JAMAICA:

COUNTRY REPORT TO THE FAO INTERNATIONAL TECHNICAL CONFERENCE ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

(2008)

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Table 1 Names of institutions involved with Plant Genetic Resources of Jamaica

ABIS	Agricultural Business Information System
BTC	The Biotechnology Centre, UWI
CARDI	Caribbean Agricultural Research and Development Institute
CPGA	Christiana Potato Grower's Association
CASE	College of Agriculture and Science Education
FA	Faculty of Agriculture, UWI
FAO	Food and Agricultural Organization
FCF	Forest Conservation Fund
FD	Forestry Department (statutory body)
IICA	Inter-American Institute for Co-operation in Agriculture
IOJ	Institute of Jamaica
JAS	Jamaica Agricultural Society
JBI	Jamaica Bauxite Company
LFMC	Local Forest Management Committee (affiliated with the FD)
LSD	Life Science Department, UWI
MOA	Ministry of Agriculture (many departments including R&D)
NCU	Northern Caribbean University
NEPA	National Environmental Protection Agency
NPI	Natural Products Institute, UWI
OAS	Organization of American States
RADA	Rural Agricultural Development Agency
R&D	Research and Development, MOA
SIRI	Sugar Industry Research Industry
SRC	Scientific Research Institute
USAID	United States Agency for International Development
UTECH	University of Technology
UWI	University of the West Indies

SECTION I: EXECUTIVE SUMMARY

Major Plant Genetic Resources for Food and Agriculture (PGRFA)

The major PGRFA are also the major export crops. These include sugar, banana, coffee, cocoa, citrus, coconut and pimento.

Minor and underutilized PGRFA

Minor PGRFA include native plants used mainly to supply the domestic market (cassava, sweet potato, corn, dasheen, coco, beans, pumpkin, squashes, peanut, arrowroot, hot pepper, tobacco, pineapple, guava, palm nuts, coconut, mamey apple, custard apple, sweetsop, mountain soursop, pond apple, star apple, Barbados cherry, beef apple, macca fat, naseberry, Jamaican walnut, hemp, and pimento. Non-food biodiversity includes timber plants, orchids, bromeliads, flowers, cotton, calabash, annatto, fibre plants and many medicinal plants such as ramoon, sarsaparilla and chainy root). Imported PGRFA also make up part of the domestic market: ginger, yam, ackee, otaheite apple, breadfruit, jackfruit, mangosteen, mangoes, lychee, carambola, avocado pear, longan, naseberry, june Plum, bilimbi, cinnamon, nutmeg, pomegranate, tropical almond, turmeric, cocona and a range of ornamentals. Both native and imported minor PGRFA make up the non-traditional export market (eg yam, sweet potato, dasheen, ackee, hot pepper, papaya, pineapple, ginger, turmeric, pimento, mangoes, pumpkin, vegetables, pulses and fruits). These are exported as fresh produce and value-added products.

New PGRFA developed in the last ten years (1996-2006)

New PGRFA developed over the last ten years include varieties of scotch bonnet pepper, sorrel, tomato, pumpkin, coconut, callaloo and citrus varieties such as ortanique. Seed supply systems are a mixture of imported seeds (majority), a few locally produced seeds while the rest of plants are vegetatively propagated.

Significant threats to the development, conservation and sustainable use of PGRFA

Some of the threats are weaknesses of the science and technology (S&T) and agricultural sector and some are specific to the PGRFA. Funds allocated for the S&T is 0.2 per cent of the national budget. While there are training opportunities at the tertiary level, specific training for agriculture and PGRFA in particular is disconnected to needs. There is no dedicated agricultural fund for research and development or any dedicated agricultural journal. Regionally, hurricanes are a threat to the conservation of rare PGRFA. Harvesting trees for timber, charcoal and yam sticks, and mining are the major threats to wild PGRFA.

Opportunities for the development, conservation and sustainable use of PGRFA

There is an increasing awareness of the importance of PGRFA in the country over the last ten years. The MOA has led this charge admirably. Also, there has been an increase in R&D groups at local Universities and other institutions that have helped in the development, conservation and sustainable use of PGRFA in various areas such as training, biotechnology, natural product development, market and business development. Local Environmental and Forest Conservation funds have also increased in this period even while international funding opportunities have decreased. Many value-added food, nutraceutical and medicinal products and an increasing number of agro-processors have developed in this period using local PGRFA and this needs to be supported and encouraged. In this period, in vitro gene banks of some PGRFA biodiversity have been established, and molecular genetic techniques used for plant improvement but this needs to be expanded. Marine biodiversity should be considered as part of the PGRFA as the Caribbean has large expanses of unchartered coastal and sea ecosystems with unknown potential.

Short-term needs

- Increased registration of farmers
- Formation of a dedicated agricultural fund for research and development or any dedicated agricultural journal.
- More short-courses for PGRFA to be undertaken on a needs basis by academia for relevant officers (to be identified) for a national PGRFA system, specifically for….
- A dedicated agricultural fund for research and development needs to be set up in a similar manner to the EFJ and be linked to the formation of a dedicated agricultural journal
- The Agricultural Library needs to be upgraded and made into a repository of all PGRFA related material.
- Increased use of technologies in agriculture: ICT (web-based databases and marketing systems, increased use of GPS and GIS, recording of best practices and COP), molecular biology (DNA fingerprints, marker-assisted breeding), biotechnology (hydroponics, protected agriculture, micropropagation, new crop development, in vitro gene banks), pathology (identification of disease organisms, breeding for resistance), cultural practices (soil solarization, soil husbandry, wind-breaks, crop rotation), post-harvest technologies (storage, value-added food and natural product development) and regulations (IP, plant variety protection, instigation of a national naming system for new varieties) in the management of PGRFA.
- Increased production of elite planting material
- Increased and more reactive marketing systems
- Increased business activities in agro-processing and value-added product development
- Increased Research whose priorities should include: development of *in vitro* propagation for new crops and conservation methods for PGRFA and wild relatives; new product development for value-added nutraceuticals and natural products; ethnobotanical, yield, biochemical and socio-economic studies (including economic competitiveness and market feasibility studies).
- Sensitization of the public and policy makers to the strategic and economic importance of PGRFA is needed.
- A national forum for PGRFA is needed, an outcome of which needs to be a dedicated and coordinated work program among the national and international stakeholders. Such a forum should indicate which PGRFA are important for food security and these be given priority attention.
- There is a need for the National Disaster Response Mechanism to be better coordinated with the agricultural sector.
- Intellectual property rights to be established for PGRFA including plant variety protection

Mid-term needs

- A comprehensive and ongoing comprehensive inventory of PGRFA for the whole country in order to determine the local varieties present (taxonomy, pictures, GPS, herbarium samples, flowering and fruiting times, comprehensive documentation), flowering and fruiting times, yields, molecular and biochemical studies, and biodiversity valuation needs to be carried out.
- Studies into genetic erosion, effect of diseases, genetic vulnerability and invasive species also needs to be carried out.
- Increased local breeding and conservation activities.
- Regulations for IPR, plant variety protection, EIAs, Protected Area System, bioprospecting and even watershed management must be developed to take into consideration the issues that pertain to PGRFA as outlined in this document.
- Branding of bidiversity

Long-term needs

- Adequately document all the PGRFA available in Jamaica including underutilized crops, wild relatives of major and minor crops and potential PGRFA.
- The characterization, evaluation and number of core collections to facilitate use needs to be both short-term and long-term.
- Assess the degree of genetic erosion, understand the causes of erosion, the role and the values (social, economic, culture, ecological) of the state of diversity of plant genetic resources for food and agriculture in Jamaica.
- Develop national, regional and international systems that protect and sustainably use the PGRFA of Jamaica for our benefit (individually and for the community) and for the benefit of others.

SECTION II: AN INTRODUCTION TO THE COUNTRY AND AGRICULTURAL SECTOR

Introduction

Jamaica is the third largest island of the Caribbean with a land area of 10,981 km^2. It has a backbone of hills and mountains surrounded by flat coastal plains, with over 60 per cent of the island having an altitude of over 230 m above sea level. Jamaica's topography is rugged: only 384,000 ha have slopes below 10^o, 330,000 ha have moderately steep slopes and 290,000 ha have slopes greater than 30^o. The highest peaks are to the east with the Blue Mountain peak reaching a maximum height of 2,256 m. The central and western parts of the island are mainly limestone hills and karst topography. Forests cover 20% of the land area. The Cockpit Country has the most developed karst topography and is still relatively undisturbed.

Jamaica's population growth rate averaged just over 1 per cent between 1993 and 1998, and 0.5 per cent between 2001 and 2006. At the end of 2007, the resident population was 2,682,100 while for the same year total visitor arrival was ~3 million. Net migration from the island was estimated at 18,100 during 1996 and 17,100 in 2006. About 38 per cent of the population was less than 20 years old in 2006 and this has held steady for the last ten years; 53% of the population was between 15 and 49 years old. At the end of 1996, approximately 50 per cent of the population resided in urban areas rising to 52 per cent in 2006. There is increasing demand on agricultural land for housing while there is increasing demand for agricultural produce especially by the hotel sector.

The unemployment rate dropped from 21 to 14.5 per cent between 2001 and 2006 while the average weekly earnings were $ 9,614 for the same period. In 2006, those employed in agriculture was 18% (in 1996 was 23%), in industry was also 18% while the rest of the work force (64%) was in services.

Tourism contributed 20 per cent of Jamaica's GDP in 1996; foreign exchange earnings were US$965 million in 1996 and US$1,887 million in 2006. Within the Caribbean, Jamaica continues to rank second after the Dominican Republic in terms of the size of the tourist sector with over 21,984 rooms (1996) to 26,039 rooms (2006). Eco-tourism is one of the largest sectors of the tourism industry globally. In Jamaica there are pockets of such activity but its contribution to Jamaica's tourism product is difficult to assess and it has been under-marketed. Community tourism is also on the rise. However, the tourist industry makes many demands on the environment, such as pressure on beaches, use of resources for craft items, use of wetlands for waste disposal, removal of sea grass beds for swimming beaches and blocking of visual and public access to the coast.

Exports as percentage of GDP dropped between 2001 and 2006 from 16.7 to 15.8 while over the same time imports rose from 46.7 to 49.0 per cent. In 2006, export earnings from traditional and non-traditional exports were valued at US$46.5 million (81% more than previous year) and US$94.4 million (6.6% more than previous year) respectively. In 2006, sugar exports earned US$ 90.3 million with the majority of this (97%) going to the EU. Budget allocation to the main Science and Technology ministries and public agencies was $ 886 million in 2006 (0.2 per cent of national budget) while the main environmental fund (EFJ) disbursed $ 275 million in 2005. There is no dedicated agricultural fund for research and development or any dedicated agricultural journal.

State of food security and trends

Several of the foods eaten by Jamaicans are not grown locally; on top of the import list is wheat followed by corn and then rice (Table 1). 'Cereals and cereal preparations' accounted for 69% of food imports in 1990 and 74% for the period 1996-2001. Supplies of such commodities are stockpiled in case of

emergency. Over the period 1990 to 2001, 1995 saw the greatest percentage of domestic food production declining steadily every year after that while importation of food has increased (Figure 1). Per capita food consumption was also highest in 1995 (536 kg/person) dropping to 419 kg/person in 2001. Jamaica is reliant in many ways on wheat (bread) and rice, the main carbohydrate sources. In times of emergency, however, rice can be grown while the percentage use of other staples such as breadfruit, yams, coco, dasheen, irish potato, sweet potato and cassava can be increased. The speed at which these alternative carbohydrate sources can be produced for consumption will depend on the availability of adequate amounts of planting material. The increasing cost of imports and increasing rural poverty has encouraged government to institute measures to encourage agriculture on idle lands and urban areas with the aim of increasing food security and rural prosperity.

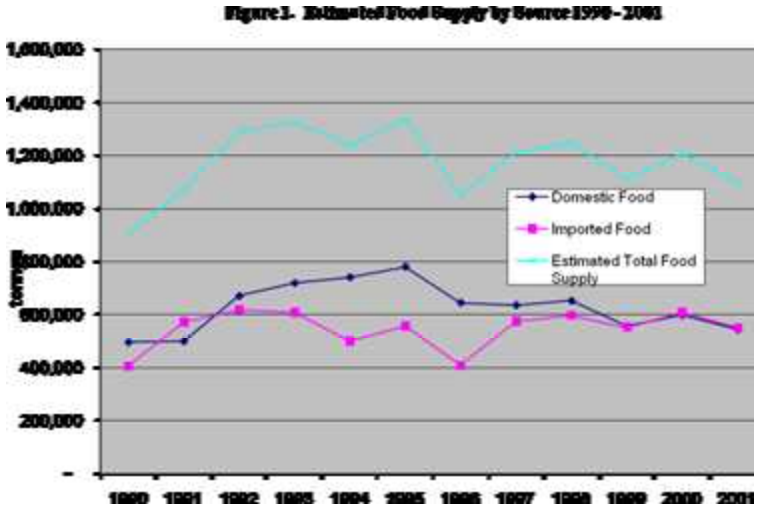
Table 1 Main Imports and Exports of agricultural products

	million US$ (1000 tonnes)		
	2002	2003	2004
IMPORTS			
Total Merchandise Trade	3,702	3,813	4,071
Agricultural Products, Total	496	432	438
Wheat	61 (336)	44 (243)	44 (336)
Maize	33 (252)	26 (212)	29 (225)
Rice, husked	14 (43)	20 (60)	20 (43)
Soybean, cake	15 (74)	22 (84)	16 (50)
Soybean, oil	20 (31)	15 (23)	14 (23)
Sugar, raw centrifugal	8 (25)	15 (43)	15 (51)
EXPORTS			
Total Merchandise Trade	1,309	1,367	1,586
Agricultural Products, Total	310	292	266
Sugar, raw centrifugal	75 (138)	67 (129)	85 (149)
Beverages, dist. alcoholic	55 (18)	68 (30)	50 (17)
Coffee, green	30 (2)	32 (3)	31 (2)
Beer of barley	11 (14)	15 (17)	17 (19)
Bananas	18 (40)	22 (42)	13 (29)
Yams	12 (7)	10 (8)	11 (8)
Fruit NES, prepared	10	6	5
Roots and tubers NES	4 (3)	3 (2)	3 (2)

The only times that the country has encountered serious food shortages is after devastating hurricanes. Hurricane Gilbert in 1988 storm left US$4 billion in damage, 40% of it to agriculture which was left in shambles. As a result of Hurricanes Charley and Ivan in 2004, 190,000 tonnes of sugar cane were lost and 100% of the banana crop causing $85 million in damage. It took three months before agricultural produce was again available. Hurricanes Emily and Dennis in 2005 exacerbated these damages while $ 3.7 million worth of damages was caused by Hurricane Dean in 2007. The banana industry always suffers the most from hurricanes. After Hurricane Dean the banana chip industry had no raw material to use for over six months and the factory had to diversify into making chips from breadfruit and cassava to survive. No banana was imported for fear of diseases.

Other than hurricanes, the island has not experienced food shortages, and if for any reason, the island was cut off from outside food supplies, local production would increase to prevent shortages. Regions with greater risk of food shortages would be those areas that are cut-off by disasters such as flooding or road damage due to hurricanes, and these shortages are quickly alleviated.

Figure 1 Estimated Food Supply by Source 1990-2001



Profile of the agricultural sector

Dualism is a feature of Jamaican agriculture with a highly organized traditional export sub-sector (crops such as sugar, banana, coffee, cocoa, citrus and pimento) coexisting alongside a currently fragmented and weak domestic agriculture. Non-traditional agricultural exports such as papaya, yams and ackee are increasingly being produced under fairly well organized conditions. The agricultural sector (crops and livestock) occupies 55 per cent of the country's land area. In 1997, 2,607 tonnes of agricultural pesticides and 44,234 tonnes of fertilizer were imported. Between 2001 and 2006, the percentage of agriculture to total GDP dropped from 6.7 to 5.9%. In 2006, the gross output from the Export Crop and Domestic Crop subsectors increased by 47.7 % and 15.7 % respectively compared to the previous year. In Export Crops, banana's output increased by 185.8 per cent (as a recovery from three hurricanes in previous two years). Within Domestic Crops, the largest increase was for plantains (145.6 per cent - as a recovery from Hurricane Ivan in 2004) followed by fruits (32.4 per cent).

An Agricultural Census was held in 1996[1] and 2007. Unfortunately, although data has been collected for the latter, it is not yet available. The figures given here, therefore, are for 1996 as compared to 1968. In 1996, there were 453,194 ha of agricultural land (25% less than in 1968) and 182,775 holdings of which 25% were women. Of the land in active agricultural crops (60% of total), 64% (174,505 ha) were in crops and the rest in pasture. Of the land in crops, ¾ was in pure stand crops and the rest as mixed crops. Of the inactive agricultural land, ¾ was in fallow and the other was abandoned. While 67% of the land was operated by individual holders (52% of these were holdings < 5 ha), 27% were operated by private companies (90% of these were > 200 ha).

The parishes with the most agricultural land are Clarendon (14% of area in parish), St. Elizabeth (12%), St. Ann (11%) and St. Catherine (11%). Export areas are Clarendon (73% of agricultural production in parish), St. Catherine (63%) and St. Mary (61%) while the areas producing mainly for the domestic market are Manchester (63%) and Portland (52%); 52% of earnings overall come from domestic crops and ~26% from export crops. Export earnings from traditional crops (banana, citrus, coffee, cocoa, pimento) decreased from US$ 57 million in 2001 to US$ 46 million in 2006.

[1] http://www.fao.org/es/ESS/census/wcares/Jamaica_1996F.pdf

The cultivation of sugarcane and later bananas, coconut, coffee and citrus on the lowlands required clearing the primary forests while coffee cultivation has caused substantial deforestation of the upland areas mainly as a result of felling and clearing of forest vegetation in preparation for planting of coffee. There are also other crops, such as yam, that are grown on slopes that are too steep. The felling of small trees for yam sticks is a major problem in some areas. This usage has been estimated at between 41 and 63 million yam sticks each year in Jamaica with an annual replacement rate of 63% or ~40 million new yam sticks being cut from forested areas each year.

Seed supply systems are a mixture of imported seeds (majority), a few locally produced seeds (scotch bonnet pepper, sorrel, callaloo, coconut) and those obtained from existing plants (eg cocoa). The rest of plants are vegetatively propagated (eg banana, yam, ginger and turmeric). The Agricultural Development Strategy focuses on expanding the domestic agricultural sector, increasing fruit crop production and increasing competitiveness of export crops. This is done by encouraging a sustained, research-orientated, technological, market-driven and private-sector led sector. Major constraints are small size of holdings, inadequate R&D and extension services and limited application of technology.

