SECOND REPORT ON THE STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE IN GUYANA

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Preface

The National Information Sharing Mechanism is a network of Guyanese institutions involved in the conservation and sustainable use of plant genetic resources for food and agriculture (PGRFA). One strategic objective is to document in a systematic way, information on activities related to the implementation of the 20 priority areas of the Global Plan of Action (GPA) for the conservation and sustainable use of PGRFA. Its overall goal is to share information related to plant genetic resources to facilitate the implementation of the GPA in Guyana.

The genesis of the project dates back to late 2010, when the National Agricultural Research and Extension Institute (NAREI) and the Food and Agriculture Organization of the United Nations (FAO) finalized a Letter of Agreement for the establishment of a National Information Sharing Mechanism (NISM) on the implementation of the GPA and the preparation of an assessment on the state of PGRFA in the country. With the technical assistance of FAO, NAREI has coordinated a country-wide, participatory process that, early this year, led to the publication of the NISM portal and database, a unique source of PGRFA information and knowledge in the country, and of this Second Report that assesses the state of conservation and use of these resources in Guyana since 1995. Funding for the project was jointly provided by FAO and NAREI.

NAREI's Focal Point activities for the establishment of the NISM included an initial meeting of strategic stakeholders held in December 2010 during which an informal National Steering Committee was set up and a tentative work plan drafted. The first stakeholders' workshop was conducted in March 2011 to formalize a work plan for both the NISM and the preparation of the national assessment, build commitment among stakeholders, and discuss with the participants indicators and monitoring tools internationally agreed.
The second stakeholders' workshop was held in June 2011 to train stakeholder representatives in the use of a computer application for collecting and sharing information and knowledge on PGRFA associated with the internationally agreed indicators. Stakeholder representatives helped to refine the project work plan and define milestone dates for their contributions to the data gathering process. CD copies of the computer application with an updated built-in knowledge base for monitoring the GPA implementation were finally distributed to all participants.
The third workshop was organized in March 2012 to launch the new NISM portal and database and to discuss and finalize the draft of this Second Report on the State of PGRFA in Guyana. The workshop also identified information gaps and agreed on solutions to fill them in.

NAREI, GUYSUCO, GRDB, and IICA (Guyana) were the principal stakeholders that provided the bulk of the information for the documented projects and references. Other valuable data were sourced through wide consultations and interactions with key resource people knowledgeable in marketing, community development, PGRFA networking, agro-project management, education, farming, agro-commodity vending, homestead management and in many other fields, who volunteered priceless information. The information migrated to and accessible through the NISM data base includes reports from about 1200 research and community development projects and more than 450 references. This information was further elaborated through responses to more than 2800 table row entries and 201 individual questions and comments archived in the NISM's *Indicators and Reporting Format for Monitoring the Implementation of the Global Plan of Action* (*IRF-GPA*); a common framework for country level analysis and presentation of data and information. The FAO guidelines and format greatly aided the distillation of this Second Report from information generated through responses to the *IRF-GPA*.

This Second Report represents a strategic analysis of eight macro-action areas on conservation management, sustainable use and improvement describing the status of PGRFA in Guyana during the last 15 years. It substantively updates the first Guyana Country Report on the Status of Plant Genetic Resources produced in 1995. This Second Report has been submitted to the FAO Commission on Genetic Resources for Food and Agriculture as an official document of the Government of Guyana.

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Executive Summary

Security in diversity

The agriculture sector is the pulse of Guyana's economy and the stability of the industry has contributed significantly to the economic and social stability of the country. Guyana has very little experiences in responding to disasters that threaten national food security. During the reporting period there have been some menacing episodes but none has had cause to activate any emergency food security plan. It should be more obvious than apparent that the stability of our national food security status is directly related to our tradition of sustainable use of plant genetic resources for food and agriculture. A cursory look around the country would reveal that the population density is concentrated within and close to the plant-based agricultural industries. For this reason, Guyanese have a traditional inseparable co-existence with agricultural systems. It is therefore logical to deduce that if the future of agriculture is threatened, so too should be the Guyanese people. Security in diversity is therefore an appropriate characterization of the state of use of plant genetic resources for food and agriculture in Guyana.

Status of diversity

Sugarcane and rice are the twin pillars of our agriculture sector. Barring only recent setbacks in the sugar industry, the sustainable use of plant genetic resources for food and agriculture in these two industries has combined to guarantee food security for all and provide an income for more than 20% of the Guyanese population that obligately must depend upon agriculture for a sustainable livelihood. The diversity among non-traditional crop species is an important complement guaranteeing our food self-sufficiency needs are met. With a new paradigm shift towards the sustainable use of plant species diversity for food and agriculture, the nontraditional sub-sector has assumed an important complementary role for food security assurance. The agriculture economy occupies approximately 161 874 hectares of irrigated land, hosting major crops, including sugarcane and rice; a diverse range of other important non-traditional crops, including coconut, cassava, a wide diversity of orchard species, green vegetables, and foraged botanicals in and around homesteads; a ubiquitous diversity of herbals; and an expansive 19 forested ecologies. Except for cassava, all agricultural products, important for food security and commercial exports are harvested within the narrow strip of coastal plains.

Status of *in situ* diversity

Plant species diversity for food and agriculture is an integral part of our national patrimony; an entitlement that is associated with an ingrained social culture of co-existence with plants. This custom is strongly manifested in homestead cultivations and subsistence farming communities. The homestead cultivation of plant species diversity for food and agriculture represents an informal but significant depository of *in situ* diversity. This paradigm is particularly appropriate because the PGRFA diversity found in homestead communities undisputedly represents the greatest diversity of PGRFA assembled in Guyana; accounting for more than 80% of the plant species diversity for food and agriculture that we see all over our country. Government policies strongly encourage this art form of '*in situ* homesteads' because to date it has been successful in so far as it supports a culture of food self-reliance and the economic benefits it brings to lower-income households. It should be an objective of research to unravel and document the extent of this diversity in homestead communities and foraging grounds. The audit could then be extended into an ethno-botanical context for pepper, cassava, coconut, and wild botanicals, and put non-traditional crop species diversity into its appropriate commercial, social and food security perspective.

Management of *ex situ* diversity

The tissue culture facility at NAREI has the only dedicated laboratory in the country capable of crop species conservation *in vitro*. Over the years, protocols for local accessions of plantain, banana, pineapple, yams, and sweet potato were established. The tissue culture facility has a mandate to provide disease-free planting materials for in-house research and to complement farmers' 'seed cuttings' requirements. But in the main, the lab seeks to adapt *in vitro* tissue culture protocols to facilitate the trans-boundary transfer of exotic crop species that must obligately depend on this avenue of germplasm exchange.

BRRS maintains a rice core collection of approximately 43 parental lines used in pedigree breeding, and currently four released commercial varieties. About 20 of these parental lines were bred on-station while the others were sourced from rice breeding networks of research institutions such as IRRI, CIAT, FLAR, and from the national rice breeding programmes of India. In addition to parental breeding lines, several thousands of pedigree lines are seasonally evaluated. The entire BRRS core collection of rice diversity is duplicated in regional and international PGRFA networks.

GARC maintains a field core collection of 43 commercial sugarcane varieties. Of these 12 are under industrial cultivation. Production is often coupled with varietal evaluation on a seasonal basis. One such evaluation is a twice-yearly rankings of varietal performance. These frequent 'ranking' evaluations are part of an intensive surveying and monitoring system across all of GUYSUCO's eight sugar estates. It enables GARC to detect varietal performance regressions as well as ascension, and where appropriate apply strategies for varietal replacement or agronomic adjustments.

NAREI is designated as the main depository of *ex situ* collections for seed-regenerated crop species. NAREI's mandate is for all crops (approximately 70 agricultural crops species) other than rice and sugarcane. During this reporting period a small nucleus of crop species were maintained on a seasonal basis. These were mostly for green vegetable crop species comprising a core collection of mostly exotic introductions of tomato and Brassica species. Local accessions of tomato, bora, pepper, eggplant, and poi are routinely maintained on a seasonal basis. *Ex situ* conservation, carried out at Mon Repos and Ebini Research Stations, is strategically transient because the storage capacity at Mon Repos Research Station was markedly reduced. The seed technology facility has recently been upgraded. NAREI has several *ex situ* field gene banks, inclusive of pineapple, avocado, cassava, yams, mango, West Indian cherry, passion fruit, cashew, coconut, Citrus species, and an array of minor orchard crop species. NAREI field gene banks are spread throughout the country at all of NAREIs research stations, plant propagation nurseries, and other smaller satellite stations. The number of species conserved in field gene banks is restrained by NAREI's capability to manage these depositories. Considering the distribution of root and tubers, and orchard crop species cultivation in Guyana, both intra- and inter-specific diversity represented in NAREI's field gene banks are under-sampled. There are extensive evaluation and characterization data for sweet potato, and a good start was made for vegetables. That similar data for other vegetatively-propagated field crop species have been hard to come by may be an artifact of a management bottle neck.

With a strong regional networking component, the conservation management of *ex situ* gene banks has placed GARC and BRRS on a very strong research foothold. NAREI's comparative capability, on the other hand, was constrained by the absence of sufficient technical competencies in gene bank management and its inability to make effective use of crop germplasm exchange networks.

The state of use

Conventional plant breeding programmes have been the only source of varietal diversity in rice and sugar. On a seven-year basis, the 'rice and sugar' sector uses a succession of a combined average of five modern varieties in commercial production. The varieties used at a given point in time are few but their genetic base is ever widening. The non-traditional sector, in the main, attempts to impose modern agricultural systems to optimize productivity from an unwieldy diversity of crop species for commercial gains. Both GARC and BRRS have a seasonal schedule of continuous crop performance evaluations. In a collaborative shuttle-breeding programme with other national programmes and coordinated by germplasm resources exchange networks, such as WICSBS and WISBEN for sugarcane and FLAR, IRRI, CIAT and the national rice breeding programmes of India for rice, GARC's and BRRS's plant breeding clones and lines are evaluated at multiple locations under diverse ecological conditions with national programmes. Rigourous evaluations carried out by local and overseas collaborating programmes have continued to guarantee stable field performance of commercial varieties. Every growing season at BRRS, field days are held on-farm where varietal demonstration plots would usually double as seed production demonstration plots. BRRS is the only agricultural research institution in the country that has a dedicated policy on farmer-participatory breeding.

Diversification of crop growing systems has historically been the main focus of Guyana's agricultural research interventions. NAREI'S strongest research capability has traditionally been in the area of crop nutritional ecology. During the reporting period, a number of green vegetable species and land races varieties were the main target of adaptation to a diverse range of improved agricultural production systems. To date, NAREI has to its credit the successful purification and adaptation of pineapple and sweet potato landrace complexes. But the efforts on vegetables were less sustainable. Generally, the response to synthetic nutritional amendments of most landrace crop species has been generally recalcitrant. In recent years, an agricultural diversification programme has been promoting increased exports of non-traditional agro-commodities. But there are marketing limitations directly attributable to an uncontrollable admixture of varietal diversity in crop harvests. This militating diversity is mainly an artifact of foraged and homestead harvests. The contradiction is that the very wide genetic diversity that we so crave is an obstacle to the economic benefits we advocate for deserving farmers. Small farms, homesteads and foraging grounds shall continue to evolve along with its people counterpart. But for the specific purpose of commercialization, Guyana's gamut of landrace varietal diversity, for the most part, may at best be relegated to crop improvement efforts.

Underlying factor driving the state of diversity

During the reporting period Guyana has entered into several international agreements. GARC and BRRS strengthened their regional PGRFA networking capacities. BRRS in addition, benefitted the greatest from training components of these agreements. Networking has elevated the sugar and rice industries on a sustainable research foot-hold. In common with the state of diversity of several other crop species, we have been unable to extract the necessary and adequate information about the diversity residing within our non-traditional crop germplasm pools. Generating reliable characterization and evaluation data is critical to utilizing plant genetic resources more effectively. NAREI's technical limitations in conservation, documentation, characterization and evaluation militate against its ability to proactively collaborate with other national programmes, and regional and international germplasm exchange networks. It is not surprising therefore, that NAREI has been unable to export significant numbers of its own landrace accessions and reciprocally, is restricted in its efforts to import significant numbers of improved accessions. Perhaps more than any other reason, NAREI's low-key participation in regional and

international PGRFA networks militated against the country's making more effective use of the opportunities and benefits to be accrued from networking.

