest loss in South America will undoubtedly cause major changes in weather patterns and agricultural practices in the Amazon Basin, an area of some 4.2 million square kilometres.

Bayard Webster is a science writer for the New York Times, New York U.S.A., (l983)
http://idl-bnc.idrc.ca/dspace/bitstream/10625/24107/1/110782.pdf

c) Watershed services:

Watershed services of forest ecosystems are diverse and inter-related and range from regulating water quality, water flow in rivers and streams to supporting biodiversity (Table 4). The importance of forests to water generation and water resource management is recognised by governments in all countries. This is particularly so for the island states, most of which are volcanic in origin and therefore rely on streams and rivers emerging from the forested interior for their source of freshwater. Given the rugged terrain, friable soils, relatively steep, short-river runs and the lack of major natural intermediate collection points (e.g. lakes), many countries have implemented measures to retain their limited inland forest cover and thereby protect their watersheds. The role of forests and in particular the watersheds that they host and protect, cannot be under-stated. Stakeholders are also becoming increasingly aware of the adverse impacts of poor practices on forests resources and especially in vital watersheds. (Note #4).

Table 4: Watershed services and beneficiaries

Watershed Service	Everyone in Caribbean societies benefit from these services
Water quality	- Residents (for drinking and bathing) - Tourists (for drinking bathing and reef preservation - Tourist developers - National Water Authorities - Farmers
Flow regulation	- Tax payers and government - Residents in flood prone areas - Farmers in flood prone areas - Road users in flood prone areas
Soil erosion control and soil fertility/ health	- Residents (land slippage control) - Farmers - Forestry department (and agriculture department) - Tourist developers - Road users (through reduced landslides)
Ecosystem integrity, biodiversity and landscape beauty	- Tourists - Tourist developers - Forestry department and timber producers or other forest product users - Academia - Wildlife/nature itself

Governments continue to face challenges in providing adequate supplies of freshwater and balancing competing needs, i.e., agriculture, domestic consumption, tourism and manufacturing industry. In many countries, the annual per capita freshwater availability falls far below the 1,000 cubic meters commonly used to measure scarcity.

Note #4: Preserving the Water Quality Function of Forest Ecosystems

During the 2010 hurricane season, the Talvern water catchment was one of five seriously degraded watersheds in Saint Lucia. The Forestry Department, supported by community stakeholders, initiated a watershed project managed through a newly formed community-based Talvern Water Catchment Group (TWCG). The aim was to improve the quality of water captured by the local Water and Sewerage Company serving Talvern and adjacent communities. 98% of the catchment was under private land tenure and largely under agriculture. Through the TWCG project, trees, including timber species and fruit (mango, citrus, breadnut) trees, were established on riverbanks and in the catchment area. Farmers were also sensitised and trained in soil conservation practices, including the planting of wattles and grasses to reduce erosion and improve river bank and soil stabilization. The project also provided water quality maintenance services by removing debris (plastics and coconut debris) from streams and river courses.

Raw water to Hill 20 Treatment Plant in Saint Lucia following heavy rains.

Pipe on left: *Highly turbid water from the intake in the deforested, agricultural area of the Talvan catchment.*
Pipe on right*: the clear water supply on the right from adjacent Marquis forested catchment.*
(Photo: C. Cox. 2004)

Much of the early dynamism behind the TWCG's activities was built on a strong sense of collective responsibility, volunteerism and community pride channeled towards environmental concerns. The group received technical support from the Forestry Department and financial assistance from the OECE-NRMU and the Poverty Reduction Fund to procure material and hire labour. This project has also contributed to sustainable livelihoods in the community built around establishment and maintenance of water catchments and plants.

When scarce freshwater resources are threatened by deforestation and inappropriate land use practices across the region, the resulting landslides in turn negatively affect the livelihoods of the rural farming poor due to the loss of crops and being cut off from markets. Watershed protection should therefore be of direct and immediate interest in agricultural development and food and nutrition security policy, strategy and practices.

The region has a poor track record of effective water resource management within watersheds which in turn affects the sustainability of the water resource itself as well as biodiversity in the watershed and coastal zones.(12) This is also contributing to land degradation within the Caribbean SIDS. Inequity in processes that determine prioritisation for water delivery often marginalise the water needs of the poor. The tourism industry in particular imposes high demands for freshwater per capita, many times that of residents of island nations. The tourism industry is also dependent on high environmental quality of beaches and coastal resources including coral reefs (e.g. scuba diving, snorkelling) which in turn is dependent on positive watershed management.(13)

d) Amelioration of high temperatures and local climate cooling

This particular function of forest ecosystems has been compromised by deforestation and degradation. It is now at the centre of the global dialogue on climate change adaptation and mitigation. This aspect is discussed in more detail in a subsequent section.

2.2 Forest Use

2.2.1 Forest Products

- ***Timber:***

Forest trees have been used as construction material since the pre-Columbian period. However, only the larger Caribbean countries of Guyana, Suriname and Trinidad & Tobago, have developed commercial timber industries and are members of the International Tropical Timber Organization (ITTO). These countries appear to have made some progress in forest management, underpinned by sustainable forest management (SFM) principles (Table 5).(14) Guyana faces additional challenges in SFM as a result of its fairly large mining industry. Other factors, such as political and social tensions, lack of secure tenure, lack of understanding and awareness, lack of skilled labour, outdated management practices and the impacts of the recent global economic and financial crises are presenting additional challenges for the achievement of SFM.

12 IWCAM. 2004. Integrating Watershed and Coastal Area Management (IWCAM) in the Small Island Developing States of the Caribbean (project brief). UNDP, CEHI.

13 John. L., Firth, D. 2005.Water, watersheds, forests and poverty reduction: A Caribbean perspective . Commonwealth Forestry Conference. Colombo. Sri Lanka. http://www.ibcperu.org/doc/isis/8086.pdf

14 Country information on Guyana, Suriname and Trinidad and Tobago, respectively, at http://www.itto.int/sfm_detail/id=12520000, http://www.itto.int/sfm_detail/id=12570000 and http://www.itto.int/sfm_detail/id=12580000.

Table 5: Key Features of Timber Production in Guyana, Suriname, Trinidad and Tobago

Indicators	*Guyana*	*Suriname*	*Trinidad & Tobago*
Forest resources	• broad forest base; • large growing-stock of hardwood timber and largely intact forests; • permanent forest estate (PFE) estimated at 5.45 million ha of production forest & 980,000 ha protection forest; • a further 7.35 million ha of state forest not yet allocated to either category;	• large forest base, over 80% forested with sizeable growing stock of valuable hardwood timber; • PFE estimated at 6.89 million ha of natural production forest and 4.43 million ha of protection forest. • a further 2.59 million ha not yet allocated to either category	• PFE is an estimated 142,000 ha of production forest (including >15,000 ha of plantations) and 59,000 ha of protection forest; • most timber production derives from planted forests, main species are teak & Caribbean pine. • Net-importer of imports round logs and squares from Guyana and Suriname for local processing
Forest management	• at least 520,000 ha of production PFE and 243,000 ha of protection PFE being managed sustainably; • National Forest Policy (NFP) widely accepted as sound guide for forest sector; • introduced/implemented a well-designed system for forest management & control in timber production forests; • new draft forest law to replace timber sales agreements and wood cutting leases with a forest concession system; • forest harvesting practices are improving with training of logging operators	• very little deforestation is taking place; • most of the PFE intact - lack of development pressure; • as of late 2003, 67 logging concessions were allocated over a total area of 1.74 million ha.; • forests produce an estimated 160,000 m^3 of industrial round wood per year; the sector is a significant employer • a coherent forest policy and legislation is under development, • the 1992 forest law is currently being revised;	• has a strong tradition in forest management; • SFM has a good footing in the country • at least 15,000 ha of natural-forest production PFE are being sustainably managed; • Individually licensed loggers are able to cut a specified number of trees or volume as defined by the Forestry Division (amounting to a 'logger's selection system); • police patrols probably help reduce illegal activities;

Table 5: Key Features of Timber Production in Guyana, Suriname, Trinidad and Tobago

Indicators	*Guyana*	*Suriname*	*Trinidad & Tobago*
Forestry management challenges	• area of totally protected forests is low, affected by insufficient control and management; • NFP not fully implemented; new laws for forest concession system yet to be enacted; • uncontrolled gold mining a major cause of forest degradation & environmental pollution; • gap between Guyana Forest Corporation core staff and agency responsible for forest management in the field.	• Current requirements for forest management plans lack strong SFM focus; • forest-management institutions are not yet equipped to oversee introduction of SFM in a commercial sector that has materialized within the last decade;	• significant institutional and policy weaknesses and development pressures undermining strong SFM tradition; • has yet to develop a workable set of criteria and indicators (C&I) for SFM suited to its special needs; • natural forests and plantations are affected *(yet quantified)* by over-harvesting, encroachment, fires and other forms of damage.

For many of the smaller Caribbean states, timber production occurs on a very small scale utilising relatively rudimentary processes based on selective tree felling using chainsaws and onsite cutting of boards using guide bars. The boards are then carried out by hand to forest trails, limiting the scale of production and capacity to meet any substantial portion of domestic demand. As a result, these countries are and will continue to be net importers of timber.


photos.tradeholding.com

- **2.2.2 Non Timber Forest Products (NTFPs)**

Usually, Non Timber Forest Products (NTFPs) and Non-wood forest product (NWFP) are used interchangeably. 'NWFP' excludes all woody raw materials, such as, timber, chips, charcoal and fuelwood, and small woods, such as tools, household equipment and carvings. In contrast, NTFPs generally include fuelwood and small woods. This is the main difference between the terms.(15) This paper NTFP. In the region, NTFPs of importance include:

i. Medicinal and aromatic plants, such as tree bark of Cinnamon, Bwa Bandé and Mauby, with growing interest throughout the Caribbean in the traditional herbal remedies.
ii. Edibile products (mainly exotic and natural fruits, bush meat and bee products). Some of the edible products are in the form of forest fruits and nuts (e.g. cohune palm nut, wild passion fruit, Brazil nut) as well as spices and essences (e.g. mauby, peppers, vanilla).
iii. Ornamentals, utensils, handicrafts. In terms of the traditional craft sector, use of calabash, sisal, palm leaves and roots is fairly common. In addition, various tree barks, flowers and resins are used to extract tannins or dyes. NTFPs also feature in various cultural and religious practices throughout the region (e.g. incense, gommyé sap).
iv. Construction material (e.g. bamboo)[16] (John 2005).

Use of the Cohune palm (*Attalea cohune*) nuts for traditional production of Cohune oil in Belize

pacsoa.org.au

(L. John 2011)

15 FAO Forestry, 'Towards a harmonized definition of non-wood forest products', http://www.fao.org/docrep/x2450e/x2450e0d.htm

16 The Potential of Non-Timber Forest Products to Contribute to Rural Livelihoods in the Windward Islands of the Caribbean. Lyndon John, March 2005, Prepared through the project "Developing and disseminating methods for effective biodiversity conservation in the insular Caribbean" CANARI Technical Report No. 334

The rural poor of the Caribbean have traditionally relied upon forest-based livelihood activities for some of their income [17], earning subsistence incomes from the harvest and sale of products in their raw, processed or manufactured form. Income generated in the NTFP sector can represent as much as 25-100% of total earnings in rural households. Persons involved in the NTFP sector tend to be landless and semi-skilled, with limited livelihood options. The average age of such persons is 50 to 70 years, seeking to produce a relatively high volume of products within a relatively short-time to earn much needed income. While both genders are involved, elderly females tend to dominate the sector particularly in sales.[18] However, not all NTF products are accounted for since some portion is utilised in domestic consumption (e.g. domestic food supplies are supplemented through communal hunting in St. Vincent and Grenada, and the domestic use of traditional herbal remedies).

2.2.2 Agro-forestry

The concept of agroforestry is not new to the Caribbean. However, the practice is not as widespread as desired. The following cases (Notes #5 and 6) illustrate that there is potential and opportunity for successful agroforestry projects in the Caribbean with benefits for providing alternative sources of food production, diversifying agricultural production and rejuvenating NTFPs species that are being extirpated in the wild.

Propagating forest tree species for the Fondes Amandes Reforestation Project (FACRP) in St. Ann's in the Northern Range in Trinidad. (Photo: Diana Francis)

17 Information from (a) Dunn, J. 2000. The Socio-Economic Importance of Non-Timber Forest Product (NTFP) use in Grenada: A Study for the Forest Policy Review Process. Grenada Forest Management Project, Grenada; and (b) Hypolite, E. 1997. Oil from Our Forests. The New Forester. Vol.Ix. Forestry and Wildlife Division, Ministry of Agriculture and Environment. Commonwealth Of Dominica.

18 Burt, M. 2002. Survey on the usage of Traditional Plants Derivatives in St. Lucia, Ministry of Agriculture, Forestry & Fisheries. St. Lucia (unpubl.)

Note #5: The Fondes Amandes Community Re-forestation Project

In Trinidad and Tobago, the Fondes Amandes Community Reforestation Project (FACRP) is as a community based organization that has acquired approval for management of state owned water catchment lands which serve the national Water and Sewerage Authority. Over 20 years ago, members of a squatter's community began farming traditional vegetable short crops on the hillside of Fondes Amandes, St. Anns, North Trinidad. In an effort to control the annual bush fires that came with the dry season, excessive soil erosion and flooding during the rainy season and resultant heavy siltation of river and water works, they began to plant fruit-bearing tree crops interspersed with hardwood trees.

The initial effort was unsuccessful due to annual fire damage and a particularly devastating fire in 1987. Subsequent fire prevention training received by the leaders of the Group, and passed on to other community members, has gradually ensured that there has been more resistance to fires and survival of a greater number of trees. This community-initiated watershed restoration and protection project supplies food and employment for its members, protects the Fondes Amandes watershed and encourages wildlife protection (Lum Lock 2003)[19]

In the early 1990s, tree planting and fire trace cutting community "gayaps" (community self help activity) have been held annually. Since it began in 1982, the project has succeeded in transforming fire climax grassland into a viable, fruit-bearing agro-forestry project. Over 1500 trees have been planted and most have survived the annual onslaught of bush fires and insects.

A group of primary school students on a field trip (2010) getting first hand experience about the FACRP activities.

(Photo: Diana Francis)

19 Lum Lock, A. 2003. (Unpubl.) Background Paper on Fondes Amandes Community Reforestation Project. Paper Prepared for the First Meeting of the Regional Action-Learning Group on Markets for Watershed Services and Improved Livelihoods, 27-28 April 2004, Canari, Port of Spain, Trinidad.

Note #6: From 'Wild' to 'Cultivated' Latanyé, Saint Lucia Agroforestry Project

Background: There is a history in harvesting leaves of the Latanyé palm (*Coccothrinax barbadensis*) for craft and broom production in rural areas, especially among women. The broom's economic and cultural importance is widely recognized in the country, as well as by the diaspora who continue to use the broom as a traditional sweeper or as souvenir. The Latanyé palm is a wild plant found mainly in the coastal tropical dry forests and seen as a 'free' resource to be harvested from private and public forest areas. Public areas are protected by the Forest, Soil and Water Conservation Ordinance of 1946, amended in 1957 and 1983.

Problem: Production of Latanyé brooms has either stagnated or declined due to variability in leaf quality, rising costs, difficulties in obtaining leaves and other materials for broom production, competition from cheaper types of brooms and changes in consumer preferences. Over harvesting of leaves to meet the demand for brooms locally and regionally, is a major threat to the wild Latanyé. This is made worse by absence of legislation for harvest/use of the palm, including control of activities on private lands, protection of the plant, praedial larceny and threat of bush fires. This could potentially cause the extinction of Latanyé in Saint Lucia and consequently, loss of livelihoods.

Opportunity: Both producers and consumers recognise, that with adequate support, production of Latanyé brooms could be expanded to meet existing and new demands, also contributing to agriculture diversification and income generation in rural communities. The plant offers many economic advantages that make it an interesting alternative or additional crop to a farmer. It has low ecological requirements, can grow on marginal lands; is indigenous with low incidence of pests and diseases and, by the morphology of its leaves, is resistant to strong winds. Maintenance costs are therefore low. Mature plants have been obtained on the more fertile soils that yield harvestable leaves within two years of planting.

Action: The Ministry of Agriculture initiated a project to propagate Latanyé in the nursery and establish it as a crop for the harvesting of leaves. To this end, the Forestry Department developed a species recovery strategy for conservation and sustainable use of Latanyé. In 2001, a Task Force, mandated to improve the conservation status and preserve the sustainable livelihoods around use of Latanyé, formulated a conservation strategy for the cultivation of Latanyé. That strategy sought to (a) cease harvesting of wild stocks of Latanyé; (b) allow the wild stocks of Latanyé to recuperate; and (c) sustain the supply of high quality brooms to the market (John, L. 2001).

Results: For the last four years, the Forestry Department has supplied Latanyé plants to approximately 35 farmers Island-wide. Currently there are 45 planted farms island-wide with the average farm size varying from half to one acre plots.

Sources:
John, L. 2001. The latanyé (*Coccothrinax barbadensis*) craft industry in Saint Lucia, Forestry Department, Ministry of Agriculture, Forestry & Fisheries; Budhram, D. 2009. Assessment of the latanye broom industry in Saint Lucia. Institutional support for Latanyé/Mauby producers in Saint Lucia. Special framework of assistance 2005 contract no. Sfa2005/slu/pe1/lmp/02. Inter-American Institute for Cooperation on Agriculture

Forest ecosystems services therefore, have become essential to the sustainable livelihoods-based poverty reduction strategies in all Caribbean countries. It is estimated that approximately 334,000 people, or 8% of the population, live in extreme poverty ($1 a day) in the poorest countries of the Anglophone Caribbean. A further five million Haitians or 65% of the population is estimated to live in extreme poverty within the Caribbean Community. The Caribbean Natural Resources Institute (CANARI) recognises the vital importance of forests to '*improved livelihoods and reduced levels of poverty*' and seeks to achieve same through participatory institutions for forest management that facilitate conservation, wise use and the equitable distribution of forest goods and services that are critical to development.

The increasing recognition and value placed on forests is evidenced by various efforts at national forest policy development, by regional environmental agreements (e.g. Cartagena Convention, OECS St. Georges Declaration) and Caribbean support and ratification of international multilateral environmental agreements (e.g. Ramsar Convention on Wetlands, United Nations Convention to Combat Desertification, Framework Convention on Climate Change and Convention on Biological Diversity). However, to a large extent, these environmental and ecosystems services of forests remain largely under-appreciated and under-valued in the Caribbean. Such services are still largely taken for granted and are generally not assessed or 'valued' in monetary terms except after disaster.

Dominica's Handicraft Industry and its many linkages (e.g. tourism, fishing), is heavily dependent on steady supplies of NWFPs such as leaves, dyes, vines, roots, reeds, seeds and seed pods, etc. The Kalinagos (Caribs) are major users of Dominica's NTFPs.

Photo and information: Arlington James, Forestry, Wildlife & Parks Division - Dominica

3. De-Foresting the Caribbean

3.1 Understanding Deforestation

The North American Space Agency (NASA) reported that all varieties of tropical forests are disappearing rapidly through human activity. This activity was mainly 'clearing the natural landscape' for farms and pastures, to harvest timber for construction and fuel and to build roads and urban areas. Although deforestation meets some human needs, it also has profound, sometimes devastating, consequences, including social conflict, extinction of plants and animals, and climate change challenges that aren't just local, but global. [20]

According to NASA, impacts of deforestation are varied and far reaching and may be grouped as follows:

- ***Biodiversity Impacts:*** The genetic diversity of tropical forests is basically the deepest end of the planetary gene pool and is crucial for the resilience of all life on Earth. Hidden in the genes of plants, animals, fungi and bacteria may be cures for cancer and other diseases that have not even been discovered yet or the key to improving the yield and nutritional quality of foods.

- ***Soil Impacts:*** Tropical soils are actually very thin and poor in nutrients. The underlying "parent" rock weathers rapidly in the high temperatures and heavy rains of the tropics, and over time, most of the minerals have washed from the soil. Nearly all the nutrient content of a tropical forest is in the living plants and the decomposing litter on the forest floor. When an area is completely deforested for farming, through slash-and-burn deforestation, the nutrient reservoir is lost. Flooding and erosion rates are high and, in just a few years, soils often become unable to support crops.

- ***Social Impacts:*** Tropical forests are home to millions of native (indigenous) people who make their living through subsistence agriculture, hunting and gathering, or through low-impact harvesting of forest products like rubber or nuts. Deforestation in indigenous territories by loggers, colonizers, and refugees has sometimes triggered violent conflict.

- ***Climate Impacts:*** Up to 30% of the rain that falls in tropical forests is water that the rainforest has recycled into the atmosphere. Water evaporates from the soil and vegetation, condenses into clouds, and falls again as rain in a perpetual self-watering cycle. In addition to maintaining tropical rainfall, the evaporation cools the Earth's surface.

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20 Tropical Deforestation, by Rebecca Lindsey, design by Robert Simmon, March 30, 2007, http://earthobservatory.nasa.gov/Features/Deforestation/

NASA further noted that deforestation often proceeds in a patchwork fashion—clearings that branch off roads in a fishbone pattern, for example, or deforested islands within a sea of forest. Direct causes of deforestation are agricultural expansion, wood extraction (e.g., logging or wood harvest for domestic fuel or charcoal), and infrastructure expansion such as road building and urbanization. Rarely is there a single direct cause for deforestation. Most often, multiple processes work simultaneously or sequentially to cause deforestation.

As in the case with soil degradation, deforestation is a result of both natural hazards and human activity. In the Caribbean, natural disturbances, such as fire, drought, landslides, species invasions, insect and disease outbreaks, and climatic events, such as hurricanes and windstorms influence the composition, structure and functions of forests.[21] According to Disturbance theory, large-scale catastrophic disturbances occurring with high frequency and magnitude can produce major gaps in forest stands (e.g. major landslides as in the case of hurricane Tomas).

3.1.1 Natural Forest Disturbances

The forest disturbance caused by the 2010 Hurricane Tomas in Saint Lucia was determined to be relatively moderate[22] (Table 6). Forest inventories undertaken in both 1982 and 2009 suggest that Saint Lucia's forests had recovered strongly from the previous effects of Hurricane Allen in 1980. This strong recovery shows that Saint Lucia's forests are capable of relatively rapid recovery from disturbance. However, due to the frequency of disturbance to the forests ecosystem in the past 30 years, by hurricane Allen (1980), Tropical Storm Debbie (1994), hurricane Dean (2007) and Hurricane Tomas (2010), there appears to be an inhibitive effect on the capacity of the forest to achieve a steady state (i.e. biomass accumulation = biomass loss).

When such disturbances create large gaps in forests, microclimatic changes may be severe enough to cause the death of all or most of the seedlings of these dominant forest species. Such larger gaps may then be subsequently eroded to their rocky substrates on hillsides or large areas of swamp soils on gentler terrain. In such situations, natural succession is set back considerably. This can also result in a reduction in the diversity of fruiting trees and the capacity of the forest to sustain some wildlife species. Loss of mature trees with established root systems reduces the extent of below-ground root stratification to anchor soils. This limits the capacity of watersheds to conserve soil and water leading to increased water percolation. This creates problems for sustaining water levels in aquifers and as well rendering forests vulnerable to wildfires during periods of drought.

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21 Extracted from (a) 'Preliminary comparative species analysis between the 2009 inventory and previous inventories' by A. Toussaint of the Saint Lucia Forestry Department; and (b) Climate change and forest disturbances. *Bioscience*, 51(9): 723–734. by Dale, V.H., Joyce, L.A., McNulty, S., Neilson, R.P., Ayres, M.P., Flannigan, M.D., Hanson, P.J., Irland, L.C., Lugo, A.E., Peterson, C.J., Simberloff, D., Swanson, F.J., Stocks, B.J. & Wotton, B.M. 2001.

22 Timber inventory of Saint Lucia's Forests. Tennent R.B. 2009. National forest demarcation and bio-physical resource inventory project Caribbean – Saint Lucia SFA 2003/SLU/BIT-04/0711/EMF/LC.

Large-gap disturbances pose major problems for forest management. Therefore a basic understanding of this natural rejuvenation system of mature primary or climax forest types is essential to prepare a rational and ecologically sound forest management plan for building forest resilience.

Table 6: Timber Damage and Loss in Natural Forests Per range (Government Forest Reserve) Saint Lucia

Range	*Damage Total ha*	*# of trees*	*damage Intensity*	*Classes*	*Value (EC$)*	*Remarks*
Dennery	30	16,260	Moderate	All	2,032,500	Majority of damage due to landslides.
Millet	25	13,330	Moderate	All	1,693,750	Same as above
Quilesse	58	31,320	Moderate	All	3,915,000	Damage due to a high landslides occurrence and moderate frequency of wind throws and snapped trees. Canopy disturbance sporadic and localized
Soufriere	200	108,000	High	All	13,500,000	Damage from large landslides. Majority of areas were inaccessible.
Northern	15	8,130	low	All	1,016,250	Damage due to sporadic medium and small landslides and low areas of snapped and wind throw trees.
TOTAL	320	177,260			22,157,500	

Evidence of Hurricane Tomas destruction, 2010, Saint Lucia

Forest destruction

Landslide in Fond St. Jacques, Soufriere

(Photos: M. Bobb, 2010)

3.1.2 *Human Activity*

As noted previously, tree felling for firewood and charcoal, clearing of large tracts of land for infrastructure development and farming are among the main man-made causes of deforestation.

- **Charcoal Production:** Historically, rural dwellers in all Caribbean countries have used forest trees for charcoal production.