Recent trends in plant production

For the period 1996 to 2006, agriculture declined by 25%. In 2006, the agriculture production index (API) was 56% (export crop production), 66% (domestic crop), 128% (livestock), 124% (fishing) of the 1996 API level. There was growth in non-traditional crops over the period as a result of a deliberate injection of capital, research and development, and as a result of recognition of the disappearing preferential tariffs that had existed on traditional export crops especially sugar and banana. The Agricultural Development Project was initiated during this period to halt the decline in the agricultural sector. Focus was given to eight priority areas: small ruminants, protected cultivation (green house, hydroponics), apiculture (bees), organic agriculture, farmer registration, fruit tree crops, fisheries, and ornamental fish.

Trends for period 1996 to 2006

- Decrease in traditional export crops and increase in non-traditional crops.
- Sugar imports dropped from 181,319 tonnes in 1996 to 138,145 in 2002 with a drop in earnings for the period from 113.8 to 66.8 US$M.
- Decrease in domestic food production.
- Increasing demand for competitively priced crop products such as jerk seasoning.

There are several encouraging trends in plant production over the last ten years:

- Trend towards increased breeding activities - this has resulted in several improved varieties such as scotch bonnet, sorrel and pumpkin.
- Trend towards a greater use of technology - examples include the use of marker-assisted breeding for scotch bonnet which reduced the breeding time and cost, the building of a state-of-the-art molecular biology lab at Coconut board for research into obtaining phytoplasma-free and resistant coconut varieties, and *in vitro* grafting of citrus varieties onto resistant rootstock. All above examples resulted from collaborative work between the University of the West Indies, Biotechnology Centre, the research and development arm of the Ministry of Agriculture (MOA) and Commodity Boards. Other examples of technology being increasingly used in agriculture include greenhouse technology, hydroponics, and artificial insemination (pigs).
- Trend towards targeted R&D activities to specific plant groupings – eg MOA Fruit Tree Crop Project, several Medicinal Plant (Biotechnology Centre) and nutraceutical (SRC) projects.
- Trend towards initiation and revitalization of *ex situ* gene banks by the MOA (many), NCU (breadfruit), CASE (a few) and UWI/BTC (medicinal plants).

- Trend towards *in vitro* gene banks - SRC (banana, plantain, spices, food crops, fruit trees and ornamentals), UWI/BTC (spices, medicinal plants, agricultural crops), and finally
- A trend towards local production of seeds which includes scotch bonnet, sorrel, pumpkin and callaloo seeds; and *in vitro* production of vegetatively propagated crops.

Driving forces behind changes in plant production

The main reasons for the increase in technology applied to agriculture as highlighted above is not clear but there are several possibilities. The Biotechnology Centre was opened in 1989 and the Molecular Biology Building of UWI in 1998. The Medicinal Plant Research Group and the Natural Products Institute, both at UWI were initiated in 1999. Such developments have resulted in a cadre of trained biotechnologists who have found jobs in various agriculture-related areas. A major nutraceutical project involving UWI, SRC and MOA between 2001 and 2007 not only encouraged R&D but also brought the entities mentioned closer together. The herbal sector was consolidated in 2002 and this has widened the number of plants being considered as viable crops. Between 1996 and 2006, communications also improved dramatically. Cell phone use and internet users were both zero in 1990 but by 2005 were 1,017/1000 people and 404/1000 people respectively. The need for more food to be produced on less land due to population pressure, more trained personnel, a more technologically-minded people, increased access to research through the internet and increased funding from local and overseas sources (EFJ, MOA, USAID) seem to be the main factors influencing the above trends.

Unfortunately, while there has been legislation within the last ten years on copyright and geographical indicators, the Intellectual Property Act still has not been upgraded and Jamaica still does not have plant variety protection. The Human Development Index - 2007/2008 Report indicates that the patents granted (per a million people) in Jamaica for 2005 was one. Much traditional knowledge exists in Jamaica for different uses of local genetic resources. This knowledge is not being adequately preserved or access regulated, and thus might be lost or enter into the public domain unprotected, which could diminish its value. There has been a trend towards documentation of this knowledge with several recent publications but a lot of work remains to be done and currently there is no legal means to protect this traditional knowledge. We need to preserve and use this knowledge or we may lose it. In 2005, receipts from royalties and license fees were US$4.7/person - this is way too low when the richness of Jamaica's biodiversity and uses is considered. At present, access to Jamaica's biodiversity is regulated through the use of collection permits and Material Transfer Agreements.

Changes needed in agricultural production systems over next ten years.

Increased registration of farmers
Increased application of technology - of machines and scientific techniques
Increased production of elite planting material
Increased communication - roads, telephones and ICT
Increased training of trainers - of new technologies eg GPS, protected agriculture, hydroponics, tissue culture, molecular biology techniques etc
Increased diversification into new crops
Increased local breeding and conservation activities
Increased and more reactive marketing systems
Increased activities in agro-processing and value-added product development
Increased databases – info on biodiversity, best practices, COP etc
Intellectual property rights including plant variety protection
Branding of bidiversity

Limiting factors and constraints affecting productivity and efficiency.

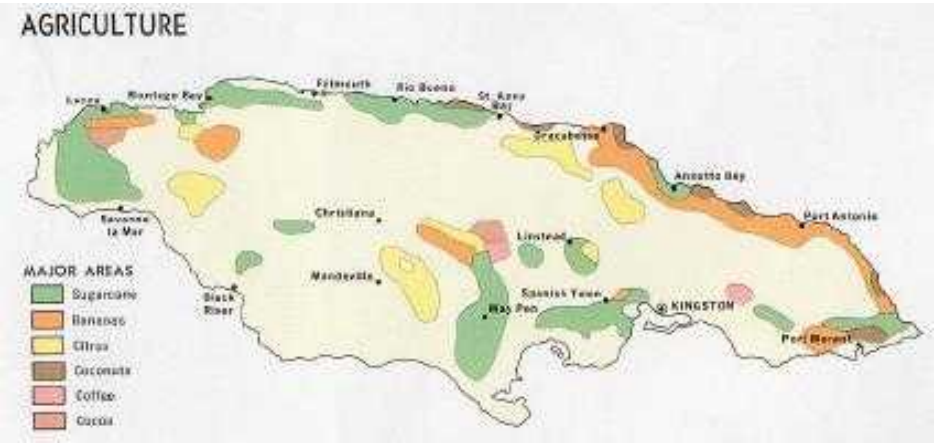
Mountainous, hilly terrain (steep slopes, karst landscape results in winding road networks) that affects communication, transport of produce, restricts land for crop production and limits plot size
Flat land is insufficient and mostly confined to the coast.
Lack of understanding of tropical soils and not enough research endeavors to solve soil pathogenesis
Low application of plant pathology tools applied to plant diseases
Low application of sustainable solutions such as soil solarization and fumigation to alleviate soil diseases
Low application of technology to farming - still fork and hoe in most cases.
Low educational levels in rural areas
Lack of understanding of propagation and importance of elite varieties to high yields
Poor marketing system

Role of plant genetic resources for next ten years

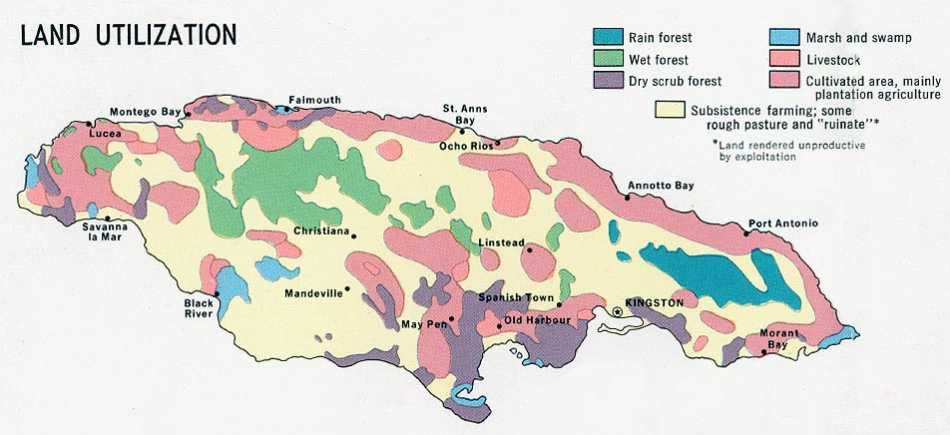
The role of plant genetic resources will continue to grow in importance over the next ten years as old markets close and new ones open, food crops become multi-use crops (eg for biofuels, biochemicals and molecular farming) and as the tension for land use between agriculture and urbanization continues.

MAPS OF JAMAICA

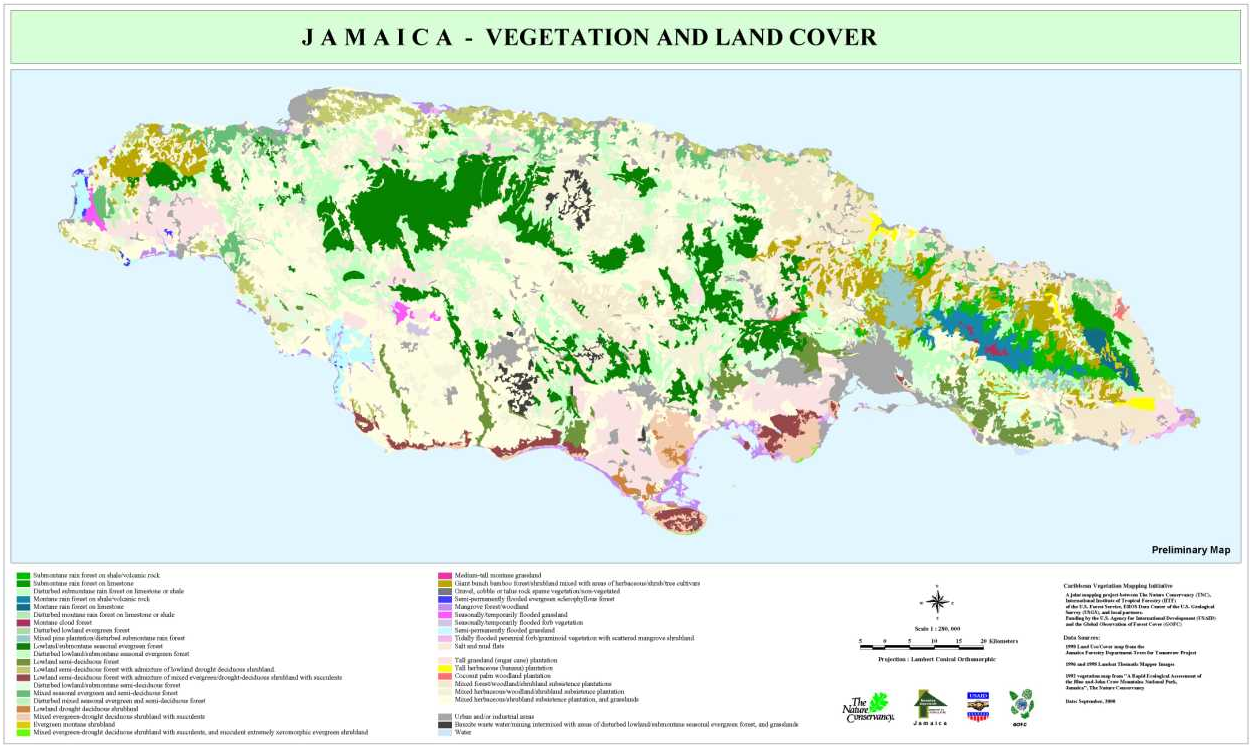
Map 1 Agriculture in Jamaica in 1968



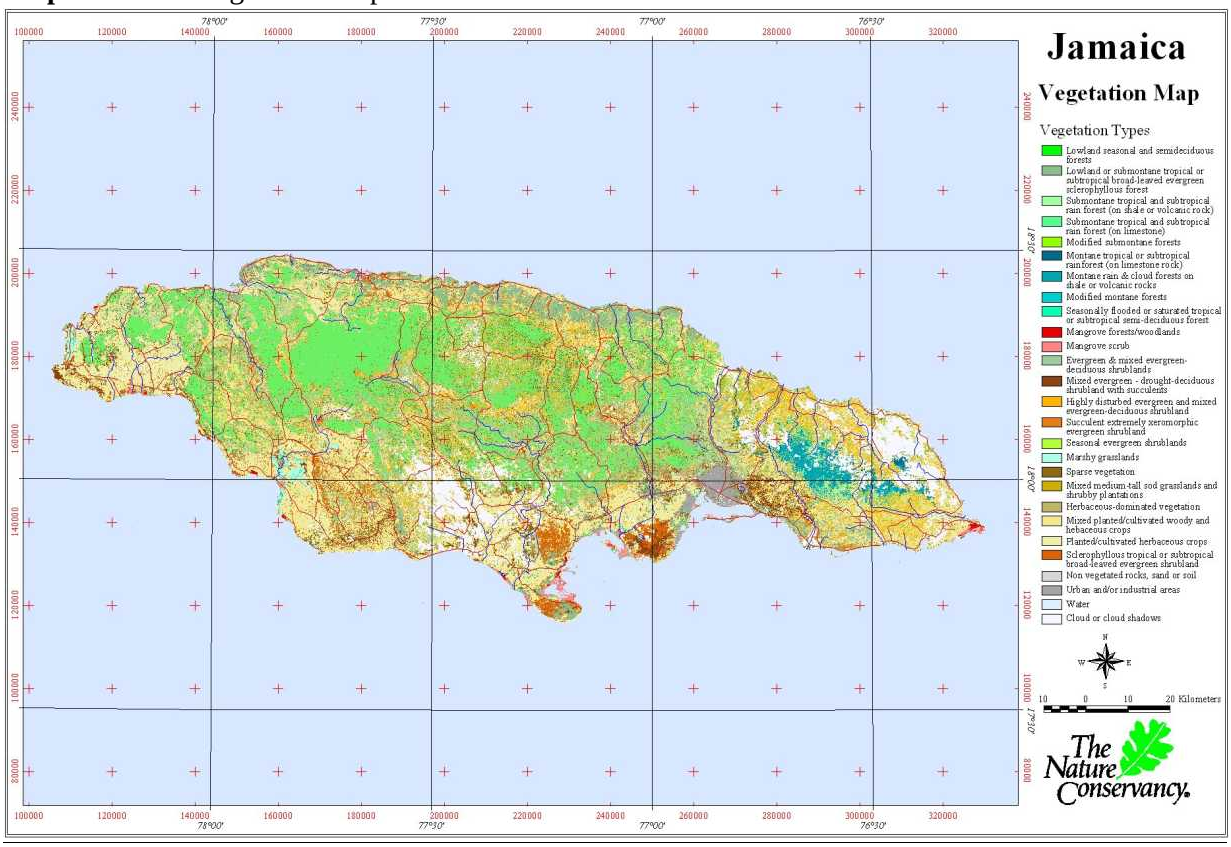
Map 2 Land use in Jamaica1968



Map 3 Land use in Jamaica in 2000



Map 4 Vegetation Map of Jamaica in 2007



SECTION III: THE MAIN BODY OF THE COUNTRY REPORT

Chapter 1: *The State of Diversity*

The wide range in microclimates, soils and physical features give rise to a variety of ecotypes. Numerous microenvironments exist for growing a wide range of crop plants and animals of both temperate and tropical origin, include endemic (found nowhere else), indigenous and introduced plant genetic resources. Many of the wild relatives of our agricultural crops are escapees as most of Jamaica's agricultural crops are introduced and these wild relatives are much fewer than those of our indigenous biodiversity. Among the variety of terrestrial, aquatic and marine ecosystems are dry and wet limestone forests, rainforest, riparian woodland, wetlands, caves, rivers, seagrass beds and coral reefs.

Biodiversity encompasses the total complexity of life and is understood at three levels – species, the genes they contain and the ecosystems of which they are part. Genetic diversity values both species diversity (relative richness in different genes) and ecosystem diversity (relative richness in the different processes to which genes ultimately contribute). An important concept of biodiversity is that it is ever changing and adapting; consequently methods of use and conservation also need to be dynamic.

The main plant genetic resources for food and agriculture

Indigenous biodiversity

Plants cultivated or used by the Tainos (who arrived ~ 600 AD) include cassava (*Manihot esculenta*), sweet potato (*Ipomoea batatas*), corn (*Zea mays*), dasheen (*Calocasia esculenta*), coco (*Xanthosoma sagittifolium*), bean (*Phaselous vulgaris*), pumpkin (*Curcubita moschata*), squashes (*Cuurbita maxima*), peanut (*Arachis hypogaea*), arrowroot (*Maranta arundinaceae*), hot pepper (*Capsicum chinense*), tobacco (*Nicotiana tobacum*) and fruits including pineapple (*Ananas comosus*). Native trees included guava (*Psidium guajava*), palm nuts (Palmaceae), coconut (*Cocos nucifera*), papaya (*Carica papaya*), mamey apple (*Mammea americana*), custard apple (*Annona reticulata*), sweetsop (*Annona muricata*), mountain soursop (*Annona montana*), pond apple (*Annona glabra*), star apple (*Chrysophyllum cainito*), Barbados cherry (*Malphigia glabra*), beef apple (*Sideroxylon rugosum*), macca fat (*Acrocomia spinosa*), naseberry (*Manilkara zapota*), Jamaican walnut (*Juglans jamaicensis*), hemp (*Cannabis sativa*), cedar (*Cedrela odorata*), blue mahoe (*Hibiscus elatus*), mahogany (*Swietenia macrophylla*) and pimento (*Pimenta dioica*). Non-food biodiversity included orchids (Orchidaceae), bromeliads (Bromeliaceae), flowers (*Blakea trinervia*), cotton (*Gossypium* spp.), calabash (*Crescentia cujete*), annatto (*Bixa orellana*) and many medicinal plants such as ramoon (*Trophis racemosa*) and sarsaparilla (*smilax regelii*). These indigenous biodiversity were either introduced well before Columbus' arrival (indigenous) or are endemic to the island.

Endemic biodiversity

An estimated 28% of the flowering plants of Jamaica (800 of 3000), 36% of the bromeliads, 12% of the ferns, 50% of the cacti and 70% of the palms are endemic to Jamaica (IOJ 2000, Table 2). An estimated 13% of known medicinal plants of Jamaica are also endemic (Mitchell and Ahmad 2006). Except for a listing in Adams (1972), not much more is known about these endemics. It is uncertain if these plant species are still endemic or can now be found on different lands, or if they have been destroyed forever. Since Adams (1972), there has been no update on the endemism of these 800-odd flowering plants. Research is needed to upgrade this document. Endemic plants with potential for food and agriculture include the endemic mountain guava (*Psidium montanum*) and the presently wild-crafted endemic root tonic plant, chainy root (*Smilax balbisiana*).