The International Treaty on PGRFA

The recent implementation of the NISM for the sustainable management of PGRFA and the preparation of the Second Guyana Country Report on the Status of PGRFA would effectively serve to generate baseline information to guide food security assurance policies. Part of this food security policy will depend upon the access or exchange of local and external sources of PGRFA. Benefits accruing to Guyana would entail networking with other national, regional and international agencies. For this reason, Guyana's 2008 ratification of the Cartegena Protocol on Biosafety, the passage of legislation for the National Plant Quarantine Act of 2011 and National Seeds Act of 2011 are strategically supportive of the National Policy on the Access to Plant Genetic Resources and the Sharing of the Benefits Arising from their Use. Accordingly, the way could not be clearer for Guyana to ratify the International Treaty on PGRFA.

Acknowledgements

The task of preparing this country report came at a most inopportune time when most stakeholders were preoccupied with a cyclic activity that significantly distracts from the usual routines of normal occupation. From the start it was obvious that the attention of key stakeholder representatives would be refocused. The core of stakeholders continued to dwindle towards the end. But during the process, the project was able to identify useful sources of hard-to-come by reports and other related PGRFA documentations. A one-man show was not inconsequential. NAREI, the project's focal point needed to shoulder the responsibility and come up with a final product. Towards this end, the management of NAREI must be commended for its concurrence to allow the NISM curator to work on a full-time basis on the project and more so in the comforts away from the normal bustling office distractions. The staff of GARC, GSA and GRDB was most helpful in providing some key gap-filling research reports, and all of NAREI's and IICA's core documentations were captured. Gratitude is especially extended to Mr Anton Dey, who, at very short notice, agreed to peruse the document and provided critical information and gap-filling reports on the work of GARC. During our more than two hours online conversation, Dr Cyril Roberts' (Plant Biotechnologist, CARDI-Barbados) debriefing provided valuable insights into the status of regional networking and practical suggestions for follow-up actions on the recommendations in the report. It is also apposite to give recognition to Ms Brotherson and Mr Tian, the twin-crew of new NAREI staff who enthusiastically extended their training on the use of the NISM data base to extract and cross-reference a list of more than 1000 species of food plants of Guyana. This updated list of food plants of Guyana is now an important appendage to the Guyana NISM Web Portal. The usefulness of the project workshops, notwithstanding, the numerous smaller inputs through consultations and interactions with colleagues, farmers, community developers, homestead managers, agro-commodity vendors, educators in the field of agricultural science, and others have, in no small way, contributed towards the rich diversity of information dispersed throughout this report. But there were times when repackaging the gamut of information to convey the most simplest of meaning was a tremendous challenge. And that's where I am most thankful for the reviewers for helping to rescue this effort.

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Abbreviations and Acronyms

Abbreviation	Name
ADP	Agricultural Export Diversification Programme
ADRON	"Anne van Dijk" Rice Research Centre Nickerie
AMCAR	Amazon Caribbean Guyana Limited
AMIS	Agricultural Market Information Service
ASSP	Agricultural Sector Services Programme
AVRDC	Asian Vegetable Research and Development Center
BRRS	Burma Rice Research Station
CARDI	Caribbean Agricultural Research and Development Institute
CDC	Civil Defence Commission
CDSS	Crop Development and Support Services
CIAT	International Center for Tropical Agriculture
CIB (Jamaica	Coconut Industry Board (Jamaica)
CGIAR	Consultative Group on International Agricultural Research
CICY	Yucatan Center for Scientific Research
CIMMYT	International Wheat and Maize Improvement Center
CLAYUCA	Latin American and Caribbean Consortium to Support Cassava Research and Development
COGENT-LAC	Coconut Genetic Resources Network-Latin America and the Caribbean
CPCE	Cyril Potter College of Education
CYMMYT	International Center for Wheat and Maize Improvement
EMBRAPA	Brazilian Agricultural Research Corporation
EPA (Guyana)	Environmental Protection Agency (Guyana)
FAO	Food and Agriculture Organization of the United Nations
FLAR	Fondo Latinoamericano para Arroz de Riego
GAP	Good Agricultural Practices
GAPA	Guyana Agricultural Producers Association
GARC	GUYSUCO Agricultural Research Center
GCDT	Global Crop Diversity Trust
GDF	Guyana Defence Force Agriculture Corp
GDP	Gross Domestic Product
GFC	Guyana Forestry Commission
GGMC	Guyana Geology and Mines Commission
GOINVEST	Guyana Office for Investment
GPA	Global Plan of Action
GRDB	Guyana Rice Development Board
GSA	Guyana School of Agriculture
GSI	Guyana Shield Initiative
GUYSUCO	Guyana Sugar Corporation

IAST	Institute of Applied Science and Technology
IICA (Guyana)	Inter-American Institute for Cooperation in Agriculture (Guyana)
IPED	Institute of Private Enterprise Development
IRRI	International Rice Research Institute
ISSCT	International Society of Sugar Cane Technologists
IT-PGRFA	International Treaty on PGRFA
Iwokrama	International Centre for rain Forest Research and Conservation
LYD	Lethal Yellow Disease of Coconut
MHOCGA	Mabaruma/Hosororo Organic Cocoa Growers' Association
MOU	Memorandum of Understanding
MTA	Material Transfer Agreement
NADF	National Amerindian Development Foundation
NAREI	National Agricultural Research and Extension Institute
NBS	National Bureau of Standards
NGMC	New Guyana Marketing Corporation
NGO	Non-Governmental Organization
NISM	National Information Sharing Mechanism
NPPO	National Plant Protection Office
NRDAPA	North Rupununi District Agricultural Producers Association
NRMD	Natural Resources Management Division
PGRFA	Plant Genetic Resources for Food and Agriculture
PGRFA	Plant Genetic Resources for Food and Agriculture
POA	Partners of the Americas
PWSCA	Pomeroon Women's Small Cottage Association
READ	Rural Enterprise and Agricultural Development Project
RWN	Rural Women's Network
TLFA	The Tri-Lakes Farmers' Association
UG	University of Guyana
UG-FAF	University of Guyana-Faculty of Agriculture and Forestry
UNDP	United Nations Development Programme
USDA-ARS	United State Department of Agriculture-Agriculture Research Service
USDA-FAS	United State Department of Agriculture-Foreign Agriculture Service
USDA-PEO	United State Department of Agriculture-Plant Exploration Office
USPO	United Patent Office
WIST	West Indies Sugar Technologist Conference
WICSBS	West Indies Central Sugarcane Breeding Station
WISBEN	West Indies Sugarcane Breeding and Evaluation Network

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II. Introduction

II.1 Geography and agricultural foundation

The Cooperative Republic of Guyana is located in the north eastern corner of South America approximately between 2 and 9 degrees north latitudes, and 56 and 62 degrees west longitudes. It is bordered on the north by the Atlantic Ocean, on the east by Suriname, west and northwest by Venezuela and south and southwest by Brazil. The area of Guyana is approximately 216 000 km2 with a coastline of about 434 km long. This narrow strip of coastal plains is, on the average, below sea level. All of the country's commercial agricultural industries are concentrated along this averaged 12 km-wide strip. A cursory look around the country would reveal that the population density (approximately 90%) is concentrated within and close to the agricultural industries. Guyanese traditional co-existence with agricultural systems is inseparable.

II.2 Socio-economic status and agricultural economy

With the rice and sugar sub-sectors as its twin pillars, the local industry has combined to guarantee food security for all and provide an income for more than 20 percent of the Guyanese population that obligately must depend upon agriculture for a sustainable livelihood. Moreover, the industry has traditionally ensured that Guyana remained a net exporter of food. Twenty one (21) percent of Guyana's GDP derives from agricultural production, and close to 40 percent of export earnings comes from agro-commodity exports. In recent years, an agriculture diversification programme has been promoting increased exports of non-traditional crop commodities. Green vegetables, roots and tubers crops, and coconut continued to show improved export performance. Over the last 15 years, the production and marketing chain for pineapple became established, and the market for industrially foraged heart of palm continued to be sustainable. Guyana is self-sufficient in all aspects of basic foods, but heavily reliant on imports of wheat, split peas, and potato that have come to be recognized as staples. Rice, however, is the *de facto* food preference of most all Guyanese. With a bountiful all-year local supply of vegetables, fish and meat, and the contribution of the local sugar-based distillation industry, the social and material component of food production have combined to ensure food security for all.

II.3 Production base of agriculture

Arable land in Guyana accounts for more than 400 000 hectares. The agriculture economy occupies approximately 161 874 hectares of irrigated land, hosting major crops, including sugarcane and rice; a diverse range of other important non-traditional crops, including coconut, cassava, a wide diversity of orchard species, green vegetables, and foraged botanicals in and around homesteads and a ubiquitous diversity of herbals; an expansive 19 forested ecologies, fishery and livestock. Except for cassava, all agricultural products, important for food security and commercial exports are harvested within the narrow strip of coastal plains.

Small farmers produce most of the fruits and vegetables grown in Guyana - 80 percent of the grain crops, 60 percent of the coconuts, and 40 percent of the coconut oil. Non-traditional agriculture in Guyana typically characterizes farming systems that are small in scale, uses low-level technology, and

are labour intensive. Nontraditional agriculture has been moving slowing away from its associative subsistence farming. But the tendency to stick to traditional agricultural practices, and an absence of supportive services to encourage farmers to adopt improved methodologies for increasing production and productivity are still characteristic the sub-sector (GUYSUCO, 2009).

Guyana's sugarcane industry is the largest in the English-speaking Caribbean. It currently sustains approximately 18 000 employees and their families, a community welfare system, and development of agricultural and industrial skills. It is currently sustained by approximately 51 000 hectares of mainly plantation systems and by a spread of several private satellite farms. Private sugarcane farmers' contribution to sugar production was approximately 8% in 2009. The rice industry is sustained by mechanization of 70 000 hectares of low-land direct-seeded farms involving about 10 000 farm families who cultivate the crop. Rice accounts for 4% of our total GDP and about 14% of our total exports.

The dairy and beef cattle, swine, poultry, sheep, goats, wildlife and other livestock such as rabbits and bees that comprise Guyana's livestock sector, are spread all over the country. In terms of its marketing chain, the poultry industry generated the largest revenue and its marketing outstripped the sugar industry for the number of people it absorbed through employment (Patrick DeGroot, personal communication, 2009). Production of rice and sugar have endured the vagaries of unseasonal weather and held its place in overseas export markets. In terms of export value and volume, close to 100 percent of non-traditional exports were obligately derived from very close to 100 percent farmer's cultivars and foraged botanicals. Incidentally, more than 80 percent of this PGRFA diversity could be sampled within homestead communities. The marketing challenges of this unwieldy diversity of agro-commodities represented a major obstacle to effectively marketing an important source of agricultural products. But the underlying constraint is that Guyana has been unable to achieve any significant crop improvement milestone within the non-traditional sector.

II.4 About the underlying status of PGRFA

Except for recent trends in the sugar industry, during the reported period, GUYSUCO and GRDB have been able to elevate the sugar and rice industries, respectively, on a sustainable foothold. Their successes have been attributed in a large way to securing the very research base that maintains the economic viability of the industries. On the other hand, the efforts of NAREI, the focal point for plant science research in the country, have had mixed successes. With responsibilities for research on 77 food plant species, the myriad responsibilities of the country's focal agricultural institution are several and diverse. Coupled with its dwindling competencies in scientific research, critical issues that would enable NAREI to more effectively conserve, manage, and sustainably use PGRFA were not sufficiently resolved, nor were they given the prominence they so deserve.