The largely unregulated, informal nature of charcoal production in Jamaica, as with the rest of the Caribbean, was identified as cause of concern in terms of the potential impact on land degradation.[23] The impact of such unregulated actions is evident in severe deforestation of Haiti from centuries of charcoal production. Much of this charcoal particularly in the exploitation of the logwood (*Haematoxylum campechianum*), was exported to France during the 19th century towards payment for Haiti's securing its independence from France. Today just about 3% of Haiti's 2,756,000 ha., has forest cover and most of its natural habitats is lost. The largest extents of wild-lands in the country are located in the south and southwest of the country, principally in the *Forêt des Pins* and the *Massif de la Selle*. Haiti's first protected area was legally established in 1926. In 1937, the country's main forest, the *Forêt des Pins*, with an area of 30,000 hectares, was established as a protected area. In 1983, an effort to manage reamining natural areas resulted in the establishment of the national parks of La Visite and Macaya (both covering approximately 3,000 hectares.[24]

The conflicts and political turmoil in the Middle East from 2008, which caused major increases in the price of fuel throughout the Caribbean, led to spiralling increases in the cost of living. Economically, the hardest hit are rural and urban poor who frequently turn to charcoal and firewood as a relatively less costly means of fuel for cooking. Indeed, in 2009, the Saint Lucian government changed its policy from subsidizing the price of the Liquid petroleum gas (LPG), to a new "pass-through mechanism"[25] for transferring the cost of LPG to the consumer. Though the aim of this policy may be to optimize budgets and to have more efficiency in the regulation of pricing of LPG, the result of this policy is that all consumers may be exposed to high global prices for LPG. There is concern over the potential negative impact of this policy, particularly given the tradition and increasing tendency to fell forest trees for charcoal and firewood.[26] The prospects of rising oil prices may have made charcoal production more attractive as a livelihood and as an alternative energy application.

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23 As documented in an Energy Plan prepared for the Caribbean Energy Sector by the United Nations Development Program (UNDP) and the World Bank Energy Sector Management Assistance Program Activity.

24 Renard, Y. 2002. Civil society involvement in forest management: the case of Haiti's terrestrial protected areas. CANARI. Technical report No. 311

25 The pass through mechanism came into effect in September 2009 and was articulated as a policy by the government in the Budget Address of the Prime Minister Stephenson King, Government of Saint Lucia, 2009.

26 Gustave. D. 2009. Development of sustainable charcoal industry in Saint Lucia. Thesis submission in partial fulfilment towards Masters degree under the 7th master's degree in management, access and conservation of species in trade: the international framework.

- **Tourism Development**

There is evidence around the Caribbean of the destructive effects of tourism on forests, particularly on tropical dry forests along the coastal regions. There has also been a shift in tourism development from the small-medium sized establishments to the mega-all inclusive sprawling hotels, golf courses and other ancillary infrastructure. In almost all instances, these hotel development projects depended almost entirely on external financing and private investment. The 2007-induced global financial crisis severely impacted these investments. Consequently, several of these hotel developments have stalled, in several instances, leaving disastrous environmental circumstances in their wake. The situation with Les Paradis, Praslin Bay in Saint Lucia is used to illustrate. (Note #7). Other examples in the region include Cap Cana in the Dominican Republic [27] and Woodford Hill in Dominica.[28]

Cleared hotel and golf course development site in Praslin, Saint Lucia

(Photo: Lyndon John)

27 http://www.acp-eucourier.info/Caribbean-tourist-ho.583.0.html
28 http://dominicanewsonline.com/dno/major-hotel-development-stalled-due-to-financial-crisis/

Note #7: *Development in Conflict: Tourism vs Forest Ecosystem Services*

Before Tourism:

Le Paradis, Praslin Bay, is one of the most beautiful and protected bays on the eastern side of Saint Lucia protected by a system of interlocking reefs, which completely protects the bay from the Atlantic swell. In 1985, this 554-acre estate area was earmarked for Le Paradis Development, which included the design and construction of the first signature championship golf course for the island. The site was also billed as a new multi-phased luxury destination development. Phase One included the first Four-Plus Star international branded hotel with premier suites, exclusive health spa, casino and conference facilities. There are also 100 private residences as well as an enclave of signature homes, all situated to benefit from magnificent views of the ocean and the golf course.[8]

Praslin Bay is also host to seamoss cultivation, introduced in 1985 to a small group of young men from the community. In the 1990s, research in species selection resulted in an expansion of seamoss cultivation at three locations on the east and south coasts. In the mid-1990s expansion in Praslin led to the formation of the Praslin Seamoss Farmers Association (PSFA) with a membership of approximately 20 men and women. The PSFA was successful in obtaining funding to establish a small local facility to produce seamoss concentrate and bottled drinks. The seamoss cultivation technology developed in Saint Lucia has been transferred to a number of places in the region, including Jamaica, Belize, Barbados, Antigua and Barbuda and St. Vincent and the Grenadines. The PSFA was the most successful example of adopting seaweed cultivation as a livelihood.

After Tourism:

In late 2004 a survey was conducted to map the extent of the existing seamoss farms as well as the area for a proposed expansion by the PSFA. At that time, there were three farms of approximately 1060m^2, 3650 m^2 and 6250m^2, the smallest in the North of the bay. This location was deemed unsuitable since it was subject to reduced salinity after rainy periods. Further, given its proximity to the proposed Le Paradis Development, there was an option to abandon the area with all subsequent seamoss farming located in the South of the bay. An area of 21ha (210,500m^2) south of Praslin Island was identified for that purpose, with a smaller area of approximately 1000m^2 adjacent to the western side of the island. A marine environmental assessment noted that '*a number of members of the Praslin community expressed the opinion that while development may be acceptable in the North of the bay, there should be no alteration of the environment South of Praslin Island'*, implying that the South of the bay should remain free of any negative impacts, particularly any elevated levels of bacteria due to sewage pollution and silt.

In November 2007, and as anticipated, Plot 1 in the North of the bay was abandoned. During 2007, silt eroded from the Le Paradis construction site accumulated on cultivation lines resulted in anoxic conditions and necrosis of the base of the [seamoss] plants, i.e. at the point of attachment to the lines. This necrosis causes plants to break free of the lines and be lost to waves and currents. As a result, the PSFA has had to abandon some of its cultivation plots, one of which was regarded as a high production area. While farmers expressed interest in returning to their preferred plots, there was need to clear the heavy sediment accumulation in the bay. Seamoss farmers were aware of plans for sediment removal but were uncertain about how this was to be achieved. In any event, constant re-suspension of the deposits by wave action affects water quality.

The Environmental Impacts of Tourism Development - Praslin Bay, Saint Lucia.
Runoff and sedimentation in Praslin Bay from hotel development site. October 2007.

Praslin Bay after clearing for construction of resort

Runoff and sedimentation in Praslin Bay from hotel development site. October 2007.

1 = live coral, Siderastrea siderea; 2 = overgrowth of coral by algae; 3 = coral mortality due to smothering by algal turf and silt.

Edited from "Assessment of impact of coastal development on Praslin marine environment", A. H. Smith, (2007).
(Photos: A. Smith)

International tourism policies have taken on board the need for the sector to be more responsible and reflect sustainable development principles. In 1994, the World Travel and Tourism Council (WTTC), which owns 5% of Green Globe International, initiated the Green Globe program with the aim of providing guidance materials and support for industry members undertaking activities to achieve sustainability outcomes in the Agenda 21 target areas. Similarly there is the Blue Flag, a certification by the Foundation for Environmental Education (FEE) that a beach or marina meets its stringent standards. FEE's Blue Flag criteria include standards for water quality, safety, environmental education and information, the provision of services and general environmental management criteria.[29]

29 The Blue Flag is sought for beaches and marinas as an indication of their high environmental and quality standards. The Blue Flag is a trademark owned by FEE which is a not-for-profit, non-governmental organisation consisting of 65 organisations in 60 member countries in Europe, Africa, Oceania, Asia, North America and South America.

3.2 Agriculture – a Problem and Solution

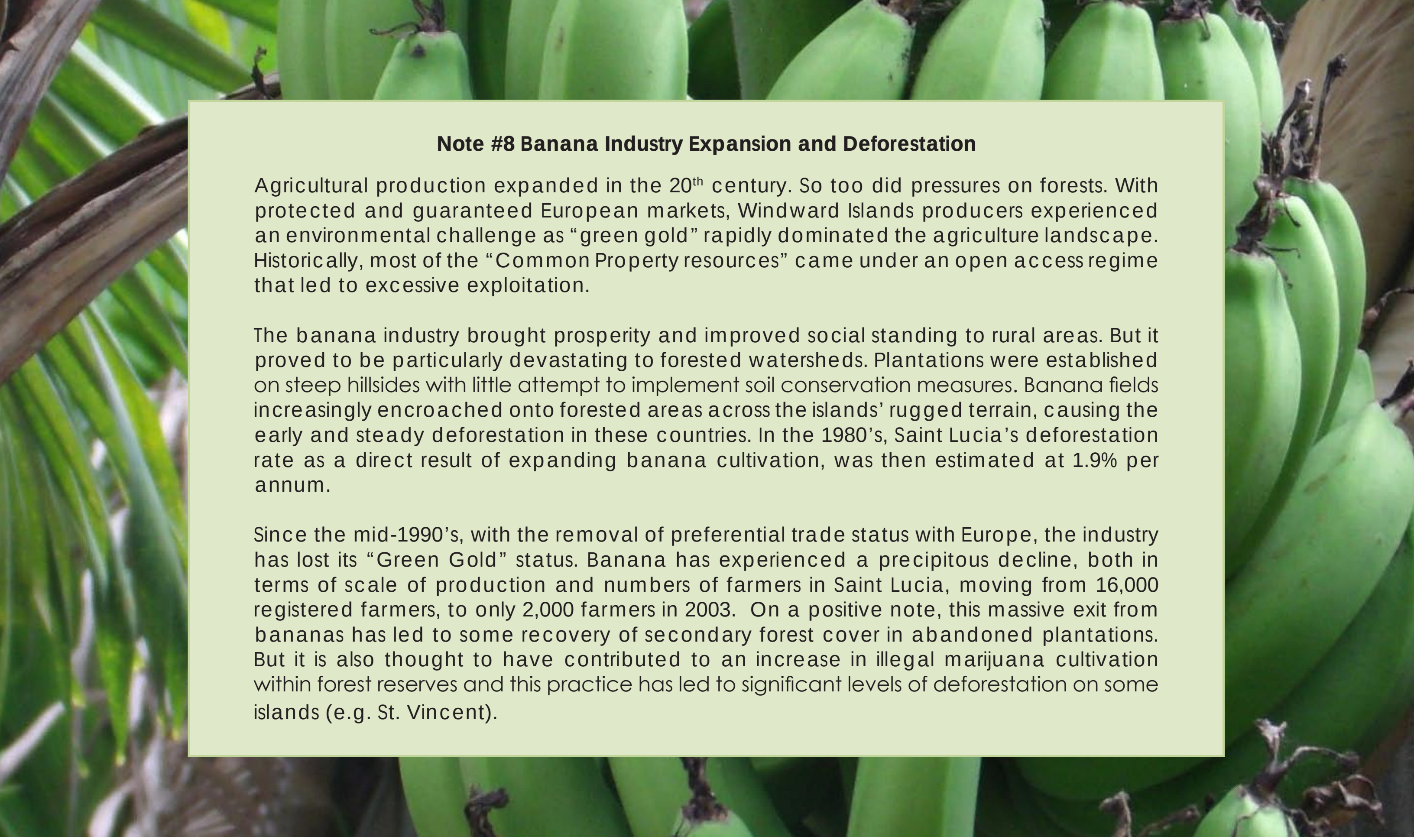
Primary agriculture in most Caribbean countries depends heavily on the natural environment. The nexus between forests and farming can therefore be regarded as the ability of the forests to protect the upper slopes from landslides and soil erosion. In many instances, forests of the Caribbean occur on hillsides, above settlements and agricultural activity. Hence healthy forests serve to reduce the frequency and levels of silt deposition on cultivated lowlands, protect freshwater resources used for irrigation and livestock and protect cultivated lands by acting as windbreaks.

Healthy forests also serve to ameliorate high temperatures which could destroy crop and livestock, and provide flood mitigation by regulating the discharge of water into streams and rivers. Forest ecosystems are essential for healthy and productive crop and livestock production. However, deforestation is compromising the ability of forests to sustain the conditions for productive farming and food production.

Again, in terms of the impact of poor agricultural practices (slash and burn farming and charcoal production), Haiti presents the most glaring situation and best documented evidence of the impacts of forest destruction and environmental degradation in the Caribbean. With the constantly rising oil prices, there is some concern that this could trigger further uncontrolled tree felling to support the growing tendency to use fuel wood and charcoal.

The situation with the banana industry is also used to illustrate the nexus between forests and farming, showing that a decline in agriculture, leads to an abandonment of fields which leaves room for recovery of secondary forests (Note #8).

Haiti presents the most glaring situation of forest destruction and environmental degradation in the Caribbean.



Note #8 Banana Industry Expansion and Deforestation

Agricultural production expanded in the 20th century. So too did pressures on forests. With protected and guaranteed European markets, Windward Islands producers experienced an environmental challenge as “green gold” rapidly dominated the agriculture landscape. Historically, most of the “Common Property resources” came under an open access regime that led to excessive exploitation.

The banana industry brought prosperity and improved social standing to rural areas. But it proved to be particularly devastating to forested watersheds. Plantations were established on steep hillsides with little attempt to implement soil conservation measures. Banana fields increasingly encroached onto forested areas across the islands’ rugged terrain, causing the early and steady deforestation in these countries. In the 1980’s, Saint Lucia’s deforestation rate as a direct result of expanding banana cultivation, was then estimated at 1.9% per annum.

Since the mid-1990’s, with the removal of preferential trade status with Europe, the industry has lost its “Green Gold” status. Banana has experienced a precipitous decline, both in terms of scale of production and numbers of farmers in Saint Lucia, moving from 16,000 registered farmers, to only 2,000 farmers in 2003. On a positive note, this massive exit from bananas has led to some recovery of secondary forest cover in abandoned plantations. But it is also thought to have contributed to an increase in illegal marijuana cultivation within forest reserves and this practice has led to significant levels of deforestation on some islands (e.g. St. Vincent).

With the loss of the preferential agricultural trade arrangements in the European market, the rate of deforestation due to agricultural activities has declined, particularly in the islands states. Today, such agricultural lands are actually threatened and are now under rural or urban housing development, factories, and/or even hotels. Those that have been abandoned to secondary forest cover at least harbour the potential to eventually revert to farming if suitable crops and related market opportunities arise. However, the changing forests of the Caribbean could also lead to changing agricultural biodiversity and availability of fresh water supplies, with implications for food production.

Historically, the farming and forest interface has not often been beneficial for the forests, nor for long-run farm systems productivity and sustainability. It is well documented that forest soils are not the best soils for agriculture. Agriculture actors should pay special attention to the good agriculture practices (GAP) that integrate and enhance effective forestry management in CARICOM as a cost effective strategy to buffer the agricultural sector from the projected pressures of climate change.

Despite the several examples of the impacts of severe deforestation, references to forested areas as "bush" or "wasteland" which should be "developed" are still quite common in the Caribbean. Evidence of the continued vulnerability of forests throughout the region is seen in the felling of trees and conversion of forest lands to meet the growing demands for goods and services. According to the National Geographic, Brazil and Indonesia, which contain the world's two largest surviving regions of rain forest, are being stripped at an alarming rate by logging, fires and land-clearing for agriculture and cattle-grazing.[30] While small-holder farming can be an issue for all countries, livestock may be more of a factor for the mainland territories of Belize, Suriname and Guyana.

Although historically, the farming and forest interface has not often been beneficial for the forests, no attempt is made, here, to establish any explicit and direct link between forest destruction and deteriorating agricultural performance.

In summary, deforestation due to natural causes and development pressures, including extensive farming, has adversely impacted forests in the Caribbean. Periodic disturbances caused by tropical storms are part of the natural development of forests ecosystems, and given time, forests should recover. In the presence of such forces, effective recovery mechanisms are put into effect by the vegetation. However the increased frequency of hurricane strikes keeps setting forests back.

Another major factor 'keeping back' forests in the Caribbean is the lack of clear national forest policies. In 2004, CANARI implemented a three-year regional project titled "Participatory Forest Management-Improving policy and institutional capacity for development". The project revealed that for most of the project countries (i.e., Saint Lucia, St. Vincent & the Grenadines, Barbados, St. Kitts & Nevis and Dominica), there was a 'forest policy vacuum' evidenced by no explicit forest policy statement, no national land use policy, no national water policy, expired forest management or strategic plans and inadequate attention to the role of forests in addressing poverty reduction. This forest policy void often results in a *de facto* forest policy environment being implemented in most states which is either based on outdated forest management plans or archaic legislation that does not address contemporary needs. It also results in unclear lines of agency responsibility for forest management. This situation has meant serious negative consequences on forests due to the summary impact of ad hoc land use decision making which de-prioritises the value of forests against competing economic sectors that are perceived to be of greater importance. Climate change, a common challenge to forest and agriculture, is already worsening the situation.

30 Forest Holocaust, Deforestation and Desertification, http://www.nationalgeographic.com/eye/deforestation/effect.html

4. Changing Climate and Forest Ecosystems

The Intergovernmental Panel on Climate Change (IPCC) under the United Nations Framework Convention on Climate Change (UNFCCC) describes climate change as *"a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods."*[31] Such changes are evident in increasing temperatures and thus increased occurrence of drought, increase in frequency and intensity of cyclonic storm activity (particularly for the Atlantic Ocean). The projected global consequences of climate change are all dire and will not occur in isolation. Rather, its effects will be augmented by pre-existing strained environmental conditions due to past and current economic activities.

Governments of the Caribbean Community, at the Thirtieth Meeting of the Conference in Liliendaal, Guyana in July 2009, noted that the region's **"***efforts to promote sustainable development and to achieve the internationally agreed development goals including the Millennium Development Goals (MDGs) are under severe threat from the devastating effects of climate change and sea level rise which has led to increasingly frequent and intense extreme weather events, damage to biodiversity, coral bleaching, coastal erosion, changing precipitation patterns ..... "*

4.1 Climate Changing Tropical Forests

Under the climate change scenarios, particularly projections of reduced rainfall, Global Climate Models (GCMs) are indicating less rainfall for the region in the future ranging from -25 mm in the 2030s to possibly -56 mm in the 2090s(32). Given a predicted reduction in rainfall coupled with increased temperatures, tropical forest ecosystem in the Caribbean can generally expect to lose diversity in ecosystems and see increasing homogeneity in habitats. This may be expected as areas of current microclimatic conditions are lost and potential large scale ecosystem shifts occur.

Projected scenarios predict a substantial increase in the dry deciduous seasonal forest (or Tropical dry forests) lifezone replacing much of the current Semi evergreen Seasonal Forests (or Tropical moist forest) areas. They also predict the possible reduction in the higher rainfall dependent regions of subtropical and tropical rainforest lifezones, which are the highest rainfall ecozones in the Caribbean. It is important that the region recognize and appreciate the gravity of such loss of biodiversity and the short to long term implications of climate change on forests. (Table 7).

31 IPCC. 2007. Climate Change 2007: Synthesis report

32 Peterson *et al.* (2002) cited in Taylor 2009. Scenario Generation For The Caribbean From Climate Models - Reflections from the Climate Studies Group, Mona (CSGM). Presentation at the Second Caribbean Climate Change Conference, Castries, St. Lucia, 23 -24 March 2009

Table 7: Climate Change impacts and forest system to be most impacted	
Concerns	**Forest systems most impacted**
1. Loss of forests heterogeneity and microclimates resulting in ecosystem shifts	Lower montane rainforests, montane, cloud montane rainforests, elfin woodlands, Fresh water swamps
2. Increased storm intensity and frequency destroys natural habitats and increases vulnerability of wildlife species	Coastal, wetland and forest habitats
3. Reduction in annual rainfall, especially in "wet" season leads to droughts which cause decreased quality of habitats and increased vulnerability of wildlife populations to disease and invasive alien species	Wetlands, rainforests
4. Increase in mean annual temperature leads to increased evapo-transpiration stress on plants and forest fires.	Lower montane rainforests, montane, cloud montane rainforests, elfin woodlands, Fresh water swamps, grasslands, deciduous seasonal forests
5. Increased frequency of ENSO (El Niño/Southern Oscillation) events leads to persistent drought conditions and frequency of forest fires	Lower montane rainforests, montane, cloud montane rainforests, elfin woodlands, Fresh water swamps, grasslands, deciduous seasonal forests
6. Sea Level Rise leading to loss of mangroves, erosion of beaches and salt water intrusion into freshwater ecosystems	Coastal habitats

The global response to climate change impacts has largely focused on the developed countries committing to stringent Greenhouse Gas reduction and mitigative measures as jointly agreed under the Kyoto Protocol (1997). A simultaneous approach has been to promote efforts for nations to address their vulnerability to climate change and the promotion of adaptive measures in the face of this serious threat. Article (2) subsection (a) of the Protocol, refers to the "*Protection and enhancement of sinks and reservoirs of greenhouse gases ...; promotion of sustainable forest management practices, afforestation and reforestation; and the promotion of sustainable forms of agriculture in light of climate change considerations*".[33]

33 United Nations. 1998. Kyoto Protocol to the United Nations Framework Convention on Climate Change

While there are still a number of uncertainties, it is envisaged that in the long run, the climatic change could affect agriculture in several ways, including:

- productivity, in terms of quantity and quality of crops and reductions in crop yields due to decreased water availability, and new or changed insect pest incidence;
- agricultural practices, through changes of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilisers;
- environmental effects, in particular in relation to frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion and reduction of crop diversity;
- rural space, through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities;
- adaptation, organisms may become more or less competitive, as well as humans may develop urgency to develop more competitive organisms, such as flood resistant or salt resistant varieties of pasture for the grazing of livestock;

The IPCC estimate of emissions from tropical forest deforestation and forest degradation in the 1990s was 1.6 billion tonnes of carbon per year or the equivalent of 20% of global carbon emissions. Parties to the UNFCCC agreed at the thirteenth meeting of the Congress of Parties (COP) in Bali in December 2007, to explore "*policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries*."

4.2 REDD and REDD+

Reducing Emissions from Deforestation and Forest Degradation (REDD, REDD+) is essentially a major Payments for Environmental Services scheme which seeks to conserve tropical forests, largely found in developing countries. The target is to halve the rate of deforestation by 2020. Commitment to REDD was advanced at the UNFCCC's Copenhagen Summit in 2009 and again in the 16th COP in Cancun, Mexico. Forests and their critical role in carbon sequestration and storage are now under increasing focus and are increasingly regarded in the context of a "Carbon +". The impetus is spurred on by emerging carbon markets and countries (40 thus far) are engaged in the process of creating national REDD strategies, in collaboration with the World Bank's Forest Carbon Partnership Facility (FCPF) and the UN-REDD programme, amongst others.[(34)] (See Note #9).

Like forests the world over, the tropical forests of the Caribbean have attracted attention for their potential role in emerging carbon markets and for REDD. CARICOM States such as Guyana (estimated forest cover 16.8 million hectares) and Suriname (estimated forest cover 14 million hectares) with their Amazon

34 Secretariat of the Convention on Biological Diversity. 2009. Biodiversity and Livelihoods: REDD benefits. Deutsche gesellschaft fur Technische Zusammenaebeit (GTZ) GmbH

forests and Belize (estimated forest cover 1.35 million hectares)[35] with its extensive tropical rainforests are particularly attractive under current terms and are already attracting REDD type investments (e.g. Guyana). Suriname is ranked 37th in the world in term of existing forest area and is one of the Amazonian countries with the highest forest biomass per hectare. To date, Guyana is the only CARICOM member that is a partner country under the REDD (Note #10). The more forested member states of CARICOM (i.e. Belize, Guyana, Suriname) clearly have carbon market value for their participation in the initiative.

Note #9: About the UN REDD and REDD+

*Reducing Emissions from Deforestation and Forest Degradation (REDD)***+** *conservation, sustainable management of forests and enhancement of forest carbon stocks*

REDD is a mechanism to create an incentive for developing forested countries to protect, better manage and wisely use their forest resources, thus contributing to the global fight against climate change. **"REDD+"** goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. REDD+ strives to make forests more valuable standing, than cut down, by creating a financial value for the carbon stored in standing trees. In the long term, payments for verified emission reductions and removals, either market or fund based, provide an incentive for REDD+ countries to further invest in low carbon development and a healthier, greener tomorrow."

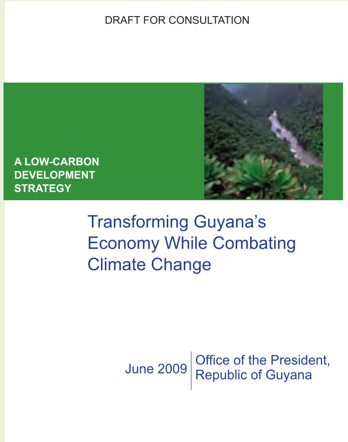
UN-REDD Countries Receiving Direct Support
Bolivia, Cambodia, Democratic Republic of Congo (DRC), Indonesia, Panama, Papua New Guinea, Paraguay, the Philippines, Solomon Islands, Tanzania, Viet Nam and Zambia

Partner Countries
Argentina, Bangladesh, Bhutan, Central African Republic, Colombia, Costa Rica, Ecuador, Gabon, Guatemala, Guyana, Kenya, Mexico, Nepal, Nigeria, Republic of Congo, Sri Lanka, Sudan

UN-REDD Programme.2009. Year in review. UNEP, FAO, UNDP. www. Un-redd.org, http://www.un-redd.org/PolicyBoard/tabid/588/Default.aspx

35 FAO. (2007).State of the World's Forests 2005. Rome. http://www.fao.org/docrep/007/y5574e/y5574e00.htm

Note #10: Guyana and REDD



In supporting the call to cut net global deforestation in half by 2020, and to make the global forestry sector carbon neutral by 2030, President Bharrat Jagdeo offered Guyana a rainforest country with over 80% of land area pristine forest, as a model to the world of how sustainable use of forest and agricultural land can deliver 37% of the world's greenhouse gas abatement potential between now and 2020. Guyana's Low Carbon Development Strategy is advanced under a "REDD Secretariat" established with the Guyana Forestry Commission" and Guyana has found financial investment from Norway's International Climate and Forest Initiative which it signed in November, 2009 and stands to potentially receive investment of US$ 250 M under this scheme. The deal was regarded as one of the biggest in forest conservation and the two Governments expressed the intent of the deal as to "provide the world with a working example of how partnerships between developed and developing countries can save the world's tropical forests."