Table 2 Species richness and endemism in plants

Terrestrial Flora	Total Number of Indigenous Species	Number of Endemic Species	% Endemic Species
Bromeliads	60	22	36.7
Orchids	230	60	26
Ferns	579	67	11.5
Cacti	20	10	50
Palms	10	7	70
Grasses	~200	1	0.5

Source: Institute of Jamaica, 2000

Introduced biodiversity

The Spaniard settlers who followed Columbus arrival in 1494 introduced a variety of crops, establishing plantations of exotic crops such as citrus (*Citrus* spp.), banana (*Musa acuminata*), sugar cane (*Saccharum* cvs), cocoa (*Theobroma cacoa)*, and ginger (*Zingiber officinale*). The British, who arrived in 1655, introduced other plants such as the otaheite apple (*Syzgium malaccense*), breadfruit (*Artocarpus altilis*), jackfruit (*A. heterophyllus*), mangosteen (*Garcinia mangostana*), mangoes (*Mangifera indica*), lychee (*Litchi chinensis*), carambola (*Averrhoa carambola*), avocado pear (*Persea americana*), longan (*Dimocarpus longana*), and naseberry (*Manilkara zapota*). June Plum (*Spondias dulcis*), bilimbi (*Averrhoa bilimbi*), Cinnamon (*Cinnamomum zeylanicum*), nutmeg (*Myristica fragrans*), pomegranate (*Punica granatum*), tropical almond (*Terminalia catappa*), turmeric (*Curcuma longa*) and coffee (*Coffea arabica*) were introduced in the 18th century. Ackee (*Blighia sapida*) and yam (*Dioscorea* spp.) were introduced by Africans and neem (*Azadirachta indica*) was probably introduced by Indians. More recently, introduced biodiversity include sweet potato varieties, fruit trees such as cocona (*Solanum sessiliflorum*) and a range of ornamentals.

Jamaican Agriculture

The vast majority of Jamaica's farmers exist on relatively small farms in the hilly interior. The 'small farm' sector supports an estimated 150,000 rural families and is the country's largest source of employment. Arable land increased from 1979 to 2004 from 135,000 ha to 174,000 ha. Over the same period, the area irrigated hardly increased (24-25,000 ha).

Small farmers, those with farms of five acres (2.02 ha) and less, constitute some 78 percent of the farming community and produce mainly root crops, pulses and vegetables. Large-scale farms account for less than one percent of the total number but occupy about 39 percent of farm lands producing mainly sugar, bananas, coffee, pimento and, to a lesser extent, citrus and cocoa for the export market.

State of diversity and relative importance of all major crops for food security.

Agriculture in Jamaica can be divided into two principal groups: large-scale farmers producing mainly for (traditional) export and small-scale farmers who supply mostly non-traditional exports and local demand. Traditional export crops, which dominate the export market, include coffee (Blue Mountain [84%] and non-Blue Mountain [16%]), pimento, citrus (oranges, ortaniques, grapefruit) and cocoa with sugar and copra (coconut) as commodities. Sugar, the leading export crop, is produced mainly as a monocrop on plantations. Raw sugar production in 2000 was estimated at 175,000 tons, down from 290,000 tons in

1978. Sugar is Jamaica's largest agricultural export, earning $66 million in 2001. Sugar is also used for the production of molasses (79,653 tons in 2002) and rum (24.2 million liters in 2002). Banana production in 1999 was 130,000 tons. Blue Mountain coffee, which is primarily exported to Japan, brings in some $12 million annually in foreign exchange earnings.

For all traditional export crops, farmgate prices fell during the period 1996 to 2006. For coffee, there has been a decrease in non-Blue Mountain coffee attributed to reduced investment by farmers in response to increased input prices as well as lower farmgate prices. For citrus, recent decreases in crop production are attributed to the negative effects of the Citrus Tristeza Virus (CTV). In response, the Citrus Replanting Program was implemented in 2001, with the aim of replanting citrus groves with resistant plants. By the end of 2006, resistant citrus groves had been planted on 1,068 ha. Pimento seed production also fell (but pimento oil production increased) since 1996 and the response was the Pimento Resuscitation and Replanting Program which commenced in 2003. Coconut production has been affected by the Lethal Yellowing disease and a program began in 2002 to 2006 to replant coconut seedlings into non-traditional areas with new varieties, in all 54,138 such seedlings were planted. Farmers that culled diseased plants regularly kept the disease at bay while other farms were completely devastated. Cocoa and banana production fluctuated during the period as they are most affected by hurricanes.

Non-traditional exports include yams (*Dioscorea* spp.), fruit juices, ackee, papayas, sweet potato, dasheen, mangoes, and pumpkin. Also in this group are the herbs, spices (including ginger and turmeric), fruits, vegetables and horticultural crops. The largest export crop in this category is the yams (mostly *Dioscorea cayenensis* yellow yam). Vegetable and melon production in 1999 amounted to 184,000 tons; principal varieties included pumpkin, carrot, cabbage, tomato, callaloo, and cucumber. Production of other crop groups (with leading varieties) in 1999 included: pulses (red peas, peanut, gungo peas), 5,000 tons; condiments (scallion, hot pepper, onion), 7,000 tons; fruits (papaya, pineapple, watermelon), 1,416,000 tons; cereals (corn, rice), 2,000 tons; and roots and tubers (yams, potatoes, plantains), 307,000 tons. Jamaica also exports tobacco, dasheen and cut flowers. Jamaica exported $227.7 million and imported $402.7 million in agricultural products during 2001.

The major crops for food security are the staples (carbohydrate sources). The island's food needs are met only in part by domestic production, and foodstuffs are a major import item. The main food crops, grown primarily by small cultivators, are sweet potatoes and yams, rice, potatoes, manioc, tomatoes, and beans. The major staple eaten in Jamaica is wheat (bread) and rice which is imported with ‘cereals and cereal products’ making up ~3/4 of the food imported. The reason for this is that bread and rice are the cheapest carbohydrates available and their availability prevents malnutrition for those that cannot afford to buy the other types of staples. Local staples, however, can be increased if the situation demands it. All other types of food imported is based more on choice (eg apple, potato) rather than necessity.

Seeds for vegetable crops, such as lettuce, cabbage, tomato, are imported every season. The farmers will not grow the next crop from seeds collected as they know the yield will be low. Wild escapees from these crops are low. The genetic diversity of vegetatively propagated crops such as ginger, yam, coco, dasheen and even pineapple is also relatively low, although for banana germplasm with reasonable genetic diversity do exist. For sugar, seeds are imported from the Barbados Sugar Breeding Station, field-tested in Jamaica. The best varieties are then multiplied, distributed to farmers and sent back to the Breeding Station for further breeding. Local diversity is greatest amongst the indigenous tropical crops that have seeds such as the scotch bonnet pepper, callaloo and avocado pear. In this group, however, varieties are rarely named or maintained as separate entities.

The dilemma is that although there are a lot of underutilized lands across the island, a high portion of food is still being imported. For example, 50-80% of the food used in the hotel industry is imported. There are a variety of reasons for this but none are insurmountable. Reliability, quality, seasonability and quantity are the main issues. The imperative for improving food security will require more investment into research and development to increase crop yields, produce elite planting material, improve cultural practices and diversify into new crops.

The major locally produced staple crops for food security includes green and ripe bananas, yam, dasheen, coco, sweet potato, and cassava. Irish potato used to be produced on a large scale but presently is not a major staple crop. These staples are mainly available as fresh produce. There is a need to process these staples to add value and preserve them for out-of-season use. Presently such value-added products on the market include a range of chips (banana, plantain, and cassava) with banana being the most common, pudding (sweet potato) and a range of cassava products including bammies, gari and pancake mix. Technology is available to make flour from these staples but they are not yet available on the market.

State of diversity and relative importance of minor crops and underutilized species for food security and agriculture.

Domestic crop production has decreased over the last ten years. Input (eg fertilizer, fuel) prices have increased while farmgate prices have struggled to keep up with inflation. Affordability rather than availability is the major factor, except after a hurricane. This sector includes a range of crops such as legumes, vegetables, herbs and spices, fruits, cereals (corn), plantain, yams, cassava, coco, dasheen, sorrel and potatoes (irish and sweet). Research into pasture grasses/cover crops has declined with the associated decline in the dairy industry. Fruits are seasonal but increasing in availability.

Products developed from the minor crops of Jamaica increase productivity as they lessen post-harvest losses exacerbated by low prices at glut times of harvest (most serious for crops that are day-length sensitive like pineapples and ginger). For example it might be cheaper for the farmer at glut periods to feed their tomatoes to their pigs rather than selling them to higglers. These value-added products, which also increase food security, include fruit juices (eg otahetie apple, june plum, guava, pineapple), tea bags (mints, lemon grass, ginger, sorrel, bissy, cerassee etc), seasonings (turmeric and curry powder, jerk seasonings), jams and jellies (eg guava, aloe, tuna), wines, liquors, rums, and root tonics (wide range of roots and barks including sarsaparilla and chainy root). Nevertheless, most minor crops are still being bought and consumed as fresh produce, or spoil, so more agro-processing ventures are sorely needed. Products developed from minor crops are also exported (eg jerk seasoning and sauces, curry powder, pimento oil, root tonics and cosmetic products).

Over the period 1996 to 2006 there has been a distinct and concerted effort towards diversification. This is especially obvious in the fruit crop sector which is growing in relative importance, for the local and overseas markets. This largely unmet market for tropical fruit concentrates has already spawned several fruit juice agro-processing ventures. Planting of fruit trees is being considered for orchards, schools, and urban areas.

Underutilized species such as breadfruit, breadnut, pineapple, culinary herbs and spices, fibre, medicinal and aromatic plants could be expanded along with the local staples mentioned above to enhance food security and increase exports. Another important use of local biodiversity is in the ornamental sector with examples being the endemic orchids, bromeliads and ferns. Diversification into biofuel crops, such as castor bean and *Jatropha* spp ., is also being considered.

A healthy and sustainable plant genetic resource base is dependent on a healthy animal population. The animals act as pollinators, seed dispersers and reducers of dead organic material. Spraying against mosquitoes, therefore, is a threat to pollinators such as bees for crops and their wild relatives. Major pollinators include bees, butterflies, moths, hummingbirds and nectarivorous bats. Fruit-eating birds and bats, and seed-eating birds, are important seed dispersers. Genetic resources from both wild animals and plants are also used to improve domestic breeds and varieties respectively. On the downside they are sometimes repositories of crop diseases such as Gemini viruses.

State of diversity of crop varieties (modern and landraces/farmers' varieties).

Most of Jamaica's major crops for food and agriculture come from imported genetic resources. However, there are a number of native and endemic plants being cultivated. The *in situ* state of diversity of crop varieties is unknown; where they are present they would be escapees. Such an escapee is the cherry tomato variety which has become wild but the extent of its distribution is unknown.

The diversity of landraces developed by farmers is decreasing as there is no way to separate and/or protect such varieties but the amount of landraces is unknown at present. There are several Jamaican selected or bred crop varieties. These include scotch bonnet pepper, tomato, pumpkin and citrus varieties. Ortanique, a citrus fruit, was a sport (mutation) found by Jamaican farmers.

There has been an increase in minor crops being grown by farmers. This increase has been encouraged by the formulation of several world-renown value-added products developed in Jamaica made from indigenous agricultural biodiversity such as Jerk seasoning using scotch bonnet peppers and pimento. Better links to the tourism market (hotels), increased research into sustainable utilization of native biodiversity (eg sorrel products, root tonics, tea bags), new and improved varieties, and the re-opening and expansion of overseas markets (eg ackee, yam) has facilitated this development. Other important bio-products include rum, liquors and vinegar from sugar cane. The minor crops affected include yams, sweet potato, sorrel, watermelon, cantaloupes, vegetables, condiments (pimento, scotch bonnet pepper etc), root tonic species and fruit tree crops like ackee. These minor and underutilized crops are increasing in acreage yearly.

Throughout the country, there are various *ex situ* collections of plant races of many crop species, the most important are highlighted below. Few farmers maintain varieties not presently in use. There are only a few farmers who will keep old varieties of banana for instance, or have a collection of yam varieties. Most use all their land for their present crop only. There are very few farmers who dedicate their land to producing planting material alone for sale. Crop varieties are being maintained for some but not all crop species by the government (MOA), commodity boards (coffee, banana etc) and research institutions (SRC, SIRI, CASE, NCU, UWI). Some of these collections are maintained *in vitro*. Some of these are supported long-term while others are on a needs or project basis.

Natural biodiversity - surveying and inventorying plant genetic resources for food and agriculture

The most comprehensive work on Jamaica's biodiversity is Adams (1972) which lists 2,888 flowering plant species of which 784 are endemic. There have been some surveys done and books written about the ferns, orchids and medicinal plants of Jamaica. Some of these have pictures but Adams (1972) has none. Current estimates (NSAPBDJ 2003) indicate that at least 3,304 species of vascular plants occur in Jamaica, of which 28% are endemic. However, the actual numbers may be higher, or lower, as knowledge of Jamaica's flora is incomplete and the abundance of some species is unknown. Jamaica is fifth in the world in terms of the presence of endemic plants and many of these plants are found in the forested areas. According to Jamaica's Conservation Data Centre database (CDC), at least 221 endemic species are classified as 'critically imperiled' and 'especially vulnerable to extinction'. However this database is very incomplete. The range of biodiversity is unknown so it's hard to estimate how much has been lost, or in danger of being lost.

Flat coastal lands

The country is extremely mountainous. Less than one-fifth is relatively flat in the form of coastal plains, inland valleys, flood plains and river terraces. The mountains rise 7,000 feet for the coastal plain in only 10 miles. More than one-half of the island stands at more than 1,000 ft (1,609 km) above sea level and over one-half of the land has slopes of over 20 per cent. The crops most often seen on the flat coastal lands are sugarcane, banana, and increasing in some areas, yam.

Interior Forests

The most recent assessment of forest cover in Jamaica was carried out in 1998. Only 8% of the total land area is natural forest - *closed broadleaved forest* with minimal human disturbance while approximately 336,000 ha (30.6%), is classified as forest (Table 3). Most of the remaining 260,000 ha is classified as *disturbed broadleaved forest* or *dry open forest*, having varying degrees of human disturbance. The latter is often referred to as woodland or scrub but these dry open forests are important components of Jamaica's forest ecology. The major forest types are: lower montane mist forests, montane mist forest, dry limestone forest, wet limestone forest, mangrove woodland, herbaceous swamp and marsh forest.

Table 3 Forestry inventory assessment

Land Use	Thousands of Hectares	% of Total Land Area
Natural forest (Primary Forest)	88.2	8%
Other Forest	247.7	22.6%
Total Forest	**335.9**	**30.6**%
Mixture of forest and other cultivation	332.9	30.4%

Source: National Forest Management and Conservation Plan, March 2001

Inventorying and surveying of selected areas (eg Portland Bight) has been undertaken by the Forestry Department, Institute of Jamaica (IOJ) as well as local and foreign universities. IOJ is the Clearing House (CHM) for biodiversity but it does not have the quantity or quality of staff nor computer systems to do a thorough job. Most of the inventories done to date have been on groups of interest such as orchids or trees, and not specifically for the genetic biodiversity for Food and Agriculture. There are several inventories and surveys that have been done that are housed in universities or botanical gardens abroad and are inaccessible to Jamaica.

State of diversity of wild plants harvested for food production

Wild species of flora make a significant contribution to Jamaica's economy. The wild plants harvested for food production are mostly gathered unsustainably from the forest. They are mostly not staples, although some do contribute to calorific intake, but they are important sources of minerals, vitamins and other important phytochemicals. The majority of fruit trees growing in Jamaica can be considered wild, whether they are in the forest or in the backyard as the variety designation is virtually unknown and many grew up from discarded seeds that 'accidentally' germinated. Non-destructive harvesting is done for fruit trees such as ackee, breadfruit, mango, june plum, tamarind, guinep, and for medicinal plants such as pimento, nutmeg, bizzy and noni. When such plants die, new plants have to arise from their own seeds as no purposeful planting occurs. This neglect may therefore lead to a decrease of such plants. This is especially so for some heavily harvested medicinal plants such as sarsaparilla and chainy root. All the near sources are gone, and wild-crafters are heading further into the forest to find harvestable plants. Most of these folks do not know how and therefore do not practice replanting. The recommendation is for replanting protocols be developed for such plants and the LFMCs and FD be trained about how to reseed the forest with such species.

Most of the trees mentioned above were once imported, but have become indigenous. There are few examples of endemic plants that have become major food plants. Pineapple is one such example but the varieties being used now are being imported. Pimento is another example but this crop has not benefitted from much local research. Indigenous forest trees are preferred for yam sticks, an important requirement for yam production. These trees are cut down as required but again, no purposeful replanting takes place.

Promoting *in situ* conservation of wild crop relatives and wild plants for food production

The area of Forest Reserves and Crown lands (land owned by Government) managed by the Forestry Department amounts to approximately 109,500 ha. Most of this area is protected as forest reserves, protected areas or national parks. Approximately 35% of all forests are designated as protected areas and over 73% of closed broadleaf forests (natural forest) have protected status. The Forestry Department is promoting in situ conservation of important biodiversity but has not specifically mentioned wild crop relatives and wild plants for food production. Research will be needed to identify which plants would fit in this category, and which of these species are most in need of conservation.

Marine biodiversity

Jamaica's irregular coastline is 795 km long and has diverse ecosystems including sandy beaches, rocky shores, estuaries, wetlands, seagrass beds and coral reefs. The majority of the living marine resources are found on the island shelf and nine oceanic banks, which together cover an area of 4,170 km^2. The island shelf is much wider on the south coast with a maximum width of 24 km. On the south coast, fringing coral reefs extend almost continuously from Negril to Morant Point.

Sea grasses are found in the shallow coastal waters around Jamaica. These include: Turtle grass (*Thalassia testudinum*), Manatee grass (*Syringodium filiforme*) and Shoal grass (*Halodule wrightii*). They provide important feeding areas for endangered marine turtles and manatees; as well as nursery areas for important commercial fish. Seaweeds are also important to many Jamaicans as they are used in traditional or folk medicine. Examples include: *Caulerpa racemosa, Dictyophaeria cavernosa, Microdictyon* sp., *Polycavermosa debilis*, and *Udotea* sp.

Coral reefs are of major social, economic and biophysical importance to Jamaica. Reefs act as natural barriers by protecting coastlines from erosion, are a source of food and income for local communities and support tourism and recreational activities. Increasingly, marine biodiversity is being explored as a source of new phytochemicals. The in situ conservation of marine biodiversity is very important and recognized especially the health of the coral reef which can influence the impact of hurricanes to the island.

Promoting sustainable agriculture through diversification of crop production and broader diversity in crops

Sustainable agriculture is being promoted by the diversification of crop production and broader diversity in crops by the concerted efforts of several local agriculturally-related institutions:

- CARDI : plant selection - scotch bonnet
- MOA: breeding of new plant varieties - Jheri Curl tolerant tomato, Bodles globe pumpkin, year-round sorrel, resistant scotch bonnet pepper
- MOA: Fruit Tree Crops Production Improvement Project - Identification of local mother plants with desirable traits for clonal propagation, establishment of 12 demonstration plots (0.5 acres each) in 2006.
- MOA: Sweet Potato Germplasm Project - 24 varieties characterized and maintained.
- UWI/BTC: Medicinal Plant Research Group - Development of a medicinal plant genebank with over 100 species; Production and dissemination of Jamaican medicinal plant monographs.