Guyana of late has been able to diversity its earnings from supportive industries, such as services, forestry, and mining. But not much has been accomplished to ease the pressure currently facing the economic performance of the traditional agriculture sector. We have seen positive responses to a programme to promote the export marketing of non-traditional crops, but the production base upon which export marketing will depend has not yet been put on a sustainable foothold. Policy holders must

ensure that competencies in PGRFA-related sciences are upgraded, retained and given due recognition. Perhaps more than any other reason, NAREI's low-key participation in regional and international PGRFA networks militated against the country's making effective use of the opportunities and benefits to be accrued from networking.

Chapter 1. The State of Diversity

1.1 The state of diversity for food security

1.1.1 The state of diversity in the sugar and rice industries

1.1.1.1 Contributions of networking

Sugarcane and rice are the twin pillars of Guyana's agriculture industry. Together, they are referred to as the traditional agricultural sector. From its inception, this sector has recognized varietal diversity and crop improvement as the nucleus of its sustainability. Rice and sugarcane are not endemic to Guyana. For this reason, the genetic background of varietal diversity used in the sector is 100 percent dependent upon infusion of exotic germplasm. All varieties used in the sector are modern varieties with very good product quality, potential for high yields and resilience to a wide range of common pests and tolerances to agro-climatic vagaries. The genetic background of all commercially released varieties are synthesized from a wide diversity of parental genotypes infused through the sector's participation in regional and international networking, and direct exchanges with national programmes. The sector has increasingly seen genetic gains for product quality. Yields from sugarcane came off its plateau during the latter half of the 1990s. The genetic gains from rice varietal improvement were significant to the extent that despite expansion into less productive ecologies the level of field yields were sustained. There were a few industry alerts for pest surges in the industry, but the rigorous regimes of monitoring and surveying effectively averted any serious impacts.

1.1.1.2 Food security through social security

In Guyana, rice literally connotes food. It is both the material and psychological basis of food security. Sugar has consistently been the highest earner of agricultural exports. The major byproduct of sugarcane industrial processing is high proof spirits distilled from molasses. Some is exported, but only after the distillation industry obligately absorbs its full quota of this by-product. Rum is not only the cultural signature of the entertainment industry, but together with rice it helps to define an identity that is uniquely Guyanese. The traditional *rice and rum* agriculture sector is a Guyanese tradition. Guyanese diehard support for the sector is a testimony of the seriousness with which we take our main social security issues, and by extension, the security our *food* self-sufficiency.

1.1.1.3 Sustaining research competence

There have been efforts to professionally upgrade the research staff of GARC. During the late 1990s and early 2000s many selected staffers were enrolled in various university Masters and PHD programmes. Because the programmes were "split", requiring the work be done in Guyana and also being done on a part-time basis, most of the participants eventually opted out (Anton Dey, personal communication, 2012). The sugar industry was nonetheless, able to maintain a high level of field operational capability in plant protection. But in recent years, the industry has seen potentially debilitating attrition of its trained competencies in plant breeding and crop nutritional ecology. During the corresponding period, researchers of BRRS benefitted from postgraduate training in plant protection, agronomy, and plant breeding. In view of the need for both industries to gravitate into the realms of molecular genetic technologies, the industries will do well to revisit their policies on sustaining a critical mass of researchers. Gene bank networking will continue to be the best recourse to sustain the sector, and policy holders must ensure that competencies in gene bank management and germplasm evaluation are retained and given due recognition.

1.1.2 The state of diversity in the non-traditional sector

The traditional crop sector comprises an unwieldy preponderance of about 70 food plant species of economic importance. As the focal point for plant science with specific responsibility for all non-traditional crop species, NAREI pursued research on 30 of these economic crops. Famous among these were the five Ps: pineapple, plantain, pumpkin, papaya, and (hot) pepper. Coconut increased its commercial significance and cassava continued in its context of food security for sessile hinterland communities. With the implementation of an export market promotion campaign, the marketing potential of fresh green vegetables, roots and tubers, and select fruits was elevated substantially. The industrial foraging of wild manicole palm also came into prominence.

1.1.2.1 The state of diversity in the green vegetable industry

1.1.2.1.1 Realized diversity

In terms of species diversity, this industry is the most transformational. The area under cultivation may be small and the extent of diversity may pale in comparison with several crops, but this industry is moving towards the model of the traditional sector. The diversity among green vegetable crop species is estimated to comprise 50 percent of modern varieties; in large part due to the marketing prowess of agro-chemical companies. The diversity within commercial stands of cabbage, pakchoy, sweet pepper and tomato is largely exotic. But local landrace diversity of carilla, ochro, squash, watermelon, bora, hot pepper, eggplant, and pumpkin, continued to dominate homesteads and vegetable farm cultivations. Incidentally, the fresh vegetable export market is dominated by the diversity of these local landrace varieties. Green vegetable farmers are becoming more specialized in their production preferences and focus on export markets is increasing. However, despite increased specialization, the diversity of green vegetables continued to increase. The uncontrolled infusion of imported modern varieties has, in no small way, been responsible for an unwieldy accumulation of vegetables species from all backgrounds of adaptations.

1.1.2.1.2 Production of diversity

Several exotics have escaped and become established in commercial production, and a significant number of the remnants are likely absorbed into homesteads. Green vegetable supplies and market prices are the most unstable at rural and municipal markets. The unstable performance of un-tested exotics under commercial production may be implicated in the fluctuations we see in times of even mild unseasonal weather. Varietal substitution and replacement may also influence fluctuation in supplies. It is not clear whether species diversity is lost because the options for cultivating exotic varieties are many, the preference for local varieties is strong, and homesteads will continue to be the depository of remnants and discards.

1.1.2.1.3 Formalizing the industry

The unpredictability of the green vegetable industry makes for an interesting study of agro-commodity market futures, in so far that it would help us to better understand the interaction among species diversity, species ecological resilience and marketing instability. A related superimposed study will do well to assess the extent of vegetable diversity and document the dynamics between homestead depositories and dedicated on-farm production. The vegetable seed industry is in the right company but may be on an unsustainable foothold. Improved regulations accompanying the new National Seeds Act of 2011 and National Plant Quarantine Act of 2011 will serve to rectify this situation and launch a formal commercial vegetable seed industry.

1.1.2.2 The state of diversity of cassava

1.1.2.2.1 In-exorable generator of diversity

Cassava represents the country's widest varietal diversity among all crop species. Apart from some possible trans-border varietal infusion, the bulk of cassava diversity is all locally generated, and possibly endemic. Guyana's PGRFA diversity is grossly under-represented in crop germplasm depositories in national programmes, and regional and international networks. A recent reciprocal MTA with CIAT and GCDT has seen the first official export of cassava germplasm from Guyana. Fresh and mostly value-added cottage products are the obligate food preferences of the increasing sessile hinterland communities. Their dependence on the crop has come to be associated with their mastery of the sustainable management of cassava landrace diversity. Traditional art-forms of cassava production has guaranteed cassava self-reliance and food security for Amerindian communities, and simultaneously continued to generate an in-exorable pool of genetic diversity. Cassava is cultivated as a means of food self-sufficiency in all 167 official Amerindian villages across all terrains of the country; and so too, comes the genetic diversity with growing the crop.

1.1.2.2.2 Diversity-rich cassava

Because of the sparse distribution of small populations of hinterland communities, large-scale cultivation of local landrace varietal complexes are rare; and so too, in recent decades, are cultivations in commercial holdings along the coast (Blair, 2010b). In view of Guyana's dependence upon 100% imports of fossil fuels, this study has taken cognizance of the bio-fuel potential of cassava to complement fuel needs in the agriculture industry, and by extension, the myriad number of byproducts that comes from cassava starch deep processing. Cassava nutritional ecology studies, aimed at maximizing biomass yields, would go a far way in exploiting this diversity-rich potential of cassava.

1.1.2.2.3 Preserving the tradition

Cassava diversity does not face any imminent threat of genetic erosion. But in recent years, inland communities, especially in the south-western region of the Rupununi savannahs have experienced unseasonal droughts and floods that caused temporary shortages of the staple. Aid agencies led by the CDC have been expedient in mitigating the impact of these emergencies. But proposals for safety-depositories, such as community-managed 'seed cutting' plots replicated as cassava diversity pools and sources of fresh tubers are to be preferred. Cassava bread, farine and cassareep are the value added products of hinterland cottage processing. They have an extremely long natural shelf life. Community-based storage of these staples is recommended as a cheaper immediate fix for temporary climate-change eventualities. The traditional art form of cassava cultivation needs to be preserved. Studies should further assess and document the extent of land race diversity. Long-term ecological research is critical to understanding and more effectively utilizing this diversity, and so too is the related strategic funding. Incentive schemes should be provided for superimposing community-managed gene banks on existing subsistence cultivations.

1.2.2.3 The state of diversity in coconut farming communities

1.2.2.3.1 Coconut marketing

During the last decade coconut has economically resuscitated itself. Years of depressed prices have decommissioned 1000s of acres of coconut plantations. In recent years, as the price of tender and mature nuts increased, even the best managed coconut farming communities can barely meet the demands of the local and export market. All homesteads have a preference for the short duration

(dwarf) varieties, and the growing tender water-nut market has come to increase its reliance on homestead sources.

Box 1.1 Market Mondays

At its commercial hub is Charity, where an oil mill, a marketing center and a women's small cottage processing enterprise is located. This central hub of the Pomeroon River district is famous for its 60-year-old tradition of *Market Mondays*. The country's first official working day is celebrated at Charity as an unofficial weekly holiday in recognition of what was once regarded as the bread-basket of Guyana. *Market Mondays* offer an indispensable forum for farmers to interact with agricultural extension officials.

1.2.2.3.2 Diversity and industry viability

The most significant depository of coconut diversity in the country has been the 'bastard coconut complex' of the lower Pomeroon River district. The community is the center of coconut commerce in the country. The 'bastard variety' is derived from naturally out-crossing populations of 'tall' and dwarf varieties and has continued its synthesis over the last 100 years. The predictability is that about 50 percent of this 'bastard' coconut population should be capable of withstanding an LYD out-break. The other diversity centers of coconut are dispersed in large and small farms along the coast, and very densely in homesteads. Coconut is the most ubiquitous ornamental in all coastal communities and is found in most all hinterland villages. The coconut palm is a major component of agro-ecological ambiance that ideally supports a food chain from common and unusual pests, birds and rodents, to roaming livestock and shade tolerant fruit-trees. Cognizant of the imminent threat of LYD to coastal and lower riparian coconut populations, NAREI has initiated a project to migrate coconut diversity to in-land safety-depositories.

1.2.2.4 The state of diversity in homesteads and of foraged botanicals

Exported non-traditional agro-commodities are derived from close to 100 percent landrace varieties. A significant quantity of produce is harvested from homesteads and foraging grounds along the coast. The diversity in these two *in situ* repositories effectively samples close to 100% of Guyana PGRFAs. They comprise a range of species diversity that includes commercial rejects, rare and common landrace remnants, obligate wild species, scorned notorious weeds converted to food sources, the usual ubiquitous collections of herbals, and a preponderance of legally and inadvertently introduced exotics. During the last 15 years, industrial foraging of manicole has added its worth to commerce. The sustainability and cultural significance of these depositories has gone mostly un-noticed. Ethno-botanical studies will do well to unravel and document the extent of this diversity and put homesteads and coastal foraging grounds into its appropriate social and food security context.

1.3 Underlying factor driving the state of diversity

In common with the state of diversity of several other crop species, we have been unable to extract the necessary and adequate information about the diversity residing within our landrace crop germplasm pools. Generating reliable characterization and evaluation data is critical to utilizing plant genetic resources more effectively. By studying the inherent basis of genetic diversity, crop improvement and crop management research can be focused upon delineating and incorporating those components that contribute the most to varietal field performance. NAREI's technical limitations in conservation, documentation, characterization and evaluation militate against its ability to proactively collaborate with other national programmes, and regional and international germplasm exchange networks. As a consequence, unreliable data so generated from inadequate documentations represent counter-effective use of time, money and germplasm material. It is not surprising therefore, that NAREI has been

unable to export significant numbers of its own landrace accessions and reciprocally, is restricted in its efforts to import significant numbers of improved accessions.