From a Caribbean perspective, it is the **"+"** elements of forest ecosystem services (watershed protection, water flow regulation, slope stabilization, rainfall generation, soil nutrient cycling and local climate cooling) that have been critical to livelihoods and regional development. In the current climate change agenda with its market-driven Carbon focus, the **"+"** represents all these other essential ecosystem services that forests provide. Hence, better understanding of forest ecosystem services and the climate change threat is important to the CARICOM SIDS response and ultimately, survival. There is a significant need to recognize the market value of these non carbon services of our forests and seek further investment in securing these services.

Against this backdrop, one must still consider, does REDD or its REDD+ format represent the interests of the Caribbean? What of CARICOM's Small Island Developing State members?

Arguably, since the "REDD+" format includes forests in "the role of conservation, sustainable management of forests and enhancement of forest carbon stocks", there is scope for some participation of CARICOM's SIDS albeit not to the same degree as the 3 continental members. Further, the Alliance of Small Island States (AOSIS) of which some of the Caribbean islands are associated, proposes that REDD should ensure that there be no adverse consequences to biodiversity, nor to the livelihoods of indigenous peoples in the international community's agenda to address impacts of climate change.

Yet the AOSIS statement regarding REDD points to an opportunity for SIDS as it states: *"In our voluntary efforts to defeat deforestation and increase carbon sequestration, finance, technology and capacity development is necessary to underpin a step-wise process for reducing emissions and increasing carbon sequestration through the conservation and sustainable management of forest crops which are good carbon dioxide sequestrators. Based on national circumstances, a well designed REDD Plus instrument will require resource mobilization from a variety of sources, including public, private and market-based, as appropriate, that employ robust methodological standards for measurable, reportable and verifiable actions. Robust environmental integrity will need to be maintained if a REDD mechanism is linked to the international carbon markets."*[36]

During its fifth Policy Board meeting in Washington, D.C. from 4th - 5th November 2010, the UN-REDD Programme approved US$15.2 million in funding for national programmes in Cambodia, Papua New Guinea, Paraguay, the Philippines and Solomon Islands, bringing the total amount of funding for UN-REDD National Programmes to US$51.4 million.[37] The Cancun Climate Change Conference (29th November-11th December 2010) continued to indicate multilateral general support for REDD+ amidst the otherwise intransigent debates on other elements of the Long Term Cooperative Action. AOSIS and other developing countries agreed that provided that adequate and predictable support is forthcoming they would focus on aiming to "*slow, halt and reverse forestry cover and carbon loss.*"

At the Cancun COP, developing countries, including the Caribbean, are requested to develop a national strategy or action plan and determine national forest reference levels, or sub-national reference levels as an interim measure. They are also required to develop a robust and transparent national forest monitoring system and a system for providing information on how the safeguards are being addressed through implementation.

The REDD+ programme is not without its challenges in terms of scientifically accounting for its primary objectives. In this regard Subsidiary Body Scientific and Technological Advice (SBSTA) has to "develop modalities for measuring, reporting and verification (MRV) of emissions by sources, and removal by sinks resulting from [REDD+] activities." The REDD+ initiative remains the most substantive multilateral global investment in forest resource management. This provides an opportunity for the region to merge its sustainable development interests (i.e. World Summit on Sustainable Development (WSSD) Millennium Development Goals (2015)) with the international climate change agenda. Indeed, since the 2009 Copenhagen Summit, the REDD+ initiative has acquired the commitment of some of the wealthier developed nations including Norway and Britain to provide financing of $4.5 billion by 2012. Further, the REDD+ has been considered one of the few luminary moments of that Summit. However, to be successful, REDD+ cannot be a "one size fits all" strategy.

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36 AOSIS. 2009. Alliance of Small Island States (AOSIS) Declaration on Climate Change

37 http://www.un-redd.org/PolicyBoard/tabid/588/Default.aspx

5. Conclusions and Options Forward

5.1 Conclusions

That forests are the lungs of the world is becoming increasingly clear!
Functions related to taking in carbon dioxide and releasing much needed oxygen, soil health and water cycling are essential to sustain life and livelihoods on Earth. Forests also provide key habitat protection for biological diversity. Ultimately, preserving forests needs to be high on the sustainable development agenda for the Caribbean region. An estimated 61% of total land area in the Caribbean region is covered by natural tropical forests. These forests are characterized by rich heterogeneity and diversity typical of the tropics. There are at least nine distinct categories of forests found in the Caribbean, each playing a vital role in maintaining socio-economic activity and biodiversity of the countries individually, and the region as a whole.

From early human settlements, rich tropical rainforests have enabled human survival!
Various regional environmental policy statements acknowledge that socio-economic development is linked to effective management of forests of the Caribbean. Forest ecosystems have and continue to provide potable water, foods, fuel, medicines, fibre, materials for housing and transportation and host a diverse range of economic activity, including provision of timber, non-timber forest products (NTFPs), fuelwood and wildlife. Many of the rural poor have earned subsistence level income from harvesting such products, selling them either in the raw form or as processed or manufactured goods. As a result of this close association, the poor are frequently blamed for the destruction of public forest reserves. However, while deforestation may be driven by poverty related issues, it has seldom proven to be the sole and direct result of poverty. Rather, deforestation may actually result from a multitude of variables including periods of national prosperity.[(38)]

Forest ecosystem functions and services are under threat!
Periodic disturbances from hurricanes and tropical storms are part of the natural development of forests ecosystems in the Caribbean. The region is already vulnerable to natural hazards as demonstrated by the devastation wrought by earthquakes, droughts and current and past hurricane seasons and tropical storms. Increased frequency of hurricane strikes keeps setting forests back. The Caribbean is also not exempt from the numerous pressures at work driving deforestation globally. These include competing pressures for housing, industry and tourism. The Praslin development in Saint Lucia is just one example of adverse effects on forests, watersheds and critical freshwater supplies. Farming is also both a problem and part of the solution.

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38 John, L. 2005.The potential of Non Timber Forest Products to contribute to rural livelihoods in the Windward Islands of the Caribbean. CANARI Technical Report No. 334. http://canari.org/documents/ThePotentialofNonTimberForestProductsintheWindwardIslands.pdf

There remains a fundamental lack of awareness by society of the vital functions and roles of forests. This has all too often led to a consequential lack of appreciation and an under valuation of the services rendered by this critical life-giving ecosystem.

Tropical forest ecosystem in the region can generally expect to lose ecosystem diversity!

There is enough evidence to suggest that the destruction of forests within a climate change scenario will lead to biodiversity change. This will, in turn, lead to changes in agricultural biodiversity and hence prospects for farming and food production. Climate change is expected to burden the natural systems with increasing temperatures, possible drought conditions and an increasing frequency of extreme events and exacerbate the serious environmental pressures already placed on terrestrial ecosystems. With the projected reduction in rainfall coupled with increased temperatures, tropical forest ecosystem in the Caribbean can generally expect to lose diversity in ecosystems and see increasing homogeneity in habitats.

This may be expected as areas of current microclimatic conditions are lost and potential large scale ecosystem shifts occur. Pressures such as forest fragmentation, reduction in habitat and the resulting adverse effects on wildlife species are already proving difficult to manage. Consequently, there is a growing appreciation that the changing Caribbean forests can or may lead to changing farming systems and capabilities with implications for food and nutrition security, etc. The effects will be felt through the compromise of the resources needed to sustain agriculture (e.g. fresh water supplies, reduced occurrence of landslides which can threaten lowlands with heavy soil deposition).

Under threat of climate change and challenges of sustainable development, the Caribbean needs high quality forests more than ever to ensure continued production of essential environmental goods and services. This includes a dynamic and sustainable agriculture industry that can be protected from the projected destructive weather anomalies and potential threats from climate change.

5.2 Options forward

The regional challenge in sustaining Caribbean forests can be summarised as the need for a new approach to forest management policy and planning processes fully integrated into developmental planning processes and valuation of forest ecosystem services that are accounted for meaningfully in national budget exercises. The issue of planning is of immediate and central importance in ensuring sustainable forest management and in preserving the functions of forests to address the pressing concerns of climate change and sustainable natural resource management. Traditionally, forestry planning functions have been placed under Ministries responsible for agriculture, lands, and/or the environment. A few Caribbean countries, such as St. Kitts and Nevis and Saint Lucia, have in recent times, established a separate ministry responsible for Sustainable Development, which oversees matters relating to forestry management.

Therein, is an opportunity to adopt ecosystem-based adaptation approaches [39] to climate change which can be a cost effective strategy for adaptation across many sectors including, importantly, the agricultural sector (Note #11).

In terms of critical actions that should be considered with some urgency in the region, , the need to:

(1) *assess the actual and potential social and economic contribution of forests in the Caribbean towards agriculture, sustainable development and climate change resilience*.

There is still much scope for the application of market based approaches to the economic valuation and monetisation of environmental and forestry ecosystems services. Increasingly, there are calls to explore the potential for market based approaches to environmental management, commonly referred to as payment for environmental services (PES). PES, broadly defined, is the practice of offering incentives to farmers or landowners in exchange for managing their land to provide some sort of ecological service. These programmes promote the conservation of natural resources in the market-place.

39 http://www.cbd.int/decision/cop/?id=7148

Note #11 – Back to Nature

The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. The application of the ecosystem approach will help to reach a balance of Convention's three objectives: (a) conservation; (b) sustainable use; and (c) the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources. There is no single way to implement the ecosystem approach, as it depends on local, provincial, national, regional or global conditions. Also, it does not preclude other management and conservation approaches, such as biosphere reserves, protected areas, and single-species conservation programmes. The ecosystem approach offers an appropriate framework to integrate the various and diverse responses and methodologies, especially in situations where there may be intense competition among sectors.

http://www.cbd.int/decision/cop/?id=7148

With the passage of the Kyoto Protocol in 1997, the carbon market has emerged as a climate change mitigation mechanism which includes carbon offsets based on forest sequestration and storage. Other potential markets for forest services include watershed protection and for landscape beauty. In this regard, conducting an economic evaluation of forest ecosystem services and developing a payment system for environmental services where appropriate, and promote integrated and sustainable forest management systems should be a top priority for Caribbean governments. (See Note #12).

Note #12 Integrated Forest Management and Development Programme (IFMDP)

In Saint Vincent, forests have been traditionally used for hunting, charcoal production, extraction of timber and production of NTFP. More recently, with the decline in banana production, forests are increasingly being used for marijuana cultivation, accompanied by settlement activities.[40] This is causing negative impacts, such as loss of soil and siltation of watercourses, which is becoming a major problem for water extraction companies and hydroelectric projects.

In an attempt to redress the situation, in 2003, the Government of St Vincent and the Grenadines (GoSVG) established the Integrated Forest Management and Development Programme (IFMDP). Its aim was to promote sustainable management of forest resources to protect water supplies, enhance the eco-tourism potential and bio-diversity, while simultaneously protecting the livelihood of other forest users. Under the IFMDP, the Forestry Department would be strengthened for more effective management of the forest resources. Also, organized Forest Users Groups (FUGs) representing upland communities would be engaged to enable a shift away from marijuana cultivation and to assist with improved watershed protection.

Such a shift was supported by an Alternative Community Livelihood Projects (ACLP) to aid in the development of viable employment alternatives in rural communities, preventing deforestation while promoting the sustainable use of the forest resources. These alternatives include the sustainable use of timber, non-timber forest products and the production and sale of charcoal. Working with the FUGs to identify and develop viable economic alternatives to marijuana farming while they help restore the watersheds it serves as a poverty reduction strategy.

A 2003 Cabinet decision provided IFMDP with 60% of its funding from Government Capital Projects and an additional 40% shared equally from St. Vincent Electricity Services Ltd. (VINLEC) and the Central Water and Sewerage Authority (CWSA). The participation of the two utility companies was non-negotiable. This GoSVG decision was reflective of an adoption of a market based system which acknowledges that key beneficiaries of watershed services should provide financial support to securing those services.

40 GoSVG 2002. Integrated Forest Management Programme. Peak Consultants Ltd. Government of St. Vincent and the Grenadines, Ministry of Agriculture and Fisheries.

(2) *determine and measure the vulnerability (sensitivity, adaptive capacity, risk) of forest ecosystems and biodiversity, particularly in the context of climate change.*

Regional, national and sectoral management plans should reflect the understanding of the need to reduce vulnerability to the increased likelihood of climate change induced disasters. Policymakers in the Caribbean will have to decide the extent to which they take precautionary measures by enhancing the resilience of their more vulnerable systems. Forest ecosystems in the Caribbean are considered to be under threat and hence among the more vulnerable systems. However, capacity for risk assessment and hence vulnerability reduction within forest ecosystems is at best, weak and ad hoc.

Typically, after disaster, in most countries, damage and loss assessment is conducted which identifies the social, environmental and economic impacts of the disaster. This assessment also quantifies losses in financial terms. However, the ability should exist, and if not, the capacity built for the Caribbean to have a more systematic approach to accounting for ecosystem services rendered before the passage of a disaster and the economic savings accrued from effective ecosystems management and resilience incurred. In this regard and given the projected frequency and severity of climate change impacts, there is now an urgent need to conduct applied research to inform and monitor the state of the regions forests , identify when critical thresholds are reached and develop strategic plans to reduce vulnerability leading to speedy recovery of forest ecosystems and biodiversity after disturbance. A basic understanding of the natural rejuvenation system of the mature primary or climax forest type is essential to prepare rational and ecologically sound forest management plans for building forest resilience, current recovery and restoration process.

(3) *foster broad based inter-sectoral planning that includes national sustainable forest management systems within an adaptation and sustainable development framework.*

As noted, fragmentation in traditional forest management planning processes has been a major institutional deficiency. Forestry management has also tended to be shifted from Ministry to Ministry, mainly between agriculture, environment or sustainable development, with changing administration and portfolio adjustments. An enabling environment requires that responsibility for forestry policy is located within the Ministry most strategically positioned and capable of managing policy implementation. Supportive governance arrangements that accommodate the participation of all stakeholders in the context of climate change are essential for successful forest sector policy.

Hence, an enabling environment must also be built on and continually foster broader inter-sectoral linkages between the various national forest management agencies and non traditional partners for forest management planning processes (e.g. CBOs, NGOs, Water authorities, tourism/ecotourism stakeholders, private sector water bottlers, utility companies, breweries, Ministries of finance, planning and trade).

With respect to sectoral policies, agriculture and tourism are two sectors that will require and stand to benefit from an inter-sectoral approach to policies, strategies and investment projects. Underpinned by an ecosystems approach, developments in the agriculture production and tourism sectors should strive to ensure minimal disturbance and/or destruction of the environment and the ecosystem services that it supports.

Such developments should seek to enhance: (i) the quality of the very environment that they depend on, (ii) the quality of life of Caribbean nationals, (iii) ability of the ecosystems to sustain production of goods and services (e.g. clean water and coastal beaches). Such agriculture production and tourism sector policies should therefore seek to strengthen positive economic incentives, support corporate and social responsibility and reinforce the integrated assessment, planning and regulatory environment.

Critically, they should also seek to employ the "polluter pays principle" when there are environmental failures.[41]

Given the interface between forests and farming, ecosystem based adaptation approaches within forest management may focus on promoting adaptation in the agricultural sector. With an understanding that freshwater is a vital element in agricultural production, healthy ecosystems and all forms of socio-economic activities, building resilience by promoting sound integrated watershed management practices is of critical importance. This can be achieved through Good Agricultural Practices (GAP), sustainable land management practices, reduced deforestation and reforestation and afforestation, where necessary.

Indeed, the Caribbean should be advancing the concept of the watershed as the basic geographical unit for land use planning and zoning. Ideally, lands would be classified according to soil stability characteristics and slope of terrain. This would offer positive benefits for forest management and enhance the efficiency in agricultural production. For example innermost mountainous terrain with steep slopes with fragile soils in the upper reaches of the watershed would be classified as forest; gently sloping to flat would be considered from agro-forestry management systems to agricultural and settlement.
This is an essential recommendation being advanced by recent regional projects including the USAID funded "Ridge to Reef" project in Jamaica[42,43] and the GEF financed Integrated Watershed and Coastal Area Management Project.[44]

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41 In environmental law, the polluter pays principle is enacted to make the party responsible for producing pollution responsible for paying for the damage done to the natural environment.

42 http://pdf.usaid.gov/pdf_docs/PDABW699.pdf

43 The Ridge to Reef Watershed Project *(R2RW)* was a five-year (2000-2005), $8 million initiative undertaken by the Government of Jamaica's National Environment and Planning Agency (NEPA) and the United States Agency for International Development (USAID). The Project sought to address the degradation of watersheds in Jamaica by improving and sustaining the management of natural resources in targeted watershed areas that are both environmentally and economically significant.

44 http://iwcam.org/

(4) *include issues related to sustainable forest management and climate change adaptation within the framework of guidelines and commitments under REDD and REDD+ on the agenda and discussion of regional meetings (COTED, etc) .*

Governments of the region must recognise the underpinning role of forests to the various sectors of the economy. Such recognition is central to the development of policies that foster investment in sustainable forest management thereby sustaining its array of services. Such fora could strengthen the environment for the design and implementation of a suite of economic based incentives to foster increased interest in protection of forest resources particularly on private lands. This would establish direct economic value for forested hillsides in the hands of private land owners thereby reducing the tendency to convert forests to other land uses.

In conclusion, ecosystem based approaches can secure livelihoods, particularly for the rural poor who tend to be directly dependent on such services, as illustrated in the case of non-timber forest products, and vulnerability to weather and climatic disasters. Such ecosystem based approaches should be used appropriately and can be adopted alongside other types of adaptation measures (e.g. structural engineering approaches).

There are many ways in which ecosystem approaches may be used as the framework for delivering the objectives of the Convention. These include, promoting effective forest management on hillsides and tree cover on riverbanks to minimise land slippage, stabilise riverbanks and reduce/mitigate flooding. Acquisition and maintenance of intact natural forests and the selection of appropriate mixes of species for afforestation is also important to reduce vulnerability to climate change impacts and enhance resilience of ecosystems. Hard engineering measures to mitigate climate change, such as, constructing sea walls and groynes along coastal areas, often have adverse impacts on mangrove forests and other coastal habitats. In addition, such measures tend to be costly in comparison to ecosystem based adaptation approaches.

Climate change poses a challenge which will once again test the adaptive nature of the Caribbean peoples to not only survive but to prosper into the 21st century and beyond. Healthy forests remain central to the region's survival and sustainable development. There are enough good examples throughout the region of getting stakeholders engaged in national forest policy development and implementation, including promoting positive watershed management practices and water conservation within an enabling policy context.

The Integrated Watershed Management approach also realises the role of various stakeholders including the poor. This approach enables communities as a whole to respond to the threat of climate change by promoting a participatory approach to implementing measures that (1) protect forests and thereby enhance resilience to climate induced threats and (2) reduce vulnerabilities in all sectors of the economy including agriculture.

Ultimately, preserving forests need to be high on the sustainable development agenda for the Caribbean region. In this regard, the ongoing global discourse is particularly timely and relevant for the Caribbean, comprised largely of vulnerable SIDS. REDD+ represents an opportunity for a regional approach to financing the Caribbean's sustainable development amidst this climate change crisis by focusing on the sustainable management of Caribbean forests. It remains one approach out of other national or regional approaches to be considered in the need to secure the region's future. However, meaningful participation in the international dialogue will require deeper understanding of the roles, functions and actual contribution of forest and ecosystem services to the region's sustainable development, the threat that climate change poses to them and the region's role in reducing regional vulnerability to climate change.

Ecosystem based approaches can build resilience in forest ecosystems and by extension in the agricultural and tourism sectors.

(Photo: IICA Guyana)

3

"Once an invasive species arrives, it's about impossible to get rid of it."

Sean Hanna

Species under Siege:
combating the IAS threat

Naitram Ramnanan
Regional Representative and IAS Coordinator
CABI Caribbean and Central America

Introduction

The Wider Caribbean Region (WCR), as a region and as individual countries, can be highly complex. For example, the archipelago of the Bahamas consists of about 700 atolls and cays of which roughly 30 to 40 are inhabited. CARICOM countries are part of the Wider Caribbean Region (WCR) which is known as a biodiversity hotspot.[(1)] This means that a large number of organisms (microbial, flora and fauna) exist within a relatively small area. More interestingly, many of the organisms or species found in the WCR are not found anywhere else in the world.

However, the Caribbean itself is rather vulnerable to a range of factors that can have substantial negative effects on this level of biodiversity: hurricanes, human encroachment on the natural environment and climate change impacts. This is further compounded by the presence of invasive alien species. Invasive Alien Species (IAS) are plants, animals or micro-organisms in all major groups of organisms, not native to an ecosystem. Within each group numerous species including perhaps as many as 10 percent of the world's 300,000 woody plants have the potential to invade other ecosystems and affect native biota in direct or indirect ways.[(2)]

This paper aims to sensitise individuals and alert decision makers about the dangers of the IAS threat to native biodiversity which, next to human capital, is the most valuable resource owned by the Caribbean region. It seeks to enhance understanding that threats to biodiversity translate to serious threats to lives and livelihoods, including agriculture and the capacity to sustain food production. Part I provides the general context for the treatment of IAS as a threat, by emphasising the importance of the biodiversity wealth of the Caribbean region. That biodiversity offers tremendous scope, for food production, non-food agriculture and a host of other viable economic activities. However, the potential of such diverse biodiversity is grossly under-appreciated and under-utilised for the sustainable development of the region. Notwithstanding its value, critical elements of the biodiversity have been altered, affected and continue to be threatened by economic activity, including farming, other facets of the agriculture industry, trade and tourism which have facilitated introduction of IAS.

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1 Information on the biodiversity profile of the WCR extracted from "Mitigating the Threat of Invasive Alien Species in the Insular Caribbean, UNEP Project Document, Unpublished, GFL/2378-2740/4995. CAB International.

2 "Plant invasions and invasibility of plant communities" Rejmánek, M. Richardson and Pyš. P. (2005) Vegetation ecology (ed. E. Van de Maarel) pp.332-355. Blackwell Publishing, Oxford.

Part II engages in a detailed discussion of how these undesirable IAS have arrived, by natural spread, or been introduced, mostly accidentally, but often times through deliberate actions, but not before the reader is treated to a detailed explanation of what exactly is an IAS. It is well recognised that while IAS may have been present in the region for decades, several of these species may have escaped detection and hence have become 'naturalised' and are now considered part of the region's biodiversity. Several examples can be found in commercial crop and livestock production and as well, among domesticated animals, including cats. Of note, however, is the clarification that not all invasives are necessarily alien species and that poor practices, such as over-use of fertilisers and their run off, would have created conditions for some indigenous species to exhibit characteristics of IAS.

Part III admits therefore, that agriculture is part of both the IAS problem and solution. IAS impacts on agriculture have resulted in higher production costs, loss of trade opportunities, with continued threat of reduced productivity and eventually reduced food production. Newer IAS threats are also emerging due to increased trade as well as other key pathways for IAS introductions, elevating the current threat levels for agriculture. For example, the potential threat of Frosty Pod Rot to the cocoa industry is being closely monitored in Trinidad and Tobago.

Part IV sets out a well defined and proven framework for combating the IAS threat that emphasises, prevention as the first and best line of defence, and if this fails, then preventing their spread through early detection, eradication and control measures as required. It is important to appreciate that both eradication and control options need to be evaluated on the basis of the likelihood of success, cost effectiveness and any potential detrimental impacts.

Part V concludes with some key points with regards to the issues, perspectives and critical response requirements for managing the IAS threat and securing sustainable food production, agricultural development and human wellbeing in the Caribbean. Utilisation of the wider concept of IAS, as opposed to 'exotic pests and diseases' has served to broaden the challenge and dialogue beyond agriculture, to environmental interests, as well as public health and the entertainment, tourism and pet services and to shed light on why IAS has become an issue. It attempts in some cases, in a direct manner, and in others, by inference, to illustrate the gravity of the IAS threat to sustainable food production, loss of income, loss of important ecosystem services, such as soil capability and eventually increased reliance on food imports.

The paper therefore seeks to provide a reference base for stakeholders in agriculture and sectors directly related to natural resources and biodiversity. It also provides basic information that can be used to support the identification of possible solutions to comprehensively and collectively combat the IAS threat.

1. Caribbean biodiversity

1.1 A Region with High Levels of Species Endemism

Biodiversity refers to the degree of variation of life forms within a given ecosystem; i.e., the biological environment consisting of the living and non-living things present in that place. The WCR has been designated as one of the world's biodiversity hotspots and spans 4.31 million km^2 of ocean and 0.26 million km^2 of land.[3] The Caribbean borders the Mesoamerica hotspot[4] and a number of near-shore and offshore islands in the Caribbean Sea are biologically important for their endemic species. The terrestrial and aquatic (freshwater) ecosystems of the Caribbean also boast exceptionally high levels of species endemism, as shown in Table 1.[5]

Table 1: Species diversity and Endemism in the Insular Caribbean			
Taxonomic Group	# Species	# Endemic Species	% Endemism
Plants	13,000	6,550	50
Mammals	89	41	46
Birds	604	163	27
Reptiles	502	469	93
Amphibians	170	170	100
Freshwater Fishes	161	65	40
Source: Conservation International, http://www.conservation.org/where/priority_areas/hotspots/north_central_america/Caribbean-Islands/Pages/biodiversity.aspx			

The marine ecosystem diversity in the Caribbean includes about 60 species of corals and about 1,500 species of fish, nearly a quarter of which are endemic. Indeed, the greatest concentration of fish species in the Atlantic Ocean Basin occurs in the northern part of the hotspot in waters shared by The Bahamas, Cuba and the United States. The Caribbean Islands have more than 160 species of freshwater fish, about 65 of which are endemic to one or a few islands, and many of these to just a single lake or springhead. As in other island hotspots, there are two distinct groups of freshwater fishes in the Caribbean: on smaller and younger islands, most fish are species that are widespread in marine waters but also enter freshwater to some degree, while on the larger and older islands of the Greater Antilles, there are several groups that occupy inland waters, including gars, killifishes, silversides and cichlids.

3 http://www.biodiversityhotspots.org/xp/Hotspots/caribbean/
4 http://www.biodiversityhotspots.org/xp/Hotspots/mesoamerica/
5 the information on species endemism in the Caribbean draws heavily from Conservation International, Caribbean Islands – Species - Unique biodiversity, http://www.conservation.org/where/priority_areas/hotspots/north_central_america/Caribbean-Islands/Pages/biodiversity.aspx

Plant diversity and endemism are very high in the Caribbean Islands, with an estimated 13,000 species, including more than 6,500 single-island endemics. Endemism at higher levels is also exceptional, with 205 plant genera and one plant family, the Goetziaceae, found nowhere else on Earth. Endemism is also significant at the island level; about one-quarter of the region's vascular flora is restricted to a single island – Cuba. Jamaica has also been ranked fifth among islands of the world in terms of endemic plants.