Supporting seed production and distribution

Seed production and distribution is also being carried out by the concerted efforts of several local institutions:

- CASE and NCU: breadfruit collection, recommend varieties for distribution
- Citrus Board: importation, production and distribution of Tristeza Virus resistant varieties.
- Coconut Board: testing for resistant varieties to Lethal Yellowing, production and dissemination of these varieties to farmers
- MOA: has held a number of training workshops in plant propagation techniques, nursery management and management of tropical and subtropical production.
- MOA: with international collaboration with seed companies to multiply seeds abroad (California) for plant species selected or bred by the MOA R&D department to be suited for Jamaica.
- MOA: produces hot pepper seeds, year-round sorrel variety etc
- Forest Department: germinates seeds and distributes several forest species such as mahogany, cedar, teak and neem for planting and reforestation efforts.
- SIRI: in collaboration with the Barbados Sugar Cane Breeding Station - sends selected varieties and receives seeds which it field-tests in several locations islandwide, suitable varieties are then selected, multiplied and disseminated to farmers.
- Innumerable farmers: callaloo seeds
- Many farm shops and other shops sell local and imported seeds of many descriptions.

- Production of elite planting material of vegetatively propagated crops via micropropagation is being undertaken by UWI/BTC, SRC and the CPGA.

Developing monitoring and early warning systems for loss of plant genetic resources for food and agriculture.

There is no such system presently being developed or practiced for Jamaica. Help would be needed to develop this. The nearest activity in this area is consultation towards the establishment of a National Food Safety Policy. As a result of writing this review, activities towards developing such a monitoring and early warning system for agriculture has been initiated and this will have to have in it a component to monitor the loss to plant genetic resources for food and agriculture.

Factors influencing the state of plant genetic diversity

Natural resources have always played an important role in Jamaica's development. The island's major economic sectors, agriculture, tourism, mining, are all based on natural resources. The pattern of economic development has therefore contributed substantially to the destruction of biodiversity. In more recent decades, urbanization has exacerbated earlier trends.

Initially, the increasing demand (in Europe) for sugar led to the development of estates for the cultivation of sugar cane on the flat coastal lowlands. Later, agricultural production expanded to include crops such as bananas, coconuts, coffee and citrus. This agricultural development required the clearing of primary forests and was ecologically very destructive. While the main impact of sugar cane and banana cultivation may have been confined to lowland areas, felling of mahogany and cedar trees for timber and clearing of forest vegetation in preparation for planting coffee has caused substantial deforestation of the upland areas. Other harmful effects to forested areas include the felling of trees for charcoal burning and yam sticks while invasive species such as bamboo can destabilise mountain slopes. In addition, the effects of chemical fertilisers and pesticides used in crop production (and to get rid of mosquitoes) have implications for the viability of non-target populations including crop pollinators.

A major factor affecting the state of biodiversity is lack of knowledge. Since the 1950-80s when a comprehensive study was undertaken by UWI, culminating in Adams (1982), there has been no ongoing comprehensive study, of the island's biodiversity in spite of the Caribbean being a 'hotspot'. The status of our endemic's are unknown and their potential for food and agriculture is also unknown. Worse, there have only been a few incomplete inventories or surveys of wild plants for food production and of crop-associated biodiversity. Those present are small in size and short in duration. A few examples are available. For the fruit tree project, bud wood is obtained from mother plants chosen for good yield. For the scotch bonnet breeding work, local varieties were chosen based on shape and similarly other varieties were collected around the Caribbean and then used as mother stock for the breeding process.

The situation is that any analysis of factors affecting the state of plant diversity must be general in degree, as the present state of Jamaica's plant genetic diversity is inadequately known. The country is not adequately assessing the genetic erosion of its plant genetic resources. The major factor that may be causing genetic erosion is the lack of laws protecting land from encroachment by agriculture, urbanization or mining. Of specific concern is the law that states that the mining companies have the right to any piece of land they so desire; they do not have to own the land they wish to mine (Mining Act 1947). Also, the lack of plant variety protection, associated lack of attention to variety and lack of knowledge of the importance of distinct varieties results in variety mixing being very common. Varieties would have to have large differences to be considered distinct. The effect of overgrazing, land clearing, deforestation,

urbanization, fragmentation, droughts, invasive species etc is largely unknown as there is no base data to compare their effect with. The state of endemism also is unknown as there has only been sporadic attempts at inventorying the country's plant genetic resources over the years and there is no real 'protected area' that is free from encroachments.

Other factors affecting the state of diversity are population pressure especially from urbanization, praedial larcency and the increase in the desire for natural foods, herbs and spices. Economics to a large degree, determines what crops farmers will grow. This is affected by the influence of pest and diseases which affects competitiveness (affecting papaya, coconut and sugarcane the worst), trade barriers (affected ackee until recently), while the interest in nutraceuticals has opened up new markets and new crops for agricultural produce and derived products.

Future needs and priorities

There needs to be a sensitizing of the policy makers to the importance of a country-wide inventorying of plant genetic resources, for crops that produce seeds (a seed inventory and the selection of lines for optimum yield), wild crop relatives where they exist, vegetatively propagated crops, associated biodiversity and wild plants for food production. Such an inventory needs to be done regularly and documentation recorded for each plant variety by area (GPS), yield, with picture, common and scientific name, varietal name and number, DNA fingerprint and associated herbarium sample. Because it is unclear whether a plant could be useful or not for food production, the entire island biodiversity needs to be inventorized. Any studies done abroad on our biodiversity need to be repatriated. Comparative analysis of crop and phytochemical yield is also needed for each crop from more than one area.

Associated with the plant inventory, as outlined above, an ongoing, regular and detailed inventory and database needs to be maintained on the farmers themselves. Farmers need to be registered and a system developed to upload their estimated and actual crop harvesting times and yields in real-time. Such a system needs to be linked to production, the market and to academic researchers. A computer system needs to be designed that will link existing officers and registered farmers in the field so as to send real-time data to a central processing facility. For this, a suitable computer system and database for data gathering, documentation, storing and dissemination will need to be designed. Since such a system would best be compatible and harmonized (laws, systems and ICT methods) with other genetic resource gathering mechanisms around the world, it is suggested that such a system be developed in collaboration with other countries.

There also needs to be a sensitizing and a change of laws so as to mandate several key areas as biodiversity reserves, such that these areas are not to be urbanized or mined, and agriculture controlled.

In order to properly assess the state of diversity, there are several capacity-building needs. We have two herbariums but few taxonomists that can identify all the plants on the island. Those that do, need to be properly compensated, and then a cadre of taxonomic and genetic experts, also breeders and field bank managers, need to be developed and supported.

There is a need for a program to collect, exploit and protect local land-races. A few known ones are wild yams, bird pepper, cherry tomato, panda apple, mountain soursop, wild peach, *Annona* species, duppy cucumber, wild callaloo and susumber. There are several plants that are eaten by local peoples but are unknown to science. The MOA library needs to be upgraded to hold information on the plant genetic resources of Jamaica.
In order to be able to assess the degree of genetic erosion, understand the causes of erosion, understand the role and values (social, economic, culture, ecological) of the state of diversity of plant genetic

resources for food and agriculture in Jamaica will require the collaboration of several groups (MOA, universities [social, economic and natural sciences], marketers, businesses including farmers and processors), with a clear agreement of tasks and goals. The country is not obtaining and using available methods for analyzing and assessing genetic diversity, erosion and vulnerability. It is recommended that the MOA and UWI collaborate to ensure that this is done. A few variety trials are being done but they are expensive to carry out. The availability of scholarships for graduate students and post-docs would be very helpful. Research to be done include ethnobotanical, yield, biochemical and socio-economic studies (including economic competitiveness and market feasibility studies). This obstacle would be easier to overcome if those that know of methods to use for accessing genetic erosion and vulnerability would collaborate with us on how to use them and assist us to put in place the necessary infrastructure to obtain and maintain our biodiversity.

Overall, the greatest obstacles facing the country in obtaining and using available methods for analyzing and assessing genetic diversity, erosion and vulnerability is lack of knowledge and awareness, lack of appropriate policy and associated resources especially in terms of support for dedicated and hard-working professionals with an interest in PGRFA. Without external help, it is hard to see how all of the PGRFA present in Jamaica can be adequately studied and sustainably used, but with increasing awareness of the economic value associated with the conservation of PGRFA, more local and international funds could and should be provided for this important endeavor.

Chapter 2: ***The State of In situ Management***

The Caribbean is a biodiversity hotspot. A 'hotspot' is a relatively small region containing a high percentage of endemic species that are in danger of extinction. In fact, the Caribbean region is one of the "hottest hotspots" as it contains 2.3 and 2.9% of the world's flora and fauna, respectively, on only 0.15% of the Earth's surface, with 30% of the higher plant species presently in the Caribbean are endemic. These findings have prompted Conservation International to designate the Caribbean among the top 8 of the world's 25 "hotspots" across the globe. The endemic species of Jamaica alone are an estimated at 28% of the flowering plants.

Two centers of genetic diversity within the overall Caribbean 'hotspot' have been identified in Jamaica. The first Centre of plant endemism is located in the Blue and John Crow Mountains, which were established as a National Park in 1991 and is part of the Protected Area system of Jamaica. The vegetation is composed of lower and montane rain forest, montane scrub, tall-grass montane savanna, cliff and landslide vegetation. The flora in this National Park consists of more than 600 species of flowering plants of which 87 are strictly endemic to the National Park. Nearly 275 Jamaican endemic species and 14 endemic varieties are found in the area. Of the 59 tree species in these forests, 24 are considered endemic (Bifani, 2001). Some of these plants are used for medicinal purposes while others have ornamental value like the orchids and bromeliads. The National Park is an important watershed for Kingston, St. Andrew, Portland and St. Thomas and contains plantations of banana, coffee and sugar cane. There is a concern that the legal protection status of such areas translates into adequate *in situ* protection of plant diversity.

The second Centre of biodiversity is located in the Cockpit country which covers 430 km^2 of evergreen seasonal forest, limestone cliff and landslide vegetation; it has Forest Reserve Status under the jurisdiction of the Forest Department. It is estimated that the area contains about 1,500 vascular plant species of which 400 are endemic to Jamaica including 100 angiosperms (including a wild relative of edible yam *Rajania cyclophylla*) and one species of fern strictly endemic to the Cockpit country.

In situ protection of germplasm is the best way to ensure that they are always available. Protected areas have been formed throughout Jamaica to help ensure that biodiversity-rich areas are not endangered. While some areas have been officially protected, funds to manage and protect them are often lacking. High population pressure also makes it hard to keep such areas free of human incursions. Although conservation of biological diversity and ecological services are now considered the foremost reasons for establishment of most protected areas, tourism or "providing the public with opportunities for recreation and inspiration" was, and continues to be, one of the motivating factors influencing the establishment of protected areas (Otuokon, 2003). Increasingly, alternative sustainable economic ventures are being encouraged to decrease pressure on these protected areas. Policies need to be developed to ensure sustainable use.

Protected areas

Protected areas in Jamaica were initiated through the Protected Areas Resource Conservation (PARC) Project. The goal of the project was "to integrate conservation of biological diversity with sustainable economic development":

- Protect critical watersheds for Kingston (capital city and major industrial area) and Port Antonio (tourist resort) – through the Blue and John Crow Mountains National Park (BJCNMP),

- Encourage new economic opportunities initially through ecotourism, and eventually by the development of pharmaceuticals or other marketable products based on the biodiversity of the BJCMNP and Cockpit Country rather than mining,
- Protection of the island's major tourist resort through the Montego Bay Marine Park
- Cockpit Country Forest Reserve and the Negril Royal Palm Reserve.

Blue and John Crow Mountains National Park

The Blue and John Crow Mountains National Park (BJCMNP) is comprised of approximately 78,000 ha and is located in the east of Jamaica covering the mountainous, interior of the parishes of St. Andrew, St. Thomas, Portland and a small section of St. Mary. All the major watersheds of eastern Jamaica have their origins within the Park including Yallahs, Hope, Wag Water, Swift and Rio Grande. The Park is a Forest Reserve and protects both primary, montane rain forest and secondary forest (Dunkley and Barrett, 2001).

The Park is internationally recognized as a hotspot for biological diversity with about 40 per cent of the flowering plants found within the Park being endemic to Jamaica. The Park is of socio-economic importance for its water supply, soil conservation and carbon sequestration services. It also has cultural significance primarily because the Maroons used these mountains for refuge in the seventeenth and eighteenth centuries.

The BJCMNP's Recreation and Tourism management objective focuses on the establishment of ecotourism within the recreational areas, particularly Holywell and to a lesser extent Portland Gap/Blue Mountain Peak. This will involve the development of an Ecotourism Management Plan. A process has been embarked on using the principles of ecotourism to assist in meeting not just the recreation and tourism programme objectives but those of other management programs. With limited funding it becomes important to increase effectiveness by implementing activities that result in multiple benefits and meet more than one objective (Otuokon, 2003).

Jamaica, like other small island states, is particularly vulnerable to species extinction because island species often have smaller geographical ranges and total population sizes than mainland species. This makes them more susceptible to significant population declines due to factors including habitat loss and alteration, environmental degradation, introduced predators and competitors, and disease outbreaks. Sound land use planning and proper use of environmental impact assessments (EIA) are essential to ensure that developments do not significantly affect Jamaica's biodiversity. There are inadequacies in the present EIA process because a system to identify critical habitats has not been established, there is no requirement to identify threatened species on proposed development sites or ensure appropriate conservation measures [such as moving endangered species, or wild crop relatives, into protected areas before development occurs], nor is the monitoring of the construction process and subsequent activities comprehensively addressed. Also, there is no legal requirement to ensure public participation in the EIA process.

Cockpit Country Forest Reserve

Cockpit Country is a rugged, inaccessible area of inland Jamaica and is home to the Leeward Maroons of Jamaica, who after a century of resistance to British rule signed a peace treaty with them in 1739. The wet limestone forest of Cockpit Country is Jamaica's largest remaining primary forest. It is an island-within-an-island of specially-adapted biodiversity found nowhere else in the world and is a last refuge for some species driven from the rest of Jamaica by humans. Cockpit Country replenishes the aquifers of five

major rivers in Eastern Jamaica: Black River, Great River, Martha Brae, Montego River, and Hector's River. These rivers supply water to St. Elizabeth, Trelawny and St. James.

The Cockpit Country landscape is of steep-sided hills and deep, closed valleys eroded from limestone bedrock is typical karst topography. The features of a karst landscape depend on the interactions between the living and non-living components of the ecosystem. If the balance is upset by sudden changes in one or more components, the whole system may be disrupted.

There has been recent controversy about the Cockpit Country as the mining companies have expressed a desire to mine the area for bauxite. Locals, scientists and NGO's responded by suggesting that the Cockpit Country should be designated a non-mining reserve and any activities in it be sustainable and non-destructive to existing biodiversity. To do that, the border of the Cockpit Country needs to be decided on and that still has not happened. A Cockpit Country Stakeholders groups has been established to express the desire of the inhabitants for sustainable development and an exclusion of mining from the area[2]. As a response to the cries of protest, the mining licenses have been either stopped or returned but the status of mining in the Cockpit Country is still undecided.

Although it is estimated that the Cockpit Country contains about 1,500 vascular plant species of which 400 are endemic to Jamaica including 100 angiosperm, this information is very difficult to find (if it is available) and there is no indication that any of these species are protected in any way. Many of the species are adapted and endemic to this ecosystem. Due to its remoteness and inaccessibility, most of the Cockpit Country has been insufficiently studied. Each scientific expedition reveals more information about the biodiversity of this 'hotspot'.

Forests not covered under the Protected Area System

The island is divided into 26 Watershed Management Units (WMUs) containing over 100 streams and rivers. These WMUs are essentially composites of watersheds that fall within 10 hydrological basins (regions). Ten watersheds have been deemed in critical condition: Rio Grande, Hope, Swift, Wag Water, Rio Cobre, Yallahs, Rio Minho, Buff Bay, Oracabessa and Morant Rivers. In these areas, deforestation and soil erosion including landslides is a growing problem. Agriculture and other activities are not regulated so *in situ* conservation of PGRFA is not ensured. Rehabilitation of these watersheds has been designated as high priority by the Government but little actual work is happening.

Surveying and inventorying of Plant Genetic Resources for Food and Agriculture (PGRFA)

While there have been several surveys and inventories done on Jamaican biodiversity, such work is fragmentary and there is no one place where all such studies can be found. The most complete compilation (Flora of Jamaica by Adams) has no pictures. Examples of such studies carried out in the last ten years include pepper (Caribbean wide collection of wild and cultivated varieties), banana (*in vitro* collection made), fruit crops (identification of elite mother plants), cassava, sweet potato and medicinal plants (*ex situ* collections made from the wild). There has been less emphasis placed on gathering wild relatives of food plants, such as the long-neck avocado. The studies that have been done are being stored in many different places, many of them not even in Jamaica. Some studies are within the MOA offices, in EIA's; by NGOs; by academics or companies; some within projects and some remain unpublished. Of the many journal articles and papers, they are scattered world-wide. There is no nationally coordinated system for surveying or inventorying of any of Jamaica's biodiversity. In order to make any sensible look

[2] http://www.cockpitcountry.org/

at Jamaica's biodiversity, it cannot be done based on others work but a strong baseline study will need to be undertaken and properly documented while past studies are gathered and compared to such a baseline study.

Actions taken to improve inventories and surveys include debt swap arrangements resulting in funds for biodiversity studies, by the Environmental Foundation of Jamaica since 1993 and the Forest Conservation Fund since 2006. Other funds have been provided IOJ, MOA and UWI. However, these efforts are uncoordinated, unplanned, inadequate (in time and space), under recorded and results are not archived in one location. Also, many of these studies have been of an ecological nature, for timber or medicinal plants but have not been focused on PGRFA.

Constraints identified for improving inventories and surveys of plant genetic resources, crop-associated biodiversity and wild plants for food production are lack of knowledge, not in work programs (in terms of finance or time), mis-match between training programs (tend to be environmental) and training needs (such as parataxonomy, plant inventory and field gene bank and seed bank management), lack of policy and priority.

Priorities for future inventories of PGRFA include cassava, solanaceae species (such as duppy susumber), fruit tree crops, citrus varieties, yams (Yampie, Hard Yam, Lucea, Moonshine, Yellow Yam, some unnamed wild varieties etc) and sweet potato. A general inventory for all PGRFA need to be done in a work program (supported by scientists) to document where we are so we can chart our progress in the future.

The main capacity-building needs and priorities to support inventories and surveys for plant genetic resources, crop-associated biodiversity and wild plants for food production include the development of an adequate ICT system and the employment of suitable university-trained personnel who are encouraged to remain linked to the academic system to ensure scientific reliability of the inventories and surveys. Most of all, the decision to do the PGRFA inventories, supported by adequate funding, is needed.