Chapter 2. [1]The State of *In situ* Management

Plant Genetic Resources for Food and Agriculture (PGRFA) in Guyana are recognized as an integral part of our national patrimony; an entitlement that is associated with an ingrained social culture of co-existence with plants. This custom is strongly manifested in homestead cultivations and subsistence farming communities where over the last 40 years it has given rise to a paradigm shift of sustainable agriculture; contributing in a significant way to the species diversity we see in agricultural systems. Generally, the history of this co-existence has been dynamic but has incorporated some important elements of stability that today is responsible for the PGRFA diversity we see all over our country. These elements are embodied in the sustainability of agro-ecosystems diversity. The unique way in which these diverse systems are managed has inexorably generated tremendous diversity in a number of PGRFA-related species. It is apposite therefore, that *in situ* conservation and use of species diversity in Guyana should be considered in the context of **four** *in situ* agro-ecosystems and three informal art forms for the sustainable use and conservation management of PGRFAs.

2.1 Large-scale commercial agro-ecosystems

2.1.1 Auditing PGRFA in the rice and sugar industries

During the reporting period and from available records, one wild relative of sugarcane (*Gynerium sagitatum*) was collected and studied. [23]This may be a rare find because Guyana is not endemic for native species of sugarcane. Rice is also not endemic to Guyana. All sugarcane and rice diversity is derived from improved strains (introduced and shuttle bred) and maintained *ex situ*.

2.1.2 Auditing non-traditional PGRFA

During the reporting period IICA (Guyana) was the lead organization in surveying and monitoring of PGRFAs. The monitoring targeted mostly threats posed by biotic stresses, and all field and in-house training activities were conducted in collaboration with the national plant quarantine service. NAREI's plant quarantine unit had a similar focus. [4]PGRFA diversity is mirrored all over the country, and quite a number of surveying and monitoring activities have been undertaken by NAREI, but there is a paucity of documented information on these interventions. Our familiarity with the ubiquity of PGRFA diversity may have very well over-looked the need for updated audits. But we know, for example, that on a commercial basis, rice, sugarcane and cowpea production depend solely on modern varieties, and about 50 percent of the amount of green 'kitchen garden' vegetables comes from modern varieties. It is a tedious task to equate the 'numerical diversity' of commercialized landrace varieties with modern

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[1]Research at GARC and BRRS do not address *in situ* management because sugarcane and rice are not endemic species of Guyana. Both industries depend upon modern varieties that are transiently replaced.

[2]It is believed that this species of sugar cane could be cultivated under modified sugarcane production methods and harvested for 'fuel wood'.

[3]The ***sombrero vueltiao*** or ***sombrero vueltiado*** (Colombian Spanish for *hat with laps*) is a traditional hat from Colombia and one of its symbols. It is made out of *Gynerium sagittatum* known locally as *caña flecha*, a type of cane that grows in the region. The word *vueltiao* is a Colombian regionalism from the northern Caribbean Region… excerpted from: http://en.wikipedia.org/wiki/Sombrero_vueltiao

[4]Surveying, inventorying, and monitoring activities are usually tied-in to collecting expeditions. But the intensity of these expeditions does subtract significant attention from auditing PGRFAs.

varieties. In terms of cultivated area, non-traditional commercial crop farming enterprises are therefore dependent on at least an estimated 95 percent local landrace varieties (Kharb and Homenauth, 2003). On a strictly commercial basis, the diversity of these land race varieties is represented by about 30 of the more than 177 food plant species. The remaining more than 140 food plant species are accounted for elsewhere in this study. This status report has been unable to document any recent surveys upgrading an audit of PGRFA species diversity. But we can surmise that quite a few entries would have been added to the baseline data on species diversity from 1972 (Persaud, 1972).
NAREI's Research Department has capability in surveying, monitoring and inventorying of PGRFAs and the focus is on non-traditional crops. But its efforts are restricted by an insufficient complement of technical personnel. A proposal by IICA (Guyana) in 2003 (IICA, 2003) to activate an [5]Inter-agency Task-force for surveying, monitoring and inventorying PGRFAs is still under review by policy-makers; government financing cited as a limitation. As indicated in the sections below, NAREI has a lead role in updating an audit of PGRFAs. Because most of our PGRFA diversity is found *in situ*, an assessment of genetic erosion is indispensable. With the exhausted capability of NAREI, a plausible complementary strategy may be to focus on monitoring threats to *in situ* diversity; financial resources withstanding. This component of research is notably missing at NAREI. More collaborative interventions with IICA (Guyana) and the phytosanitary services are needed. More emphasis, funding and a dedicated gene bank curator/manager should therefore be added to meaningfully enhance the currently low level of surveying, inventorying and monitoring activities. The offer of collaboration with the USDA-ARS, with the GCDT and CIAT, and IICA (Guyana) should be embraced and strengthened.

2.1.3 Status of landrace diversity

Pineapple (*Ananas comosus*), cassava (*Manihot spp.*) and sweet potato (*Ipomoea batatas*) varieties are about the few landrace species for which uniform crop stands have been achieved. But in the main, commercial crop stands of landrace varieties are usually characterized by a mixture of two or more varieties, variants and strains. These mixtures are carried over from one cropping season to another. Stands of these crop mixtures are thought to be more resilient to pest infestations, and those abiotic stress-tolerant components would at least ensure enough yields for the crop to be harvested. But significantly, persistence of these crop mixtures serves not only to conserve crop diversity, but over time can generate substantive additional within-crop diversity. This phenomenon has been a clear case for coconut and cassava (elaborated elsewhere in this report). There is also evidence of naturally generated diversity in commercial land race crop species such as pepper, sweet potato (NARI, 2004 b), and pumpkin. But for landrace vegetables, and especially hot pepper, varietal mixtures are a contamination menace that reduces market value. The market value of harvested products notwithstanding, it is apparent that commercial orchards and vegetable gardens are often deliberately planted to multiple varieties. The commercial merit of this practice defies logic, but it will appear that commercial enterprises, while displaying an apparent penchant for the security in diversity are rather oblivious to its very value. A summary audit of PGRFA diversity is further elaborated in Section 2.2.1 below.

[5]Formation and operationalization of an Animal and Plant Health Surveillance Unit-The 'plants' component is proposed to be a National Surveying, Monitoring and Inventorying Coordination Task Force. Key stakeholders in the PGR Component would come from GUYSUCO, GRDB, NAREI (Plant Quarantine and Research) and IICA.

2.2 An informal sustainable art form for *in situ* conservation of PGRFA

2.2.1 Community-managed *in situ* homesteads

2.2.1.1 Homestead community-managed *in situ* diversity

While commercial farming has reduced the overall crop diversity in the world, Guyana serves to present a slanted modification of this fact. The sustainable use and [6]homestead cultivation of PGRFA represent an informal but significant depository of *in-situ* diversity. It is clear that this collection of crop diversity has not been the subject of any significant ethno-botanical study. But one pertinent question is this: Is homestead *in-situ* crop diversity managed? This documentation answers in the affirmative. And here we wish to proffer *in situ* PGRFA in the context of 'homestead community-managed *in situ* diversity'. This paradigm is particularly appropriate because the PGRFA diversity found in homestead communities undisputedly represents the greatest diversity of PGRFA assembled in Guyana. In this and subsequent sections of this chapter we seek to further proffer the notion that Guyana's cultural norms are strongly complementary to ecological forces in generating natural diversity of PGRFA and directing its distribution.

2.2.1.2 About the diversity of PGFRA in homesteads

There is evidence that suggests government policies on food self-sufficiency have taken hold on the Guyanese psyche to the extent that the general attitude of Guyanese has evolved into a tradition of cultivating PGRFA. The inadvertent introduction of the pink mealybug disease complex in 1996 is one detrimental outcome of this custom (NARI, 1996; NARI, 1997a). But in the main, government policies strongly encourage this art form of *in situ* homesteads because, to date, it has been strongly successful in supporting a culture of food self-reliance and it brings economic benefits to lower-income households. Accordingly, in 'food self-sufficiency through *in situ* homesteads' all social strata of Guyanese have been contributing towards the sustainable use and conservation of a diverse range of PGRFA. It is not surprising then that a paradigm shift from *in situ gene banks* to *in situ community homesteads* should serve as a testament of how personal Guyanese take towards conserving their plant biodiversity heritage. Considering the ubiquity of community homestead cultivations, a more pertinent question is: What can we not expect to find in *homestead community in-situ gene banks*? [7]Homestead 'gene banks' are personal properties and cultivation of homestead PGRFAs have not been the subject of enforcement of statutory limitations. Left unchecked over centuries, the sustainability of this art form has given rise to an unwieldy, undocumented diversity of plant species. This unwieldiness is due, in part, to the cultural reluctance of many homesteaders to 'not cut fruiting trees'. The attempts to domesticate plant species such as bird pepper (*Capsicum frutescens*), carrion crow bush (*Cassia alata*), sour plum (*Spondias dulcis*), fat pork (*Chrysobalanus icaco)*, jamoon (*Syzgium cuminii*), owara (*Syagrus romanzoffiana*), stinking toe (*Hymenaea courbaril*) and monkey apple (*Annona glabra)* are but a few of the more anecdotal attempts to tame 'obligate wildness', and explain this enthusiasm for *in situ* homesteads. When homestead species diversity includes exotics such as pitahya (*Hylecerous undatus*), lichee (*Litchi chinensis*), akee (*Blighia sapida*), grape (*Vitis vinifera*), sweet tamarind (*Tamarindus indica*), Parika banana (*Musa spp.*), three-corner plantain (*Musa spp.*), rambutan (*Nephelium lappaceum*),

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[6]The typical homestead is divided into three sections: Home Garden (mainly fruit-trees and florals), Kitchen Garden (Vegetables), and Back-yard Farm.

[7]There are designated and proposed protected areas in Guyana. But none of these protected ecologies specifically addresses the conservation of PGRFA.

kukarit (*Attalea maripa*), somotoo (*Passiflora nitida*), Suriname cherry (*Eugenia uniflora*), noni (*Morinda citrifolia*), wild black pepper (*Piper nigrum*) and spicy physic nut (*Jatropha integerrima*), it is beyond the imagination to ascertain what species are not represented. [8]Except for the notorious weedy shrub, antidesma (*Antidesma ghesaembilla*), the thin line between cultivated and wild goes without notice. This compilation was not privy to any study documenting the range of PGRFA diversity within homesteads. But it is plausible that an audit of homesteads should capture at least 80 percent of the entire diversity of PGRFA in Guyana, and that molecular genetic analysis could capture and document this extent of diversity.

2.2.1.3 The future of *in situ* homesteads

A typical homesteader is wont to plant anything that appears worthy. Rural markets are a good 'seed' source of PGRFAs for out-of-area shoppers. But wider PGRFA diversity is sourced through residents, friends, family members and co-workers in remote areas routinely criss-crossing the country and returning to their homesteads with collected 'seed' materials. Un-customed trans-border creep of PGRFA is an avenue that is often overlooked. Collecting expeditions in 2008, for example, targeted random homesteads along two streets in Georgetown and scions of 17 mango accessions were collected. During the 1997 *El niño* period, random homesteads in west Berbice were visited to rescue sweet potato varieties and 27 accessions were taken. A 2007 expedition to upper east Demerara and west Berbice randomly sampled 24 homesteads and 21 varieties of mango trees were tagged. Examples abound for all other homesteads that cultivate PGRFA diversity. Within large communities, varietal diversity for hot pepper, coconut and mango will usually 'max-out' among a sample of fewer than 30 percent of homesteads.