Goetzia elegans flowers Source: home-and-garden.webshots.com

A wide range of ***animal species*** is also endemic to the Caribbean. For example, Jamaica is ranked as having a high level of endemism for animal species, estimated at 98.2 percent of the 514 indigenous species of land snails and all of the 22 indigenous species of amphibians. The Caribbean Islands have 41 endemic mammal species, including two endemic rodent families: Solenodontidae and Capromyidae. The family Solenodontidae includes two surviving but endangered species; the Cuban solenodon (*Solenodon cubanus*) and Hispaniolan solenodon (*S. paradoxus*), which are rare giant shrews. The Capromyidae includes 20 species of rodents, known locally as hutias, which are prized for their meat.

Dominica Sisserou parrot (*Amazona imperalis)* Source: worldatlas.com

According to Conservation International, over 600 species of birds have been recorded in the Caribbean, 163 of which are endemic. Of these regional endemics, 105 species are confined to single islands. Thirteen bird species have already gone extinct; six of those species were of the genus Ara, the large and brightly-feathered macaws. The Cuban macaw (*Ara tricolor*), the last of the six to disappear, was hunted to extinction for food and the pet trade during the second half of the 18th century. Among the most important bird symbols for conservation in the Caribbean are the parrots, including the St. Vincent parrot (*Amazona guildingii*, VU), the Saint Lucia parrot (*Amazona versicolor,* VU), and the imperial parrot (*Amazona imperialis*, EN) of Dominica. All three species are strikingly colored and rely on undisturbed forest for survival.

More than 120 bird species migrate from their breeding grounds in North America to winter in the Caribbean. The Caribbean is the most important (and sometimes the exclusive) wintering ground for a number of North American species such as the declining Cape May warbler, Northern parula, black-throated blue warbler, palm warbler and prairie warbler. It is also the only wintering ground for globally threatened migrants such as kirtland's warbler, Bicknell's thrush and (the possibly extinct) Bachman's warbler. In Trinidad and Tobago, 467 bird species have been recorded. These include six globally threatened species. Saint Lucia's avifauna (i.e. birds) totals 177 species, of which seven are endemic and seven are globally threatened.

The Insular Caribbean is also particularly rich in reptile diversity, with 502 species, of which 469 (93 percent) are endemic. The diversity includes several large evolutionary radiations of lizards, such as the anoles (*Anolis*; 154 species, 150 endemic) with their colourful dewlaps used in displays; dwarf geckos (*Sphaerodactylus*; 86 species, 82 endemic); and curly tails (*Leiocephalus*; 23 species, all endemic) that hold their tails in a coil as they run. What this means is that there are species diversities in these lizards that are very unique and based on the specific conditions present in the country. This lizard fauna includes the smallest lizards in the world, *Sphaerodactylus ariasae* from the Dominican Republic and *S. parthenopion* from the U.S. Virgin Islands. Also included in the reptile fauna are nine species of rock iguana, all threatened, from the genus *Cyclura* including some that are over one metre long. The Jamaican iguana (*Cyclura collei*, CR) was thought to be extinct until a small population of about 200 individuals was rediscovered in 1990 in the Hellshire Hills of Jamaica.

The region's rich source of diversity in flora, fauna and microbes and in particular the high levels of endemic species may be the most abundant resource and second to human capital in terms of potential to chart a path for sustainable development in the Caribbean.

Biodiversity is emerging as a fundamental resource for bio-prospecting, the study of organisms for potential applications in food, fuel, nutraceutical, pharmaceutical and other industries. Bio-prospecting is a multi-billion dollar industry that could greatly support sustainable development and product innovation in the Caribbean and contribute to the achievement of multiple development goals. These include generating revenues for protected areas, conservation projects and local communities; building scientific and technological capacity to study and manage biodiversity; raising awareness of the commercial and non-commercial importance of biodiversity; creating businesses dependent upon the sustainable management of resources; and generating large profits[6]. These benefits may occur at the local, national or regional levels which also offer scope for cooperation within the Caribbean.

6 Beattie, A.J. et al. 2005. New Products and Industries from Biodiversity, www.maweb.org/documents/document.279.aspx.pdf

1.2 Agricultural Biodiversity, Food Production and Nutrition

It has been observed that '...*we (Caribbean) accept that our nutrition must be based on five basic products - wheat, corn, potatoes, rice, soya bean,..., when we decided or someone decided for us that our nutritional base must depend on a narrow base of genetic material that someone else defines ..... and yet there are 270,000 species of plants in this world.*'[7] In this regard, promoting an appreciation of the value of region's diversity is of utmost and urgent importance. Indeed, the region's biodiversity is 'priceless'!

Placing renewed emphasis on sustaining the natural variety of crops and animals contributing to agriculture, including neglected yet nutritious traditional foods, can improve food security and address growing global concerns over poor nutrition and its negative health effects.[8] Meeting the challenge of feeding the world population of around nine billion by 2050 will require consideration, of not only sustainably producing sufficient food, but also working towards diversified nutrition. This is the challenge of providing a healthy diet for all. Agricultural biodiversity plays a central role in meeting this challenge.[9] The diversity of crops and their wild relatives, trees, animals, microbes and other species contributing to food production – known as agricultural biodiversity – can counter global trends in hunger and micronutrient malnutrition, obesity and diet-related chronic illness which have reached critical levels in over one-third of the world's population. Agricultural biodiversity is also absolutely essential to cope with the predicted impacts of climate change. [10]

According to GEF, agricultural biodiversity provides the mainstay for millions of people worldwide and food security to the world's most vulnerable populations.[11] This underscores the importance of not only valuing biodiversity in general, but importantly, valuing agricultural biodiversity and understanding its links to good nutrition. The launch of the 'Biodiversity for Food and Nutrition Project' is a most timely and absolutely critical project which aims to address the narrowing variety of people's diets, with nutritionally-poor processed foods dominating the dinner table.[12] Examples of these foods, some of which have gained global popularity [13], are:

7 Extracted from discussion at a CaRAPN-CTA-IICA-CARDI Agriculture Round Table (ART) Caribbean Week of Agriculture (CWA) 2008

8 'New Agricultural Biodiversity Project to Improve Nutrition and Food Security Worldwide - Undervalued Yet Nutritious Traditional Foods Can Make the Difference' press release from the launch of a new international project at the World Nutrition Rio Congress 2012. www.bioversityinternational.org

9 Braulio Dias, Executive Secretary, Secretariat of the Convention on Biological Diversity (CBD) at the launch of the Biodiversity for Food and Nutrition Project in Rio de Janeiro on 28 April 2012.

10 Emile Frison, Director General of Biodiversity International, at the launch of the Biodiversity for Food and Nutrition Project in Rio de Janeiro on 28 April 2012.

11 Monique Barbut, CEO and Chairperson of the GEF

12 The Global Environment Facility (GEF), the world's largest public funder of international environmental projects, is supporting the multi-country project led by Brazil, Kenya, Sri Lanka and Turkey. Biodiversity International is coordinating the project with implementation support from the United Nations Environment Programme (UNEP) and the Food and Agriculture Organization of the United Nations (FAO).

13 New Agricultural Biodiversity Project press release (ibid)

- Indigenous leafy vegetables such as amaranth leaves, cleome and nightshade, which are now acknowledged as significant sources of vitamins, minerals and anti-oxidants.
- Lycopene-rich guava varieties, acerola and pitanga. In Brazil, which already has a great deal of biodiversity in its food supply, these former garden fruits are now commercially produced and processed. Another nutrient-rich fruit from Brazil and elsewhere is the popular açaí berry.
- Food condiments and spices, which have recently been reported to have anti-diabetic, anti-inflammatory, anti-mutagenic, and anti carcinogenic properties. Spices also contribute to daily intakes of iron, zinc and calcium.
- Arugula (or rocket), a nutritious vegetable once collected as a wild food, and quinoa, an extremely nutritious grain-like crop from the Andes, have both found wide-scale acceptance in the grocery aisles and on restaurant tables throughout the world as a healthy and tasty food. Quinoa holds particular promise in that it is highly adaptable to different climatic and geographic conditions. The United Nations has declared 2013 to be the year of the Quinoa.

Quinua (Quinoa) plants near Cachora, Apurímac, Peru. Altitude: 3800m
(Photo: Maurice Chédel, Wikipedia)

1.3 A Region With Vulnerable and Fragile Biodiversity

The area of ocean encompassing the islands of the Caribbean, excluding Bermuda, is nearly 5 million km². The total area of land is approximately 240,000 km². The average percentage of protected land area for Caribbean and Central America is 8.6 percent compared to a global average of 10.8 percent. The Exclusive Economic Zones (EEZ) of the insular Caribbean countries far exceed the national land areas. Hence, there is a ratio of sea : land of about 20:1.[14] This large ratio of water to land, as well as the presence of many landing sites on the extensive coastlines make it very demanding to conduct effective inspection and surveillance activities to prevent the introduction of IAS and subsequent spread within the Caribbean.

Consequently, the absence of clear borders in the marine environment makes small island states particularly vulnerable to IAS introductions and also severely limits management options. Detection of IAS, particularly at low densities, is difficult. Species spread in a three-dimensional fluid system, where monitoring is a difficult and costly task. Moreover, many eradication and control options (e.g. clearance, shooting, pesticides, herbicides, biological control, etc.) that are used in terrestrial biota are harder to apply in the aquatic systems. The vulnerability and fragility of biodiversity on small and fragile islands[15] was reiterated at the 9th Conferences of the Parties (COP9) in 2008. Among the key reasons is the relatively low buffer capacity of small islands to severe environmental fluctuations and events. Hurricanes and other severe weather events have already taken a toll on the natural environment and climate change also presents substantial threats to vulnerable marine, freshwater and terrestrial biodiversity in the Caribbean.

The vulnerability of small and fragile islands also derives from the fact that species often become concentrated in small and fragmented areas. At these marginal breeding sites they are subject to various natural and anthropogenic pressures that endanger their survival. Some endangered species have below critical mass breeding populations. Their interchange is further restricted by habitat fragmentation. However, those species that have evolved on islands have done so free from competition with large numbers of other species and therefore lack adequate defences and are susceptible to invasions by alien species. As a result, islands exhibit the highest proportion of recorded species extinctions brought about by a number of factors, including IAS.

Marine environments in particular, present particularly challenging conditions for the control of bio-invasions. This fact is well illustrated by the example of the 25 acre Maria Island, located 1,000 metres off the south-eastern coast of Saint Lucia (Fig. 1). Maria Island is home to the most threatened, endangered and endemic reptile species of all of Saint Lucia's protected areas. There are eight reptile species on

14 Annex 1: Project Document Section 2: Background and Situation Analysis (Baseline Course of Action), "Mitigating the Threats of Invasive Alien Species in the Insular Caribbean", funded by the Global Environment Facility (GEF) through the United Nations Environment Programme (UNEP).

15 http://www.cbd.int/decisions/?m=COP-08&id=11013&lg=0

Maria Island of which five are endemic to Saint Lucia. This high rate of endemism on such a vulnerable, small and fragile habitat is of serious concern given the extent to which limited land and other resources are being altered for use, with irreversible loss of biodiversity. The area is also a nesting site for sea turtles, migratory terns and white sea-urchins, and is both a marine reserve and a bird sanctuary. It is extremely vulnerable to IAS, arriving via natural pathways and/or human activity, such as avian influenza and rats, respectively.

Fig 1: Maria Island off South-East Coast of Saint Lucia an island-wide Nature Reserve

The World Conservation Union (IUCN) expressed deep concerns about IAS threatening marine ecosystems at the 3rd World Conservation Congress in November 2004.[16] Globally, preliminary findings of the Millennium Ecosystem Assessment (MEA) confirmed IAS as one of the major drivers towards homogenisation of ecosystem biodiversity in marine environment (i.e., making all marine environments the same). Invasions are less likely to be accurately recorded and monitored in marine, as opposed to terrestrial, environments making this an increasingly challenging issue for the Island-archipelago of the Caribbean.

The vulnerabilities associated with a concentration of species in small and fragmented areas are also evident in high altitude forests which are the best preserved areas on many tropical islands. As explained in the preceding paper, tropical forests are important to water catchment, protection against storms and soil stabilisation, among other ecosystem functions. These forests are tremendously diverse, but limited in expanse, rendering their habitats vulnerable.

16 IUCN 3rd World Conservation Congress, November 2004, *Marine Highlights*. www.iucn.org/themes/marine/pdf/PostWCC_KeyMarineMsgs.pdf

Differences in precipitation patterns have led to climatic conditions that vary greatly from one mountainside to another, creating multiple "bioclimatic micro-regions", depending on the orientation and altitude. Increased temperatures and longer dry seasons resulting from climate change may result in the dry bio-climate of lower to mid elevations developing in the higher altitude regions. This disruption of the existing equilibrium runs the risk of creating favourable conditions for invasive alien species and may eventually impoverish high altitude forests.

In as much as climate change effects are a reality to be dealt with, adaptation strategies remain the best bets for addressing the climate change challenge. In its "Initial National Communication on United Nations Framework Convention on Climate Change (UNFCCC)", the Dominican Republic is considering the importation of exotic forest trees with tolerance to drought and high temperatures. In its adaptation strategies, the Bahamas makes direct reference to IAS and the importance of reviewing the suitability of alien (exotic) saline-adapted species of timber trees for the Bahamas.

Casuarina equisetifolia radically alters the temperature, light and soil chemistry of beach habitats, and inhibits the growth of native dune and beach vegetation, vital for coastal ecosystems. It also affects the habitat of nesting sea birds, sea turtles and the highly endangered native Iguana Species.

Source: IAS magazine, CABI
(Photo: Michael Kesl, biolib.cz)

2. Arrival of Invasive Alien Species

2.1 Clarifying an Alien Species

> **Note #1. Quick IAS Facts!**
>
> Invasive Alien Species are plants, animals or micro-organisms in all major (taxonomic) groups of organisms, **Not Native** to an ecosystem, such as, viruses, fungi, algae, mosses, ferns, higher plants, invertebrates, fish, amphibians, reptiles, birds and mammals.
>
> Within each group, numerous species, including perhaps as many as 10% of the world's 300,000 woody plants, have the potential to invade other ecosystems and affect native biota in a direct or indirect way.

To the modern-day reader, the word 'alien' would more than likely conjure up images of science fiction movies and creatures from outer space. For the longstanding agriculturalist and Caribbean nationals, the word 'alien' is reminiscent of the distinction given to non-nationals seeking to purchase land outside of their country of origin, i.e., 'Alien land holding license'. In both instances, use of the word 'alien' sends the message that the particular object or subject is new to an area, is not a native, has no '*locus standi*' and hence does not 'belong'!

Therefore, use of the word alien to describe the presence of some marine, freshwater and terrestrial species found in ecosystems in the Caribbean is meant to denote precisely that; that these species did not originate in, and hence do not belong to Caribbean ecosystems.

Alien species can be found in all major classification of living organisms. These include viruses, fungi, algae, mosses, ferns, higher plants, invertebrates, fish, amphibians, reptiles, birds and mammals. Within each group, numerous species, including perhaps as many as 10% of the world's 300,000 vascular plants (certain plants with specialised tissue which allows them to grow larger and reproduce better), have the potential to invade other ecosystems and affect native biota in a direct or indirect way. However, the Convention on Biological Diversity (CBD) defines Invasive Alien Species (IAS) as "*species whose introduction and/or spread outside their natural past or present distribution, threaten biological diversity*". Alien species are therefore introduced outside of their native range. By way of terminology in the agriculture sector, there tends to be a general interchange between IAS and exotic pests/diseases.

This distinct terminology differentiates those invasive species that are alien, from invasive species that are native to the particular environment. In case of the latter, these species become disruptive via a dominant colonisation of a particular habitat – usually as a result of the loss of natural controls, such as a predator species. Though these may generally be grouped together under the category of pests, it must be noted that IAS represent a very specific type of disruptive organism that negatively impacts native biodiversity and ecosystem functions and services.

2.2 Clarifying the Invasive Alien

Not all alien species - plants, animals or micro-organisms - introduced into an environment/eco-system become invasive. The 'Tens Rule' proposed by Williamson and Fitter (1996), is a probabilistic assessment of the proportion of species that reach particular stages in the invasion process. For an alien species, this process goes through introductions (or escape into the wild for the more adventurous), casual, naturalization and then to pest status.

The Tens Rule is premised on the prediction that:

- 10% of imported species remain undetected and/or escape to become casual;
- 10% of casuals becomes naturalised, and
- 10% of naturalised species become pests

Note #2. Quick IAS Facts!

An indicator of invasiveness is how successfully an IAS invaded elsewhere. Common characteristics of IAS include rapid reproduction and growth, high dispersal ability (ability to move from one place to another), phenotypic plasticity (ability to adapt physiologically to new conditions), and ability to survive on various food types and in a wide range of environmental conditions.

In short, the 'Tens Rule' implies that only roughly 1% of the introduced species become invasive and are pests. However, the mere fact that a significant number of IAS enter and/or are introduced should also be of serious cause for concern regardless of whether it is only 1% of such arrivals/entrants that do in fact become pests. It is that 1% that becomes the greatest cause for concern because of their detrimental impact on biodiversity and the economic sectors that depend on them.

Some alien species tend to have common biological traits that allow them to survive, thrive and become invasive once they have arrived and/or are introduced into an environment. These traits can be summarised as follows:

i. The ability to produce large numbers of offspring (high fecundity). Invasive plants produce copious amounts of seed, with a high viability that gives them a greater chance of survival in the wild. For example, the invasive white top weed produces approximately 2 million seeds within a month of germination.

ii. The ability to reach reproductive age in a relatively short time (short time to maturity). This enables them to expand their populations exponentially, producing two or three generations within a year. Good examples are rabbits, rats, cats, mongoose, which were introduced into the Caribbean, and have become very invasive.

iii. *The ability to spread rapidly.* Many IAS especially those that are microscopic can be spread through various medium, such as wind, water, contaminated soil, farming equipment, and/or attached on humans and animals, that facilitate easy spread and over long distances. They employ very successful dispersal mechanisms. For example, one cocoa pod infected with Frosty Pod Rot can

Bamboo's rapid growth slows the recruitment of native tree species and can significantly reduce and displace undergrowth of native grasses and shrubs that are important for some birds and many other native species.

Source: IAS magazine, CABI
(Photo source: commons.wikimedia.org)

produce seven billion spores per day[17] that can be transmitted by wind for several kilometres making it an extremely infectious disease. Similarly the Lionfish can produce millions of fertile eggs in one spawning that can be carried in sea currents to invade new areas. Many invasive plants produce fruits and berries that are attractive to birds, bats and other animals that eat them and disperse the seeds. In addition they tend to be very opportunistic and thrive on disturbed areas.

iv. *They have few natural enemies:* Invasive species tend to thrive in non-natural habitats due to the lack of predators, pathogens and diseases that would otherwise keep their numbers and growing populations in check. Often, an invasive species may be transported into the Caribbean region but its natural enemies are not. This was the case of the Pink Hibiscus Mealy Bug (PHMB) that caused havoc in Grenada in the 90's and later in Trinidad, until a biological control programme introduced two natural predators for ongoing control.

v. *They can live and survive anywhere:* IAS do not have specific or narrow growth requirements and can generally thrive anywhere, from degraded to healthy environments. They successfully establish and thrive in areas in which several other species may find it difficult to survive. Once established, they often alter their habitat conditions and adjust their growth requirements to better suit their own survival and expansion. Some invasive plants have been shown to demonstrate allelopathy, i.e., the production of chemicals that inhibit the growth of other plants nearby.

17 'Application of chemical and biological agents for the management of frosty pod rot (Moniliophthora roreri) in Costa Rican cocoa (Theobroma cacao)' R.P. Bateman, E. Hidalgo, J. García, C. Arroyo, G.M. ten Hoopen, V. Adonijah' and U. Krauss, Annals of Applied Biology ISSN 0003-4746, 5 July 2005

It is important to understand that not all invasive plants and/or animal species are alien species. For example, invasive native plants are indigenous species which: are dominant over other regenerating natives, compete against preferred species, are generally less palatable than preferred species and regenerate profusely, often in response to disturbance of the land, such as clearing, fire or overgrazing. Invasive native plants are often associated with profuse regeneration. This dense re-growth can be so great that it becomes a problem - preventing the regeneration and growth of other species of native plants (including preferred native grasses), reducing carrying capacity and contributing to soil erosion. In areas that are 'over-cleared', dense tree and shrub regeneration can be managed as part of a re-vegetation strategy. Or, depending on the species of native plant, they can be used to generate a long-term economic return from a range of products, including timber.[18]

In the Caribbean, a major factor contributing to native invasive plants is farming, that is, poor agricultural practises, particularly overuse of and consequently, run-off of fertilisers, which has altered the natural environment and created conditions for over growth of some native species. One good example is the native aquatic weeds in Guyana, such as the dotted duckweed *(Landoltia punctata)* and alligator weed *(Oxycaryum cubense)*, which are exhibiting several properties of invasive alien species - mainly aggressive and rapid growth – associated with excessive fertiliser run-off. These aquatic weeds have now overtaken the canals and are becoming an invasive aquatic plant species, blocking up waterways.

Cassava Hornworm

(Photo: TTABA)

The outbreak of the hornworm in cassava plantations in 2010 in Trinidad is another good example of the stressed environmental conditions (severe dry spell) that favour a native pest to become invasive and cause severe losses in a short space of time.

18 Invasive Native Species at http://brg.cma.nsw.gov.au/index.php?page=invasive-native-species

2.4. IAS Pathways

A clearer understanding of what makes an alien species invasive will enable a similarly clearer understanding on the various methods by which alien species arrive, enter or are introduced into a country or region. Basically, IAS move by the four "Ts": trade, travel, transportation and tourism. This simple representation gives a very good overview of the pathways and the associated range of the IAS issues. Pathway analysis is used to derive information on how IAS are currently getting in to new areas, and consequently to inform effective measures to prevent future introduction.

A pathway is simply described as the means by which an invasive species may be brought into a foreign environment (intentionally or otherwise). Once an IAS establishes itself in a new area, it is difficult to determine the pathway of introduction. An excellent review of the pathways of introduction of IAS was done by Meissner et al (2009)[(19)] for the greater Caribbean. In this review, the major pathways are identified as well as the associated factors that increase the vulnerability of Caribbean territories to the introduction and spread of invasives. This seminal analysis identified nine distinct pathways for the introduction of IAS into the WCR. None of these were regarded as a low risk to agriculture.

i. Human Movement

At the crux of the movement of IAS is human activity as defined by the four "Ts". The WCR is among the most heavily-visited region in the world, with visitor arrivals predominantly by air, and to a lesser extent, water and land.

Air Arrival: Each human movement pathway carries some risk of exotic pest introduction. Plant and other potentially damaging species and organisms may be spread unintentionally from (a) carrying the pest on themselves, clothing, or shoes; and/or (b) transporting the pest on objects brought to or taken from an area (e.g., handicrafts). IAS may also be introduced intentionally as deliberate human activity to collect and move the species and/or organisms to different locations. The obvious potential of humans to facilitate spread of alien species, the immense number of travellers into and within the GCR, and an overall insufficient level of phytosanitary safeguards warrant the high risk status associated with this pathway.

Meissner et al (2009) cited UN-WTO 2008 data as reporting an estimated 19 million visitor arrivals into Caribbean countries annually, by air. In 2006, international tourist arrivals numbered 19.4 million, 7 million and 18.7 million for the Caribbean islands, Central America and South America, respectively.

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19 Unless otherwise specified, this section draws almost exclusively from the study 'Evaluation of Pathways for Exotic Plant Pest Movement Into and Within the Greater Caribbean Region', January 9, 2009, Revised June 4, 2009. Caribbean Invasive Species Working Group (CISWG) and Plant Epidemiology and Risk Analysis Laboratory (PERAL) Center for Plant Health Science and Technology (CPHST) United States Department of Agriculture (USDA) by Dr. Heike Meissner (project lead), Andrea Lemay, Christie Bertone, Kimberly Schwartzburg, Dr. Lisa Ferguson and Leslie Newton

Meissner et al (2009) also cited USDA's reports of interceptions of seeds, plants and flower bulbs in airline passenger baggage, and findings by McCullough et al. (2006) that 62 percent of pests intercepted at U.S. ports of entry were associated with baggage. According to Meissner et al, (2009), close to 4 percent of international air passenger groups arriving in the U.S. had plant quarantine materials in their luggage, with three quarters of these materials estimated to routinely escape detection. In 2007, baggage inspections at airports in U.S. Gulf States (Florida, Alabama, Louisiana, Mississippi, and Texas) resulted in 126,136 plant quarantine material interceptions, 374 soil interceptions, and 4,049 pest interceptions (3,620 of them being U.S. quarantine pests). The USDA (2008) concluded that pests such as the tropical grey chaff scale, Medfly and citrus canker have been repeatedly intercepted in airline passenger baggage.

Inspection of airline passenger luggage is common, but cannot keep pace with the ever-increasing passenger volume. The level of agricultural inspection of airline passenger baggage varies among Caribbean countries and among airports in the same country. For example, in Martinique, flights from France are not inspected; there is no inspection of passengers travelling from the U.S. mainland to Puerto Rico and the U.S. Virgin Islands; and flights between the islands of Trinidad and Tobago are also not subject to agricultural inspections. Similarly, movements within the many inhabited islands of the Bahamas are also not inspected.

Sea Travel: Once in the WCR, visitors often move between countries, crossing land borders through cruise ship, private yachts, ferry, high-speed catamarans and other small vessels that are usually not subjected to strict phytosanitary inspections. Perhaps a general awareness among travellers of the lax enforcement of such inspection procedures has encouraged the frequent collection and transport of viable plants or plant parts, live insects or snails, wood pieces or soil that may contain pests.