For such efforts to make a better contribution towards knowledge and planning for wild biodiversity and PGRFA, these individual efforts will need to be coordinated using one internationally-compatible data gathering and database system used by all institutions (local and overseas) who take part in inventories and surveys of Jamaican plant biodiversity. A conservation policy and work program will need to be supported as field gene banks, seed banks and protected areas need on-going funds to survive and make a worthwhile contribution. A proper database and archiving system is also needed. The two hotspots described above should be priority areas for such studies. However, it should be remembered that the wild plant genetic resources for food and agriculture may be found outside of these two hotspots so other areas need to be surveyed as well.

Other recommendations include the need to have a national forum on PGRFA to bring together all the stakeholders to determine what has been done already for PGRFA, to identify the benefits of such an approach, to document what research and development is being done now, and how we can continue to work together.

Supporting on-farm management and improvement of plant genetic resources

A few farmers are trained in the on-farm management and improvement of PGRFA but this is limited and insufficient. There is a need to train farmers in order to equip them to do their own conservation of PGRFA. It is suggested that farmers can be encouraged to manage and improve PGRFA on-farm if it were economically viable. Ideas on how to do this include: providing such farmers with training and

technical support, linking such endeavors with eco-tourism, and providing a suitable legal and incentive framework (such as a tax break). Under the fruit tree project, fruit trees were selected and farmers trained in seed and nursery production while receiving financial and technical support. Such efforts did not replace wild varieties. Now this component of on-farm management has reciprocity as such farmers can be asked to provide bud wood for further expansion.

To date, there is no policy or incentives related to on-farm management of PGRFA. Any on-farm improvements of PGRFA are initiatives of individual farmers on their own recognizant. There has also been no national or regional forum for stakeholders involved with on-farm conservation. There are also very few on-farm participatory plant breeding programs or activities. Even in the public sector, there are very few breeders, plant breeder programs or even plant propagators. Neither is there any institutional support for local or small scale seed production. When such on-farm endeavors arise, eg for production of callaloo seeds, it is a private initiative with negligible public support. Packages of callaloo seeds locally produced are now sold (irregularly) at stores throughout Jamaica, with callaloo being sold in markets and supermarkets and this has also encouraged export of the crop. With this development, however, there has been neither recognition of specific callaloo varieties nor any means to do so. However, the government and scientific community do support such breeding programs as it is recognized that higher yields will be difficult without them. The will is there but not the means (financial and regulatory).

Other additional actions that support on-farm management is the development of markets for products originating from traditional and underutilized crops. This includes canning of crops for the ackee and callaloo export market and development of a range of derived products such as cassava bammy and pancake mix, aloe jam, sorrel chutney, otehiti apple juice, breadfruit and cassava chips, and vacuum packaged yam. These are sold locally and exported.

Assisting farmers in disaster situation to restore agricultural systems

There are many documented interventions for helping farmers after hurricanes. RADA has a preventative and disaster-recovery program. This includes cutting down banana trees, pruning trees and land stabilization. Commodity boards, NGOs and international groups such as IICA also work with farmers. Distribution of seeds and other crop supplies is essential. This is done on a needs basis after disasters (hurricanes, land slippages or floods). Some crops, such as banana, do not survive a hurricane episode (or even a high wind episode) and such farmers will need crop insurance or would need to diversify their farm during the recovery period. Crop insurance for banana began in 2007.

As a response to Hurricane Ivan in 2004, a different approach was taken. The hurricane disaster recovery period was used to introduce a farmer registration system and new technology. Along with distribution of seeds and fertilizers, greenhouses were built and this resulted in a quicker food recovery response. When another hurricane came, it quickly became evident which structures worked and which didn't. Crop production benefited from the increased application of technology (such as greenhouses), distribution of seeds, planting materials and fertilizer after floods and hurricanes. By 2007, greenhouse or protected agriculture was established on about 1% of area and 5% of production on about 200 acres. For some selected crops such as tomatoes, bell peppers and lettuce, an even higher percentage of their production is under protected agriculture. As well as the speed of recovery after the hurricane, this development is freeing up fragile landscape - for example, tomato is no longer being produced on sloped lands. However, for crops not amendable to greenhouses, there was a longer time lag for recovery (especially for banana which sometimes recovered just in time to be destroyed by another hurricane or disaster [eg high winds] in the following year). In order to protect such crops, imports are curtailed and farmers supported as much as possible.

The major constraint to establishing effective plant genetic resources disaster response mechanisms is the unpredictability of such disasters. Added to this is the poor road quality and hilly terrain making it difficult to get to farmers after a disaster. This is compounded by the difficulty in determining who has the greatest needs. A proper data gathering system will assist greatly in this area.

Needs and priorities in establishing an effective PGRFA disaster response mechanisms include determination of a national focal point, a dedicated 'disaster' phone-line at the national focal point which is linked to cell numbers of the relevant officers and provision of 'disaster' vehicles and equipping of extension officers with real-time GPS devices. There is a need for the National Disaster Response Mechanisim to be better co-ordinated with the agricultural sector. There is a need to improve the communication planning and coordination mechanisms. This is being implemented in 2008 for the first time. Such information will need to be available for use in restoring PGRFA following disasters so sensitization of those involved with developing this system is a priority. Another priority is the equipping of the relevant authorities with needed weather systems such as rain gauges and earthquake monitoring units. Improvements of facilities before disasters will also help eg strengthening bridges, cleaning gullies, building schools to disaster recovery standards. There must be care in building highways to provide for drainage as during disaster events, poor drainage can lead to floods which can affect crop production.

There is a need to know what is on the land before a disaster. This will require monthly crop reports and estimates. A database would provide a facility with information as to what the 'normal' pattern was prior to the disaster. This will provide information as to what kind of seed stock is needed and how to distribute aid.

To improve regional and international disaster response, we need an independent weather reporting system. In the Caribbean, we rely heavily on overseas programming and they often do not highlight relevant areas in the Caribbean in real-time although they have been getting better. Such a warning system is needed for tsunamis as well as hurricanes, high rain and drought events. Also, there is increasing talk towards crop-insurance schemes to ease the damage from hurricanes but also from droughts. This is important as the probability of a hurricane strike has risen in recent years from one on 16 years to one in three years, due to global climate change.

Priorities for future inventories and surveys of plant genetic resources, crop-associated biodiversity and wild plants for food production.

There are no planned priorities for future inventories and surveys. Funding remains a limiting factor. As a result of this review, the following priority crops were identified: cowpeas, yams, avocado, cassava, sweet potato, cocoa, pomegranate, breadfruit and wild relatives of pumpkin, fruit trees, scotch bonnet, sugarcane. Other priority PGRFA includes yam stick tree species, spices and medicinal plants. The two 'hotspots' are priority areas for protection by the Forest Conservation Fund but inventories and surveys depend on such projects being formulated and accepted by the Fund.

Promoting *in situ* conservation of wild crop relatives and wild plants for food production

Jamaica presently has policies for protected areas but they are not being properly respected or maintained. Such policies need to be strengthened and supported by on-going work plans (these should become sustainable or adequately supported in the budget or by international commitment on a long-term basis to ensure continuity). It is also suggested to make it mandatory for any important biodiversity found during an EIA to be moved to a protected area for *in situ* conservation before development of the area (urbanization etc) is allowed.

Conservation can be encouraged by spending money to properly maintain protected areas for *in situ* management of wild relatives of PGRFA. This will be facilitated by the development of research groups including taxonomists, economists, ecologists, agriculturists, breeders etc for *in situ* conservation, development of *in situ* gene banks, sustainable use and development of alternative livelihoods.

The greatest limitation to *in situ* conservation of plant genetic resources, crop-associated biodiversity and wild plants for food production in Jamaica is population pressure on the land for development and mining. Therefore, protection of such plant genetic resources has to be a long-term commitment of government (eg no mining in the Cockpit Country and BJCMNP). Since these areas represent hotspots, international assistance to protect this biodiversity should be considered by international biodiversity conservation groups such as GEF.

Other limitations are lack of knowledge, lack of vision, and lack of priority in work programs. There is no legal requirement to inventorize our biodiversity. We have no comprehensive inventory of our biodiversity and such as exists has not been considered for its economic value. There is a serious lack of documentation.

The major research priority therefore is to undertake a comprehensive inventory of PGRFA for the whole country in order to determine the local varieties present (taxonomy, pictures, GPS, herbarium samples, flowering and fruiting times, comprehensive documentation), flowering and fruiting times, yields, molecular and biochemical studies, and biodiversity valuation. Studies into genetic erosion, effect of diseases, genetic vulnerability and invasive species also needs to be carried out. Studies into developing *in vitro* propagation and conservation methods should definitely be part of the research priorities. Linkages need to be forged and maintained between the MOA, FD and the academic community to secure and sustainably use crop-related PGRFAs. There needs to be sensitization of the public and policy makers to their strategic and economic importance. There needs to be a national forum, an outcome of which needs to be a dedicated and coordinated work program among the national and international stakeholders.

Policy development priorities to support improved plant genetic resources *in situ* management has to begin with a comprehensive inventory and national forum followed by sensitization and meeting with focus groups to provide mechanisms that will allow for sustainable development along with conservation of the PGRFA. A policy priority is also to require that any study or research on Jamaica's PGRFA must provide two copies to an upgraded National Agricultural Library.

Chapter 3: *The State of Ex situ Management*

There are times when *ex situ* germplasm collections are needed: whether field, seed or *in vitro* collections. For developing countries, *ex situ* germplasm collections can be quite difficult to establish and maintain so support needs to be adequate, multi-purpose and developmentally sustainable. For example, field collections of medicinal plants can be linked to production of elite planting material for commercial production. Tissue culture procedures can be used to develop *in vitro* germplasm banks for conservation of genetic resources while providing elite planting material to farmers. *In vitro* protocols are especially needed for endemic and endangered accessions so they can be conserved and perpetuated for the future but all these types of *ex situ* germplam collections require adequate on-going financial support.

State of collections

Botanical gardens

Botanical Gardens have traditionally been used in Jamaica to gather and maintain germplasm, both to send them overseas and to receive incoming germplasm. Public Gardens presently in service include the Hope Botanical Garden Estates, Castleton, Bath and Cinchona. The Hope Botanical Estates has no listing of its present flora, and few historical records. The gardens have mainly been used as a transit facility for incoming germplasm (for food and horticulture) rather that a place to conserve germplasm of cultivated species or to conserve wild relatives of such species. The Hope Botanical Estates has an operating plant nursery which supplies the gardens and the public with various plant species. The gardens have established horticultural, xerophytic and palm gene banks while a medicinal tree grove is being established. The other public gardens have been used to collect seeds and bud woods of different species and conserve germplasm. Cinchona, for example, has collections of lychee, longan, mangosteen, raspberries, and blackberries.

Field and seed banks

The MOA, Research and Development Division has maintained field banks from early colonial times (including botanical gardens and private collections) and seed banks since 1990s. The present storage facility for the seed bank is inadequate (in size) and lacks a back-up system.

Throughout the country, various collections of plant races of many crop species have been initiated and are being maintained with varying degrees of success. The active field banks of the MOA are maintained at the Bodles, Orange River and Top Mountain Research Stations. These *ex situ* field collections include pepper, pumpkin, sorrel, pigeon pea, cow peas, cassava, sweet potato, mango, star apples, *Annonas* spp., pomegranate, cashew, june plum (tall and dwarfs), breadfruit, ackee, oteheite apple, guavas, nutmeg, West Indian cherry, and exotics (miracle fruit, lychee, cherimoya, longan, mamey apple, camu camu, and cocona [*Solanum sessiliflorum*]). Recent accessions include a collection of Caribbean-wide varieties of hot pepper

Other active *ex situ* collections are being maintained by the Coconut Industry Board (coconut), Banana Board, UWI (Medicinal Plant collection), CARDI (hot peppers, sweet potato), private nurseries (Citrus Growers Association). There are two *in vitro* collections (SRC and BTC, UWI).

Ackee (*Blighia sapida*)**:** Since 2000, under government's support of the fruit tree crop sector, ackee is an US $ 40 million expanding industry. Commercial orchards of over 1,000 ha are being established. A genebank of ackee at Bodles has two main accessions (butter and cheese).

Avocado (*Persea americana*)**:** Avocado is being rapidly expanded in commercial orchards. Genebanks are being maintained at Bodles and Orange River (16 accessions). Many varieties have been lost. There are presently many varieties of avocado in Jamaica that need to be rediscovered and reassembled.

Banana (*Musa* spp.)**:** Banana is adversely affected by hurricanes and high wind episodes. A field genebank is being maintained at the Bodles Research Station operated by Banana Board with over 147 accessions. An *in vitro* collection of banana accessions is being maintained by SRC.

Castor beans (*Ricinus comunis*): (several accessions) have been introduced by the JBI.

Citrus (*Citrus* spp.): The MOA has introduced germplasm under the Citrus Replanting program. Under this program, eight rootstocks resistant to tristeza were imported. Reintroduced indigenous varieties that were 'cleaned up' included ortanique but there was a physiological difference in the fruit obtained. Over 38 accessions are maintained in private nurseries (Citrus Growers Association) under the oversight of the Citrus Protection Agency.

Cocoa (*Theobroma cacao*)**:** Cocoa germplasm is being maintained at the Orange River Research Station, commercial plantations and in farmer's holdings. It is estimated that six accessions are being maintained at Orange River.

Coconut (*Cocos nucifera*)**:** A coconut genebank is being maintained by the Coconut Industry Board where over 54 accessions are being held. Traditional plant breeding is being supported by genetic techniques to overcome the threat of lethal yellowing.

Mango (*Mangifera indica*)**:** 48 accessions are being held at Orange River. Commercial orchards are being established. Mango is used for local consumption, agro-processing and export of fresh fruits, mainly to Europe.

Pasture grass and legume germplasm**:** Recent introductions include mulberry, *Trichantera*, pasture grasses, jara grass and several *Panicum maximum* (Jamaican guinea grass, Mombassa), *Pennisetum clandestinum* (Kikuyu grass pure) and *Pennisetum purpureum* (King grass, Meyberon, dwarf elephant grass, N69 and Napier grass) varieties. There has not been much recent interest in this area because of the down-turn in the livestock industry.

Peppers, hot (*Capsicum* spp.)**:** Scotch bonnet (*Capsicum chinense*) collection is being maintained at Bodles and West Indian Red (*C. chinense*) at CARDI.

Pimento (*Pimento dioica*)**:** The MOA through its export division maintains a nursery for pimento seedlings. There is a genebank of pimento at the Orange River Research Station. Improved selection techniques for pimento include approach grafting and this has resulted in the selection of high yielding cultivars. The acreage in pimento has increased due to governmental support and distribution of seedlings. This crop is important for domestic consumption and as an important foreign exchange earner (Table 4 does not include export of pimento oil which is substantial). Several value-added products are also sold internationally. Total exports for whole pimento, pimento leaf and berry oils, liquors, jerk seasoning etc earned ~US $ 5 million in 2006.

Table 4 Pimento exports for 2006

Jan-Dec 2006		Kilogram	J$ FOB Value	US$ FOB Value
Pimento (allspice), dried, crushed or ground.	Canada	9,023	3,725,564	56,827
	India	10,000	3,197,611	47,998
	Japan	57,552	23,181,738	355,322
	Netherlands	50,000	13,004,740	200,804
	Netherlands Antilles	10,000	2,411,616	37,205
	Sweden	20,000	8,818,070	136,008
	Trinidad And Tobago	1,016	456,763	7,112
	United Kingdom	28	40,387	614
	United States	106,941	37,496,898	568,595
	TOTAL	264,560	92,333,388	1,410,484

Source: Jamaica Export Association

Root Crops**:** Several root crop germplasm collections have been made over the years, with a lot of them being lost for one reason or another. Presently there are Sweet Potato varieties being maintained at CARDI (8) and MOA (Top Mountain, 22 accessions). For cassava, seven accessions are being held at the Bodles Research Station while the Bauxite Institute introduced 3-4 accessions from the Dominican Republic. Cassava continues to be an important domestic and export crop for Jamaica and a number of food products have been developed such as bammy (local bread), pancake mixes, chips, while there has been increased attention for its use in animal feeds. Yam varieties were being conserved at the Biotechnology Centre, UWI but were lost after staff changes; some varietal collections are being conserved by a few farmers.

Medicinal plant collections**:** A medicinal plant garden *ex situ* gene bank is being maintained by the Biotechnology Centre at UWI with between 50-100 plant species being represented by at least one plant. The medicinal trees are being planted at Hope Botanical Gardens in a medicinal tree grove.

***In vitro* collections**

Scientific Research Council: The Scientific Research Council *in vitro* gene banks includes banana and plantain local and international varieties (58 varieties), cassava (9), sweet potato (12), yam (2), pineapple (2), coffee, ginger (4), sorrel (2), turmeric, fever grass, vanilla, boston fern, natal plum, jack fruit, rose apple and sugarcane. The ornamental collection includes anthuriums (25), african violet (5), bamboo jasmine, gloxinia, kalanchoe, pink ginger, pink rose, syngonium, white begonia and orchids (8).

The Biotechnology Centre, UWI: The Biotechnology Centre has an active tissue culture collection of mainly medicinal plants. Plant species presently *in vitro* include: aloe (*Aloe vera*), ackee, arrowroot (*Maranta arundinacea*), bottle brush (*Callistemon viminalis*), cerassee (*Momordica charantia*), chainy root (*Smilax balbisiana*), ginger, fever grass (*Cymbopogon citratus*), medina (*Alysicarpus vaginalis*), neem (*Azadirachta indica*), pepper elder (*Piper amalgo*), pineapple (2), sarsaparilla (*Smilax regelii*), scotch bonnet pepper, spirit weed (*Eryngium foetidum*), strong back (3), tuna (*Opuntia cochenillifera*), turmeric, wicker (*Philodendron* sp.) and yam.

Ex situ management of germplasm

Farmers save seeds for their crop (from themselves or neighbors) for some of their crops such as sorrel, okra, gungo peas, callaloo, pumpkin and peanut (informal multiplication of seeds). Local (formal) production of indigenous seeds is being undertaken by the MOA for pumpkin, sorrel, scotch bonnet pepper and corn using better seed production techniques, and improved varieties in some cases, but without using a reference nomenclature. The MOA also produces grafted fruit trees. Hybrid seeds are not saved by farmers. These are sold locally by international markets based on local recommendations and feedback and include tomato, cabbage and sweet pepper varieties.

There is no nomenclature in place to name new varieties. They are named on the whim of those concerned but have no reference number. It is suggested that an internationally accepted system be used to name and classify these varieties such as a Plant Introduction System. Of concern is the need to separate the varieties in the first place, by using phenotypic and genetic (DNA fingerprinting) characteristics. Another concern is that when researchers gather food varieties (eg cow peas, yams etc) and the researcher finishes their research, the collection is not disbanded and lost.

Sustaining existing *ex situ* collections

Several actions have been taken to sustain *ex situ* genetic resource collections over the past ten years. Some have been successful and some have not. International collaboration with FAO with local funding from EFJ, FD and MOA has been useful but inadequate.