> ***Box 2.1 We are planting… what?***
> *There are examples, not widely known, of farmers who attempted commercial scale plantings of food-grade pulses donated for the poor to a local NGO, and sown seeds from imported food-grade peanut in-the-pod. And when one day a senior administrative staff (working in a reputable research organization) observed that weevils were avoiding his stored food-grade beans he had this notion that the beans could be a good candidate for commercial scale production and export. The manager had to be convinced that the beans would not germinate. But the judgment of a community development officer who sourced food-grade potato tubers (Solanum tuberosum) from vendors at a community market and tried to cultivate the tuber samples on a subsistence basis in hinterland communities is not without concern. The experimental attempt to re-establish planted manicole palms is however, a novel idea worthy of support.*

Arising out of the *in situ* homestead experience, there is evidence that coconut and hot pepper have good economic potential. The marketing potential of mango is under-exploited. Cassava is important for its food security in native hinterland communities, but its potential as a source for starch, including its known source of bioenergy is not without recognition. The social, ecological and economic value of coconut is covered in the next section. Cassava, mango, and pepper are summarized in Sections 2.3.1, 2.4.1.2, and 2.6.1, respectively. [9]Suffice it to mention though, that homestead cultivation is not an occurrence. With currently thriving new housing development projects, the distribution of PGRFA will spread fast and wide, and so too will be a multiplier effect on diversity. It should be an objective of

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[8]Unto 2010 antidesma was reported as one of the 'dirty dozen' weed problems on GUYSUCO Estates. The fruits of this shrub are coveted for the fomenting spirited wine it ferments.

[9]It may be apposite to note here also that the forerunner of urban and sub-urban PGRFA homesteads is the 'Garden City' Georgetown that has ever since been transformed from a floral decadence to an *in situ city* for PGRFA diversity.

research to use molecular genetic analysis to study and document the extent of this diversity in homestead communities, and to extend this audit into an ethno-botanical context for pepper, cassava, coconut, and wild botanicals with commercial potential.

2.2.1.1 A case for coconut

In any location in Guyana the coconut tree is conspicuously both a sign and evidence of human habitation. It is the most ubiquitous food plant and ornamental in coastal ecologies. Together with the abundance and diversity of other orchard crop species coconut constitutes an agro-ecological ambiance that ideally supports a food chain from common and unusual pests, birds and rodents to roaming livestock and shade tolerant fruit-trees. Without coconut, potentially devastating scenarios would likely make livelihood unbearable for human habitation. One such scenario can very well materialize with what is considered an imminent and plausible invasion by coconut LYD (Paul *et al.*, 2007; Paul, 1999a; Paul, 1999b).

[10]Coconut diversity includes a preponderance of strains of the 'Jamaica tall' and 'Panama tall' (Paul, 1999b), and four dwarf varieties: Bronze, Yellow, Green and Orange. Two recognized but not prominent variants of tall types are known as 'Clara Nut' and 'Kukarit Nut'. The only surviving collection of coconut (Tall x Green Dwarf) hybrids, synthesized in 1982, is found at NAREI's Mon Repos Research Station. The Lower Pomeroon River Sub-district is the commercial center of the coconut industry and hot-spot for coconut diversity in Guyana, and the most relevant LYD-related coconut diversity is found there. This predominantly commercial coconut-farming community is the native home for a naturally out-crossing population of coconuts known locally as the 'bastard coconut' variety. This population has been in genetic synthesis for more than 100 years. The evolving population is generated mainly from out crossings between the green dwarf type and diverse genetically evolving strains of tall types. From an estimate reported in Paul (1999b), the security significance of this 'bastard coconut' complex is for 50 percent of its population to survive an LYD outbreak.

> ***Box 2.2 A note on species extinction***
> *Considering the threats and experiences from recent climate change episodes (extended coastal flooding and more floods and droughts in the Rupununi hinterland Region, for example) there is a need for a national strategy to conserve threatened crop species through dedicated field gene banks. Cassava represents a special case for genetic erosion. But threats of species extinction from biotic stresses such as lethal yellowing disease of coconut, makes it imperative to formalize in-situ conservation.*

The coconut tree, and by extension its plantations, is specifically noted to host a diversity of shade tolerant fruit species, insects, birds, rodents, parasitic and useful fungi, as well as grazing and browsing livestock. Because of its dominance and prominence in coastal homesteads and its economic significance in the Lower Pomeroon River and coastal plantations, without this 'coconut tree' component the resulting ecological imbalance can potentially degrade the livelihood these ecologies support. On the one hand, former coconut pests can likely reap havoc on homestead diversity. And on the other, coastal climate change would come in a flash with un-predictable but debilitating changes that would potentially make our coastal landscape un-recognizable to us. Guyanese can hardly ever

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[10]The 'Clara Nut' is characterized by thrushes with a small number of large fruit. A pink pericarp is found under the fruit pedicel. An instance of this 'pinkness' variation can also be encountered for yellow dwarf in one homestead on the east Bank Demerara, and for 'tall' varieties in another homestead on the upper east Coast Demerara.

envisage what coastal life will be without this ubiquitous palm of life. Cognizant of the impending danger of LYD, NAREI's project to migrate coconut diversity to in-land safety-depositories must of necessity be intensified with urgency.

2.3 **Community-managed *in situ* subsistence farming**

Community-based food production is an integral component of Amerindian cultural traditions. The material basis of this agricultural tradition is the diversity of farmer-saved 'seeds' to plant the next crop from season to season. For this reason, conserving PGRFA is, in reality, an effort to preserve this cultural tradition. Specifically, by continuously planting traditional crops, season after season, farmers have developed a familiarity and a very good understanding of the agronomy of traditional crop plants. In other words, they have become familiar and comfortable with the crop species diversity used to sustain their livelihoods. Such it is, that over hundreds of years, hinterland communities have developed an art form proven to be capable to meet their food needs even in times of crop failures and at the same time conserve the crop species diversity that their livelihood so much depends upon.

> ***Box 2.3 A note on in situ gene banks***
> *Considering the limited geographical coverage of PGRFA collecting missions and limitations on threshold management capacity of NAREI's gene banks, and subsistence farming aside, on-farm and community managed crop gene banks are a viable complement to ex-situ conservation. This opinion is based on the reality that coastal homesteads and hinterland communities are the de facto depository of Guyana's PGRFA diversity. [11]Community field gene banks, such as the initiative in the St Ignatius-Kumu Farming Community, are a good avenue to accelerate in situ conservation. Stakeholders should therefore take cognizance of the fact that several remote farming communities are vulnerable to food shortages caused by climate change phenomena, and that proactive interventions on the part of NAREI and other organizations can go far toward mitigating the threat to food security.*

The case of cassava is here used to illustrate how this art form of subsistence farming serves to conserve the diversity of PGRFA.

2.3.1 A case for cassava

In terms of food security in traditional hinterland communities, and especially in Amerindian households, sustainable food crop cultivation is by far, most critical. Of the several PGRFAs cultivated under hinterland subsistence farming, cassava is by far the single most important food source. A summary treatment of the conservation of cassava diversity is therefore in order. Cassava owes its diversity to its unique native cultivation practices. While a sizeable area of cassava is devoted to commercial production on the coast, the cultivation of cassava in hinterland communities is of a subsistence nature. Using a coastal farming community as a unit, 3-4 landrace varieties dominate commercial production and old varieties are usually replaced. Whereas in hinterland subsistence farming communities there is a preponderance of morphologically distinct landrace varieties and new varieties are constantly added. The cycle of cassava cultivation is continuous and oblivious to seasonal variations. This varietal mixture should have the ability to withstand vacillations in climate and pest extremes. This resilience has given rise to the notion that the native gene banks of cassava diversity should contain a strong genetic component for adaptation and field persistence. For this and other

[11]During the 2009 extended drought conditions in the Rupununi Region, residents of the Villages of St Ignatius and Kumu in Central Rupununi adopted a cooperative approach to strategically setup a 3-acre community cassava plot in the village community of Kumu. The aim was to provide a secure village source of cassava for farine.

reasons coastal cassava diversity pales in comparison with hinterland diversity. Elias et al. (2001b) unraveled how this art form of cassava subsistence agriculture has been naturally and inexorably generating genetic diversity on a sustainable basis in the 70-homestead community of Rewa (North Rupununi). This phenomenon, by extension, can safely be extrapolated for other native cassava-cultivating hinterland communities. It would appear that this drive for generating genetic diversity is closely linked to the subsistence lifestyle of native Amerindian culture (Elias *et al.*, 2001a). In short, this method of subsistence cultivation ensures field persistence through the use of the buffering effect of genetic diversity from crop to crop, and this persistence of cassava cultivations ensures community food security upon which the livelihood of native hinterland communities exits. This phenomenon is all the more stronger evidence that informal community-managed on-farm gene banks should be brought to prominence and supported.

This *community subsistence farming* art form sustainably increases genetic diversity and at the same time ensures food security for sustainable livelihoods. In their research of this art form, Elias *et al.* (2000a) postulated that the genetic diversity in fewer than 4 villages in Guyana would be greater than that within the core collection of CIAT. In Guyana where there are 167 similarly recognized cassava-cultivating Amerindian villages, the agro-ecological spread of *in situ cassava diversity* generated through *community-managed subsistence farming* diffuses to all extremes of Guyana's hinterland. Cassava growing ecologies include the coastal Protected Area of Shell Beach and the abandoned settlement of Jonestown in the North West District, the mountainous Monkey Mountain village in the Pakaraima highlands and the extremely isolated Village of Masakenari in the deep south of the country, the friendly expanse of the Rupununi Savannahs, and the near coastal communities of Wakapao and Cabacaburi just off the Pomeroon River.

It is likely that the inexorable co-existence *cum* co-evolution, between native Amerindians and cassava diversity may have been responsible for its persistence under a wide range of agro-ecologies. The heterogeneity of cultivated cassava populations may be the basis of its climate resilience. This notion is an indication that the cassava gene pool of Guyana may contain useful genes for field persistence. [12]So, isn't this climate resilience of cassava a *crop persistence strategy* imposed by *community-based in situ management of diversity*? This characterization of Guyana's cassava diversity makes it a credible candidate for research on climate resilient crops. The extended drought of 2009 in the Rupununi may have tested some perceived limitations of cassava climate resilience. But sadly, the recommendations of Paul (2009b; NARI, 2009) were not taken on-board at that time.

In terms of cassava *ex-situ* management capability, NAREI's efforts are saturated. Compounding this bottleneck are the logistical challenges to access the more remote centers of tremendous cassava diversity, such as the upper reaches of the Barima and Waini Rivers, villages of the Pakaraima highlands, remote riparian communities of the mid-Mazaruni, and the mostly friendly 'farine type' cassava terrain in the expansive Rupununi Savannahs. The cost for transport logistics for a national effort is currently very prohibitive. With the limited capacity of NAREI to effectively manage expanded *ex-situ* gene banks, acquiring the means to access cassava accessions may not always justify the end results. The current debatable notion is that cassava genetic diversity may well be better preserved *in situ*. But in the interest of the international community and by extension, Guyana, one plausible alternative is to attempt some form of formal *in situ* management, such as strategically located community-managed field gene banks that capture an evolving core collection of community-based diversity and double as a

[12]And by extension, what about *in situ* homesteads?

source of food and 'seed' cuttings. These interventions would provide food and livelihood security assurance against crises imposed by for example, droughts and floods (Paul, 2009b).

2.4 'Sustainable' subsistence and commercial foraging

2.4.1 [13]'Sustainable' commercial foraging

2.4.1.1 Foraging food species diversity

'Foraging' for PGRFA is a significant activity in both coastal and hinterland communities. It is an art form of harvesting without planting best understood by residents of rural and hinterland communities. From a subsistence point of view, it is an important complement to hinterland subsistence farming, and from an economic stand point, it naturally complements homestead cultivations. Apart from private homestead, rural communities as well as urban and suburban areas are deluged with an intensity of naturally populated PGRFA pockets of abandoned, unprotected open spaces. The expanse of foraging grounds in the hinterlands is better left to the imagination. But in coastal urban areas and rural communities these comprise an array of abandoned private properties, government-owned reserves and parapets along roadways, abandoned farms and the parapets of access dams aback of villages. These apparently unassuming areas serve as rich browsing grounds for domesticated livestock and in particular foraging grounds for residents. They mimic the diversity found in homestead cultivations but contain a greater diversity of wild and weedy relatives of crops. But generally, crop and food plant species diversity is much reduced due, in part, to the intolerance of some species to extremes of foraging. The livestock component especially serves a useful function of disseminating and distributing the diversity of PGRFA, including those of herbals. A significant portion of marketed fruits are sourced from these 'extended farms' known in colloquial terminology as 'children inheritance properties'. Foraging is relevant because it is responsible for an unwieldy array of intra-specific (intra-crop) diversity of roots and tubers, fruits and vegetables entering community and municipal markets where the produce is sold fresh and whole, and in a significant way enters the export market; from whence cometh the new paradigm of 'commercial foraging'.