Cruise passengers: Passengers aboard cruise ships in particular, tend to visit multiple, climatically similar locations within a short time period. In so doing, they may easily and unintentionally carry viable pests that can potentially survive and thrive in new locations. Over 10 million cruise passengers departed from North America in 2007. Almost half of all North American cruise itineraries are headed to the Caribbean. Current trends towards ecotourism and 'private island experience' mean that more natural and pristine areas are visited by cruise passengers. A short, intensive data collection effort targeting the red palm mite, *Raoiella indica*, in 2007, led to over 30 pest interceptions on cruise ship baggage at Florida ports. Almost all of these interceptions were on leaves of the coconut palm (presumably handicrafts). As cruise ship passengers and baggage are not routinely inspected at many ports in the GCR, the presence of most of these pests would go undetected.

Black Sigatoka is a leaf spot disease of banana that can cut a tree's fruit production in half. It is believed to originate from an area named Sigatoka in the Pacific islands. It is estimated that 15-20% of the price of bananas reflects the cost of disease control that are used to produce the fruit.

(Photo: CARDI)

Inter-Island Ferry: In 2007, a 3-day data collection exercise targeting the ferry between Puerto Rico and the Dominican Republic resulted in 68 plant quarantine material and 7 pest interceptions.[20] Assuming that the inspections detected every quarantine material and pest present (over a 3-day period alone) this would translate into about 5,000 plant quarantine materials and 500 pests per year arriving in Puerto Rico on this ferry. Only a small percentage of plant quarantine materials and pests are actually intercepted by routine inspections. In many places, ferry passengers are not subject to agricultural inspection, leaving this pathway largely unmitigated.

Other marine travel: While the exact number of private yachts and other small vessels is difficult to quantify, persons travelling via such means depend on local markets for provisions and farmers often supply agricultural products directly to sailors at marinas. Agricultural inspections on small vessels are rare throughout the GCR, including the United States. As such, there are very few obstacles to persons moving any agricultural product, living organisms, or plants for planting around on small vessels. *Mycospharella fijiensis*, the causal agent of the dreaded black Sigatoka disease, is believed to have entered Trinidad via this pathway. Black Sigatoka is now present in Saint Lucia wreaking havoc on that island's banana industry. There are similar concerns that *Moniliophthora roreri*, the causal agent of frosty pod of cocoa, may spread in the same manner. This could have disastrous consequences for Trinidad and Tobago, and by extension, the region which is gearing up for investment in cocoa estate rehabilitation.

Land travel: In the Insular Caribbean, the island of Hispaniola (which houses both Haiti and the Dominican Republic) and Saint Martin are home to more than one country and can be accessed via land borders. All of the Central and South American countries in the GCR share land borders with at least two other countries. Many of these countries have a

20 Caribbean Risk Assessment Group, 2008.

vibrant informal trade of agricultural products and handicrafts. Traders, agricultural day workers and tourists routinely cross these land borders, often at unofficial (unstaffed) border crossings. Even at many official crossings, no agricultural inspection takes place. The Coffee Berry Borer and Medfly are believed to have been introduced to new areas in Central America by persons crossing land borders.

> **Note #3. Quick IAS Facts!**
>
> Of 220 tree species intentionally introduced into the GCR, at least 179 have established in the wild, many of them growing invasively
>
> Of 191 invasive plants examined in one study, 66 percent were introduced deliberately to the insular Caribbean through the horticultural pathway (a)
>
> (a) Evaluation of Pathways for Exotic Plant Pest Movement Into and Within the Greater Caribbean Region, January 9, by H Meissner et al.

ii. Hitchhikers

All IAS are essentially hitchhikers, using one or more 'transports' to move them from one place to the other. A "hitchhiker" is defined as a pest moving in or on a commodity which is not one of its hosts, or on/in a conveyance (airplane, ship) or shipping container. IAS may get into or onto a commodity, conveyance, or container either by pure chance (e.g., nematodes in soil on truck tires) or because they are attracted by certain conditions or characteristics of the item. For example, flying insects may be attracted by airplane lights during night time loading[21] and insects or molluscs may find shelter on or in cargo containers.

Imports of used vehicles, including used garbage trucks and used tyres are becoming more common in the Caribbean offering heightened possibilities of introducing IAS. Pests originally associated with a shipment of a host commodity (fruit, seed, whole plant, etc.) may be left behind in a container or conveyance after offloading, thus becoming a hitchhiker. The scientific literature cites numerous cases of hitchhiker pests arriving at ports in cargo holds, aircraft cabins, or shipping containers[22]. Maritime vessels, including ship decks, holds and stores, may be contaminated with live pests, soil or other debris. Of the 6.2 million cargo containers entering maritime ports within the GCR, more than 1.4 million were estimated to have arrived with contaminants. Inspections of maritime vessels, including ship holds and stores, at U.S. ports-of-entry have resulted in interceptions of live pests, including pests of agricultural importance. The immense number of conveyances and containers being circulated in international trade make this a high risk and potentially difficult pathway to control.

iii. Ballast Water

A very important pathway for introducing aquatic IAS into the Caribbean is ballast water, which is the water ships take in for stability and trim before a voyage. Ballast stabilises ships in the water and is a necessary feature of commercial shipping. It is primarily composed of water and is full of stones, sediment and thousands of living species. Once the ship arrives at its destination it may release this ballast water into the new bay.

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21 Caton, 2003 in Evaluation of Pathways for Exotic Plant Pest Movement Into and Within the Greater Caribbean Region', January 9, 2009, by Meissner et al.

22 these studies include Dale and Maddison, 1984; Gadgil et al., 2000; Gadgil et al., 2002; Smith and Carter, 1984; Takahashi, 1984

International shipping industries are responsible for the majority of these alien species invading foreign waters. Over 3,000 marine species travel around the world in ships' ballast water on a daily basis. Once introduced ballast water could also facilitate their faster spread within the region. Marine invasive species, such as, the recent introduction of the lionfish are an important threat to commercial fisheries as well as coral reefs that are important to the tourism sector.

iv. Plant Propagative Material (PM)

The importation of PM material from one country is a deliberate human act. This occurs very often in the Caribbean in an unregulated fashion. A large number of tree species intentionally introduced into the GCR, through the horticultural pathway have established in the wild, with many of them growing invasively. While in such instances, the accompanying IAS are unintended, they can, however, occur even through regulated means as systems to screen and detect organisms such as viruses are very difficult. Consequently infested or infected PM may be one of the primary means through which plant pests and pathogens invade new areas.

IAS that are introduced on PM have the advantage of being moved together with a suitable host plant. PM is usually planted in a climate conducive to its growth, which are usually the same climatic conditions required for its associated IAS. The plants are often planted in groups, thereby providing ideal conditions for a pest population to establish. This pathway is very significant since large numbers of IAS move in association with PM. During 2007, 1,541 pests of quarantine significance were intercepted at U.S. ports of entry in commercial shipments of PM from the GCR. Many of these invasives are situated in crevices or on the underside of PM and are very small or indistinct so that they are mistaken for anything from lint, thread or fluff. For example, most mites are not detected during port-of-entry inspections of PM and presumably most other types of minute organisms are also missed. Unless these IAS are specifically being targeted, the chances of detection are low. In addition, pathogens are virtually ignored.

Meissner et al (2009) identified the following reason why pests are not identified in PM at ports:

- overwhelming workload;
- pressure to perform quick inspections;
- inadequate working conditions (e.g., lighting, space);
- difficulty of detecting minute and hidden pests, especially pathogens;
- lack of appropriate diagnostic tools for pathogens;
- knowing which pathogens to screen for is difficult because of the wide diversity of PM being imported;
- limited knowledge. For example, more than 10,000 pathogenic species of fungi and viruses are estimated to cause diseases on plants, and many of these are economically important[23] and perhaps only 10 percent of all existing fungi have been described.

23 A Plant-Associated Microbe Genomics Initiative: What Is It and Why Do We Need It? by Jan E. Leach, Scott Gold, Sue A. Tolin and Kellye Eversole, at: http://www.apsnet.org/publications/apsnetfeatures/Pages/MicrobeGenomics.aspx

A review of the phytosanitary laws of the GCR countries showed that most regulations regarding PM are aimed at preventing the introduction of pests associated with plants, but are not concerned with the invasiveness of the plants themselves. Although many countries require phytosanitary certificates, inspection and freedom from soil material, none seem to require weed risk assessments as a condition for import. The regulated pest list[24] of most countries either contains no weeds at all or specifies only a small number of plants, which tend to be agricultural weeds that are not likely to be imported as PM. The regulated plant list provides a concise detailing on all major pests, and disease species and their vectors (i.e. a species that hosts a disease) as well as the common name(s) used in identifying the IAS (pest or disease). The list effectively represents known threats to local agriculture, environment and economy that the respective country wishes trading partners (in the context of Sanitary and Phytosanitary regulations) to be cautious of.

v. Wood Packaging Material (WPM)

WPM presents a high-risk pathway for the movement of IAS into and within the GCR. Wood pallets, crates and dunnage are commonly used packaging materials in international trade. WPM has been recognized as a pathway for the spread of IAS, including arthropods, nematodes, molluscs, weeds and plant pathogens [25]. WPM is often produced from low-grade wood of multiple species [26], often with bark still attached. WPM is routinely re-used and re-conditioned[27], making it difficult to determine its origin. Countries that have adopted the standard ISPM 15 of the International Plant Protection Convention [28] now require WPM to be either fumigated or heat-treated prior to import. However, potentially harmful species are being intercepted on WPM even after the implementation of ISPM 15 in the USA. The percentage of cargo with WPM differs between countries of origin. A large number of IAS intercepted on WPM may have the potential to become naturalized in the GCR.

vi. Forestry-Related Pathways

As emphasised in the preceding paper, forests are of immense ecological, economic and social importance in the Caribbean. The GCR (excluding the U.S.) reported imports of 16.2 thousand metric tons of untreated wood and wood products in 2006. Imports of secondary wood products, such as tools, ornaments and trinkets exceeded 13.6 thousand metric tons during the same time period[29]. A US pest risk assessment found 510 pest species of US quarantine significance to be associated with secondary wood items[30]. These pests included bark and ambrosia beetles, wood borers, moths, pathogens, and weed seeds. Non-timber forest products (NTFPs) are widely traded throughout the GCR. Bamboo, in particular, is important in Central America and the Caribbean islands and is a known pathway for insect

24 Link for an example of the USDA regulated plant list: http://www.aphis.usda.gov/import_export/plants/plant_imports/downloads/RegulatedPestList.pdf.
25 Pasek, 2000; Allen and Humble, 2002
26 Clark et al., 2001
27 Clarke et al., 2001; Bush et al., 2002
28 IPPC, 2006
29 UN Comtrade 2008
30 USDA APHIS 2007

pests [31]. Moreover, the similar climate means that the IAS have a higher chance of being naturalized in the new environment. Thus the likelihood of invasion is substantially increased. In 2006, these countries reported bamboo exports exceeding 170 metric tons, 50 percent of which were traded among the reporting countries and 13 percent went to the US[32].

Christmas trees were shown to pose a pest risk after intensified inspections of Christmas trees imported into Puerto Rico led to substantially increased pest interceptions[33]. Some 300 pests were reportedly found, with the potential to spread or become introduced into the GCR, that move on wood or non wood forest products.

Trees for planting: Large numbers of trees are imported for use in agro-forestry operations. Traits desirable for agro-forestry, such as rapid growth, high fecundity and the ability to fix nitrogen, also mean a high invasive potential. One study found that of 220 intentionally introduced tree species, 179 (81 percent) were naturalized or invasive in the GCR[34]. Exotic tree species can displace native vegetation, disrupt native fauna and alter environmental conditions (e.g. lower water table, increase frequency of fires, etc.). In addition to becoming invasive themselves, trees for planting may serve as a pathway for IAS. IAS that are introduced on a live host have a higher chance of becoming established.

vii. Airline Passenger Baggage

As indicated above, international air travel constitutes a significant means of unintentionally moving IAS. Tourists and other passengers may often and unknowingly carry pests (e.g. snails, weed seeds), or items that are infested with pests and diseases (e.g. fruits or vegetables). Airline passenger baggage therefore represents an important pathway for the movement of IAS into and within the GCR. Port inspections can discover only a fraction of what is entering.

The sheer volume of passenger baggage makes it unlikely that the existing pest/IAS risk associated with airline passenger pathways can be mitigated effectively by inspection alone. Data collected by the U.S. federal government concluded that the pest/IAS risk associated with passenger baggage is considerable. It estimates plant quarantine material (QM) approach rates (i.e., the percentage of sampling units containing QMs) and the annual number of plant QMs entering the U.S. in airline passenger baggage. Many travellers are unaware of existing laws concerning plant QMs and the potential consequences of introducing IAS.

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31 USDA APHIS 2006
32 UN Comtrade 2008
33 USDA APHIS PPQ 2008
34 Kairo 2003, cited in Meissner et al. 2009 (ibid)

viii. International Mail

Public and private postal services are an often overlooked pathway for the movement of IAS. Almost any item can be sent by mail, either legally or illegally. Controlling mail contents presents an immense challenge to any country. The degree to which mail is inspected varies widely within the GCR, from 100 percent in Jamaica, to minimal inspection in Martinique. They estimated that the GCR (excluding the United States) may annually receive over 14,000 public mail packages containing MPS, with up to 4,000 of these being propagative materials.

Statistics on private mail volumes are not easily accessed, but market studies suggest that 10 percent of packages are moved by public mail in the Caribbean while 90 percent are moved by private mail and courier services, which may compound the ease with which IAS are introduced.

Note #4. Quick IAS Facts!

Changing climate will create suitable conditions for the further spread and invasion of invasive and potentially invasive species. Changes in weather patterns and increasing temperatures may also enable species to expand their current range as is the case of disease carrying mosquitoes. Increased carbon dioxide enrichment in aquatic ecosystems will affect all organisms and could also contribute to the invasiveness of certain terrestrial and aquatic species.

ix. Natural Spread

Natural spread of pests throughout the GCR seems likely, given the close proximity of islands and land masses. Biological and atmospheric events and processes interact to facilitate aerial dispersal of organisms (plant pathogens, insects, and mites) over long distances to cause widespread infections or infestations. Wind plays a significant role in the movement of IAS throughout the GCR. The route of natural movement between close land masses most likely follows prevailing winds, which move from the Windward Islands (the most south easterly islands), toward the northwest to the Leeward Islands and on to the Greater Antilles and the South Eastern United States.

Raoiella indica, the red palm mite, was detected in Martinique in 2004. Less than a year later, the mite appeared on coconut palms on nearby islands. Finding *R. indica* populations on very tall and older coconut palms in Saint Lucia strongly supports the premise that wind currents dispersed the mite[(35)]. Soon after, *R. indica* became established in Dominica, Guadeloupe, St. Martin, Saint Lucia and Trinidad and Tobago. It was found in Puerto Rico in November of 2006 and in West Palm Beach, Florida, in December of 2007. This invasive has been spreading rapidly, aided by winds and by commerce, and it is expected to become naturalized throughout the subtropical and tropical regions of the Western Hemisphere.

35 Raoiella indica in the Americas by Hoy et al., 2006, at https://www.ippc.int/.../1132171138640_Raoiella_indica_in_the_Am...

Some IAS are capable of long-distance migration, such as from Africa to the GCR. A few significant plant pathogens, including sugarcane smut *(Ustilago scitaminae),* sugarcane rust *(Puccinia melanocephala),* and possibly blue mold of tobacco *(Peronospora tabacina),* were carried by wind from Africa into the GCR[36]. *Schistocerca gregaria,* the migratory locust, has probably been carried many times from Africa to the Caribbean by tropical cyclones, though it never became established.[37] Thomas (2000) showed that a small percentage of the exotic arthropods in Florida originated in Africa and that the major points of origin are Asia and the Pacific and the Neotropics.[38] While long-distance migration of plant and animal pests and diseases into the GCR is considered a pathway for IAS introductions, in comparison to transport as a result of trade, commerce, and tourism, to this point, it is a pathway of lesser importance.

The issue of natural spread is becoming more important, particularly in the context of more extreme weather variability and impacts of climate change. Hurricanes, other severe weather events and climate change impacts favour 'natural' spread of IAS in the WCR. The United States Geological Survey (USGS)[39] expressed fears that the invasive and presumably wind-dispersed scale the Wild Cochineal Insect *(Dactylopius ceylonicus),* which was released on Nevis in 1979 to control an invasive cactus, may negatively affect the south-western U.S. on account of how climate change has altered the way and range in which winds and thus the insect moves. The insect is used to control invasive cactus, but also poses a threat to native cactus species and may thus irreversibly alter the environment of the south-western United States.

As wind and storm patterns become more violent, the range of dispersal/spread of such invasive species may increase. In Bermuda, increased hurricane activity has eroded coastal areas left vulnerable by the presence of Australian Pine/Horsetail (*Casuarina equisetifolia)*, a fast growing, shallow rooted and often invasive tree that tends to topple in strong winds taking pieces of the soft costal soil and limestone with it[40].

Climate change which disrupts and sometimes displaces native plant and animal species is also expected to create conditions suitable for the spread and invasion of new exotic organisms by creating new environments for them to survive. One expression of climate change is an intensification of severe storms. Already oceanic water currents are changing and cyclone activity is believed by many to have

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36 Purdy et al., 1985; Introduction of Sugar-cane rust into Americas and its spread to Florida. Plant Dis. 69:689-693. Nagarajan and Singh, 1990. Long Distance Dispersion of rust pathogens. Annu. Rev Phytopathol. 28:139-153.

37 'Hurricane-borne African Locusts (Schistocerca gregaria) on the Windward Islands' by C. Howard Richardson and David J. Nemeth, from the issue "Caribbean Hurricanes", GeoJournal, Volume 23, Number 4 (1991), 349-357, DOI: 10.1007/BF00193608

38 Section 2: Exotic Pests of Plants: Current and Future Threats to Horticultural Production and Trade in Florida
and the Caribbean Basin by W. Klassen, University of Florida, Homestead, C. F. Brodel, USDA/APHIS/PPQ Plant Inspection Station, Miami, FL and D. A. Fieselmann, USDA/APHIS/PPQ, Center for Plant Health Science & Technology, Raleigh, NC

39 USGS (2006) *Invasive Species and Climate Change.* http://pubs.usgs.gov/of/2006/1153/pdf/of06-1153_508.pdf

40 Petit J. & Prudent G. 2008. Climate Change and Biodiversity in the European Union Overseas Entities. IUCN, Brussels, 178 pp., http://www.reunion2008.eu/pdf/en/42.10_LOW_FINAL_book_EN.pdf

increased as a result. Increased atmospheric carbon dioxide levels and carbon dioxide enrichment in aquatic ecosystems (i.e. carbon-dioxide dissolving in water) are another aspect of climate change that is expected to encourage the invasiveness of certain terrestrial and aquatic species. A positive interaction of increased carbon dioxide and temperature was observed for the invasive aquatic plant dioecious hydrilla (*Hydrilla verticillata*) which showed maximum growth response to increased carbon dioxide levels at elevated water temperatures[41].

What these myriad pathways and associated issues show is a case of vulnerability (Table 2). The Caribbean environment with its numerous unique species of special fauna and flora, the natural environment that supports agriculture and food production, utilities, tourism and industry, are at risk of being altered and in some cases lost on account of the introduction of IAS. Almost none of the Caribbean countries have completed documented studies of all the species that occur naturally. Forest species and marine environment with their rich biodiversity are poorly documented with little or ad hoc baseline surveys. Therefore it is possible that countries in the region might have had species being extinct because of IAS or other factors that are not known.

Table 2: Pathways and Risk Rating for IAS

Very High Risk	Medium Risk	No Rating
Human movement	Airline Passenger Baggage	Maritime trade
Wood Packaging material	Natural spread	
Forestry related pathways	Mail	
Propagative material		
Hitchhikers		

While the context of IAS speaks to effects broader than agriculture, agriculture cannot be separated from the present consideration of pathways given that it is most times the first sector to be affected by the presence of an IAS. Consequently, the discussion on pathways will highlight IAS of interest to agriculture and the natural environment, and will also refer to them in that context as pests and/or diseases.

41 U.S. Environmental Protection Agency (EPA). (2008) Effects of climate change for aquatic invasive species and implications for management and research. National Center for Environmental Assessment, Washington, DC; EPA/600/R-08/014. http://www.elistore.org/Data/products/d18_04.pdf

3. IAS Invasions and Agriculture Impacts

3.1 Common Origins

Agriculture and IAS share a common origin - the natural environment and biodiversity. This makes agriculture, and in particular, primary production, more vulnerable to the destructive impacts of IAS.

Primary agriculture – crop and livestock production, agro-forestry and fisheries – whether for the production of food, fibre, or other goods and services, depends on the natural environment. An IAS can affect a wide range of plant species that are important to maintenance of economic activity and the natural environment, such as the situation with the Pink Hibiscus Mealybug in the early 1990s. Introduction of IAS is among the number one causes of risk and potential loss of biodiversity that supports agriculture and food production. This is particularly so in small islands.

The wealth of biodiversity in the Caribbean may be the best option for the region in stimulating businesses as new uses are discovered for native fauna and flora in developing agri-industries linked to pharmaceuticals and health. A good example of this is the development of a treatment for prostate cancer derived from a native species, the Jamaica Ball Moss[(42)]. The completion of the treatment is deemed to be equivalent to a US$ 726 billion-dollar industry [(43)]. This is just one example of a nutraceutical application of Caribbean biodiversity which could be under threat from IAS introduction and naturalisation. Loss of this biodiversity prior to the discovery of an IAS, could prove to be an effective barrier to agricultural diversification limiting the opportunities for broadening the scope of non-food goods and services.

As emphasised by Ahmad, soil is an absolutely critical resource in the Caribbean generally, and particularly, for agriculture and food production. Aggressive alien species alter soil chemistry, moisture-holding capacity and change characteristics of the soil structure which can adversely affect soil fertility and reduce the suitability of farm lands for certain crop production. The common bamboo (*Bambusa vulgaris*) is an IAS that has quickly inhabited lands previously cleared for farming.

Also as emphasised by John tropical forests constitute another important resource in the Caribbean, contributing to water catchment, slope stabilisation, storm protection and coconuts which help to preserve the sea coast. The associated benefits and positive externalities of having healthy forests are generally not factored into consideration of just how *well* farming activities are enabled and how far other economic activities, (tourism) and public services (water supply) and power generation (hydro-electricity) are supported. Therefore, the threat of IAS provokes a consideration of just what is at stake should these resources no longer be available due to alteration as a result of IAS introductions.

42 The treatment is said to be able to reduce and eliminate prostate cancer. Dr. Henry Lowe who developed the nutraceutical

43 The Jamaica Observer, 2010. “Jamaican scientist makes prostate cancer breakthrough”. www.jamaicaobserver.com/news/Prostate-cancer-breakthrough_8208575

Understanding the pathways through which IAS can arrive and/or be introduced is important in the fight to stop IAS. This is important because once they enter the level of naturalisation, the cost in eradicating or controlling them becomes much higher. A total number of 552 species were reported as alien to the Caribbean region. This estimate has recently been updated to close to one thousand. It includes species regarded by one or more authors/respondents to be naturalised (established in the wild) or invasive (established and spreading or constituting a biological, environmental or socioeconomic threat to the region).[44] (Table 3). The countries with the largest number of reported alien species were the Dominican Republic (186), Puerto Rico (182), Bahamas (159), and Jamaica (102).

Table 3: Number of species reported alien or naturalised/invasive by country

Country	Exotic In	Naturalised or Naturalised and Invasive In
Antigua-Barbuda	45	18
Anguilla	9	9
Guadaloupe	31	5
Montserrat	26	3
St. Kitts-Nevis	5	2
Barbados	60	30
Dominica	34	7
Grenada	37	5
Saint Lucia	37	4
St. Vincent-Grenadines	32	2
Haiti	63	18
Bahamas	159	93
Cuba	60	8
Dominican Republic	186	147
Jamaica	102	52
Trinidad and Tobago	61	23

Definition of terms:

Exotic = known to be present in the Caribbean in cultivation, captivity or in the wild.

Naturalised = known to be established in the wild in at least one Caribbean country.

Invasive = established in the wild and reported to be spreading, and/or regarded as a threat to a native species, ecosystem or causing a socio-economic impact.

Source: extracted from 'Invasive Species Threats in the Caribbean Region', Report to the Nature Conservancy, prepared by Moses Kairo and Bibi Ali, CAB International

44 This information heavily from "Invasive Species Threats in the Caribbean Region", Report to the Nature Conservancy, prepared by Moses Kairo and Bibi Ali, CAB International www.issg.org/dastabase/species/reference_files/Kairo%20et%20al,%202003.pdf

3.2 Agriculture – a Problem and Solution

The reality is that commercial agriculture in the Caribbean is based largely on alien species of crops and livestock. Fortunately most of these are not invasive, are controllable and pose no threat to human well-being or the environment. If left unattended they will not pose a threat to biodiversity. Examples of this are that the abandoned sugar cane lands in St. Kitts which are reverting to grasslands and shrub. If left alone, these lands will look more like secondary forests in a few years. It should however be noted that *Leucaena*, an invasive shrub, is present on these abandoned lands and if left unchecked could dominate this landscape in the years to come.

Other examples include Guyana, where the canals used for transporting sugar cane have become over-run with both native and invasive aquatic weeds interfering with the use of the canals for transport. In addition, some species of aquatic weeds (e.g. hyacinth) can dominate water ways used for irrigation making the use of pumps and other equipment difficult, as well as contributing to the drying up of stationary pools of water on account of high transpiration rates. Also, many of these aquatic weeds consume a significant amount of the dissolved oxygen in water which can make aquaculture unfeasible.

However, it is also important to understand that in some instances, IAS introductions are often made deliberately for perceived economic benefits as well as for use as biological control agents. For example, the small Indian Mongoose was deliberately introduced in 1872 to control rats in sugar cane fields in Jamaica and has become a major invasive and damaging species. Other introduced species, such as goats, pigs, donkeys and cows, have become important to livestock production in Caribbean. These can also become feral (wild) and do untold damage to the natural environment, including changing the composition of flora, if they escape into the wild. In some instances feral animals can completely denude the vegetation in sensitive environments. This in turn has a devastating impact on endemic species. The Jamaican iguana is threatened through competition for food by feral goats while the ricordli, another endemic iguana that occurs in the Dominican Republic, is threatened by donkeys, cattle and cats.