- Botanical gardens: Plant species have been lost from botanical gardens as priorities change over the years, or as a result of neglect, disease or old age.
- Field collections: PGRFA have been lost from field collections due to praedial larcency, lack-of-use (cocoa), loss of field labels and field notes, abandonment of field stations, lack of long-term commitment and insufficient on-going work programs.
- Seed collection: The seed collection is properly maintained but has no stand-by generator.
- In vitro collections: Several species have been lost from *in vitro* collections because of change of staff, no dedicated staff to maintain the collections, change of priority plants, ending of project funding, lack of adequate growth-room space and low levels of on-going funding.

Worst of all, lack of proper documentation and characterization, in a similar format regardless of the collection, has prevented what knowledge has been gathered to be used to prevent mistakes being made over.

The greatest constraints to sustaining *ex situ* plant genetic resource collections over the next ten years are lack of (project and continual) funding, lack of appreciation of the importance of such collections, insufficient dedicated staff, lack of specific training, lack of use of trained people, insufficient equipment, lack of facilities, lack of a proper coordinated IT system for recording varieties being collected, irregular electrical supply (less important but still a threat), praedial larcency, and finally, but not exhaustively, threat of hurricanes and other natural disasters.

The greatest constraint to expanding plant genetic resources *ex situ* collections over the next ten years would be lack of priority and therefore funding and training for such activities. Without policy support, such collections will continue to be made and maintained only where individuals are interested to do so and will remain uncoordinated. The full contribution of such collections to the economy would also not be fully realized.

Priorities for sustaining and expanding *ex situ* plant genetic resource collections over the next ten years for major and minor crops and wild PGRFA include: collection and recording of land-races and wild relatives of crop species especially the fruit trees, expanding and stabilizing the present and potential economic crops with collections of wild relatives and new crops such as medicinal plants, and expanding seed and *in vitro* collections. Establishment of a documentation system backed by the requisite authority to ensure it is used should be done in real time and in long-lasting formats. This includes methods to record varieties in *ex situ* collections so if field labels are lost, vital information will not be lost. None of the collections mentioned above have duplicate accessions elsewhere, nor are there any legal instruments to facilitate this. Sustainable funding needs to be provided for this as a priority. An important policy that needs to be adopted is to protect the PGRFA for all crops in spite of present economic use.

Documentation of past and present *ex situ* PGRFA collections is fragmentary with many being lost. In 1995, the FAO documenting system was used for such collections but the software became obsolete and the data could not be transferred. This document and associated database represents the most comprehensive attempt of documenting our PGRFA. The present FAO system will be used to better document Jamaica's *ex situ* PGR collections but to prevent previous losses, a paper copy will be made each year of the excel files. It is felt that since one is never sure when wild biodiversity may become PGRFA, that all of our biodiversity should be dealt with in one comprehensive database and documentation system.

Research needs include determining the levels of seed viability of seed gene banks and development of *in vitro* short-term and long-term conservation and multiplication protocols for the various crops and wild varieties (for those without seeds). Other research needs include establishing methods for suitable *ex situ* field germplasm collections and breeding (traditional and molecular methods) for better varieties.

There have been a few cooperative arrangements established with regional and international networks to enhance *ex situ* plant genetic resources conservation. The most important are FAO and CARDI and to a lesser extent seed companies. For example, pumpkin varieties bred locally are sent to California and Japan for bulking-up to prevent genetic erosion. If such bulking-up is done locally, the plants would have to be grown in isolation cages or protected houses and sometimes it's just more economical to do it offshore.

Seeds from the seed bank are regenerated on a periodic basis depending on the crop to ensure viability. Standard management practices are employed to prevent genetic erosion of collections during regeneration. No such arrangement is in place for planting out *in vitro* collections. *In vitro* methods used must maximize genetic integrity (use of preformed meristems and prevention of adventitious growth) and these methods must be made mandatory (eg methods that minimize adventitious growth and do not damage the meristematic shoot tip).

Maintaining viability and preventing genetic erosion in *ex situ* plant genetic resource collections over the next ten years will require a change of culture. The whole idea of a plant variety is strange and there is no plant variety protection in Jamaica. Such protection needs to be legalized. Priority will therefore have to be given to training as to the importance of maintaining viability and prevention of genetic erosion and training in methodology to accomplish this goal. Such training will need to be a priority for regional and international cooperation. Help will also be needed to identify and bring in new genetic material, networking for inventories, for duplicate collections, material transfer agreements, IP and Plant Variety Protection. Such a problem occurred in the coffee sector. New varieties were brought into the county to test for yield and possibly improve the local strain. This new genetic material escaped due to hurricane damage and now threatens the taste of Blue Mountain coffee.

Planned and targeted collecting of Plant Genetic Resources

The collecting activities undertaken in the past ten years to improve *ex situ* plant genetic resource coverage have been highlighted above. There are gaps in collections not for the major crops (sugar, pimento and coconut germplasm collections being better off than cocoa and coffee) but for the minor crops, underutilized crops, forages, wild plants for food production and wild relatives. These gaps have not been identified in detail nor plans developed to fill these gaps.

The greatest constraints to undertaking collecting missions to overcome gaps and address priority needs is lack of gap identification, lack of suitable documentation systems, lack of priority and therefore attention and lack of dedicated continuous funding. Collection priorities and needs are unknown at present. Conservation efforts are needed for important species that cannot be conserved effectively as seeds. Research needs and priorities in relation to enhancing the collecting of PGRFA have been highlighted elsewhere in this document.

Assessment of major *ex situ* needs

The following are priority needs for Jamaica: sharing the burden of the costs of conservation of endemic, wild species and wild relatives of food species in our hotspot with others, improved germplasm management, filling the gap in collections, developing low cost conservation technologies, developing global regeneration efforts, developing global but also locally suitable and useful documentation systems, enabling safety duplications, and development of pathogen-tested collections of priority crops.

Chapter 4: *The State of Use*

Natural biodiversity can be used in sustainable and unsustainable ways. Direct uses of plant genetic diversity in Jamaica were identified. The list below is in no way exhaustive but serves as a base for further research and refinement.

- Agriculture – major and minor crops, primary and value added – food (land and sea), spices, flowers and other ornamental plants especially endemic orchids, honey, sauces, sugar, liquors, tonics, fruit juices, ice cream, soaps, molecular characterization of plants such as hot peppers, beans and yams;
- Wild biodiversity – timber, ethnomedicines, bio-pesticides, aromatic plants, herbal teas, tonics, essential oils, natural products, fragrances, cosmetics, building materials, natural fibres, craft, charcoal, yam sticks, tanning leather, dyes;
- Biotechnology – rums, vinegar, wines, provision of high quality and quantity of planting material of various crops through tissue culture (micropropagation and somatic embryogenesis) including food crops, ornamentals, fruit trees, natural fibres and medicinals), hydroponics, composting, biodigesters, biopesticides, and production of transgenic crops such as papaya;
- Tourism – beaches, land and marine parks, nature reserves, natural attractions, eco-tours and trails, heritage festivals, hiking, adventure excursions and community tourism. The number and types of indigenous and endemic plants are always a source of fascination and their use has be monitored very carefully;
- Cultural, artistic and aesthetic value – folklore and traditions, pictures, songs, carvings, seeds used to play games, trees for rest and beauty;
- Educational – taxonomy, habitat research, bioprospecting on land and sea for plants, agricultural research;
- Experimental – natural products from medicinal plants, production of new industrial raw materials from micro-organisms (production of xanthum gum from *Xanthum campetris* on fermented molasses), production of soil inoculants, biogas, biodiesel and molecular farming.

Tourism

Tourism is dependent on the natural environment (such as white sand beaches, rivers, mountains, forests and associated biodiversity). The diversity of Jamaica's landscape presents unique vacation opportunities. Tourism has traditionally focused on carefully designed botanical gardens, medicinal springs, and white sand beaches, but now there is a perceptible shift to the cool forested interior streaming with unique plant life. Closely associated with tourism, the cottage craft industry has produced skilled craftsmen and artisans who specialize in woodwork and weaving using indigenous Jamaican timber (eg mahogany) and non-timber (eg wicker) forest plants. Community tourism is also on the rise. Heritage festivals are becoming commonplace such as the Yam, Jerk and Curry Festival. A call has also gone out for a Jamaican food festival.

Tours of various types through the forested interior are becoming more common. The Bowden Pen Farmers Association reopened a historic hiking trail used by the Maroons over 300 years ago as part of its efforts to promote Jamaica's heritage and ecotourism. The five-mile Cunha Cunha Pass Maroon Trail, which links the parishes of Portland and St Thomas, was the site of some of the most intense battles between British colonists and African runaway slaves known as Maroons, who eventually won their independence after years of fighting. This project is expected to bring economic opportunities to the

community while giving visitors a chance to learn about Jamaica's historical heritage, medicinal plants and cultural diversity. Community members would not only be educated on some of the resources in the area but they should also take advantage of economic benefits such as filling the need for accommodation[3].

Tourism can be used as a marketing tool to introduce new products made from minor and underutilized PGRFA into new markets.

Agriculture

Jamaica's total land area covers over 1 million ha, 25 percent of which were under cultivation in the 1980s. The total cropland in 1999 was 274,000 ha. In 1985, about 145,000 ha, mostly in the coastal plains, were determined to be highly fertile, and another 350,000 ha were suitable for cultivation with various limitations. The remainder 160,000 ha of agricultural land remained idle or underutilized.

The state of use of biodiversity in agriculture is often for food but increasingly for non-food uses. Sugarcane still covered over 25 percent of all agricultural land in use. The uses of plant biodiversity for agriculture have been extensively described elsewhere in this document.

Forest biodiversity

Jamaica's forests are the main repositories of wild biodiversity, especially the endemics. Jamaica's forests are also largely disturbed forests with many of the original trees such as mahogany removed while many of the imported trees are now indigenous. Forests play an important function in air purification, conservation of water supplies, soil formation, climate modification and protection of the coastal lowlands and marine ecosystems from the effects of flash flooding and sedimentation.

Jamaica's forests provide diverse economic employment opportunities. Products extracted from the forest include: fruits, fuel wood, medicinal plants, yam sticks, lumber for construction and furniture, fence-posts, wood for fish pots and charcoal, also wicker and other materials for craft items. Wood and charcoal provides energy used in the popular jerk food industry. In addition, the age-old search for new foods, medicines and textiles from the wild, now termed bioprospecting, still continues[4].

Many Jamaican craft items utilize forest biodiversity such as the straw baskets made from the sisal plant, bags made from banana leaves, wicker furniture from the *Philodendron* plant, and furniture from bamboo and can lead to further diversification of crops. Many medicinal plants are wildcrafted (gathered from the wild) from the forests.

Bioprospecting, and the use of genetic resources in biotechnology, opens up a wealth of potential uses, particularly in agriculture, the pharmaceutical industry, botanical medicine, and the cosmetic industry. Some potential biological resources include Red Nickel, being used to develop a commercial drug, dye from bitter wood, an anti-cancer drug from guinea-hen-weed and a sea urchin (*Lytechinus variegatus*) with many more potential opportunities (Mitchell and Ahmad 2006). However, the obligation to protect and preserve this traditional knowledge has not been addressed in any systematic manner and there is no standard definition of what is 'traditional knowledge'. There also needs to be a concerted effort to protect and use this traditional knowledge for development or it will be lost for all.

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[3] Jamaica Observer http://www.jamaicaobserver.com, July 14th, 2003

[4] Institute of Jamaica, Natural History Division http://www.instituteofjamaica.org.jm/biodiversity.htm.

Bioprospecting

Countless biological resources of unknown value are destroyed in the process of harvesting a few products such as trees for timber from the forest[5]. Tropical forests and marine habitats are being destroyed because they are not fully valued for their role as reservoirs of the world's biological resources. There is a growing recognition that tropical forests and marine waters are valuable reservoirs for products yet to be discovered and developed for use by man.

Bioprospecting includes more than the search for compounds that may lead to new, commercially viable wonder drugs. Non-timber forest products have also yielded promising results in the search for

- New foods and fibers
- Pathogens, predator insects and botanical pesticides to control agricultural pests
- Native plant species of commercial food crops that through cross-breeding can introduce resistance to pests or tolerance to harsh growing conditions.
- Marine habitats hold similar promise.

Bioprospecting can produce significant economic and social benefits if done sustainably. Money from such concessions can flow back into habitat protection and management while generating employment and income for local communities. Countries can also benefit from royalties and patents emerging from new chemical and product development.

Bioprospecting is an approach to conservation of biologically rich areas that warrants serious consideration for fostering environmentally sustainable development. The participation of local communities in such activities and programs should be encouraged. However, the following safeguards need to be instituted:

- Regulation. To ensure that bioprospecting does not destroy some of the resources it seeks to tap.

- Distribution of benefits among industrial and developing countries. To ensure that developing countries are not at the mercy of large multinational firms who will patent and control the biological resources they locate e.g., access to new food crops propagated from their own native species.

- Distribution of benefits among participants within participating countries. To ensure that the benefits from bioprospecting are shared among stakeholders – the government, scientists, local communities and protected areas to ensure sustainable ecosystem protection and management.

- Autonomy and control. To ensure that local communities and indigenous populations do not lose control of their resources and the benefits of bioprospecting by outside bioprospecting ventures.

- Social and development priorities. To ensure that scarce development resources do not get lost in the search for potential payoffs, that a system of national parks or ecotourism interests are also satisfied.

- Distribution of benefits throughout the community. To ensure that the development benefits the masses rather than just a few.

[5] Win-Win approaches to Development and the Environment, Bioprospecting and Biodiversity Conservation (July 1996) Centre for Development Information and Evaluation, US Agency for International Development.

Expanding the characterization, evaluation and number of core collections to facilitate use

Jamaica has no established mechanism to record distribution of samples of conserved plant genetic resources to breeding programs except through material transfer agreements. These MTAs are not readily accessible or centrally archived. The sugar cane industry is the exception with the breeding station for CARICOM being in Barbados. Crosses are made there and seeds distributed every year to national programs. These seeds are grown out and tested under local conditions. A sample of each selected variety (which is given a unique number with the first two digits being the year of selection) is sent back to Barbados to be used for further breeding work. Other examples of local varieties being sent abroad include pepper (*Capsicum chinense*) and pumpkin seeds to Trinidad and Tobago, and sweet potato varieties to CARDI.

Within Jamaica, seeds are sold from the MOA but the location where the seeds are planted is not recorded. None of the varieties are given a unique number but each is given a unique name. So far, seed banks, field banks or *in vitro* germplasm collections are not advanced enough to facilitate use but have been used for conservation only. An exception to this would be some of the fruit tree collections which are being used to obtain more bud wood for distribution. On a small scale, micropropagated plants are available with the major crop plantlets being distributed or sold being ginger, sweet potato, banana and pineapple.

Increasing genetic enhancement and base-broadening effects

Disease-resistant varieties of scotch bonnet pepper (*Capsicum chinense*) with genetic enhancement from other *Capsicum* spp. was bred with the help of marker assisted breeding techniques. Many of the crops grown in Jamaica are not optimised to our conditions and because they are not native, wild varieties or related species are scarce. For such crops, lines need to be collected and varieties optimised by selection and/or plant breeding (assisted with such molecular techniques as marker-assisted breeding) and protected as a variety. This variety protection is a priority before new varieties are brought in for testing. Such crops should be selected and/or bred not only for high yield but also for suitable agro-processing requirements (eg cheese ackee for canning, high starch content in potatoes for chips) or phytochemical levels (eg citral levels in fever grass or eugenol in pimento). Collection, selection and breeding should be made part of a national work-plan, allocated to the relevant institutions and research groups.

Lychee and Logan were plants imported quite some time ago but newly imported varieties are more adaptable than the older varieties. When varieties are brought in for testing, care should be taken that the local varieties are not changed. This may have happened in the case of the Blue Mountain coffee variety. Ginger imported to make up the shortfall in Jamaican ginger has left the supermarkets and is being farmed and it is no longer certain how much of the ginger area is in which ginger variety. Also, citrus fruit taken abroad for in vitro grafting did not produce the same type of fruit when it was returned.

Promoting agriculture through diversification of crop production and broader diversity in crops

There has been a growing tendency of farmers to experiment with new crops as market needs change. Agriculture has been diversified as new crops have been promoted (eg medicinals) and elite planting material (eg hot pepper, pumpkin) has been made available. This has been discussed elsewhere in this document.

Promoting development and commercialization of underutilised crops and species

There are a few institutions that promote the development and commercialization of underutilised crops and species by developing value-added products. RADA has a food development section that has been producing, and assisting others to make, many value-added food products from local PGRFA. Examples include: bammies, gari, flour (cassava), pancake mixes, pancake syrup; chips from cassava, breadfruit and dasheen; jams and jellies and technical assistance in the processing of peanuts and tamarind balls. The food technology section of SRC has also developed many value-added products such as jerk seasoning, the patty, sorrel products (squash, chutney, liqueur, topping, sauces), mushroom products (jam, soup, cake mix and pickle), flour from yam and breadfruit, chips from banana, potato, plantain and breadfruit, soups, condiments, preservatives, liqueurs, jams and jellies. Training is also given by the SRC in various aspects of food processing eg solar drying, juice making and meat processing. Other examples of agro-processing include herbal teas and production of pimento oil. Identification of plant species with potential for commercialisation, development of ex situ gene banks, natural products research and provision of planting material through tissue culture also promotes the development of underutilized crops and species into commercial commodities.

Supporting seed production and distribution

Seed production and distribution is both a private and public sector function in Jamaica. The private seed providers try to develop and have available to farmers, seeds of plant varieties that they need. For example, with the increase in greenhouse production since 2003, seeds are being sold that suit the greenhouse environment as well as the open field. The seed providers are very cognizant of the major diseases affecting plants in Jamaica and provide the latest bacteriocides, fungicides and other products to prevent disease, and the plant varieties that produce a crop that Jamaicans will buy eg large tomato fruit resistant to local diseases such as gemini-viruses and nematodes. Many seeds needed by Jamaican farmers can be produced at a more economic rate abroad for some varieties so seed production has been outsourced.

The public sector seed providers are affiliated - Bodles, RADA and Forestry Department. Seed production and distribution from these entities has increased in the last ten years but is still inadequate. Plans are in place to upgrade this activity. Farmers are asking for more seed (and willing to pay for it) than is being supplied. Money and training needs to be invested before the imbalance between supply and demand for elite planting material is reduced. Some of the constraints identified are: technical reason (not enough people of a particular skill set eg plant breeders, budders), shortage of bud wood, institutionalism (in the government the system is not in place to enable profit to be ploughed back into the activity), and security issues (physical [stealing of the crop without understanding the need for the seed] and genetic [need for separation to prevent cross-pollination]). There are some plants that do not produce seed; these plants are vegetatively propagated and are prone to diseases. For these crops, there has been a renewed interest in elite planting material. While the knowledge of how to produce micropropagated planting material has been present since the 1980s in Jamacia, the recent increase in technology being applied to agriculture (with the recent introduction of greenhouses) has resulted in an increased interest in other technologies such as micropropagation.