These market centers also serve as a lucrative source for out-of-area shoppers to collect 'seeds' of a wide diversity of PGRFAs that add to their homestead diversity. Homestead staples such as genip (*Melicoccus bijugatus*), mammey (*Mammea americana*) and peach (*Diospyros discolor*), and the on-farm coveted avocado (*Persea americana*) are prized spill-overs in 'children properties'. In addition, jamoon (*Syzygium cumini*), tender green and ripe mangoes (Mangifera indica), sour plum (*Spondias dulcis*), dunks (*Ziziphus mauritiana*), whytee (*Inga sp.*), guava (*Psidium guajava*) and coconut (*Cocos nucifera*) are a few of the wild and cultivated fruit species entering the formal fresh and whole fruit markets in municipal centers, as well as into the export market chain.

[13]The Plant Protection Act of Guyana 2011 and the Seeds Act of Guyana 2011 address all plant species and all crop species, respectively. Issues of *in situ* protection of crop wild relatives and wild food plants have wide coverage. The National ABS Policy adopted in 2007 (EPA (Guyana), 2007), does place wide restrictions on wild species and some of these do include crop wild relatives and wild food species. The ABS document, however, is more focused on external access to Guyana's PGRFA for academic biodiversity research and commercial product development. Currently, except for the industrial foraging of heart of palm, existing Protected Areas are not known to oppose sustainable harvesting of wild flora for food.

2.4.1.2 A case for mangoes

[14]Since its initiation in 2005, NAREI's project for the establishment of out-station depositories of targeted crop species has recovered 17 accessions from the old Ebini mango nursery. Mango diversity sampled along thoroughfares in Georgetown, east and west Coast Demerara and west Coast Berbice has so far netted 54 mango accessions. Twenty four (24) of these were planted at Ebini Research Station in 2006, and 27 were planted at NAREI's St Ignatius Research Station in 2007. Additional mango diversity is predicted to come from the east Berbice area (especially the Corentyne Sub-region), west Demerara Region, Homesteads in the Township of Linden, and the Essequibo Coast and Pomeroon River. A 2007 cursory survey around the Lethem-St Ignatius Township in Central Rupununi identified and tagged 11 accessions (Paul, 2007a). It is estimated that at least 90 accessions can be accumulated for *ex situ* conservation.

Marketed fruits of mango come in both ripe and unripe tender ('green') grades. Ripe mango can conveniently be processed into puree, and both ripe and 'green' grades of mangoes can be processed into blended flavoured beverages. But only 'green' mangoes can be processed into the popular cottage-produced relish locally known as *chutney*. This documentation has been unable to ascertain the demands for marketable volume of processed green mangoes. There are speculations that there may be a significant niche market in the Caribbean and North America for 'green-mango chutney'. But export data gleaned from phytosanitary certification records (Squires *et al.*, 2009) lacks sufficient evidence to support this speculation.

During the coastal floods of 2004-2005 no significant reports of mango devastation were reported (Chesney *et al.*, 2005; Fredericks, 2008). This observation gives credence to the perceived stress tolerance of mangoes. Together with their tolerance to extreme 'foraging', large-scale establishment of commercial mango orchards does not seem to be an attractive alternative. [15]This conclusion may be related to the reason why this study was unable to document the establishment of any large commercial-scale mango orchards. Accordingly, despite the feasibility for commercial mango orchards, the current status of commercialization seems to suggest that the traditional art form of 'foraging' may be sufficient to fulfill current and immediate future quantitative demands of mango. This example of commercializing an under-exploited crop is not only further evidence of the extent to which we depend on 'foraging', but also gives credence to the importance we see in cultivating diversity-rich species. Nevertheless, marketing mango and other diversity rich fruits, roots and tubers, and vegetables species is symptomatic of a common dilemma. Unable to fulfill the demands for reliability of supply, product uniformity and consistent quality would militate against large volume marketing of fresh, whole and processed produce. These marketing limitations are all directly attributable to an uncontrollable admixture of varietal diversity in crop harvests. This militating diversity is mainly an artifact of foraged and homestead harvests. The contradiction is that the very wide genetic diversity that we so crave is an obstacle to the economic benefits we advocate for deserving farmers.

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[14]Unable to access any documentation as to their origin, personal communications have indicated that these were originally sourced from Florida in the United States of America.

[15]Absent from the NISM database is the establishment of a large private crop cultivation enterprise at Gold Digging (Tacama Savannahs) in which the large crop orchards established then included one for mangoes (RN Cumberbatch, personal communication, 2011). The current status of this enterprise is unknown.

2.4.1.3 Foraging for herbals

Herbal foraging has also put sustainable *in situ* conservation of PGRFA diversity on an alternative art form basis. They include an unwieldy preponderance of species diversity represented in food and agricultural crops, crop-relatives and wild plants. Some of these non-crop species have become domesticated in homesteads and the line between domesticated and wild is very blurred. Herbal PGRFA foraging has been in Guyana's folk history from time immemorial. But very recently, collecting and commercialization of herbal diversity has been elevated to a 'state-of-traditional-arts'. Foraging for 'medicinals' still invoke interesting tales and notions of legendary proportions. But with the recent prominence of the government-sanctioned un-official herbal industry, the state of the 'healing science' has been elevated to clinical status. An elaborated treatment of herbal PGRFAs is outside the scope of this documentation. But cognizant of the propensity of 'herbal clinics', there is some scope to increase the popularity and awareness of the benefits of traditional nutraceuticals. This 'herbal' example is yet another case of the prominence given to the conservation and sustainable use of *foraged* PGRFA.

2.4.1.4 The Situation regarding foraged manicole.

[16]Foraging is the fore-runner of domesticated agriculture and even in this modern-day era of agriculture, it is still given prominence to the extent that it may become a sustainable industrial art form for the *in situ* conservation of a range of PGRFAs hitherto untapped. But can industrial foraging serve to conserve *in situ* wild PGFRA?

[17]One significant and 'extreme' mimicry of the foraging' art form is the commercialization of the 'heart' of the manicole palm by AMCAR. Manicole is a prominent wild component of plant species responsible for the mechanical integrity of natural riparian defenses inland. This heart of palm venture is export oriented and accounts for a substantive transient employment of mainly rural riparian communities. It would be good for us to examine its merit in the context of 'sustainable foraging' for the *in situ* conservation of manicole, and if it does not serve the 'conservative' function then this venture should be relegated into its appropriate context.

2.4.1.5 Industrial foraging by bees

[18]With an apparent decline in our coastal honey production enterprise, 'foraging' bees on forested concessions analogous to those for forest timber, was, and still is, one of the proposals emanating from the 2008 Fifth Caribbean Bee-keepers Conference. From a conservation perspective, the idea seeks to apply the concept of *sustainable industrial foraging*, bringing pre-domesticated agriculture into its full circle. [19]Forestry timber enterprises, such as the joint arrangement between Iwokrama and Tigerwoods Guyana Inc., will do well to consider this feasible complement to their struggling partnership. In view of the need for sustainable forestry through reduced emissions from deforestation and forest degradation, policy-makers should consider submissions on this proposal and elevate honey production onto a sustainable industrial footing.

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[16]Analogous to gathering

[17]'harvesting without planting'

[18]http://www.agriculture.gov.gy/FifthCBCNov2008/index.htm

[19]Inferred here is the Iwokrama International Centre for Rain Forest Conservation and Development.

In summary, commercial foraging serves as a significant component of sustainable livelihoods through complementary incomes for commercial investors, rural vending and rural households. The dependence on this sustainable avenue of livelihood rests on the sustainable use of the PGRFA diversity that commercial foraging so effectively conserves.

2.5 'Sustainable' subsistence foraging

In hinterland communities 'subsistence foraging' is legendary, and even a summary treatment would do no justice to this art form. Suffice it to mention, however, that the sustainability of subsistence foraging for PGRFA in hinterland Guyana is very much alive in many sessile communities. Determination of hinterland species diversity usable for food and agriculture is an onerous and likely inexorable task. A more progressive approach may be to determine the diversity of species that are not used for food and agriculture. There are more than 5,300 botanically classified monocot and dicot plant species in Guyana (NARI, 1995). Due credit must be given to Wheat and Persaud (1963), and Persaud (1972) for providing documented baseline data of plants usable for food in Guyana. [20]But adopting this latter 'what is not' approach leaves us no other option than to definitively debunk the notion that there are fewer than 200 food plants in Guyana. The diversity of PGRFAs in the hinterlands (and by extension Guyana) is transiently restricted to experiences encountered from foraging. And it will take more than the experiences of all the thousands of foragers to come up with a realistic estimate of species diversity useable as PGRFA in Guyana. In short, with 19 forest ecologies covering 83 percent of Guyana's land mass, the numerical extent of species diversity for PGRFA in Guyana is better left to our needs, conveniences and imagination.

Suffice it to mention though, that subsistence foraging does come up with some coveted 'trophies' such as the fruits of the rare and priceless turu palm (*Oenocerpus bataua*) that would hardly ever be encountered in market stalls; so too are tocuma worms unearthed from decaying stumps of palm trees, and sustainably trashing the forested wilderness of its [21]white haiari (*Lonchocarpus martynii*), bitter wood (*Quassia amara*) and red kapadula (*Davilla kunthii*). The skills required may be demanding but hinterland foraging can be a truly gratifying pastime.

2.6 'Nature farms' in forested wilderness

Abandoned crop islands in forested wilderness are well known but not highly recognized. These crop plant patches, also known as *nature farms* and *nature gardens*, originate mainly from abandoned camping grounds of hinterland mining and lumbering work force, and usually, random encounters through forest surveys will uncover some of these. It is also postulated that these nature farms can be established naturally without human interventions (M Jarvis, personal communication, 2011).

These 'crop islands' are more an artifact of the 'homestead food-self-reliance' analogy than an ardent need for a source of foods. Left over time, these patches serve as a unique reservoir of PGRFA diversity,

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[20]An updated list of more than 1050 food plants of Guyana has been compiled by Brotherson et al. (2012). This list, extracted in part from the NISM database, can be found at the Guyana PGRFA web portal (http://www.pgrfa.org/gpa/guy/welcome.htmx).

[21]White Haiari (*Lonchocarpus martynii*) is a liana found in certain forest ecologies. Mixed with hot pepper, it is grounded to a mash and spilled in shallow-water creeks to intoxicate fishes for the catch. This is a native Amerindian art of 'hauling in the fishes. Red Kapadula (*Davilla kunthii*) and bitter wood (*Qussia amara*) are used to concoct traditional nutraceuticals.

and whenever the opportunity gives way they have been lucrative targets for NAREI's collecting expeditions (CR Paul, 2007a). It is not uncustomary for hinterland dwellers to retain these nature farms and develop them as a source of subsistence food supply.
Cassava, sweet potato, papaya, carila, granadila, hot pepper and pumpkin diversity are often the most prevalent nature farm 'residues'. But hot peppers, pumpkin, papaya, sweet potato and cassava diversity can be expansive; faunal and human agents being effective disposal agents of these crop species. These nature farms are basically transient in nature, but some are reported to be very elaborate (M Jarvis, personal communication, 2011). It is not surprising that plant seed-carrying faunal and humans agent should account for the spatial distribution of a diverse range of crop landrace varieties aforementioned. This dispersal phenomenon suggests that the dynamism of nature farms makes them somewhat paradoxically transient but sustainable. And while this mode of sustainability does not seemingly generate new diversity it does serve to distribute *a priori* diversity. [22]It is plausible that faunal dispersal of PGRFA diversity should give rise to the well-known 'same species different name' controversy. This issue is especially relevant to the diversity found in crops such as pepper, cassava and sweet potato because for these crops, it questions the realized extent of diversity with a species.