Feral pigs that escape due to poor housing are causing severe disturbance to Saint Lucia's native forests. Some pasture species can escape cultivation and have disastrous impacts on our natural environment. These forage species can significantly increase the fuel load of native vegetation that are fire sensitive making them fire prone and so likely to present changes to native biodiversity in the long term. Often some of these species are more fire tolerant giving them a competitive edge to spread after each fire event.

Hence while the origins of several commercial crops and livestock in the Caribbean are alien species, the fallout from their intentional introduction for their perceived value as food, fibre, lumber and for use in the aquarium and pet trades, were not, at the time of introduction well understood or even appreciated. The iconic coconut palms that often symbolise the idyllic Caribbean tourism product are in fact, alien species, originally from the pacific or the Far East. In many instances large parts of our natural spaces, regarded as 'native' by the populace, really represent alien species that have 'naturalised' over time. As a result, these species no longer pose any threat to biodiversity or human well-being. Indeed, they have now blended into the region's biodiversity.

The foregoing discussion highlighted clearly, that agriculture can be both a cause (through various pathways) and a solution (detection and various control measures) to the IAS problem. However, due to the nature of farming and the agriculture industry and its direct interface and dependence on natural resources, it is in the direct and strategic interest of agriculture stakeholders to build capacity for IAS management. Indeed, based on the IAS outbreaks over the years, agriculture professionals have accumulated a wealth of experience and several have been trained in areas of identification, management and treatment of these pests and infectious diseases. Such experiences and expertise can undoubtedly be utilised in the broader efforts to combat IAS.

The farming solution also offers an environment for observing and developing natural (biological) control measures for IAS. For example, the farm has traditionally been a testing ground for observing species interactions, especially in identifying and categorising predator-prey relations (e.g. ladybugs preying on aphids). In this way, the objectives of farming systems development and IAS management can coincide in mutually-reinforcing ways that benefit not only the agriculture industry, but the wider goal of preserving biodiversity and mitigating problems caused by invasive organisms. In this regard, species from the Caribbean can be potentially useful elsewhere. Cock (1985)[45], observed that as the neotropics have been and continue to be a source from which arthropod pests have accidentally, through commerce or other means, found their way into other continents, this has created a demand for their natural enemies to redress invasion caused by these introduced IAS.

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45 Cock, M. (1985). A Review of Biological Control of Pests in the Commonwealth Caribbean and Bermuda up to 1982. Farnham Royal: Commonwealth Agricultural Bureaux (CAB International).

3.3 IAS Agriculture Impacts

IAS are not a new phenomena in the Caribbean, particularly in agriculture. Unfamiliar species have traditionally been termed 'exotic pests' that affect crop and livestock of economic significance. Among the most commonly listed 'pests' have been the Pink Hibiscus Mealy Bug (PHMB, *Maconellicoccus hirsutus),* the Tropical Bont Tick (TBT, *Amblyomma variegatum),* Carambola Fruit Fly (CFF, *Bactrocera carambolae)* and Giant African Snail (*Achatina fulica).* The CARICOM secretariat has traditionally attempted to track these 'exotic pests' in order to protect the agriculture industry and the health and safety of agricultural natural resources. While these and others are indeed pests within the agriculture sector, at a broader environmental level, they fall in the category of IAS.

> **Note #5. Quick IAS Facts!**
>
> IAS are second to habitat destruction, as the cause of species extinction. They cause enormous damage to biodiversity and to the valuable ecosystem upon which we depend. IAS introduced by humans are a leading cause of species extinctions and populations decline on Island ecosystems worldwide.

Within relatively recent times, there has been a shift in the terminology from the specific reference to 'pest' to the more general category of IAS. Perhaps a major factor driving this shift has been growing global attention of the potentially detrimental impacts of invasive aliens on fragile eco-systems. Moreover, such concern goes beyond pest (insects and other arthropods) to include diseases/pathogens (viruses, bacteria, etc.). Thus, the basis for the specification in the terminology reflects the fact that the issue is not solely an agricultural issue, but also one impacting biodiversity, economic activity, and in several cases, public health.

There has been an ongoing debate, mostly a philosophical division, between agricultural scientists/practitioners and environmentalists on the use and application of the terminologies; i.e., whether the term 'exotic pests' is still relevant and whether instead, reference should be made to IAS. The basis for the agriculturalists' arguments is that not all IAS are of economic significance to the agriculture sector. Therefore diluting agriculture's focus away from dealing with the specifics of the 'exotic pests' to the broader category of IAS may not be a cost-effective strategy. The environmentalists argue that since all 'exotic pests' are IAS, and that most of these so called 'exotic pests' are sustained in the environment where their agricultural hosts are not necessarily present, then a more fundamental and long term approach should be a broad-based strategy that covers IAS both in agriculture and the wider environment.

Whatever the terminology used to describe the organisms or pathogens that affect or potentially threaten agriculture, the environment and public health i.e., 'exotic pest' or 'IAS', there is a general agreement that since they are seldom indigenous/native to an area or ecosystem, there is always the risk that they are harmful. IAS or 'exotic pests and diseases' as they have commonly been referred to, have exacted quite a toll on agri-industries in the Caribbean. In fact, since 1978, St. Kitts and Nevis has been plagued with the tropical bont tick, which had had adverse economic and social impacts.

In order to understand the impacts of IAS on agriculture, and specifically food production, it is important to understand the nature of such impacts. In general, impacts of IAS can be understood from three main perspectives – environmental, economic and social. These are explained briefly below. Generally, however, impacts of IAS tend to focus on biodiversity and ecosystem loss. Currently, the focus is more on agricultural health and human health. Only a few concerned enviornmentalists look at the biodiversity impacts.

Environmental impact

As expected, and by their nature, the initial impact of IAS will be manifest in the destruction of affected areas and habitats, and eventually, the wider environment. Many small sparsely populated islands and/ or areas and regions within countries that are not populated have had their landscapes altered by the presence of invasives, such as, feral donkeys, cattle and goats. Christmas bush (*Chromolaena odorata)*, for example, affects the nesting sites of crocodiles, directly placing these populations at risk. Also Bird Life International (BLI) has implicated IAS in nearly half of the recent bird extinctions[(46)]. Many of these birds are critical to their ecosystems through their contributions to seed dispersal of important native trees. These birds are also an important aspect of the country's tourism product.

The majority of plant and animal species (95 percent) are affected by introduced predators and are frequently subject to multiple impacts from a range of invasives. Predation by introduced dogs, pigs and mongooses and habitat destruction by sheep, rabbits and goats have been implicated in some cases. However, predation by introduced rats and cats and diseases caused by introduced pathogens, are now recognised as the most deadly cause. For example, the *Solenodontidae* family (family of small burrowing mammals) includes two surviving but endangered species which are threatened by IAS, such as, mongoose, feral cats, rats and dogs and by human exploitation.

Research published in January 2010 in Biology Letters by Alaux C. et al suggested a strong link between protein nutrition and immunity in bees.[(47)] Protein nutrition was in turn related to the diversity of pollen sources. Where bees were limited to narrow diversity of pollen sources, such as ecosystems that had greater presence of invasive plants, the immune competence of bees were compromised leading to poor apiary health. This potentially has implication for a wide range of crops that are dependent on bees for pollination. This study demonstrates the intricate link between food crops and biodiversity within a native ecosystem. However, IAS can have other impacts on the economy through effects on agriculture, fishing, forestry, tourism, etc., through structural damage (e.g., zebra mussels in waterways) and through public health issues (H1N1 virus) and loss of worker productivity.

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46 http://www.birdlife.org/action/science/sowb/pressure/44.html

47 Alaux, C., Ducloz, F., Crauser, D. And Le Conte Y. 2010. Diet Effects on Honeybee Immunocompetence. < http://rsbl.royalsocietypublishing.org/content/6/4/562.full.pdf+html >

Economic impact

As is now being appreciated, environmental destruction comes at a price. IAS-induced destruction of biodiversity will therefore eventually compromise the productive capacity of natural resource dependent industries, mainly agriculture and tourism, two critical economic sectors in all Caribbean countries. Several agriculture industries, especially those of economic importance to income earning, employment and foreign exchange, have and continue to suffer economic losses from IAS introductions and invasions, both in terms of direct losses from reduced yields and outputs and as well, indirect losses from increased costs of control and management treatments.

Although it is difficult to quantify economic losses, estimates from Florida indicate approximately US$1 billion in control costs and losses between 1995 and 2001 as a result of newly introduced invasive species affecting agriculture[48]. The average annual spending of the USDA-APHIS on its emergency programs for the period 1989-2002 rose exponentially from about US $6.4 million in 1989 to US $334.8 million in 2001, or about 32.7 percent annually.

Concise data on the economic loss caused by IAS in the Caribbean is limited. Losses caused by the PHMB outbreak in Grenada for the period 1995-1998 totalled US$18.3 million. In Trinidad and Tobago, potential losses to agriculture and forestry were estimated at US$125 million. However, successful control considerably reduced this to US$ 5.1 million over the 1994 to 1997 period. Crop losses caused by the PHMB throughout the entire insular Caribbean were estimated at US $138 million, exclusive of the costs of control and export losses[49]. Reappearance of the classical swine fever in Haiti in 1996 took a heavy toll, leading to death of 80 percent of the swine population. Costs of the on-going program of eradication in Haiti and the Dominican Republic have been estimated at $12.1 million.

Social impact

IAS also leads to adverse health impacts with heavy costs to society. Outbreaks can restrict travel from and to affected areas eg swine flu, disrupt school system (e.g., from outbreaks of rats to H1N1 virus), limit hosting of public events, such as, cultural festivals; affect availability of local foods due to devastation on local agriculture, increase the demands on health systems and significant loss of productive man hours due to ill health. The situation in St. Kitts and Nevis as a result of the Tropical Bont Tick, clearly illustrates how economic and social impacts interact when an IAS strikes commercial industry. (Note #6).

48 USDA estimates
49 Ranjit Singh

Note #6

Understanding IAS Socio-Economic Impacts

The Tropical Bont Tick (TBT) in St. Kitts and Nevis Livestock Sector

Calf showing severe case of dermathophilosis

The tropical bont tick (TBT) was first identified in St. Kitts in 1978.(a) Initially, infestation was observed on cattle that developed a severe dermathophilosis, a skin disease caused by bacterium called Dermatophilus congolensis (for which the TBT is a vector). This disease, which can affect many species of both domestic and wild animals, causes the formation of pus-filled scabs and sores on animal's skin that can eventually lead to death. Over a seven year period, TBT spread to most areas of the island, affecting cattle, sheep and goats. As a result, the small ruminant population saw dramatic decline from 6,000 cattle, 9,000 sheep and 7,000 goats in 1984 to an estimated 400, 800, and 1,000, respectively, in 1990. In Nevis, demathophilosis killed nine out of every ten heads of cattle.

In addition to the death of the animals, consumption of local beef, mutton and chevron all but ceased as people were frightened by the sight of animals infected with dematophilosis. The aversion by consumers resulted in a fall in demand and further loss to producers. This was a major factor leading to St. Kitts and Nevis becoming more heavily dependent of food imports, with serious implications for food and nutrition security.

Projects to control the disease in 1983 and in 1995 yielded some results. Cases of dermatophilosis declined from 657 in 1995 to 153 in 1996 with continuous treatment of Flumethrin and stronger institutional capacity in the Department of Agriculture for treatment compliance, monitoring and TBT surveillance. As a result, the animal population rebounded to 3,000 cattle, 6,000 sheep and 4,500 goats, with almost double the number of animal owners to 810. By 1998, the TBT was confined to three foci. The remainder of the island was declared provisionally tick free. However, after a premature termination of the program, including massive public awareness/relations, TBT infestations have returned and continue to paralyze the livestock industry in St. Kitts and Nevis.

Sources: St Clair P, K. 2000. Tropical bont tick (Amblyomma variegatum) eradication in the Caribbean. The St. Kitts experience." Ann N Y Acad Sci 916: 320-5 http://www.caribvet.net/divers.php; Photo: FAO 2005

With the emerging understanding of the broader IAS issues, the apparent ease of spread and the potentially debilitating environmental, economic and social impacts, Caribbean countries are becoming more ‘alert’ to the threat of new species, particularly the more invasive types. PHMB may have thrust the exotic pest/IAS issue more into the public domain. However continuous outbreaks of invasives illustrate the seriousness of the IAS problem in the region. Among the more recent and new IAS threats include the Citrus Greening Disease, Red Palm Mite and Cocoa Frosty Pod[50]. The recent rapid spread of the lionfish has led many to fear the invasion of marine invasive species and their effects upon the fragile marine resources of the Region and the potential devastating effect on those depending on these resources for their livelihoods. There are several agriculture industries currently under IAS threat and as well, under IAS watch. Some of these industries and their IAS threat and impacts are briefly profiled below.

In these and several other agri-industries effective control systems have yet to be mainstreamed in the industry and as a result, infestation of Citrus Greening Disease and Red Palm Mite, respectively, continue to plague these crops. The presence of IAS may further complicate arrangements for trade, thus limiting access to potentially profitable markets. Increased costs also derive from higher bio-security standards that now need to be incorporated to meet the requirements for trade. Under internationally agreed regulations, importing countries are adopting stricter bio-security measures that could in effect ban imports from countries with a pest or disease considered invasive. These additional costs at the farm-level move through the agri-food chain and may adversely impact the cost competitiveness of Caribbean commodities.

50 Citrus greening: http://theboxmove.weebly.com/1/category/malaria/1.html; Red Palm Mite: http://www.freshfromflorida.com/pi/enpp/ento/r.indica.html; Averroa Mite: http://wataugaces.blogspot.com/2011/04/new-formulation-for-varroa-mite-control.html; Frosty pod: http://www.plantmanagementnetwork.org/pub/php/review/cacao/

Agri-Industry/IAS threat:	IAS Symptoms and Impacts
Citrus	
	**QUICK FACTS** **Citrus Greening Disease (CGD)** • also known as huanglongbin or yellow dragon disease, • first noted by farmers in China in the late 1800s[a] • introduced into the Western Hemisphere in 2004 • 'discovered' in Jamaica in 2008. • caused by a bacterium *(Liberobacter spp.)* • spread by two species of psyllid insects: the Asian citrus psyllid *(Diaphornrina citri Kuwayama)* and the African citrus psyllid *(Trioza erytreae)*.

SYMPTOMS/IMPACTS

- appearance of yellow shoots on a tree;
- blotchy leaf mottle and vein yellowing that develop on leaves on a single shoot/branch;
- may cause small, narrow leaves and short stems that give plant growth a bunched appearance;
- twig dieback, poor flowering, stunted growth
- loss of fruit and poor fruit formation *(small, misshapen, with some green colour remaining on ripened fruit)*.
- progressive yellowing of entire canopy in fully infected trees
- fruit on mandarin orange trees appear half orange-half yellow

NB: Infected Citrus plants may not show symptoms for years following infection.

[a] www.aphis.usda.gov/publications/plant_health/content/printable_version/faq_citrus_greening.pdf

The citrus industry in CARICOM, mainly in Belize, Jamaica and Trinidad and Tobago, is significant in terms of its contribution to employment, income generation, exchange earnings food security and economic diversification. In Belize in particular, the citrus industry spanned the entire country, with an estimated worth of US$32.24 million (or Blz $67.1 million). In the 2007-2008 season alone, sales to the Belize Citrus Growers Association (from 527 growers), totalled 7,102,188 million boxes.[51] The presence of CGD is a major economic threat to the industry, on which a significant number of farmers, farm families and their rural communities depend for livelihoods. Since its introduction in 2008, the CGD has become a serious threat to the agriculture sector and livelihoods in Jamaica, where the industry is worth an estimated US$40 million (J$4 billion). In Jamaica, over 95 percent of total citrus production is utilised locally for the fresh fruit market or in processing, while approximately four or five per cent is exported. Direct and indirect employment is estimated at between 19,000 to 20,000 jobs, of which 6,000 are employed at the farm level.[52]

51 Francisco Gutierrez (2009) Citrus Greening in Belize: a new threat to the citrus industry. http://www.calcitrusquality.org/wp-content/uploads/2009/06/gutierrez-hlb-in-belize.pdf (viewed 22/11/10)

52 Minister of Agriculture of Jamaica, Dr Tufton as reported in the Jamaican Gleaner include date of print

Agri-Industry/IAS threat:	IAS Symptoms and Impacts
Coconut and Horticulture Crops	
	**QUICK IAS FACTS** **Red Palm Mite (RPM)** • *Raoiella indica Hirst (acari: Tenuipalpidae*); • a pest of coconut, areca palm and date palm in the Eastern Hemisphere (Egypt, India, Iran, Israel, Mauritius, Pakistan, Sri Lanka and Sudan); • distinguishable from spider mites by their red colour, long spatulate setae (hairs) and flattened bodies; • spread largely by transport of infested plants or plant material, including seed coconuts and handicraft; • 2004 sighting of red palm mite on Martinique was the first in the Western Hemisphere; • in 2005,mite presence confirmed in Saint Lucia and Dominica, and later in Trinidad, Guadeloupe, Jamaica; Dominica; St. Kitts and Nevis; and Grenada among others;

SYMPTOMS/IMPACTS

- usually found on the underside of leaves, often in large groups of hundreds of individuals and are visible to the naked eye
- cause necrosis (death) of leaves of host plants, affecting fruit development and may cause the subsequent death of the plant.
- could also seriously affect wild bananas *(Musaceae);* heliconias (*heliconiaceae);* and gingers *(Ziniberaceae)* which increase the reach of spread within the horticulture trade and the possibility of spread beyond farms into the natural environment
- infestation has been severe in Trinidad with Coconut Growers Association reports of yield losses in excess of 75%

NB: RPM is a serious threat to native biodiversity as well as to agriculture mainly coconut and banana production and the tourist trade as the several palm species

Agri-Industry/IAS threat:	IAS Symptoms and Impacts
Beekeeping and Honey	
	**QUICK IAS FACTS** **Varroa Mite** • an external parasitic pest which feeds off of the haemolymph; (equivalent of blood) of the bees; • cause the disease known as Varroatosis; • Varroatosis appeared in France in 1982 after being propagated in Asia. It spread to the US; • reportedly present in most Caribbean countries;

SYMPTOMS/IMPACTS

- cause death of an entire colony either through early death or by making bees susceptible to viral infections
- responsible for loss of apiary and hives and a reduction in the number of beekeepers and reduction of honey per hive
- increases production cost from application of treatment estimated at approximately US$10-13.00 per hive per year.

The beekeeping industry is also of particular importance, which unlike other industries, stems from the fact that no honey imports are allowed into some, if not all countries of the region. This is due almost solely to the potential and devastating threat and impacts of diseases on bee colonies. Indeed, the Second Caribbean Beekeeping Congress noted that in excess of 5,000 persons are engaged in beekeeping regionally and managing in excess of 202,000 colonies. The Caribbean produces 6.25 million kg of honey annually, generating revenues in excess of US$50,000,000.00 which still does not satisfy current regional demand.[53]

53 McLaren L.E. (2002) Proceedings of the Third Caribbean Beekeeping Congress. Kingston Jamaica. http://www.moa.gov.jm/agents/data/carib_beekeeping_congress_3rd.pdf (viewed 21/11/10)

Agri-Industry/IAS threat:	IAS Symptoms and Impacts
A range of Food Crops, Garden Plants and Native Vegetation	
	**QUICK IAS FACTS** **Giant African Snail** • *Achatina fulica* a tropical species native to East Africa; • are about 1 cm tall, it can grow as large as 20 cm and weigh as much as a kilogram; • are hermaphrodite(have both male and • female sex organs) and after a single mating can lay up to 1,200 eggs; • a mature snail, six to seven months can live up to nine years; • widely distributed in southern and eastern Asia, as well as many islands of the Indo-Pacific; • already present in several Caribbean countries.

SYMPTOMS/IMPACTS

- impact a range of indigenous vegetation, food crops and garden plants
- they feed on over 500 plant types, including agricultural and food crops. They are a host for the rat lungworm, which causes eosinophilic meningitis in human beings, making them also extremely dangerous to human health.

NB: Once established , the snail is extremely difficult to eradicate

Head of the Entomology Section of the Ministry of Agriculture, Food, Fisheries and Water Resource Management, Ian Gibbs is "urging Barbadians not to become complacent about this pest, continue the battle. It's not just an agricultural problem but a potential public health issue. Let's try to bring it down to as low a number as possible and if we can eliminate it from the island that would be even better." Mr. Gibbs cited the Ministry's Giant African Snail Bounty Programme as one of the reasons for the decline in snail numbers, noting that from March 2009 until December 2011, some 346 tonnes of snails were received and burnt. "That amount represents just over 10.8 million snails which have been removed from the population of the island..."

Extracted from: "Fight Against Giant African Snail Continues" By Andre Skeete. Published: February 1, 2012. http://www.gisbarbados.gov.bb/index.php?categoryid=15&p2_articleid=7361

Agri-Industry/IAS threat:	IAS Symptoms and Impacts
Cocoa	
	**QUICK IAS FACTS** **Frosty Pod Rot (FPR)** • an invasive disease originally identified in Ecuador in 1917, which spread rapidly to other countries in Latin America during the 1970s; • caused by the basidiomycetous fungus Moniliophthora roreri; • is present in nearby Venezuela; • **currently absent from Trinidad and Tobago and the wider Caribbean;**

SYMPTOMS/IMPACTS

- only infects the growing tissue of the pods making young pods more susceptible to infection
- in early stages of infection FPR symptoms may be indistinguishable from those of witches' broom and *Phytophthora* black pod until the light-brown mat of powdery spores forms on the pods surface
- produces large quantities of powdery spores, giving it high potential for transmission and spread in range
- infested plantations suffer dramatic yield loss, leading to neglect of trees by farmers and eventually complete loss of production.
- losses usually amount to 70-80% of cocoa yield have been recorded, leading to the abandonment of farms and plantations, even loss of up 30,000 tonnes of cocoa in some parts in Latin America.

Cocoa contributes to soil stability, biodiversity conservation and sustainable livelihoods! Trinidad and Tobago is home to one of the world's most diverse collection of cocoa germplasm, hosted at the International Cocoa Gene Bank at La Reunion Estate, Trinidad. It is also globally recognized as the producer of the highest quality world renowned 'fine flavoured cocoa'. Trinidad and Tobago - through partnership with the Ministry of Food Production, the University of Trinidad and Tobago and the European Union - is moving to rehabilitate its cocoa industry. But a major threat is the number of pests and diseases that affect cocoa, including **Frosty Pod Rot** which can cause decline in yield of up to 80%. Source: V.Ferguson-Dewsbury

Agri-Industry/IAS threat:	IAS Symptoms and Impacts
Fisheries and Coral reef Tourism	
	**Lion Fish** • *Pterois volitans and Pterois miles,* are coral reef fishes from the tropical waters of the South Pacific and Indian Oceans; • a "sit-and-wait" predator • first seen in 1985 North Carolina, USA, in Bermuda in 2001 and now found in the western Atlantic Ocean • first seen in the Caribbean in the Bahamas in 2004, and is now as far as Tobago; • are efficient carnivores that feed on a wide variety of smaller fishes, shrimps and crabs,

SYMPTOMS/IMPACTS

- highly invasive in the Caribbean, due to its negative impacts on the reef ecology, economy and public health
- research in the Bahamas show negative effects of lionfish on native Atlantic coral-reef fishes[b]
- stomach content analyses and observations of feeding behaviour over a 5-week period in 2007, showed that reductions in native fish density of coral-reef fishes, by as much as 77%, in the Bahamas were almost certainly due to predation by lionfish [c]
- have the potential to decrease the abundance of ecologically important species such as parrotfish and other herbivorous fishes that keep seaweeds and macro-algae from overgrowing coral
- potential for loss to commercial fishers and reef-based tourism is severe.
- Venomous spines are also a serious threat to human health.

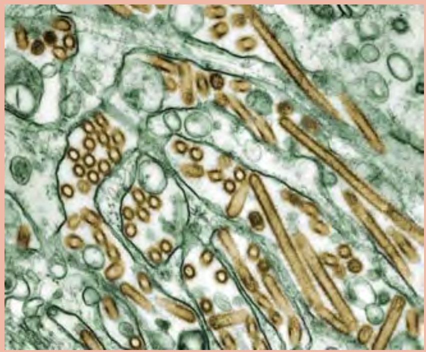
[b] Albins & Hixon, 2008

[c] Schofield, PJ, JA Morris, Jr, JN Langston, and PL Fuller. 2010. Pterois volitans/miles. USGS Nonindigenous Aquatic Species Database, Gainesville, FL., http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=963 Revision Date: 2/15/2010

Source: Trends and Tools in the Management of the Pet Trade as Pathway for Invasive Alien Species in the Wider Caribbean Region, by Ulrike Krauss, Invasive Species Coordinator, Forestry Department, Ministry of Sustainable Development, Energy, Science and Technology, Union, Saint Lucia

Agri-Industry/IAS threat: | **IAS Symptoms and Impacts**

Poultry



Colorized_transmission_electron_micrograph_of_Avian_influenza_A_H5N1_viruses.
Source: Wikipedia

Avian Flu Virus - H5N1

- highly pathogenic and affects wild birds and poultry populations with also a threat of cross-over to humans;
- be present in most East Asian countries, and parts of Bangladesh, Egypt, India and Nigeria.
- since November 2004, has affected wild birds and poultry populations in 61 countries throughout Asia, Europe, the Middle East, and Africa;

SYMPTOMS/IMPACTS

- Poultry deaths due to culling and disease stand at more than 300 million, causing substantial losses for poor farmers
- costs to governments of containing the epidemic in terms of equipment, materials, transport and personnel
- no single country can protect itself against an influenza epidemic.

The poultry industry is the largest livestock industry in the Caribbean and hence a major source of food supplies (protein), revenues and employment, both in primary production and processing. For example, the poultry industry in Trinidad and Tobago is regarded as the largest agro-food manufacturing sector after the beverage sector with significant linkages to other sectors. In 2005, total wholesale sales were estimated at roughly US$26 million (TT$1,160 million) comprising of 1,100 million for broiler meat and 60 million for eggs. This corresponded to an industry output of 80,000 tonnes of broiler meat and 90,000 eggs[54]. A further 75 million was the value for value added purchases. The industry earned 2 million in exports and employed approximately 10,000 persons are employed. It is noteworthy that vegetable farmers depended heavily on the chicken manure for their production. The introduction and spread of diseases such as the Avian influenza could wipe out this industry with serious economic implications for livelihoods and the economy.