Seeds and other propagating material needs to be provided by both private and public sources at a reasonable price. In providing seeds, care needs to be taken that desired characteristics are maintained eg to ensure that sorrel seeds provided will indeed produce sorrel all year round and that there is no genetic erosion. Some the constraints to overcome in attempting to increase the market for local varieties are small farm size (low throughput), hilly terrain, poor roads, and trade barriers (SPS, eg EU requirements). The response to this has been to identify niche markets (eg Blue Mountain coffee), develop farmer groups

and cooperatives, encourage linkages between agriculture and tourism, provide IP protection such as geographical indicators, and develop agro-processing ventures (to prevent spoilage and increase value of the product). This has been accomplished in the last five years especially by better coordination between government bodies, NGOs and academics.

Developing new markets for local varieties and 'diversity-rich' products

Development of new markets means market research but also requires a research component for development of new derived products such as jams and jellies. The Food Technology Instiute, an arm of the SRC, does excellent work in this regard. The largest problem is to provide new products from local varieties in adequate quantities at the required standard of new markets. That is why most new products are usually introduced locally before overseas markets are sought. To continue expanding, however, sufficient quantities of elite planting material, better cultivation methods, better transport and market systems with adequate certification standards, will be required.

Utilization and enhancing the use of plant genetic resources

Recent improvements in crop production can, to some degree, be attributed to the use of particular varieties. Some examples of this include the extension of sorrel production year round by the use of the year-round sorrel variety, increased scotch bonnet production and productivity due to the use of locally-bred resistant varieties, increased pumpkin production due to the new variety 'global', increased fruit production due to the use of selected varieties, and increased citrus production due to the use of grafted varieties on resistant root stock. All the above varieties were released since 2000.

There are several constraints that we face in terms of improving the use of our plant genetic resources. These include very low levels of characterization and evaluation (has only been done for some major crops), few core collections for which access has been provided, low levels of documentation of varietal ancestry (only for sugar), lack of characterization and evaluation (only collecting), low numbers of plant breeders, low use of trained molecular biologists, low knowledge of demands for pre-breeding and breeding activities amongst research groups and policy makers, insufficient funds, weak technocrat and policy development, insufficient infrastructure (need power back-ups and irrigation systems for example), lack of integration and coordination amongst conservation and utilization programs, researchers, breeders, genebank managers and farmers; and a poor concept of varietal importance.

Activities undertaken to enhance the use of plant genetic resources include

- increased collaboration between academics, other researchers and the MOA,
- increased utilization of underutilised species such as ackee and fruit trees,
- exploration of market opportunities for new crops and derived products is mostly undertaken by Jamaica Trade and Invest (JTI), Jamaica Export Association (JEA) and the Private Sector Organization of Jamaica (PSOJ). The competitive cluster approach of the JEA is used to maximise these opportunities. The institutions most involved with the development of new food and natural products are UWI, SRC and RADA.
- Encouragement of the participatory approach with more on-farm research by the formation of Local Forest Management Committees (LFMCs) in 2007 to work with the forestry department in the conservation and management of forest resources.

Over the period 1996 to 2006, there have been no training provided in plant breeding techniques of Jamaica's PGRFA. Some base-broadening activities have taken place but there was more before 1996 than after. In terms of landraces/farmer varieties, in some cases, the MOA breeding program obtained varieties from farmers (sorrel) and farmers have also been given varieties, but usually the development of land races is a one-way street. On the farm, there is a poor concept of a plant variety, and there is no strategy presently employed to address genetic vulnerability in the farming system. Characterisation of PGRFA has happened in a limited and fragmentary way, and no information system has been established for germplasm characterisation. Some core collections have been established but they need to become a permanent feature of the national workplan. In only a limited way has there been a participatory approach to plant breeding mainly through the fruit crop training component. Promotion of the use of landraces/farmer varieties has happened by default as in many cases this is all some farmers can afford.

The regulatory and policy framework for the greater use of plant genetic resources has not improved either during the last ten years. There are no marketing, policy or legal obstacles (except lack of adequate IP and Plant Variety Protection) to achieve diversification of crop production but rather a lack of data, low use of R&D and appropriate technology (eg greenhouses, hydroponics, tissue culture, molecular biology techniques and diagnostic kits, nursery management) applied to crops (present and potential), resistance to change (a farmer needs to be convinced of market availability and a large increase in yields to change plant variety), low processing capacity and an inefficient distribution/marketing system. Such obstacles need to be overcome as we have a growing local market and are close to even larger overseas markets.

The following activities are current priorities: improvement of the regulatory and policy framework; characterisation, collection, testing and selection of PGRFA (crop varieties, landraces, and wild species); encouragement of the participatory approach for on-farm research and improvement of PGRFA; increased use of technology in agriculture; search for new market opportunities; continuing development of marketable products from crop and forest species; and increasing crop diversity by encouraging farming of underutilized species. Priorities for breeding include base-broadening activities, training and utilization of more plant breeders, seed technicians and genebank managers, training in identification and alleviation of genetic vulnerability, formulation of plant breeding goals and closer coordination of breeders and biotechnologists. More than anything there has to be an increase in awareness of the role of characterization and evaluation of the PGRFA, their economic and social value, and to identify the gap that are limiting the full utilization of our local plant genetic resources.

Crop improvement programs and food security

The best way to describe our crop improvement programme is 'basic formal-sector crop improvement program in place, germplasm identification, and evaluation programs'. The methods employed for plant breeding in the country include recurrent mass-selection, back crossing, *in vitro* grafting and marker-assisted breeding. Transgenic papaya resistant to papaya ring spot and West Indian cotton with herbicide resistance are also being developed. Crops benefitting from these programs and their effect on food security have already been outlined. Crops resistant to pests and disease due to local breeding programs include scotch bonnet pepper, tomato, coconut and sugarcane. Participatory crop improvement programs include peppers (*Capsicum* spp.), coconut and pumpkin.

With the increased need for food security and the increased realisation of the importance and potential contribution that native, indigenous and endemic biodiversity can make to the economy, we expect for there to be an increased use of plant genetic resources in the next ten year. We are aiming towards developing a technological-savvy, modern and sustainable agricultural system using an increasing proportion of locally developed varieties.

Chapter 5: *The State of National Programmes, Training and Legislation*

National Programs

There is no National Program for Plant Genetic Resources. Instead, attempts have been made over the last ten years by several local institutions (MOA, UWI, SRC, CASE, NCU) to collect, conserve, select, maintain and evaluate crop and plant biodiversity but there is no national coordination or data gathering mechanism. Funds from debt-swapping (EFJ, FCF) have provided biodiversity funds that have helped these endeavours. The government gives policy support for conservation activities for indigenous crops, other crops of economic importance and wild relatives, current and potential; including agro-forestry and agro-processing. The Forestry Department has policy responsibility for protected areas (*in situ* collections). However, there is no legal framework for plant genetic resource strategies, plans and programs (more details below). Any cooperation between those involved with PGRFA is ad hoc and unplanned. Support for interventions leading to development of plant genetic resources as described in this document seems to have increased over the last ten years but due to the fragmentary nature of the interventions, it is difficult to tell if there has been an increase or decrease in funding to PGRFA over the period. There are gaps in interest, financial support, unmet needs and priorities but these have not been identified. A short description of interventions for development of PGRFA over the last ten years is given below.

Development of new species and plant varieties

Jheri Curl tolerant tomato*:* This was a response to the near devastation of the crop in 2001 by TYLCV 'Jheri Curl'. In a three year project, the R&D section of the MAO in collaboration with the AMSA seed company screened tomato seeds at Bodles. This led to the identification of several hybrids tolerant to TYLCV. These tolerant tomato seeds are being supplied to the local and international markets.

Bodles Globe Pumpkin*:* Development of this variety represents ten years of work. A high-yielding cultivar of uniform shape and size has been developed. This variety was named 'Bodles Globe' and was bred to give a uniform round shape and produces a 20 t/ha yield. Seeds are produced by Bodles and sold.

Sorrel: A new sorrel cultivar was developed that can grow all year round giving a crop every three months. Seeds are being produced by Bodles. The MOA R&D section also has a stockpile of the most promising planting material from farmers for testing.

Jamaican Programs relevant to PGRFA

ASSP (Agricultural Services Support Program)

- *Market identification.* Has helped seal contracts for the supply of 4.2 million kg of produce of farmers valued at $ 210.6 million with exporters, supermarkets, processors and hotels.
- *Escallion production project.* Identified by market studies to be a competitive crop due largely to growing demand by the 'jerk' trade.
- *National Food Safety Program.* The ASSP has financed a national consultation on food safety towards the establishment of a National Food Safety Policy. The following issues were highlighted: need for product certification, necessary linkages with National Accreditation

Body, establishment of a Food Safety Agency, establishment of a Plant Health Coordinating Committee and formation of a National Codex Committee.

Animal forages

This entailed an evaluation of a range of indigenous forages eg mulberry and various (*Pennisetum*) grasses. A two year study on grass production was conducted by the Dairy Board and WINDALCO.

Citrus Replanting project (2001-2007)

This project has produced certified planting material against a back-ground of increasing CTV disease levels since 1999. Importation of improved germplasm, resistant citrus root stock, was imported.

Coconut project

The 'Sustainable Coconut Production Through Control of Coconut Lethal Yellowing Disease' project funded through the FAO's Common Fund for Commodities (CFC) and the governments of Jamaica, Mexico and Honduras was initiated in 2002. A modern molecular biology lab was built and operated begun with the collaboration of the Biotechnology Centre, UWI. Through this project, pure genetic genotypes were identified within the Malayan dwarf coconut population, increased knowledge of the coconut genome, established many characteristics of the phytoplasma that causes Lethal Yellowing and identified 12 common weeds in Jamaica, which could be alternate or alternative hosts to the phytoplasma.

Fruit tree crop project

This project identified superior plants from which budwood was taken for multiplication. Details are provided elsewhere.

Production of value-added products

- *The RADA Home Economics Unit* has developed many food products such as bammies, pancake mix, gari and cassava chips from cassava. Further information has been provided elsewhere in this document.
- *The Scientific Research Council* has developed several food products. The Natural Product Unit of SRC has also developed several products (lotions, jams, jellies) etc using essential oils, oleoresins of locally produced plants such as lemongrass, rosemary and ginger. Training and processing facilities are also provided by SRC.

University of the West Indies

- *Several departments* are involved with developing natural products from local diversity. These include the chemistry, pharmacology and biochemistry departments, and the Natural Products Institute (identification and bioactivity testing of phytochemicals).
- *Herbarium.* The UWI herbarium is a comprehensive collection of herbarium ….. of Jamaica's PGR that are regularly referred to by local and overseas personnel. The PGRFA are underrepresented in this collection as is the case with the other local herbarium collection housed at the Institute of Jamaica.
- *Medicinal Plant Research Group, BTC*. This research group manages a medicinal plant gene bank at the Centre and a medicinal tree grove at the Hope Botanical Gardens. The MPRG also manages an active *in vitro* medicinal plant collection and is involved with DNA fingerprinting and natural product development.
- *Transgenic Plant Research Group, BTC.* This research group is developing transgenic plants eg papaya and the West Indian Cotton.

Other Research Institutions

- CASE has a collection of breadfruit but it is unclear what work they are doing with PGRFA.
- The NCU also has a project with breadfruit but it is also unclear what work they are doing with PGFA.

Networks

There is no national networks for plant genetic resources. What is in place is informal. CARDI provides a Caribbean-wide network for PGRFA and is represented in Jamaica by a unit on the UWI Mona Campus. The ASSP, MOA/RADA, the consortium supporting the Jamaican Chapter of Caribbean Herbal Business Association and the Jamaica Cluster Competitiveness Project (JCCP) provide very important networks for the development of PGRFA in Jamaica.

These networks need to be strengthened so as to encourage exchange of plant genetic resources between countries, facilitate training and off-site multiplication, and for plant and pathogen identification.

Education and Training

Long-term training relevant to PGRFA is being undertaken mainly by local universities (UWI, NCU, UTECH) in environmental issues, virology, propagation and horticultural methods, pathology and biotechnology (tissue culture, micropropagation, somatic embryogenesis, molecular techniques, genetic fingerprinting, genetic modification). Training in advanced plant breeding and taxonomy is less available but needed. Interestingly, persons trained in the above areas find it difficult to find jobs in the area they have been trained in. Training of extension officers is being done by CASE and needs to include training in ICT and biotechnological techniques as well as agricultural training.

Short-term training courses are mostly being carried out by HEART and NCTVT; relevant courses are nursery management, horticulture, and landscape management. UWI and SRC also provide short courses in relevant areas. For PGRFA, certificate courses need to be developed in para-taxonomy, horticulture, plant protection, greenhouse management, hydroponics, seed pathology, gene bank maintenance and mass propagation techniques (cuttings, grafting, budding) on a needs basis.

Policy makers in agricultural and governmental bodies need to be sensitized to the potential of new technologies and their implications for PGRFA. Although there has been increased interaction over the years, interaction between academics, MOA and policy makers is still low and inadequate. The result is that a strategy has not yet been developed to address the education and training needs for plant genetic resources managers and users.

Co-ordination between the education and training institutions on one hand, and those components of the PGRFA who need training on the other hand, is so poor as to be virtually non-existent. Co-ordination between the training needs of the country and the actual training being offered is poor. There is no training plan in place and no formal methods to determine the needs in this area. No strategy has yet been developed to address the education and training needs for the plant genetic resource sector, neither for conservation nor for sustainable use.

Legislation

There is no over-arching country policy for plant variety conservation. There is a lack of people in the legal machinery with an understanding of agricultural needs. However elements of conservation are in several legislations. Gap analysis is therefore required. There continues to be a need for a coordinating national program for plant genetic resources present in Jamaica. There is also a dire need for plant variety protection.

Jamaica is party to the following International Environmental Agreements: Biodiversity, Climate Change, Kyoto Protocol, Desertification, Endangered Species, Law of the Sea, Marine Dumping, Marine Life Conservation, Nuclear Test Ban, Ozone Layer Protection, Ship Pollution, and Wetlands. However, Jamaica is not party to any treaty that protects plant varieties. The legislative framework in Jamaica does not comprehensively protect ecosystem diversity, species diversity or genetic diversity. A new framework is needed that recognizes the components of biodiversity and ensures the sustainable use of biodiversity in Jamaica.

Status of major international environmental treaties	Year of ratification/signature
Cartagena Protocol on Biosafety	2001
Framework Convention on Climate Change	1995
Kyoto Protocol to the Framework Convention on Climate Change	1999
Convention on Biological Diversity	1995
Vienna Convention for the protection of the Ozone Layer, 1988	1993
Montreal Protocol on Substances that deplete the Ozone Layer	1993
Stockholm Convention on Persistent Organic Pollutants, 2001	2007
UN Law of the Sea	1983
UN Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa	1997

Jamaica's current environmental legislation provides a basic framework for the conservation and sustainable use of biodiversity. Although there is ~52 pieces of legislation that impact on the environment, none of these comprehensively address the protection, conservation and sustainable use of biodiversity. A new and more comprehensive framework is needed that recognizes the components of biodiversity and will ensure its sustainable use. In this regard, several pieces of legislation are being reviewed and others are being developed in order to address this deficiency. These include amendments to the Wild Life Protection, Fisheries and Watershed Acts, regulations under the Endangered Species (Protection, Conservation and Regulation of Trade) Act (2000) and the development of legislation for Biosafety.

Many of the national policies impacting biodiversity are sectoral in nature. The Jamaica National Environmental Action Plan (JNEAP), which is updated triennially, outlines major environmental problems and emphasises the necessary corrective measures to be undertaken by ministries, agencies, private sector and civil society organisations. PGRFA is underrepresented in the JNEAP. There are also species recovery plans developed by the National Environment and Planning Agency (NEPA) in collaboration with partners, for selected species.

There are gaps in the policy framework, including the areas of biosafety, traditional knowledge, conservation of land races and wild relatives of food crops, access and benefit sharing to name a few. However, ongoing projects and programs, draft policies and plans will address some of these areas. As a small island developing state, Jamaica's biodiversity is vulnerable to pressures from many areas. Factors which contribute to the loss of biodiversity in Jamaica includes poverty; over-consumption by some sectors of society; lack of public awareness and education; habitat/ecosystem conversion and degradation; unsustainable harvesting of some species; pollution; and the spread of alien invasive species.

Although Jamaica has not yet passed legislation or regulations relevant to plant genetics resources for food and agriculture, a lot of preparatory work has been done. The FAO commissioned a Study on Jamaica's National Legislation related to Plant Genetic Resources and its consistency with the Treaty, which study was completed in January 2006.

Emanating out of this study a roundtable/workshop was held on February 28, 2006 which heralded a Cabinet Submission for Cabinet to grant its approval to Jamaica's accession to the treaty and the promulgation of suitable legislation. Jamaica acceded to the Treaty on March 14, 2006 and Drafting Instructions were issued to the Chief Parliamentary Counsel on May 29, 2006, following working sessions with inter-ministerial groups involved in the management of agriculture and biodiversity.

To date, two draft Bills have been devised by the Chief Parliamentary Counsel. However, the Ministry of Agriculture is not satisfied with the drafts and is, along with the Attorney General's Chambers, reviewing the same with a view to devising a Bill to adequately cover Jamaica's obligations as a signatory to the Treaty. The following legislation, adopted since 1996, is being used to protect plant genetic resources as they pertain to present or potential food and agriculture:

> Natural Resources Conservation (Prescribed Enterprise, Construction and Development) Order, 1996: A list of prescribed types of enterprises, construction or development is contained in the Order e.g., reclamation of wetlands, construction of roads, hotel development, clear-cutting of forested areas. A permit is required to undertake any of the prescribed developmental activities. The Permit and Licensing System became effective in January 1997.
>
> The Forest Act, 1996, is the only piece of legislation in Jamaica that uses the word 'biodiversity': The Act vests responsibility in the Conservator of Forests for developing and maintaining an inventory of forests and lands suitable for the development of forests. The Forestry Department is required to make an assessment of forestry lands to determine their potential for maintaining and enhancing biodiversity. Provisions have been made in the Act for the controlled utilisation of forest resources in a rational manner. Jamaica has over 100 gazetted forest reserves. Under the Act, private lands may be acquired for declaration as forest reserves. One of the purposes of forest reserves is to protect and conserve endemic flora and fauna.
>
> Endangered Species (Protection, Conservation and Regulation of Trade) Act, 2000: The Endangered Species Act provides for the conservation, protection and regulation of trade in endangered species. The Act was prepared to allow the Government of Jamaica to fulfill its obligations under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Information Systems

There are many advanced computer training facilities and programs available in Jamaica, from short-course to the doctorate level. Nevertheless, the application of advanced computer technology to agriculture is still low. While the MOA has successfully been increasing its use of ICT over the years with many officers linked electronically, there is a lot left to be done. There is no national information management system to support the efforts to sustainably use, develop or conserve plant genetic resources. The development of the web-based information system ABIS is a promising development and needs to be nurtured, protected and supported. ABIS was developed by RADA to provide information on crops, livestock and agricultural production, markets and stakeholders to support the business of agriculture. Registration of farmers is also an ongoing priority of RADA; 104,432 farmers were registered by September 2008. The computerized documentation systems for each institutions listed in the appendix may or may not be in standard format and may or may not be allow for data exchanges. Such analysis has not been done but in as much as standard programs such as Word and Excel is widely used, and should be the basis of such standard program, this should not be too difficult to achieve.