2.6.1 The diversity of hot Pepper landraces in Guyana

A NARI-CARDI 1999 joint collecting expedition in Guyana (H Adams, CR Paul and G Parris, personal communication, 2011) and several other local NAREI collecting expeditions were carried out for hot pepper landraces during the reporting period. Hot pepper landrace diversity was sampled from the Pomeroon River in Region 2; Moruca, Shell Beach, Arawau River and Mabaruma in the North West District; Kurupukari and Fair View in Central Region 8; west Coast Berbice in Region 5; and the east Bank Demerara in Region 4. The total *ex situ* collection, including more than 50 exotics, stood at more than 130 in 2005. These were all lost in-storage when the seed storage facility at Mon Repos malfunctioned in 2006.
Records on the evaluation of landrace varieties are scant. [23]But there were breeding interventions using landrace varieties sourced from Guyana. These interventions aside, the varietal diversity of hot pepper landraces in Guyana is recognized but not well documented. Hot pepper is widely consumed to the extent that it is not conceivable that there are households without a bottle-on-the-ready of this popular relish. We are aware that in homestead cultivations and subsistence farming, as well as the many small commercial production gardens, crop stands of hot pepper will almost always contain a preponderance of varietal mixtures. The pioneering work of Sasikumar (2010) on spice species diversity in Guyana confirmed this trend. Marketing these mixed harvests of hot pepper crops is fraught with challenges of product acceptance in the export market (S Anthony and J Bhojedat, ADP, personal communication, 2011). Nevertheless, this mixed-stand cultural practice for hot pepper is the production preference of all cultivators. The underlying knowledge about hot pepper in Guyana is that it can be found in all parts of the country. From uninhabited tepuis and inaccessible mountain ledges, to nature farms in forested wilderness and in all homesteads and farms, hot pepper is as ubiquitous as the areas birds can fly to.

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[22]In different communities there are different names for what appears to be morphologically similar varieties and conversely, same name for morphologically different varieties.

[23]This study has been unable to document evidence of any local base broadening efforts or trait integration/transfer intervention for pepper. But a 2004 regional project to breed hot-pepper in collaboration with CARDI is acknowledged (H Adams, personal communication, 2010).

This distribution of hot pepper diversity is, in part, characterized by its naturally-aided faunal and human seed dissemination agents. Complementary to this dissemination mechanism are the phenomena of 'nature farms', covered in Section 2.6. It is plausible that 'nature farms', in a systematic way, should contribute to the ubiquitous distribution of hot pepper in Guyana, but distribution alone does not necessary explain the accompanying diversity.

In summary, it is plausible that hot pepper diversity may be symptomatic of the 'same species different name' issue, in that the ubiquity of hot pepper diversity is known but the depth of this diversity is not. This *ubiquity* issue of hot pepper offers an opportunity to study and document its distribution (persistence of diversity, sustainability and dynamics of transient nature farms, etc.), to map out a strategy for *in situ* management, and a sampling plan for *ex situ* collections.

Chapter 3. [24]The State of *Ex situ* Management

3.1 Management of *in vitro* stored and regenerated crop diversity

The tissue culture facility at NAREI has the only dedicated laboratory in the country capable of crop species conservation *in vitro*. Ex-plant materials are collected from NAREI's managed *ex situ* field gene banks and from on-farm *in situ* sources. Over the years, protocols for local accessions of plantain, banana, pineapple, yams and sweet potato were established, and only recently, during the latter part of 2011, the protocol for cassava was upgraded. These five crop species represent major sources of food in Guyana. The tissue culture facility has a mandate to provide disease-free planting materials for in-house research and to complement farmers' 'clone seed' requirements. But in the main, the lab seeks to adapt *in vitro* tissue culture protocols to facilitate the trans-boundary transfer of exotic crop species that must obligately depend on this avenue for germplasm exchange. The laboratory facilities do not support commercial-scale production of tissue-cultured plantlets. Nevertheless, there is potential to scale-up the process, and the materials to do so can be maintained for long-term *in vitro* storage of various strains of the crop types aforementioned. Towards mid-2011 the storage capacity of the tissue culture laboratory 'maxed-out' at more than 2000 vessels of 27 local accessions of cassava, 7 of plantain, 3 of sweet potato, 3 of pineapple and one exotic introduction of banana. *In vitro* slow growth protocols refined at NARI have an averaged one-year storage record from a single passage of subculturing. And storage of *in vitro* propagules has been maintained for as long as six continuous years (NARI, 1997a). But with the absence of functional standby emergency electricity generation during the latter years of this reporting period, *in vitro* stored accessions were often pruned to losses. Restoration of NAREI's standby electricity generation plant is currently underway.

3.1.1 Assessing protocols for effects on clone stability *in-field*

Data have not been compiled for response of different crop species to regeneration *in vitro*. There are however, ongoing studies on refinement of media formulations and subculturing techniques. One specific study is currently still evaluating the clone stability in-field of an exotic banana accession. Observations from this study revealed that considerable morphological variations were manifested *in-field* and it is putatively concluded that these may be an artifact of 'hybrid breakdown'. In 2007 and 2011 the laboratory hosted the final year projects of two students from the Faculty of Agriculture and Forestry of UG. During the first quarter of 2011 the laboratory successfully adopted a protocol for *in vitro* regeneration of cassava. The receipt of 17 cassava accessions from CIAT through CLAYUCA in 2011 was piloted through this newly adapted protocol. This germplasm exchange is in part, a forerunner to a current NAREI-GCDT project that would see the regeneration and safety-duplication of Guyana's cassava genetic resources at CIAT. Through this arrangement, Guyana would benefit from rapid repatriation of its cassava diversity from international, national and regional sources following a local disaster. The St Ignatius-Moco Moco Community Farming Group has been identified as a potential candidate beneficiary of this collaboration. NAREI has a similar agreement with the USDA through a project to sustainably use and conserve PGRFAs. Sweet potato is one of these candidate species.

To date the lab has developed protocols for trans-boundary *in vitro* exchange of Musa species, sweet potato, yams, pineapple and cassava. The tissue culture facility is currently under extensive upgrading to

[24]NAREI, BRRS, and GARC are the only institutions where formally managed *ex situ* collections are held.

include a Biotechnology component. These infrastructural renovations, which will greatly enhance NAREI's biotechnological capability, have temporarily curtailed all *in vitro* storage activities. During the last 10 years, there has been only one dedicated senior staff working on plant tissue culture projects. The status and needs for *in-lab* technical competencies are summarized in Section 6.7.

3.1.2 *In vitro* interventions at GARC and BRRS

In vitro culture of sugarcane at GARC has been reported but the extent of that activity has not been elaborated in the reports made available for this study. It is known that at least one joint project on sugarcane tissue culture was initiated in collaboration with NAREI (Maxine Cummings, personal communication, 2011). BRRS does not have tissue culture capability.

3.2 Management of *ex situ* conventional seed crop diversity

3.2.1 *Ex situ* management in the sugarcane and rice industries

GARC maintains a transient core of seeds derived from seasonal inter-varietal crosses of sugarcane. While this collection is not of conservation priority, short-term storage facilities at GARC allow for seasonal delays in the evaluation of seed-derived sugarcane clones. On a seasonal basis, approximately 32 varietal clones rotate in the working collection. These putative varieties are sent to several national programmes collaborating in sugarcane breeding networks such as WICSBS and WISBEN, and the national program of Barbados and Indonesia.

BRRS maintains a rice core collection of approximately 43 parental lines used in pedigree breeding, and currently seven released commercial varieties. About 20 of these parental lines were bred on-station while the others were sourced from rice breeding networks of research institutions such as IRRI, CIAT, FLAR, and from the national rice breeding programmes of Suriname (ADRON) and India. In addition to parental breeding lines, several thousands of pedigree lines are seasonally evaluated. These evaluation data are used to upgrade the characteristics of parental lines. The short-term storage capacity withstanding, the entire BRRS core collection of rice diversity is duplicated in foreign collaborating gene banks. The varietal improvement at BRRS is a relatively intensive high-capacity programme and some amount of strain is placed on human technical resources and seed storage capacity. During the reporting period not more than three senior staff worked in the Department of Breeding. Significant assistance was received from India through its ITEC scientific exchange programme. To deal with an increasing volume of breeding material, BRRS will have to inevitably increase its *ex situ* holding capacity. Increasing capability in seasonal evaluation and characterization of several thousand lines will require the adoption by BRRS of a strong biotechnology component for high throughput screening, and post-graduate level training for its staff.

3.2.2 *Ex situ* management of non-traditional PGRFA

3.2.2.1 Ex situ management at NAREI

NAREI is designated as the main depository of *ex situ* collections for seed-regenerated crop species. NAREI's mandate is for all crops (approximately 70 agricultural crops species) other than rice and sugarcane. For several years, however, NAREI's seed storage facility has been largely non-functional and only recently were efforts made to re-establish and refurbish its seed technology department. A reduced capacity notwithstanding, during this reporting period a small nucleus of crop species were maintained on a seasonal basis. These were mostly for green vegetable crop species comprising a core collection of mostly exotic introductions of tomato and Brassica species. Local accessions of tomato, bora, pepper, eggplant and poi were routinely maintained on a seasonal basis. *Ex situ* conservation, carried out mainly

at Mon Repos, Ebini and Kairuni Research Stations, is strategically transient because the seed storage capacity at Mon Repos Research Station is markedly reduced, and the management capacities of field gene banks have been saturated. For these reasons, only a narrow base of green vegetable species diversity, open row field crops, clonally propagated orchard and roots and tuber crop species could be maintained. To a greater extent, the conservation of spice crops (ginger, black pepper, tumeric, and ginger) were conveniently superimposed upon on-farm evaluations plots.

3.2.2.2 The intervention of agro-chemical companies

An important collection of exotic green vegetable seed species sold by private agro-chemical companies is not captured in NAREI's *ex situ* collection. These companies fill a critical void in the seed supply chain and their role in jump-starting the seed industry is recognized. But NAREI has the formal authoritative mandate for monitoring and controlling the introduction of exotic crop species. Several green vegetable varieties, past and current, supplied by these companies have entered the commercial cultivation system without the procedural intervention and official concurrence of NAREI. Currently there is no evidence, but it is plausible that there could have been 'escape episodes' implicating the periodic surfacing of hitherto not observed crop responses to biotic stresses.

3.2.2.3 *Ex situ* management and evaluation of vegetables and open-row field crops

Analogous to green vegetables, conservation of *ex situ* collections of open-row field crops is also transient. Regeneration is on a seasonal basis and this activity was carried out mainly at NAREI's Ebini and Kairuni Research Stations. All accessions were of exotic introductions and include corn (1), soya bean (20), cowpea (10), sorghum (2) and pigeon pea (1). There were some local vegetable varieties of tomato, hot pepper, eggplant and ochro (*Hibiscus esculentus*). But quite a number of the vegetable varieties under commercial cultivation were imported and distributed by private agro-chemical companies. Local collecting expeditions might have been routine, but only one specific formal collecting expedition was reported for green vegetables (Ralph *et al.*, 2006). The cultivated diversity of field crops is narrow and so too is the diversity of open row landrace varieties. For this reason, the prospect for finding additional diversity among local landrace accessions of open-row field crops may be low.
For all crops species, characterizations and evaluations are done at St Ignatius, Ebini, Kairuni and mainly at Mon Repos Research Stations. NAREI also conducts evaluations at smaller-capacity satellite stations along coastal Berbice and Corentyne, and at Hosororo near the Township of Mabaruma in the North-west Region of the Country. On a small scale, agronomic evaluations are coupled with seed regeneration for both green vegetables and open row field crops. Brassica species, eggplant, hot pepper, tomato and poi have been the main target for green vegetables. Whereas soy bean and cowpea are the main targets for open-row field crops. Characterization and evaluation data have neither been systematically nor procedurally accumulated. There are many data gaps revealed in reports. The bulk of data derived from these trials are not meaningfully amenable to analysis. The Department of Plant Biotechnology and Genetic Resources has the leading mandate for PGRFA research at NAREI. For this purpose NAREI has formulated a Plant Genetic Resources Management System (Paul, 2007b) with a module for warehousing evaluation data. But since its introduction in 1997, there have been major gaps in data submissions and currently much of these data have become un-retrievable. The limitations of conventional seed storage capacity has curtailed local collecting for many vegetable species and hence significantly restricted the number of accessions stored *ex situ*. The diversity of landrace varieties of hot pepper for example, has been grossly under-sampled. The paucity of local conventional seed species in NAREI's *ex situ* collection is, in part, the result of this double dilemma. Also for these reasons, the strategic approach to *ex situ* management in the country should be reviewed, and with it the status of

NAREI's *ex situ* management capabilities must be urgently upgraded. An analysis and recommendations of these needs are elaborated in Chapter 6.