54 Association of Poultry Producers Association. (2007). Presentation to the National Consolation on Food Prices, Bishop Anstey High School/Trinity College East Trincity, College East Trincity, Tacarigua. August 15-16 2007.

4. COMBATING the IAS Threat

4.1 Prevent them from entering!

Prevention is the best approach to the control and management of IAS. Preventing harmful introductions before they occur is the most effective means to avoid or minimize risk. Investments in prevention are cost effective! They help to avoid significant long-term economic, environmental and social costs associated with ongoing control and management. Prevention activities will ultimately result in fewer unintended introductions, and fewer intentional introductions with unintended consequences.

Critical Preventive First Steps:

The Draft Regional IAS Strategy highlights the following first steps:

Step 1: Conduct risk assessment: - identify the potential IAS that may enter the country/region and prioritise preventative action based on the risk.

Step 2: Conduct pathways analysis to prioritise pathways according to risk. Once the IAS has been identified a pathways analysis must follow, i.e. identifying all possible means of entry into the country/region. Although international trade and travel are believed to be the leading cause of harmful unintentional introductions, there is no detailed knowledge base on the actual pathways, except in very few countries.

Step 3: Develop and implement plans for managing pathways for high-risk IAS (indentified in step 2) - developing relevant protocols at the identified pathways to prevent IAS entry.

With respect to Step 1, species assessed for risks, i.e., for their likely invasiveness, would be added to a white or black list depending on the outcome of the investigation. However, since invasiveness of alien species can vary with time, genetic composition of the introduced population and man-made changes (e.g. in land use), the species on the white lists have to be re-assessed in appropriate intervals, e.g. environmentally benign species can become invasives. The most reliable method for predicting a species' invasiveness is to extrapolate from its record as an invasive species under similar conditions elsewhere. Invasiveness cannot be reliably predicted. Species known to be invasive elsewhere must be considered high priority 'black list' species. A stakeholder proposing an intentional introduction has to prove the safety of the species in a risk assessment process before introduction.

With respect to Step 2, Global Invasive Species Prevention (GISP) recommends that exclusion methods based on pathways is a more efficient prevention strategy since it allows for concentrating efforts where pests are most likely to enter national boundaries. Exclusion methods include: (a) quarantine laws and regulations; (b) accessibility of information on invasive organisms; (c) public education; and

(d) inspection. A further benefit of the pathway approach is that it enables identification of more species, vectors, pathway systems, and underlying introduction mechanisms as well as revealing more false negatives of the individual species approach.

Currently, the individual species approach that targets certain individual species deemed as 'pests' in the country or elsewhere ('black lists') tends to be the more common approach for the IAS prevention. Usually, these targeted species tend to be predominantly of economic importance for the agricultural, forestry, or human health sectors. GISP also advises using pathway-based exclusion methods to avoid wasting of resources associated with the individual species approach. Countries that are more advanced in adopting effective bio-safety measures such as Australia and New Zealand now incorporate all potentially dangerous organisms, not only from an economic view but also from the perspective of protecting their native biodiversity. This approach employs "white lists" which effectively treat all non-native species as invasive and harmful to native biodiversity until proven as not a threat.

Note #7. 'Blacklisting' IAS

Invasive species need to be arranged in a priority list that considers the extent of the area infested by the species, its impact, the ecological value of habitats invaded, and the difficulty of control.

Species with the highest priority would be those known or suspected to be invasive but still in small numbers, species which can alter ecosystem processes, species that occur in areas of high conservation value, and those that are likely to be controlled successfully.

High Priority Action for Preventing the IAS:

Step 4: Coordinate and harmonise Caribbean/regional risk management processes. Harmonisation is very important especially in trading of goods and services. With the increase in trade as a result of globalisation, risk management should comply with international standards to prevent unnecessary border restrictions, as was the case with the Swine flu (H1N1) in 2009. Early warning systems are thus important to risk management capacity.

Step 5: Increase national capacity for inspections and enforcement at borders for import commodities, pathways and vectors. Once the critical pathways have been identified for high risk IAS, activities and protocols defined in Step 3 should automatically kick-in.

Step 6: Cooperate with international organizations to prevent IAS introductions at their source/point of origin. In most cases accidental introductions are a result of trade. Therefore to prevent entry of high risk IAS, measures to be taken at exporter country will require some form of international support and cooperation.

Step 7: Develop and implement a national public education campaign and targeted outreach initiatives (including codes of conduct) in partnership with stakeholders. Such educational programmes can be a great asset in preventing IAS entry into a country/region. Educating the public about the impacts of releasing non indigenous organisms into the environment can also help prevent accidental introductions.

Step 7 is of particular and general importance to the entire effort at preventing IAS introductions. It must be emphasised that education is a key component of successful prevention and management methods. The public has to be informed why prevention measures are taken and what impact failure can cause. The public as well as the companies concerned should perceive prevention measures not as an arbitrary nuisance but rather as a necessary aspect of travel and trade to care for the future commercial and natural environment.

Medium Priority Action for Preventing the IAS:

Step 8: Conduct and support research on methods/technologies to treat/prohibit commodities, pathways and vectors to reduce impacts or risks of introduction to acceptable levels. Such research can provide policy makers with the necessary knowledge and tools to combat IAS and in developing new techniques for management/control of critical pathways.

Step 9: Conduct and support research aimed at developing tools to better predict the probability of invasion and invasiveness of alien species and to identify new pathways for IAS.

These recommended steps highlight important information and technical requirements and provide a structured list of best practices for immediately addressing an IAS threat. However, when preventing IAS entry or introduction fails, then the focus must immediately shift to preventing their spread and invasiveness.

Note #8.
Towards IAS Early Warning Systems

The Frosty Pod Rot (FPR), present in neighbouring Venezuela, is a serious threat to the cocoa production in Trinidad and Tobago. In 2011 the Ministry of Food Production Lands and Marine Affairs began the process of developing an early warning system. This system was built on:

- Training of trainers (9) comprising of scientific, extension staff and representatives of the cocoa farmers, in laboratory and field identification of the pathogen Moniliophthora rorei, at CATIE, Turrialba where researchers have been working on finding management solutions to the problem in Costa Rica.
- Situation assessment through a rapid survey undertaken by the returning trainers to confirm the absence of the disease;
- A public awareness campaign to warn stakeholders and the general public of the seriousness of threat.
- A risk pathway assessment for possible IAS introduction that would facilitate targeted inspection to prevent introduction of the invasive pathogen. To facilitate routine surveillance, all the farmers' plots were to be entered into a GIS database.
- A hotline was established to report any sightings of possible symptoms that could be FPR.
- Developing an emergency response plan that would be put in effect in the event of disasters.

4.2 Prevent them from Spreading!

Early Detection

Once an alien species is introduced to a new country in the region, there will be a brief period when its chances of establishment will hang in the balance. However, based on the Tens Rule, not all introduced species will become established and only a small percentage of those that establish will become invasive. Not all alien species will necessarily become invasive, so species known to be invasive elsewhere, especially those spreading within a region, should be priorities for early detection. In this situation, early detection becomes the next best and absolutely critical defence strategy.

The process for early detection of invasive species includes:

1.Surveys: Both general and specific surveys are critical. Site specific surveys include production systems that are targeted by the IAS, such as poultry for the H5N1 virus. Surveys may also be required by specific 'species', such as specific surveys for the Red Palm Mite in palm and other host trees close to air and sea ports. Data collection and storage are also essential aspects of the survey process.

2.Expertise: The need to develop and have access to a corps of experts/trainers is important. In this regard, issues such as, who to train, training needs and appropriate training centres become important. The experience of Trinidad and Tobago with training of trainers in its attempts to establish an early warning system for FPR becomes instructive. It is also instructive to note that this training was for just one species of IAS. Therefore the issue of 'training needs' is an especially critical one for Caribbean countries given the wide range of existing and potentially new IAS threats of marine, terrestrial and aquatic origin. Under such circumstances, having an expertise corps of 'general IAS practitioners' may potentially have greater impact than a few specialist IAS experts for a relatively narrow range of IAS.

3. Back-up: Contingency plans and funding: aimed at developing alternative protocol, especially in high risk/vulnerable areas, that would complement local strategies by creating a broader capture net on early detection activities such as in identifying/detecting, reporting and initiating control actions (rapid response). Integrated rapid response networks are critically important in supporting contingency plans and often employ both formal and informal mechanisms. There should also be an allocation of emergency funds for quarantine and eradication measures in order to eradicate, contain, or control invasive species immediately upon detection before they can establish and spread. More recently, greater public involvement is being considered as a strategic asset in detection and minimising the likelihood of spread through education and broad sensitisation on simple detection and reporting procedures. This helps in reducing the financial cost of response networks and information exchange needed.

Ideally, early detection of IAS should be based on a system of regular surveys to find newly established species. However, to date, the prevailing systems in the Caribbean are generally 'species specific', targeting IAS known to be of economic importance to agriculture and human health. There has been very limited activity in terms of continuous surveillance and early detection for species that pose potential threat to biodiversity. That several invasive species are known to be present in protected areas and Ramsar sites[55] provides sufficient evidence of both a general lack of surveillance as well as similar lack of concerted efforts to eradicate these species.

Limited resources and expertise are usually cited for such deficiencies. Therefore, given such capacity limitations, site-specific surveys to detect presence of alien species in general, could prove to be a useful strategy. A determination of which sites should be surveyed could include issues, such as, areas of high conservation value, areas with highly endangered species, and high-risk entry points, such as, air and sea ports. For such general surveys to be effective, the country must have, at least, well-trained staff that can identify non-indigenous species in many taxonomic groups. After introduction, the longer an IAS goes undetected at this stage, the less opportunity there will be to intervene. Eradication will rapidly cease to be an option the longer an alien is left to reproduce and disperse. Delayed detection also means fewer available options and a likely increase in the cost for control and/or eradication interventions.

Using the cocoa FPR, as an example and given the nature of the disease, the best means of managing the threat of invasion and if introduced, preventing spread, is through early detection. Recognising early signs of the disease and taking quick action by removing diseased pods from the trees before 'sporulation' and applying control treatments (usually pesticides) are essential to management strategies. This will require constant surveillance and the implementation of phytosanitary measures which can be intensive and costly. Therefore prevention, whether of introduction and/or spread of invasion through early detection should always be the first and most critical line of defence.

55 Wetland sites of international importance based on the Ramsar Convention.

4.3 Control their Populations

The four main and inter-connected strategies for dealing with established IAS are Eradication, Containment, Control and Mitigation. The key issues of these general strategies are in keeping with the thrust of the GISP programme.

Note #9. Managing IAS

Going beyond boundaries

The target area for IAS management may be an entire country, all or part of an island, or all or part of a reserve or conservation area, or more than one country in a region.

This justifies managing IAS eradication or control programmes on an ecosystem basis, especially when ecosystems are similar among Caribbean countries. Political commitment, cooperation and coordination through regional projects are a must!

4.3.1 Eradication:

Eradication is the elimination of the entire population of an alien species, including any resting stages, in the managed area. When prevention has failed to stop the introduction of an alien species, an eradication programme is the preferred method of action. However, eradication, as a successful and cost-effective strategy, is only possible through early detection. The possibility of early eradication or getting a new coloniser under effective early control makes investment in early detection worthwhile.

Eradication programmes can involve several control methods on their own or in combination. There are few situations where a single method is a proven eradicator of an invasive species. Therefore it is wise to plan for and use a combination of possible methods, which will vary depending on the specifics of the IAS. In the past, successful eradication programmes have been based on:

i. mechanical control, e.g. hand-picking of giant African snails and hand-pulling of invasive weeds;
ii. chemical control, e.g. using toxic baits against vertebrates and spraying insecticides against insect pests;
iii. biopesticides, e.g. *Bacillus thuringiensis* (BT) used against insect pests;
iv. sterile male releases, usually combined with chemical control, as in the case of the New World screwworm fly *(Cochliomyia hominivorax)*;
v. habitat management, e.g. grazing and prescribed burning;
vi. hunting of invasive vertebrates, e.g., feral donkeys, goats, rabbits, pigs.

Not all organisms, including some invasive alien species, lend themselves to eradication efforts, and this must be well understood in efforts to develop eradication strategies for IAS. In this regard, eradication should only be attempted if there is likelihood that it can be successful. A careful analysis of the costs (including indirect costs) and likelihood of success must be made (rapidly) and adequate resources mobilised before eradication is attempted.

If eradication of the invasive species is achieved it is more cost-effective than any other measure of long-term control. An eradication programme that is unlikely to succeed, irrespective of how attractive the intervention may be, should never be attempted. When eradication also fails, then the required option is to try to contain the invasion and adopt systems and strategies for ongoing management and control.

4.3.2 Containment:

Containment of non-indigenous invasive species is a special form of control. The aim is to restrict the spread of an alien species and to contain the population within a defined geographical range. Spread of individual and/or colonies beyond this containment is effectively suppressed, also limiting/preventing the likelihood of introductions into areas outside the defined containment area. As was the case with eradication, containment programmes also need to be designed with clearly defined goals, including barriers beyond which the invasive species should not spread and habitats that are not to be colonized and invaded. In order to establish these parameters there needs to be clear understanding of why the containment is being done in the first place. For example, such purposes could be to protect particular areas or habitats from invasion and/or to allow sufficient time to mobilise other control and/or eradication measures.

Detection capabilities are also essential to containment, especially in terms of the ability to rapidly detect new infestations, i.e., whether the invasive alien species has spread from the margins of its distribution, or has been introduced in completely new areas. Since initially, these new infestations will be at very low densities, early detection may be challenging. However, detecting new infestations is critical to implement control measures in as timely a manner as possible.

The methods used for containment are the same as those described for prevention, eradication and control. However, the distinction between containment and eradication is not always clear-cut depending upon the scale of operations considered. A species most likely to be successfully contained in a defined area is a species spreading slowly over short distances. The nearest suitable habitat for the species should be preferably separated by a natural barrier, or an effective artificial barrier. The most suitable cases for containment are habitat islands without suitable connections that would allow the easy spread of invasive species. The spread of alien freshwater species between different parts of watersheds is a good example where containment may be possible.

Containing a species in a defined area will, however, need constant attention and control of the species at the border and prevention measures against spread of the species. Thus, successful containment is difficult to achieve and involves several different costly methods. In this regard, a particularly important additional element is ‘Monitoring’, in which public engagement and involvement is essential to the process.

4.3.3 Control:

The objective of control strategies of non-indigenous invasive species is for long-term reduction in the density and abundance of their populations to a level below a pre-set and acceptable threshold. Under this threshold, the potential harmful effects to biodiversity and the economy that could result from invasions are considered acceptable.

To achieve the objective, it is not always clear as to what this threshold level should be. Precise predictions of the behaviour, spread and impacts of invasive alien species introduced into new environments are not available. Too many of the parameters used to describe the situation are no more than informed guesses. In many cases even the taxonomic status of the invasive species is uncertain. Research to identify and establish 'at risk' indigenous biodiversity, their risk tolerance levels and the nature and scope of the potential adverse impacts will be required to inform management strategies. Fortunately, descriptions of methods used to control certain species and their effectiveness under specific environmental factors are available. These experience-based reports are essential for management of invasives and need to be made increasingly available, for example in databases accessible through the Internet.

The successful control of the population of an invasive species itself can have indirect effects on native species, the ecosystem, and the entire local biodiversity. Suppression of the invasive alien population below a particular threshold level can tip the balance in favour of native competing species. The weakened state of the invasive species allows native species to regain ground and even further diminish the abundance of the alien species. In rare cases, this might even lead to complete eradication of the alien species. However, caution is advised with respect to evaluating, beforehand, the potential effects of reducing or eradicating the invasive species in a habitat to ensure that the impacts from such interventions are largely positive. For example, removal of an aggressive invasive plant from a site might need to be accompanied by planting of indigenous species to fill the gaps, to prevent these gaps being filled by other unwanted species. Hence combining control strategies with habitat restoration efforts to support native species and re-establish/regenerate natural systems, though not the principle goal of control efforts, could be considered an important complementary strategy.

There are a large number of specific methods to control invasive species. Recognizing the highly complex nature of invasives ecology and the importance of local conditions, general statements about suitable control methods for groups of alien species, in specific habitats or world regions should be approached with great caution.

It is worth reiterating the various common types of methods that can be utilised to control biological invasions:

i. Mechanical control
ii. Chemical control
iii. Biological control, which includes biopesticides, pathogens for control of vertebrates and biological control of freshwater and marine targets, and plant diseases
iv. Integrated Pest Management (IPM) include some or all of the above in addition habitat management where appropriate, such as, prescribed burning and changing abiotic factors
v. Hunting and other use of non-indigenous species to control the population.

Cock (1985) noted that of the above methods, biological control has had a long history in the Caribbean[(56)]. (Table 4) Early attempts at biological control targeted rats (mainly the imported *Rattus rattus (L.))* which by the middle of the 17th century were causing considerable damage to sugar cane and incurring high control costs, including the introduction of ferrets into Jamaica and introduction of the small Indian mongoose (*Herpestes auropunctatus* (Hodgson)) from India in 1870s. Other attempts at biological control also targeted the economically important export crops of citrus, coconut, cocoa, coffee, cotton, banana and other ornamentals, with limited successes.

Black or Ship Rat (rattus rattus) pose a serious threat to the country's rarest wildlife. Famously prolific breeders, a single pair of rats can give rise to well over 1,000 descendants within one year. Some scientists have put that figure at 15,000.

(Photo: John Cancalosi, FFI-OICP)

56 Cock, M. (1985). A Review of Biological Control of Pests in the Commonwealth Caribbean and Bermuda up to 1982. Farnham Royal: Commonwealth Agricultural Bureaux (CAB International).

Table 4: Summary of biological control programmes in the Caribbean region which produced substantial or complete control

Invasive Alien Species	*Common name*	*Effective control agents*	*Countries*
Insect pests			
Aleurocanthus woglumi (Ashby)	*Citrus black fly*	*Encarsia opulenta (Silv.)* *Eretmocerus serius (Silv.)*	Bahamas, Barbados, Cayman Is. Jamaica
Aleurodicus cocois (Curt.)	*Coconut whitefly*	*Encarsiella noyesi (Hayat)*	Barbados
Aspidiotus destructor Sign.	*Coconut scale insect*	*Cryptognatha nodiceps (Mshl.)*	St. Kitts-Nevis, perhaps other islands
Diatraea saccharalis (F.)	*Sugar cane borer*	*Apanteles flavipes (Cam.)* *Lixophaga diatraeae (Tns.)* *Metagonistylum minese (Tns.) Paratheresia claripalpis (Wulp.)*	Barbados, Antigua, Barbados, Dominica, St. Kitts, Guyana, St. Lucia, Dominica
Icerya purchasi Mask.	*Cottony cushion scale*	*Rodolia cardinalis (Muls.)*	Antigua, Bahamas, Barbados, Cayman Is. Jamaica, Montserrat, Nevis, St. Kitts.
Plutella xylostella (L.)	*Diamond back moth*	*Apanteles plutellae (Kurd.)*	Barbados
Spodoptera frugiperda (J.E. Smith)	*Fall armyworm*	*Telenomus remus (Nixon)*	Barbados
Weeds			
Opuntia spp.	*Prickly pear cactus*	*Cactoblastis cactorum (Berg)*	Antigua, Cayman Is. Montserrat, St. Kitts Nevis,
Tribulus cistoides L.	*Jamaican feverplant*	*Microlarinus lypriformis (Woll.)*	St. Kitts

Source: Cock, M. (1985). A Review of Biological Control of Pests in the Commonwealth Caribbean and Bermuda up to 1982. Farnham Royal: Commonwealth Agricultural Bureaux (CAB International)

The Commonwealth Institute of Biological control now CAB International, present in Trinidad since 1947, has been active in promoting biological control in Latin America[57]. The research and development of bio-pesticides from natural enemies offers some opportunity for the region. In fact, the importance of developing and encouraging widespread use of bio-pesticides falls well within the options for soil saving and rehabilitation requirements discussed in Ahmad's paper. It therefore goes without saying that the option of biological control and integrated pest management "offers a major advantage since it is a natural process (environmentally-friendly) which harnesses the normal functioning" and interactions of organisms within an ecosystem.

57 See Greathead 1971; 1976 and Rao et al 1971 that reviews exports of beneficial organisms form the neotropics to Africa, Asia and Western Europe

For some species, effective control will require a combination of the measures noted above. For example, Control of varroa mite *(affecting bees)* can best be accomplished using several strategies, similar to integrated pest management techniques commonly used in much of agriculture. This is because chemical treatments alone (e.g. commercially available miticides) can pose a threat to humans through chemical contamination of honey and bees wax and hence needs to be carefully administered. Organic treatments often involve treatments with essential oils, sugar esters, and oxalic and formic acid sprays. In contrast, control of red palm mite is currently through use of pesticides.

However, given concerns over the adverse health impacts of agrochemicals, the US Institute of Food and Agricultural Sciences (IFAS), is currently undertaking research for long-term, biological control agents. Some of the possible biological control agents that have been useful in the Eastern Hemisphere include predatory mites (*Phytoseiidae*), predatory beetles (*Chrysomelidae*), lacewings (*Chrysopidae*) and other mite predators.

All control methods, with the exception of classical biological control, which is self-sustaining, need long-term funding and commitment. If the funding ceases, the population and the corresponding negative impacts will normally increase, perhaps leading to irreversible damage.

Since in the short-term, control seems to be a cheaper option than eradication, it is often the preferred method. Funding and commitment do not need to be at such high levels as for eradication programmes, and funding can be varied between the years depending on the perceived importance of the problem, political pressure and public awareness. However, the lower recurring costs are deceptive, since in the long run effective control is more expensive in total than a successful eradication campaign.

4.3.4 Mitigation:

If eradication, containment and control are not options or have failed in managing an invasive alien species, the last resort is to “live with” this species in the best achievable way and mitigate impacts on biodiversity and endangered indigenous, and in some cases, even introduced commercialised alien species. Mitigation as used in this context differs from containment and control in that the activity undertaken does not directly affect the invasive species in question but rather focuses on affected native species.

Mitigation is most commonly used in the conservation of endangered species and can be approached at various levels. At its simplest and perhaps most extreme form it could mean the translocation of a viable population of the endangered species to an ecosystem where the invasive species of concern does not occur or, in the case of a rehabilitated system, no longer occurs.

Indeed the experience of the Carambola Fruit Fly (Bactrocera carambolae) (or CFF) eradication programme in Guyana and Suriname illustrates the adverse consequences of delayed action after early detection of an invasive. The CFF is a destructive fruit fly species, endemic to Southeast Asia. It also illustrates the importance of cooperation among countries and with the international community and importantly, the need for continuous funding to maintain the effectiveness of an IAS management based on containing and controlling spread of an invasive (Note #10). Among the operational recommendations proposed by the CFF programme managers in 2004, include the need to continue to monitor the CFF population, with the objective to increase the knowledge about the ecology of this species in the South American continent, where it will probably spread beyond its present range and to continue critical actions, since the longer it takes to restart the programme, the more expensive it will be on resources and time.

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Note #10: Controlling an Invasive is a Continuous Process

the CFF is introduced and establishes

- In 1975 flies, not yet identified as CFF, first detected and collected in Suriname, most likely introduced in fruit transported by travellers from Indonesia by air. Six years after detection, in 1981, the flies were confirmed to be CFF. In 1986, five years later, the international community deemed the presence of oriental fruit fly in Suriname to be an important threat to the production and marketing of fruit throughout tropical and subtropical America and the Caribbean.

the CFF spreads and invades

- In 1989, the CFF is detected in French Guiana, and detected in Guyana in 1993, then in 1996, in March, in the city of Oiapoque, Brazil. Lack of funding and coordination among the international community allowed the fly to expand its geographic distribution, out from Paramaribo to the west reaching the border of Republic of Guyana and to the east and south into French Guiana and the State Amapá, Brazil. Many countries in the region were at risk to lose large amounts of money if CFF were permanently established. A 1995 USDA/APHIS study estimated such losses at from 2.5% for cashew, breadfruit and Suriname cherry to 50% for carambola.

Importance of International Cooperation

- In 1998, International institutional initiated efforts to eradicate CFF kick-started by an IICA-organised meeting to analyze the status of the CFF infestation in Suriname. Efforts continued with additional contributions from FAO and from the USDA-APHIS, which financed a large pilot control program in western Suriname and eastern Guyana. The success of this latter project led to the launching of a regional program. Between 1999 and 2001 the regional CFF program was implemented with a goal of eradication from areas in the border with Guyana and in the south of the country.

The fact that the two countries shared common borders made a regional or at least a simultaneous program essential to eradicate the CFF. The fact also the French Department de la Guiane and Brazil are neighbour countries indicate the program should be a sub- regional program including the four countries.

Results from Action

In May, 1998, Guyana was declared fruit-fly free, A sharp population reduction or eradication was achieved in areas where the program was working. Over 80% of Suriname was CFF-free or with population near zero. In 2001, the population of CFF in Suriname as well as in the Oyapock area (border Brazil-French Guiana) was lower than the previous year.

Impacts of "No Action"

From June 2004 on, no control has been applied to hamper the spread of the CFF in Suriname. As a consequence, the fly has been spreading to previously eradicated regions. The only area that has not been re-infected yet is the Western part of Coronie and the Nickerie District in Suriname. The CFF has reappeared in Guyana.

Lessons Learnt

An eradication program needs a continuous flow of funds and well-established technical, human and facility infrastructure in order to reach the final goal – ultimately eradication, or at best, control. Financial constraints that disrupt control activities will lead to resurgence in the IAS and spread beyond previously managed areas.