There is a need to develop a national information system but also to utilize international systems like the one used to support this report. This will allow for better international comparisons. The main needs and priorities for developing and enhancing our information management system for plant genetic resources and seeds is development of internationally compatible software and provision of adequate numbers of dedicated servers, computers, affiliated machines and dedicated trained personnel along with relevant training and development of adequate networking for the national program for PGRFA.

Public awareness

The degree of awareness of the roles and values of plant genetic resources is low-limited-awareness with awareness being higher amongst professionals than the general public and policy makers. There has been no awareness programs developed for plant genetic resources. The main reason for this is limited human resources in the form of overworked professionals. A few responses to different problems have increased public awareness obliquely to the importance of PGRFA. This includes the 'Eat Jamaica' plan by the JAS as a response to the poor support of Jamaican farmers and has highlighted the need for local production. High oil prices have made the need for food security more obvious, while the report that mining companies want to mine in the Cockpit Country has raised awareness of the importance of native and indigenous biodiversity. This report will further raise public awareness. The main constraint to developing public awareness is lack of knowledge of the importance of Jamaica's biodiversity to the price of bread.

Chapter 6: *The State of Regional and International Collaboration*

The state of regional and international collaboration is growing but is still poor. Some development has occurred as internet and email usage has grown (climbing from 0 in 1990 to 404/1000 in 2005 in Jamaica) but developmental planning and practice is still fragmentary. In the Caribbean, there are many interested groups but they find it hard to build critical mass. A rationalisation of such groups needs to occur.

Information about Jamaican biodiversity is scattered and fragmented. The flora of Jamaica is poorly characterized and there are not enough trained taxonomists. Furthermore, identification of Caribbean biodiversity is rudimentary, as the genetic diversity has not been characterised using up-to-date molecular biology tools, except in a few cases. Studies on population dynamics and other ecosystem studies are also fragmentary and inadequate. Most of the flora and fauna that have been identified are in outdated documents and there are no comprehensive documents, or any biodiversity-related databases, created for the entire Caribbean. Valuation of biodiversity in the Caribbean is in its infancy. Regional and international collaboration to alleviate these realities is non-existent so unless a concerted effort is made, the reality in the next ten years will probably be the same.

Of greatest concern is the amount of studies that have been done on Jamaican flora (including plant collections) which Jamaica does not have access to as they are archived in overseas universities and botanical gardens.

Regional collaboration on PGRFA

The Caribbean Agricultural Research and Development Institute: CARDI (www.cardi.org) is the major institution for agricultural R&D in the Caribbean. CARDI has stations in 13 countries of the Caribbean with the Board of governors being the Ministers of Agriculture. CARDI impacts regional agriculture through technical assistance, technology development and transfer in plant pathology, virology, nematology, agronomy, soil and animal sciences. CARDI has been accessing, characterising, evaluating and improving germplasm of a wide range of crops and provides improved material to clients as well as supplying germplasm to international collections (Mitchell and Ahmad 2003). PROCICARIBE (www.procicaribe.org), the Caribbean Agricultural Science and Technology Networking System CARDI developed in 1996, has several regional networks: CARIFRUIT, CRIDNET, CARIVEG, CAROT, CASRUNET, CARINET, CAPEGENET, CAPHNET, CIPMNET, CLAWRENET, CAMID and CAIS.

The European Union. The EU has assisted the PGRFA mainly for the banana industry. The European Union Banana Support Program was developed to improve competitiveness of the Caribbean Banana Industry.

- *Banana Improvement Program (BIP)* - commenced in 2003 and seeks to provide technical assistance to improve the efficiency and productivity in the banana industry.
- *Rural Diversification Program (RDP)* - commenced in 2006 and aims to promote sustainable alternative agriculture and non-agricultural economic activities amongst those negatively affected by the new banana regime.

Food and Agriculture Organization: The listserver (FAO-Carib-Agri at carib-agri-l@mailserv.fao.org is a service provided by the FAO Sub-Regional Office in Barbados) has been very useful in allowing discussion of agriculturally related topics. REDBIO, the Technical Cooperation Network on Plant Biotechnology in Latin America and the Caribbean, is useful for the Spanish Caribbean but not too useful to the rest of the Caribbean as everything is in Spanish.

The Inter-American Institute for Cooperation in Agriculture: IICA (www.iica.int/home.asp) can be found outside of the Caribbean but IICA also facilitates regional collaboration in agriculturally related matters but not specifically for PGRFA.

USAID. Several recent projects of the USAID are relevant to the development of Jamaica's PGRFA.

- *Ridge to Reef project.* Provided funds for some inventory work. Results are not readily available.
- *Agriculture resuscitation after hurricane Dean.* The USAID and IICA provided technical support for greenhouse/protected agriculture and encouraged the application of technology to agriculture.
- *Protected Areas and Rural Enterprise (PARE) project:* The aim of this project is to aid rural growth by encouraging sustainable enterprises. The activities related to PGRFA include:
    - Technology transfer for improved production technologies
    - Formation of farmer group clusters
    - Building of market linkages with hotels, fast food restaurants, supermarkets and processors
    - Establishment of alternative livelihoods to prevent forest intrusions.

Institutional capacity

Increased institutional capability is needed for the wise use of biodiversity regionally and internationally. This includes trained personnel - taxonomists, environmentalists, biotechnologists, biosafety officers; IT (computer databases, web site development, bioinformatics capability), and environmental economists (for valuing biodiversity). Training is also required for policy makers. Educational programs directed to different groups (e.g., school children, fishermen, farmers, etc) are a must.

Some areas that need increased institutional capacity are the:

- Compilation of information on biological diversity of the region, which could inform and promote conservation and sustainable use of the region's PGRFA.
- Development of methods to extract and collate social and economic data that is pertinent to the threats to and the use of food and agricultural biodiversity in the region.
- Storage of biodiversity information - hard copy and on the Internet. For the Caribbean islands that are so divided by water, sharing of information via the Internet is essential. A Caribbean Biodiversity Data Bank is needed (that includes data on PGRFA). Such databanks should be linked to larger systems such as the Germplasm Resources Information Network, www.ars-grin.gov/ (GRIN) and the Inter-American Biodiversity Information Network (IABIN).
- Facilitation of interdisciplinary studies on biodiversity.
- Training of taxonomists.
- Increasing linkages between agriculturists and other scientists and farmers especially for on-farm research.
- Protection of new plant varieties.
- Masters programs and certified courses developed around a theme such as food and agriculture genetic resources, medicinal plants, ethnobotany, tourism, water, waste, biodiversity management, policy and planning on a needs basis.
- There is a need to encourage the production of biodiversity-related and food-crop educational training material especially for the primary schools such as Readers on different topics such as Food Crops of Jamaica, Uses made on Jamaican biodiversity, Jamaican wildlife, Medicinal Plants

of Jamaica, butterflies in the forest, Coral reefs etc with lots of pictures and simple words; How to manuals on compost making, making aquariums, Caterpillar hatching jars, school gardens etc; Web pages for schools etc.

- There is a need to produce, at the secondary and tertiary level, biodiversity-related training material such as information booklets and sheets.
- There is also a need for information booklets and sheets for adult readers to encourage life-long learning of the importance of PGRFA for Jamaica's benefit.

International Collaboration for PGRFA

Several international collaborations have been beneficial for development of Jamaica's PGRFA. International financial support for PGRFA has decreased over the last ten years.

The Food Agriculture Organization. The present initiative of the FAO has been very useful to the realization and development of Jamaica's PGRFA. The FAO has been the main international body influencing the direction of Jamaica towards the more sustained and active use of its PGRFA.

International Horticultural Society. The IHS has not had much effect locally.

IICA has provided policy support for regional collaboration in biotechnology and its application for agriculture.

IPGRI has not had much effect locally.

UNEP. The UNEP IWCAM project

USAID projects in the Caribbean are not coordinated or easily accessible.

UWI is a regional university with campuses in Jamaica, Trinidad and Barbados. UWI has many training, innovation and R&D groups in various areas eg agriculture, geography, life sciences, chemistry, biotechnology and environmental sciences relevant to PGRFA development. This regionalization has helped collaboration and is a strength that should be built on.

EU projects in the Caribbean are not coordinated or easily accessible.

These regional and international links are not nationally coordinated but instead exist mainly as links that individual researchers have developed or due to regional and international programs.

Jamaica's needs and priorities for future international collaboration are related to understanding the state of diversity on an on-going basis and in response to various factors, enhancing *in situ* and *ex situ* management of PGRFA, enhancing sustainable use of PGRFA, enhancing training and legislation, enhancing public awareness with the need for information management (to gather, share and utilize data) and early warning system for plant genetic resources being of the highest priority.

The effect of EPA is one international agreement recently signed and it is unsure what its effect on the sustainable use, development and conservation of PGRFA will be.

Barriers to implementation of global and regional MEAs

A number of barriers hinder treaty adoption and national implementation of the commitments made in treaty agreements. Duplicity of efforts due to the small size of the geopolitical disparate Caribbean islands is hard to avoid. A regional approach including regional treaty guide and workshops is recommended.

Case studies from four Caribbean countries have identified the following constraints:

- Limited financial, technical and human resources
- Lack of political priority for environmental protection and sustainable development
- Lack of information and understanding of treaty benefits and costs
- Lack of national focal points responsible for treaty ratification and adherence to commitments.

Constraints on national implementation of treaty commitments were identified as:

- Lack of expertise and inadequate financial and human resources to ensure legislative follow-up and enforcement
- A tendency on the part of international financial institutions to support projects rather than long-term institutional capacity building
- Other political priorities
- Lack of comprehensive framework environmental legislation (UNEP, 1999) [6].

[6] Caribbean Law Institute (1998b) cited in UNEP (1999).

Chapter 7: *Access to Plant Genetic Resources for Food and Agriculture, Sharing of Benefits Arising out of their Use, and Farmers' Rights.*

Access to plant genetic resources for food and agriculture

Crops important for agriculture in Jamaica have no threatened or endangered species as the majority of crops plants in Jamaica are not endemic. There are some locally bred species where virtually all the breeding/selection activity has been done by the MOA (eg hot pepper, pumpkin). Since there is no plant variety protection, locally bred varieties are usually interbred with other varieties within a short time span. Plant propagation tends to be done by individual farmers and has tended not to be specialist activity except for a few farmers that specialize in the production of hot pepper and callaloo seeds. Access to local and overseas PGRFA is limited only by the ability of farmer's to pay for them.

Sharing of benefits arising from their use

There is no clear distinction between improved and traditional varieties in Jamaica. Varieties developed from local breeding efforts (MOA R&D section) are given names but there is no systematic naming system. These varieties have been distributed without recording to whom they were distributed, where they were planted, with no information being given as to the importance of or even guidelines as to how to maintain the variety. For the sugarcane industry, breeding and testing is a continuous progress and the local Sugar Industry Research Institute (SIRI) can state how much of each variety is in which area. No other crop is so organized. Farmers tend to obtain seeds or cuttings individually. For the fruit tree project, areas to which plants are planted has been recorded but not for the plants sold one by one to the public at forums such as Denbigh.

Farmers' Rights

Again, it is difficult to assign farmers rights when there is no designated plant variety on which to confer those rights. First, plant variety protection would need to be obtained. Jamaica's farmers are well aware of the advantage of cross-pollination to produce stronger off-spring and except for those crops that are produced vegetatively such as yam, pineapple, banana, plantain, farmers do not tend to separate varieties and except in a few cases such as dwarf June plum or year-round sorrel, it would be difficult to instigate such a practice now.

Legislation

Jamaica is a signatory to the CBD.

Chapter 8: *The Contribution of PGRFA Management to Food Security and Sustainable Development.*

Sustainable development

Within a developing country such as Jamaica, there is a need for the development of policies and plans that protect existing food and agricultural biodiversity (presently in use and potential) but also allows a country to continue to develop. Activities that can be undertaken that will lead to more sustainable use of plant genetic resources for food and agriculture in Jamaica include:

- Development of scientific capability for sustainable use of food and agricultural biodiversity within the Caribbean, in collaboration with the wider society;
- Comprehensive inventory of biodiversity (terrestrial and marine) in terms of local and scientific names, pictures, locations, identification by modern taxonomic methods such as biochemical and molecular analysis;
- Cost of production should be determined for all plants growing in Jamaica and comparative studies be done with other countries of the Caribbean;
- Long-term studies of biodiversity should be undertaken, to document seasonal changes, and to document the effect of development;
- Climate studies should include monitoring of sea levels and temperature on a long-term basis;
- Marine biodiversity studies should be further supported considering most of the Caribbean is sea;
- Development of databases and Internet sites that document Jamaican biodiversity in a simple and assessable way while protecting the intellectual and genetic property of Jamaica;
- Repatriation of studies of Jamaican PGRFA (including herbarium samples and plants) presently stored outside of country back to Jamaica. Documents developed outside of Jamaica, related to Jamaican biodiversity should be placed in libraries within Jamaica. Any document developed by institutions in collaboration with, or on behalf of Jamaica, should be mandated to deposit at least two copies in a selected Jamaican library, in English;
- Efforts should be continued to find and store, in one place, all documents and internet pages that relate to Caribbean biodiversity, and make it widely accessible;
- Eco-tourism and community tourism should be further developed – on land, at the sea shore and marine;
- Tourism and Health should be used as the backbone to unite the Caribbean into a single PGRFA system;
- Development of more sustainable uses of biodiversity such as compost making, bio-digester, agro-forestry, organic farming and value-added agro-processing should be encouraged and supported;
- More sustainable ways of maintaining and using our marine resources should also be developed;
- *In vitro* collections for conservation should be supported, especially for endemic and indigenous varieties.
- More studies should be done on breeding of known crops, and on cultivation practises for new crops such as medicinal plants and crops not grown in any particular area to increase variation and increase competitiveness.

- Consideration should be given to activities that inform the general public of the importance of conservation and sustainable use of our biodiversity;
- Finally, studies into the sustainable use of protected areas should also be undertaken.

The following substantive recommendations should be carefully considered by governments, planners, private sector entities, and other stakeholders:

- Commit financial and human resources for developing and implementing sustainable uses of biodiversity, such as agro-forestry, organic agriculture, urban agriculture, green hotels, and eco-tourism. Conservation practices need to be intensified and encouraged such as contour farming.
- Extraction of wild biodiversity or overharvesting of marine species is unsustainable and methods need to be developed to increase productivity while ensuring conservation and environmental preservation.
- Protected areas need to have some form of economic activity to allow for their autonomy and upkeep. Where this economic activity is agricultural it should have strict guidelines and where it is tourist-related, it should have clear capacity limits coupled with strict guidelines.
- Methods for the valuation of biodiversity need to be developed and used both at the policy and implementation levels.
- The advantages derived from using Caribbean biodiversity needs to benefit the people of the region. This means regional institutions need to be strengthened and information gathered from the region be repatriated back to the region. The capacity for information gathering, database development and dissemination of biodiversity knowledge needs to be strengthened as a matter of urgency.
- Biodiversity training programs need to be developed specifically for PGRFA. There is a dire need for taxonomists in the region. Research programs aimed at a better understanding of the development and maintenance of biodiversity in tropical ecosystems and use of that understanding to identify, isolate and sustainably develop products based on this biodiversity need to be encouraged.
- The Caribbean 'hotspot' needs to be more widely recognized by conservation organizations within and without the region and help needs to be given to the Caribbean to ensure that the special biodiversity found only within this region is not lost to mankind.
- The most difficult challenge for the region, whilst lacking the necessary socio-economic, institutional and technical capacity to deal with such a varied biodiversity and increasing population density, is how to ensure the fair and equitable sharing of benefits from the use of its biological diversity resources.

APPENDIX

Table 2 Names of plants mentioned in this country report

Ackee (*Blighia sapida*)
Annatto (*Bixa orellana*)
Arrowroot (*Maranta arundinacea*)
Avocado (*Persea americana*)
Banana (*Musa acuminata*)
Barbados Cherry (*Malphigia glabra*)
Bean (*Phaseolus vulgaris* L.)
Bilimbi (*Averrhoa bilimbi*)
Blue Mahoe (*Hibiscus elatus*)
Breadfruit (*Artocarpus altilis*)
Bromeliads, (Bromeliaceae)
Calabash (*Crescentia cujete*)
Callaloo (*Amaranthus viridis*)
Carambola (*Averrhoa carambola*)
Cassava (*Manihot esculenta*)
Castor bean (*Ricinus comunis*)
Cedar (*Cedrela odorata*)
Cinnamon (*Cinnamomum zeylanicum*)
Citrus (*Citrus* spp.)
Coco (*Xanthosoma spp.*)
Cocoa (*Theobrama cacoa)*
Coconut (*Cocos nucifera*)
Coffee (*Coffea arabica*)
Corn (*Zea mays*),
Cotton (*Gossypium* spp.)
Custard Apple (*Annona reticulata*)
Culinary herbs (several)
Dasheen (*Calocasia esculenta*)
Duppy cucumber ()
Ginger (*Zingiber officinale*)
Guava (*Psidium guajava*)
Hemp (*Cannabis sativa*)
Hot pepper (*Capsicum chinense*)
Jackfruit (*Artocarpus heterophyllus*)
June Plum (*Spondias dulcis* Forst. (syn. *S. cytherea* Sonn.).
Longan (*Dimocarpus longana*)
Lychee (*Litchi chinensis*)
Mahogany (*Swietenia macrophylla*)
Mamee apple (*Mammea americana*)
Mango (*Mangifera indica*)
Mangosteen (*Garcinia mangostana*)
Medicinal plants (366 and counting)
Mountain Soursop (*Annona montana*)
Naseberry (*Manilkara zapota*)
Neem (*Azadirachta indica*)
Noni (*Morinda citrifolia*)
Nutmeg (*Myristica fragrans*)
Orchids (Orchidaceae),
Ornamentals (many)
Otaheite apple (*Syzgium malaccense*)
Palm nuts (Palmaceae)
Papaya (*Carica papaya*)
Peanut (*Arachis hypogaea*)
Pimento (*Pimenta dioica*)
Pineapple (*Ananas comosus*)
Pomegranate (*Punica granatum*)
Pond apple (*Annona glabra*)
Pumpkin (*Curcubita moschata*)
Sapodilla (*Manilkara zapota*)
Squash (*Cucurbita* spp.),
spices (many)
Star apple (*Chrysophyllum cainito*)
Star fruit (*Averrhoa carambola*)
Sugar cane (*Saccharum* cvs)
Sweet potato (*Ipomoea batatas*)
Tobacco (*Nicotiana tobacum*)
Tropical Almond (*Terminalia catappa*)
turmeric (Curcuma domestica)
yam (*Dioscorea* spp.)