Source: Final Report Program for Eradication of the Carambola Fruit Fly *(Bactrocera carambolae)*in South America, Operation Period 1999–2004, IICA Office In Suriname (2004)

5. Conclusions and Options Forward

5.1 Conclusions

The region is a rich source of biodiversity

Many of the organisms or species found in the WCR are not found anywhere else in the world. The terrestrial and aquatic (freshwater) ecosystems of the Caribbean also boast exceptionally high levels of species endemism. These may be the most abundant resource and second to human capital in terms of potential to chart a path for sustainable development in the Caribbean. Biodiversity on the region's small Island states is fragile and particularly vulnerable to their relatively low buffer capacity to severe environmental fluctuations and events. The fact that species become concentrated in small and fragmented areas and that some endangered species have below critical mass breeding populations, which are further restricted by habitat fragmentation, further exacerbates their vulnerability.

IAS represent a very specific type of disruptive organism that negatively affects native biodiversity

IAS are second to habitat destruction as the cause of species extinction. They cause enormous damage to biodiversity and their capacity to provide uninterrupted valuable ecosystem services. IAS are being introduced at an increasing rate. The key pathways, the 4-Ts - Trade, Transport, Travel and Tourism – are directly related to their spread, either deliberate or accidental. Because the Caribbean is a region of 'large unprotected borders', once an IAS is introduced into one Caribbean Island it is likely to become invasive in the rest of the region. Further, once an invasive species arrives, it's about impossible to get rid of it!

Changing climate will create suitable conditions for the further spread of IAS

Changes in weather patterns and increasing temperatures may also enable species to expand their current range as is the case of disease-carrying mosquitoes. As wind and storm patterns become more violent, the range of dispersal/spread of such invasive species may increase. Increased carbon dioxide enrichment in aquatic ecosystems will affect all organisms and could also contribute to the invasiveness of certain terrestrial and aquatic species. It appears that successful IAS introductions into the Caribbean come from an area of similar ecological conditions and one with which the region has significant trade ties.

Agriculture shares a common origin with IAS -biodiversity- making the sector vulnerable

Aggressive alien species can destroy forests and hence their water provisioning functions and can affect soil fertility thus reducing productivity and scope and increasing cost of food crop production. IAS are not a new phenomena in the Caribbean. The reality is that several commercial crops and livestock in the Caribbean were originally alien species introduced intentionally to be exploited for their value as food, fibre, lumber and other purposes.

Some of these commercial species - including goats, pigs, cows and certain pasture species - can escape cultivation and have disastrous impacts on our natural environment. Fortunately most of these are not invasive, i.e., if left unattended they will not pose a threat to biodiversity. A good example is the sugar cane plantations which when abandoned tend to revert to natural-type vegetation. Pests and diseases that affect agriculture and human health are seldom indigenous to an area. Over time, a number of these 'exotic' pests and diseases have affected food crops and livestock. Their adverse impacts have been felt in environmental, economic and social costs, which generally, have not been well quantified.

The threat of IAS is therefore very real, with the potential for multi-sector impacts
In 2008, Lauretta Burke et al. concluded that the coral reef-associated tourism contributed significantly to economies of Tobago and Saint Lucia. The authors' valuation of the 'pull factor' of coral reefs' share in tourist arrivals was an estimated 40% for Tobago and 25% for Saint Lucia. Direct economic input was estimated at US$43.5 million for Tobago and US$97.6 million for Saint Lucia. However in addition to the adverse impacts of deforestation, as was clearly illustrated by John in the case of Praslin Bay in Saint Lucia (forest paper), IAS damage could exacerbate an already vulnerable situation and could incur high environmental, economic, financial and social costs to the Caribbean, especially to the island economies.

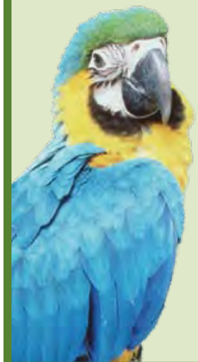
Caribbean countries are becoming more 'alert' to the threat of new species, particularly the more invasive types. With a global focus on food and nutrition security amidst serious concerns about impacts of climate change on water resources and food production, it is important to be aware of, and understand how IAS impact on lives, livelihoods, biodiversity and the environment. Such understanding can go a long way in determining feasible options for preventing IAS introduction and controlling their populations once they have 'arrived'.

Projections of an increase occurrence and frequency of IAS in the future
In both the short and long term the prognosis for IAS in the Caribbean is for an increasing number of introduced new species into the region and for increasing spread of IAS that are present in some islands to spread to islands that are presently free. The spread of fruit flies into almost all islands of the OECS that were free of these pests up to a decade ago is indicative of this trend. The recent spread of the Giant African Snail from the French islands to the OECS, Barbados and Trinidad and similar occurrence with the Red Palm Mite is all indicative of this trend. The reason for this is greater movement of people, goods and transport of sea and air craft. The increased incidence would also be aided by natural phenomena such as global warming and climate change that are causing more frequent hurricanes and other severe weather.

The abandonment of agricultural lands that previously cultivated crops such as sugar cane and bananas and whose cultivation would have kept many invasive plants in check would now lead to those plants becoming invasive spreading to adjacent lands. Resulting in additional costs in bringing those lands into production in the future. Also, a clear link has been established between urbanisation and the introduction of new IAS. Urbanisation and the conversion of agricultural lands for use in real estate such as housing and hotels and other industrial uses would thus exacerbate the IAS problem.

Prevention is the best approach to the control and management of IAS

Risk assessment to identify the potential IAS that may enter the country/region and prioritise preventative action must be a first critical step. Managing the IAS threat and/or IAS invasions must be informed by an initial assessment to define the management goal, the target area and the management priorities, that should include the invasive target species affecting the area and the native species threatened. Species known to be invasive elsewhere must be considered high priority 'black list' species. GISP also advises using pathway-based exclusion methods to avoid wasting of resources associated with the individual species approach. Public education is also a key component of successful prevention and management methods. However, continuous and long term attention to the IAS threat will require a structured management programme built on four main and inter-connected strategies, Eradication, Containment, Control and Mitigation, as also recommended by the GISP programme. This will be particularly important in situations when an IAS has already been introduced and hence reducing its adverse impacts becomes the emphasis.



SOS - Save Our Species

"Tens if not hundreds of West Indian animals have already been lost because humans have unwisely released harmful species from other parts of the world. To do nothing is not an option."

Jenny Daltry, Senior Conservation Biologist with Fauna & Flora International.
in 'Meet the world's rarest snake: only 18 left' by Jeremy Hance, mongabay.com, July 10, 2012. http://news.mongabay.com/2012/0710-hance-stlucia-racer.html#




5.2 Options forward

In any discussion of options forward, it should be clearly understood that the endgame, the ultimate goal of managing the IAS threat and invasions should be the conservation or restoration of intact ecosystems that support the delivery of ecosystem services, including water supply and food production. Managing the invasive alien species itself, becomes one pivotal element of that goal.

The control measures defined above for managing established IAS are only one tool in the ultimate goal to maintain, conserve and/or restore biodiversity and mitigate problems caused by invasive organisms. Hence habitat restoration, preservation of an undisturbed ecosystem, re-installation of the natural succession rate and time can be considered critical management goals. These intact areas can provide sustainable use of ecosystem services, including and particularly for food production.

In developing a management strategy, priority setting should also be considered principally from the viewpoint of ecosystem and species values. While the priority-setting process can be difficult, partly because many factors need to be considered, priorities can be identified according to four categories, through which the worst IAS can be filtered and 'screened-out':

i. current and potential extent of the species on or near the site;
ii. current and potential impacts of the species;
iii. value of the habitats/areas that the species infests or may infest; and
iv. difficulty of control.

Further, as noted previously, the lack of data, documentation and research on biodiversity, indigenous species and IAS in the Caribbean could complicate and frustrate such priority setting processes. In such a situation, the next best option for management of invasives is that of adopting/adapting best practices available in other parts of the world. Thus, it is important to accumulate the available information, assess all potential methods, and use the best method or combination of methods to achieve the target level of control.

The experiences of the H1N1 in Asia and even the PHMB in Grenada and Trinidad and Tobago are instructive in this regard. As illustrated by these experiences as well as others, in most cases the best practice to manage an invasive alien species may involve a system of integrated management tailored for the species and the location. This should avoid wasting resources associated with the individual species approach to IAS management. As well, there is always the situation where political and public support and the availability of external financing may drive a pest-specific management project that might be of lesser priority.

Given the IAS threat, the policy and regulatory environment for IAS management requires an urgent and focused shift. This shift should not only be in the direction of agriculture, but as well directed at other sectors including tourism, public health and the pet/landscaping service. In this way, addressing the IAS issue becomes one of public policy, interest and engagement. In some ways it is similar to the public engagement on HIV/AIDS and the control of littering in that there is no fail-safe monitoring or enforcement system, but rather must rely on the individual responsibility and diligence of the public and by facilitating their compliance.

In this regard, there will be:

(1) need for *integrated cross-sectoral polices and strategies, under a general environmental and natural resource management umbrella that provides the holistic and coordinated framework for actions in agriculture, as well as all other sectors that are directly linked to the IAS threat*

Developing this holistic and cohesive policy framework should be guided by the call for a common and ultimate goal of maintaining, conserving and/or restoring biodiversity and mitigating problems caused by invasive organisms – i.e., the preservation of biodiversity. As an initial measure, access to sensitive natural areas should be restricted – especially with respect to the breeding grounds of endemic species. Limited access reduces the likelihood of introducing IAS that could disturb specific niches in the ecosystem where endemic species thrive. Effective policy formulation must be supported by the development of a list of pathogens of economic importance – periodically updated - for which plant material should be tested on a regular basis. Policies need to be better implemented and for this to happen, a strong and harmonised regional legal framework is an essential requirement.

(2) ***need for*** *updated and harmonised legislative, regulatory and enforcement framework in the region to safeguard IAS introductions and spread, particularly given the trans-boundary movement of species*

All countries possess plant and animal health and quarantine legislation which encompass the management of invasive species and other biotic threats. These include the requirement of phytosanitary certificates for all imports of propagative materials, indicating species and variety of the imported plants and certifying freedom from pests based on clearly specified inspection protocols. Other legislation related to apiculture, coastal and marine environments, forest, protected areas and wildlife, relate to invasive species in so far as they define the territories of the respected countries and regulate activities which may result in the introduction or export, internal spread and management of invasive species. (Note #11).

Piecemeal updating of legislation by certain countries is inadequate. There is need for a harmonised regional legal framework for the control of invasive species in the Caribbean region which can complement and co-exist with the existing plant and animal legislation. The enactment and implementation of harmonised legislation based on international standards and conventions will enable Caribbean countries to meet the requirements of international conventions such as the World Trade Organisation (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), Convention on Biological Diversity and the International Maritime Convention and empower national authorities to put the necessary precautions in place to limit the introduction of invasive species.

Invasive species issues spans both environmental and agricultural policy and legislation. Prior to the 1980s, environmental legislation in the Caribbean was largely inadequate and dispersed over several enactments. Responsibility for administration of applicable legislation was likewise distributed across several governmental departments and unsupported by appropriate institutional arrangements to coordinate and direct relevant initiatives. With the advent of the United Nations Conference on Environment and Development in Rio de Janeiro 1992 and the United Nations Global Conference on the Sustainable Development of Small Island States in Barbados 1994, Caribbean Governments instituted improvements in their environmental legislative frameworks. Some countries passed legislation in an attempt to coalesce environmental management functions into single institutions and developed regulatory procedures for integrated environmental management. Further, a legislative framework must be in place to give inspection and surveillance authorities and their staff the legal right to seize and destroy any material that could potentially introduce invasive species into an area.

Environmental crime is growing into a very lucrative industry. International cooperation and shared responsibility, enabled by various Multilateral Environmental Agreements (MEAs), are the only effective approach. Customs officers have the primary responsibility for controlling trade across borders. The Green Customs Initiative (GCI) aims to prevent the illegal environmental trade by enhancing the capacities of customs officers to understand and enforce multilateral environmental agreements through effective monitoring, detection and seizure of illegal shipments. GCI was created by UNEP, the World Customs Organization (WCO) and various MEA Secretariats.

Source: IAS magazine, CABI

Visit: http://www.greencustoms.org/index.htm

Note #11

Status of Laws for IAS Management - selected Caribbean countries

Several countries have had species-specific invasive species legislation which indicates that impacts of the introduction of non-indigenous species were historically recognised. These include:

- The Control of Live Fish Act: exists in Saint Lucia and Trinidad
- The Mongoose Act: exists in Trinidad and Tobago

However, such laws are very limited and provide an incomplete/limited perspective of the broader IAS problem. Some countries have attempted to develop more strategies and laws that offer wider coverage of IAS issues, including:

- National Invasive Species Strategy (NISS): only exists in the Bahamas, complemented by legislation related to invasive species embodied in other sectoral laws which define official powers, regulations and penalties.
- National legislation: Jamaica incorporated national legislation which reflects their commitment to upholding international commitments, such as the CBD and CITES.

Generally, environmental legislation in Caribbean countries remains weak due to the non-incorporation of international conventions and standards into national law. In contrasts, given the importance of farming, agricultural legislation has generally been more developed than environmental legislation. However, agricultural legislation still remains outdated and not reflective of either modern sanitary and phytosanitary concepts or agreed-upon international norms. For example, existing plant and animal legislation does not provide the necessary instruments to prevent the introduction, spread, and management of invasive species, as well as other pests.

Source: See ciasnet.org

(3) ***need for*** *building capacity for IAS management, particularly strengthening preventive measures at key pathways, early detection and surveillance.*

High levels of surveillance, particularly at ports of entry, are an essential and irreplaceable element to complement effective control measures in contemporary agriculture and thus prevent introductions and spread of IAS. The alternative to effective surveillance and control is expensive pre-treatments that then render the exports uncompetitive.

The range of IAS from microbial, viruses, insects, plants and animals that are specific to terrestrial, freshwater and marine ecosystems requires continuous updating of skills of those involved in surveillance activities. This calls for a higher level of training among all stakeholders from producers, manufacturers and regulators, to properly equip them for conducting effective surveillance. In almost all Caribbean countries, the human resources dedicated to surveillance activities for IAS is limited to a few plant quarantine officers, few public health and veterinary officers. In particular, there is need to increase the presence and visibility of agricultural inspectors at marinas and to publicise interceptions to deter potential violators. For agriculture specifically, once an invasive species or pest or disease is introduced to an agricultural system it invariably increases the cost of production of the affected commodity. However, the costs of controlling IAS tend to far outweigh the costs of monitoring and prevention, which underscores the importance of systems for continuous IAS surveillance. Consequently, IAS surveillance and control become an additional but essential cost factor if farm operations are to remain efficient and outputs marketable and competitive.

Research and information systems must be in place to allow for effective warning systems that ensure that front line surveillance and monitoring staff have the right training, tools and support services to intercept and destroy potential invaders before they become a problem.

A surveillance strategy that includes pre-border and border inspection and interception is essential to verify authorised introductions, detect illegal introductions, and detect unintentional introductions through key commodities, pathways, and vectors. At the same time, many countries currently have and are increasingly looking toward pre-border activities that aim to intercept invasive alien species at their source or point of origin.

(4) ***need for*** *Information, knowledge and Best Management Practices on IAS for both decision making and for high impact and continuous public sensitisation and education.*

This is particularly important and directly related to effective capacity for inspection, surveillance, identification and research on IAS in the Caribbean. At the international and regional levels there are many organisations dealing with IAS including hosting databases and websites for information, public awareness and regional and international collaboration to managing IAS. These resources are not used in taking initiative to protect Caribbean borders or even in raising general awareness on species that should not be brought in. Conversely, little information is submitted to these mechanisms as a result of the limited work being done at the country level. Also, work on IAS within the Caribbean has also been largely focused on pest and diseases of major crops and livestock. This agriculture bias is a self defeating approach to tackling the devastating impact of IAS. Most IAS that affects agriculture also have an impact in the environment or it survives in the natural environment in low numbers when there are none and then invade the fields.

Despite the efforts of organisations such as IICA, FAO, CABI, Caribbean Plant Health Directors Forum and CISWIG, among others to document and disseminate information on IAS the reality is there is still insufficient information to inform management options for the control of IAS in general. Exceptions are the ones such as Pink Hibiscus Mealy Bug that received substantial funding for research work to be done.
Information on all aspects of the problem must be widely disseminated to all stakeholders. This could only be achieved through effective coordination at the national, regional and international levels. In particular, public awareness programs may help to keep travellers from unknowingly introducing exotic

species. Most IAS are unknowingly moved and often the culprits are all of us who take up a flower or part of a plant for our home gardens. A Caribbean-wide educational campaign on the potential ecological and economic consequences of exotic species introduction should also be taken. Therein, this segment of the population which has been largely left out of the agriculture discussion on IAS may be more adequately covered, and so sensitisation against careless introduction of invasives, as well as more broad-based interventions in reporting sightings of IAS to facilitate early detection. In the case of intentional introduction of IAS such as in smuggling, larger fines may help; but must be supported by more regular surveillance.

Education and awareness campaigns should also caution visitors to natural and agricultural areas about prevention of IAS by highlighting simple steps that can be taken such as through sanitation practices (e.g., washing of shoes, checking clothes for seeds, etc.) at natural and agricultural sites visited. In that way, tourists can aid in preventing or limiting the extent to which IAS spread. This could be further supported by mandatory sanitation practices by cruise ship passengers when getting on and off cruise ships as this segment of the tourist trade represents the most island-hoppers. Selling educational products (e.g. postcards, calendars, souvenirs, etc.) could assist in raising funds to finance these interventions.

Lastly, test results and experience with controlling IAS should be more widely shared within the WCR. The lack of information on the status of IAS in neighbouring countries, as well as records by agricultural and customs officials of identified IAS is a major deficiency in national IAS management systems. This remains a major factor in the movement of IAS within the Caribbean, and so should be factored in as a priority for regional cooperation.

(5) ***need for*** *continuous financing to combat the spread and mitigate the impacts of IAS*

Sustaining resources remains one of the most pressing challenges for the effective monitoring and enforcement necessary to address the vulnerability of the Region to IAS. However bio-prospecting offers an option for developing sustainable livelihoods around study and preservation of native biodiversity. Particular care should be given to the scope of legible companies (e.g. developing local firms or hiring skills of foreign companies) and the terms of access and use should be well regulated based on knowledge of the life-cycle behaviour of the prospective species. In addition, implementing a suitable user fee system for eco-tourist sites could be an option for raising funds for IAS prevention and management. Such options demonstrate the ability to develop sustainable programmes that do not make interventions seem a further strain on the national budget.

Most countries in the region are parties to several international treaties that call for action on IAS. However their commitment under these agreements has not translated to the level of funding to resolutely address the problem. The absence of studies that concretely quantifies the impact of IAS in the region also makes it difficult to prioritise this problem to attract the required level of funding from national authorities. While international funding is available often it does not cover basic but essential cost such as personnel to conduct routine surveillance. Currently many national public services in the Caribbean have a freeze on the creation of new jobs in the public service making it difficult to address this emerging problem in a sustainable way.

(6) ***need*** *for adopting a regional approach to combating the IAS problem given the moderate to high risk of IAS introduction from the various pathways and the vulnerability that derives from the large unprotected borders of the Caribbean*

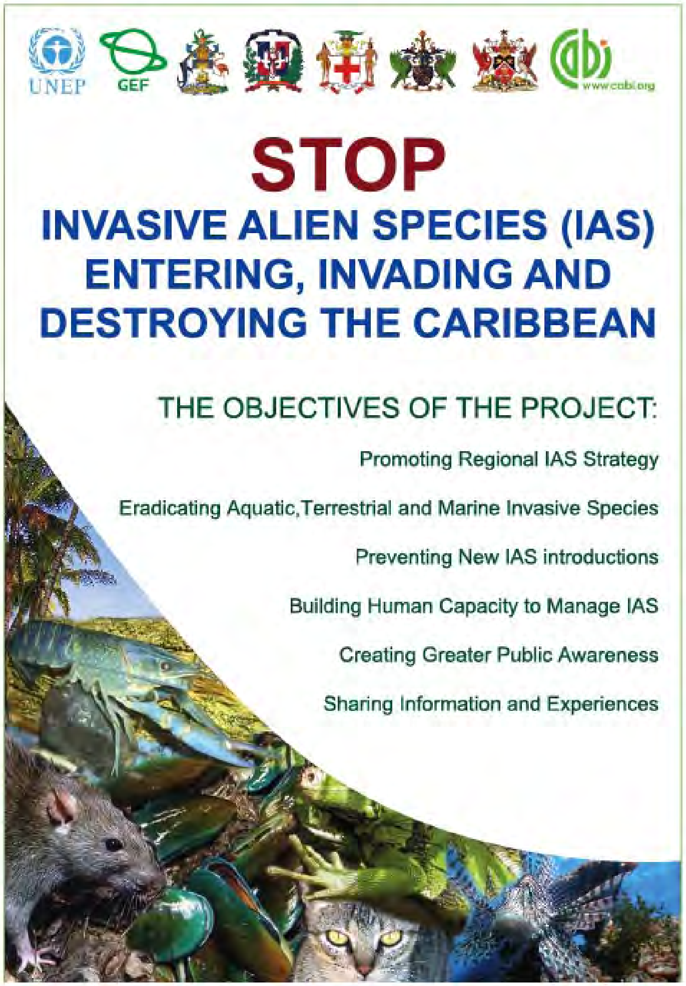
At the Caribbean regional level and internationally an acceptable level of coordination exists for combating this problem. However it is weaknesses at the national level that limits the effectiveness of the existing regional coordination mechanisms. There is a wide range of agencies at the national level that need to work together who have not traditionally worked together. These include health, trade, tourism, education, environment and the information and communication sectors. This cross sectoral communication and networking is largely lacking both at the regional and national levels in the Caribbean.

Several regional and international initiatives and treaties exist for the prevention the introduction of IAS into the Caribbean. At the CARICOM level there is The Caribbean Animal Health Network (CaribVET) which is a collaboration network involving veterinary services, laboratories, research institutes, and regional/international organizations to improve animal and veterinary public health in all the countries and/or territories of the Caribbean.

The global objective of the regional network is to improve the regional sanitary situation and to contribute to the harmonisation and reinforcement of animal disease surveillance and control activities in the Caribbean to prevent the entry of new animal diseases into the region and to contain the spread of contagious diseases from infected islands to clean areas in the region. The Chief Plant Health Directors Forum has a similar mandate with respect to crop pest and diseases. The Inter American Institute for Cooperation on Agriculture (IICA), the Food and Agriculture Organisation (FAO); CARICOM Secretariat; the Caribbean Invasive Species Working Group are other regional organisations with programmes for strengthening the capacity of the Caribbean region to combat the threats posed by invasive species to the agriculture sector.

The project: “Mitigating the Threat of Invasive Species in the Insular Caribbean” being managed by CAB International has developed a draft regional strategy for managing IAS and is executing 12 pilot projects in the Bahamas; Dominican Republic; Jamaica; Saint Lucia and Trinidad and Tobago related to the prevention, control and eradication of some key invasive species in the region.

Caribbean states have recognised the need for a regional strategy and expressed strong interest in linking up their national efforts in implementing Article 8 (h) of the Convention on Biological Diversity (CBD) to mitigate the threats of IAS in the Caribbean. Countries in the Caribbean are also contracting parties to the *Convention on the Protection and Development of the Marine Environment of the Wider Caribbean* of 1983 and its *Protocols on Specially Protected Areas and Wildlife* (SPAW Protocol of 1990) and *Pollution from Land-Based Sources and Activities* (LBS Protocol) of 1999. Article 12 of the SPAW Protocol refers specifically to the control of alien species. Responding to this need, CABI, in collaboration with a wide range of partners, developed and is implementing aproject on *"Mitigating the Threats of Invasive Alien Species in the Insular Caribbean"* funded by the Global Environment Facility (GEF) through the United Nations Environment Programme (UNEP).



A Call to Action

management
prevention
strategy

detection
rehabilitation
coordination
information
restoration

The Caribbean Invasive Alien Species Strategy (CIASS) 2011-2015

is a framework for Invasive Alien Species management in the Caribbean Region. The CIASS will help to create an enabling environment for effective IAS management in the Caribbean by placing priority on five critical elements and pursuing seven key objectives.

Prioritising 5 equally essential elements:

1. **Prevention** of potentially harmful intentional and unintentional introductions;
2. **Identification** of new invaders and rapid response procedures to eliminate or contain them on detection;
3. **Management** of established and spreading invaders through, containment and/or control;
4. **Rehabilitation** and restoration of species, habitats/ecosystems
5. Strengthen **Knowledge Management Systems** to make effective use of information generated or acquired to combat IAS.

Pursuing 7 Critical Objectives

1. Establish a Regional Coordinating Mechanism by building on existing processes with national and regional support;
2. Establish mechanisms to reduce IAS spread in the region through identified pathways;
3. Strengthen national and regional institutional frameworks to allow effective IAS management;
4. Strengthen mechanisms for exchange among national, regional, inter-national stakeholders;
5. Facilitate evidence-based IAS management through research and monitoring;
6. Design and use methods such as raising public awareness on IAS to prevent or control harmful intentional/un-intentional introductions and mitigate regional spread of IAS;
7. Develop a regional CIASS fund to secure adequate financing to implement activities.

The CIASS calls for a better understanding IAS challenges in order to define strategic actions that address them directly, including adopting an eco-system approach to IAS management to protect bio-diversity, trade and livelihoods. The CIASS also calls for Governments to commit to preventing the introduction, control or eradication of those alien species including living modified organisms, which threaten ecosystems, habitats or species and with support from relevant agencies, '*to take the necessary measures to protect, preserve and manage in a sustainable manner, threatened ecosystems, habitats and species!*"

The theme of this CIPO – Farming Change – was chosen to provoke thought from two perspectives: i.e., whether farming in the Caribbean has changed over time, and especially now, in response to food and nutrition security imperatives; and whether agriculture and the farm sector in particular, are poised to take advantage of the dynamics of the changing natural environment in a manner that provides sustainable environmental, social and economic benefits for the economies, societies, and communities in the Caribbean.

This CIPO focuses largely on the second perspective, i.e., the changing situations in the agriculture natural resource base and the implications for sustainable farming and food production. The separate yet inter-related discussions on soils, forests and biodiversity, converge towards a critical conclusion – that while they are all essential to sustainable food production, these natural resources are under threat from human activity. For the resource-scarce and vulnerable Caribbean, saving soils, forests and species and promoting efficient and sustainable use of these resources can offer tremendous scope for future development and resilience in an era of climate change and economic volatility.

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