3.2.3 Management of *ex situ* field gene banks

3.2.3.1 The *ex situ* field gene banks of GARC

GARC maintains a field core collection of 43 commercial sugarcane varieties. Of these 12 are under industrial cultivation. Production is often coupled with varietal evaluation on a seasonal basis. One such evaluation is a twice-yearly rankings of varietal performance (Mangal et al., 2002a). These frequent 'ranking' evaluations are part of an intensive surveying and monitoring system across all of GUYSUCO's eight sugar estates. It enables GARC to detect varietal performance regressions as well as ascension, and where appropriate, apply strategies for varietal replacement and agronomic adjustments. Several of these corrective interventions were in response to differential varietal performance caused by pest pressures and to a lesser extent, edaphic stresses (Dey et al., 2002).
Guyana is not known for indigenous sugarcane endemism and therefore local collecting is not an integral activity of GARC. Varieties cultivated at GUYSUCO are a product of collaborative breeding projects across several countries coordinated by sugarcane breeding networks such as WICSBS and WISBEN. Over the years, hundreds of breeding clones were sourced from regional and other national programmes, and GARC would have reciprocated in kind. So some varieties cultivated in Guyana are also cultivated in other countries. Comparative evaluation data documented in other countries would naturally compliment and contribute to those collected locally. Overall, sugarcane varieties cultivated on GUYUCO estates are selected for stable field production performance. The collaborative agreement between GUYSUCO and WISCBS and WISBEN on shuttle breeding saliently addresses a varietal security issue because it allows rapid acquisition of replacements and complementary cultivars from national and regional programs following crop failures or industry-related disasters. With duplicated nurseries in other national programmes and regional networks, GARC should be able to overcome routine challenges in managing its *ex situ* field gene banks.

3.2.3.2 About *ex situ* field gene banks under NAREI

NAREI has several *ex situ* field gene banks, inclusive of pineapple, avocado, cassava, yams, mango, West Indian cherry, passionfruit, cashew, coconut, Citrus species and an array of minor orchard crop species. NAREI field gene banks are spread throughout the country at all of NAREIs research stations, plant propagation nurseries and smaller satellite stations. The generation of *in situ* diversity in Guyana is obvious and inexorable. NAREI does have the spatial *ex-situ* capacity for field gene banks to representatively accommodate a sample of Guyana's *in situ* diversity. However, it is not conceivable in the medium-term, that national gene banks could develop *ex-situ* management capability to accommodate a realistic sample that is both representative and manageable. Genetic diversity in cassava makes for a very good case.

Cassava

NAREI's Kairuni, Ebini and St. Ignatius Research Stations house the larger depositories of the national *ex situ* national cassava collection. All together there are a total of 87 accessions in whole at Kairuni, but a reduced number of various entries are duplicated at the other two locations. However, this sample grossly under-represents the known cassava diversity (Elias, 2000, NARI, 2009).

Orchard Crops

Considering the distribution of orchard crop cultivation in Guyana, both intra- and inter-specific diversity represented in NAREI's field gene banks appear under-sampled. This under-representation is an artifact of a bottle neck in NAREI's management capability. While land space availability does not pose any restrictions, the currently small pool of technical resource personnel does. Adding more accessions will require prioritized collecting that must be accomplished in a determined period of time with existing human resources. However, the capacity for the medium to long-term management of comprehensive collections appears unsustainable under the current situation. In summary, NAREI technical capacity is too limited to fulfill its mandates of local plant genetic resources conservation. The geographic spread further trumps available transportation and logistical support. Even if the capacity of gene banks were to increase, current and near-future management capability would not cope. Not feasible to collect and unable to manage is a double dilemma that is further analyzed in Box 3.1 and Section 3.2.3.4.

Box 3.1 A warning on disaster preparedness

An integral component of ex situ conservation projects has been the establishment of out-station mass-regeneration 'seed cutting' plots of cassava and sweet potato cultivars, and 'seed suckers' plots of Musa species. It was envisaged that at any given point of need about two hectares of planting materials for each of these species would be available to farmers for rapid distribution in an emergency scenario. NAREI's Research Stations at St Ignatius in Central Rupununi was the location targeted in 2009, and efforts were initiated for Kairuni and Ebini in 2007. Even before the St Ignatius location was identified residents had already established a cooperative 5-acre community cassava cultivation plot to supply homesteads with 'farine type' cassava (Paul, 2009b). This community initiative was wholly supported by NAREI'S St Ignatius Research Station that provided mechanical land preparation services and was pre-empted to mitigate the then extended drought period. Since 2009, the St Ignatius community plot has not been visited, but the last status update reported that the effort is still continuing. On the other hand, no progress has been made at Ebini and Kairuni. Several efforts were made to invigorate these projects but due to limited resources and a low priority setting, NAREI was unable to bring these interventions to any level of fruition. During this very period commercial and subsistence farming communities as well as homestead cultivations across the country withstood quite a few episodes of extended unseasonal floods and droughts (Paul, 2009b, NARI, 2005). [25] *Coupled with these climate change fiascos was an imminent 'flash' disease epidemic of 2010 that continues to wilt the plantain and banana industry into oblivion. Hinterland villages in the Rupununi Region bore the brunt of these near-disasters, and coastal and riparian commercial plantain farming communities are still reeling from the devastation of their once lucrative source of livelihood. Is it not a parody that failure to setup up a comprehensive central surveillance unit as proposed and supported by IICA (Guyana) since 2003 (IICA (Guyana), 2003) should come full circle to instigate a near disaster situation? Such it is that when international collaborators are taking Guyana's disaster preparedness into consideration (Paul, 2010), we remain oblivious to the potential perils of our own local food security situation. Prolonging this untenable situation is reneging on Guyana national responsibility to ensure seed security for our farming communities; and by extension food security to the nation. Recommendations to prevent a repeat of these fiascos are elaborated in Sections 8.2.2.4 and 8.2.2.5.*

3.2.3.3 The pioneering work on spices

The current spice programme was accommodated under a NAREI-ITEC scientific exchange programme in 2008. Following targeting collecting expeditions in the country, by 2009, field depositories of local accessions of black pepper (7), ginger (14), and tumeric (8) were assembled at Mon Repos Research Station. A group of 23 trees, maintained at two on-farm locations near NAREI's out-station at Hosororo (in the north-west Sub-district) comprised the 'lone' nutmeg accession. An accession of the rare

[25] A thematic study should be commissioned to investigate the potential for isolated hinterland areas with this Musa production capability in an attempt to resuscitate the plantain and banana industry. This unfortunate situation should not be considered a pending disaster, but rather a new and promising opportunity to safeguard Musa species diversity and launch a new vista for the plantain and banana industry.

cinnamon was collected and remained conserved at Mon Repos and Kairuni. This collection of spice species diversity was sourced from municipal markets in Georgetown (part for turmeric) and on-farm from the Pomeroon River District, the east-Bank Demerara, Wes-coast Demerara, and mainly from the North-west Sub-region. This assembly possibly represents the country's pioneering efforts to amass an *ex situ* field genebank depository of local spice species diversity. Later in 2010, other on-farm evaluation plots spread over the country, served as replicate depositories for ginger and turmeric. Black pepper accessions were duplicated at NAREI's satellite at out-station Hosororo.
'Seed stock' generation of black pepper and nutmeg especially, are still posing a challenge. The results from on-farm evaluation of ginger and turmeric were most promising. A black pepper breeding initiative was initiated in 2009 with field plots established at Mon Repos and Hosororo. The variability among black pepper accessions were reported to be low but one putatively superior accession was identified. Another common wild species (*Piper spp.)* was identified for its potential as rootstock resistance to foot-rot disease of black pepper. This scientific exchange facilitated short-term training for the local counterpart in India. Through this engagement, a dust-free turmeric polisher and ginger grinder were sourced from India and deployed towards the research efforts. This documentation could not capture additional data from these 'spicey' interventions. But from all indications, much field research progress was made for ginger and turmeric. Breeding progress for black pepper remained challenging, and not much was achieved for nutmeg. Documentations on spice cultivation practices relevant to Guyana are captured in a number of brochures (Sasikumar and Sukhna, 2009; 2010b). And the pioneering contributions of the spice expert are captured in his deputation report (Sasikumar, 2009). The tenure of the ITEC spice expert concluded in 2010.

3.2.3.4 Collecting local accessions

In Guyana, varietal diversity within pineapple, cassava and coconut is derived wholly from local accessions. This within-species diversity has been the target of collecting. Several expeditions were conducted during the reporting period to sample and monitor PGRFA diversity (Paul, 2006). [26]Hallmarks of these expeditions were the accumulation of accessions from the 'bastard coconut' complex of the Lower Pomeroon River in 2001, 2007 (Paul, 2007d) and 2009 (Paul, 2009a); the sampling of cassava diversity from Shell Beach in 1997 and 2007, and the Moruca Sub-region in 2007; the 2004 NARI-CARDI joint expedition to sample hot pepper diversity in the North-west sub-region and on the Corentyne Coast. The 27 accessions of sweet potato collected during an expedition to west Berbice during the *El niño* period in 1997 was very rewarding.
Logistical constraints in many cases far outweigh relevance of priorities and needs. While the narrow scope of current collecting missions are sustainable, the cost of expanding geographical coverage for adequately targeted collecting efforts appears unaffordable. From a conservation perspective, an *in-situ* approach would certainly be preferable. However, this may not be the case for endemic crops for which improvement programmes depend on making accessible, a wide variation in gene bank collections. In addition, the opportunity to study the dynamics of PGRFA diversity in a community on-farm setting should be an added incentive to international collaborators.

[26]Not reported in the NISM Database was an April 2011 Guyana (NAREI)-Jamaica (CIB) Joint activity for the Survey and Monitoring of the incidence of Coconut Lethal Yellow Disease (LYD) in Guyana. The areas covered were coastal homesteads and forage grounds in Demerara and Berbice, as well as the municipality of Linden-Wismar in Region 10. DNA molecular diagnostics conducted at the CIB did not detect the presence of the LYD disease agent in the tissue samples taken from Guyana.

The older collections of mango and avocado still maintain diversity components derived from exotics introduced in the early 1960s. Newer collections of Citrus species, cashew and passionfruit are also infused with exotic introductions. Guyana does not have a history of PGRFA exports. This may be the reason why the PGRFA diversity of Guyana is grossly underrepresented in international gene banks (Karen Williams and Ted Kisha, USDA, personal communications, 2009). [27]Generally, apart from one shipment recorded last September 2011 for cassava, this status review has been unable to locate official records of exports during the reporting period. On the other hand, Guyana has greatly benefitted from introduction of germplasm from both nearby and far away countries; showing no exception to the interdependence on PGRFA that affects all countries.

3.2.3.5 Evaluation of accessions in field gene banks

There are extensive evaluation and characterization data for sweet potato, and a good start was made for vegetables (Ralph *et al.*, 2006). Advanced characterization and evaluation interventions are in progress for cassava. That similar data for other clonal field crop species have been hard to come by may be an artifact of a management bottle neck. Management incapacity will logically suggest that we prioritize by species significance. This potential solution gives credence to the recommendation of thematic crops research units.

3.2.3.6 Commercializing propagules from field gene banks

NAREI's plant propagation nurseries also have a long-standing tradition to sample the diversity reservoirs on-farm and in-homesteads for plant buds and scions, and fruit seeds for rootstock propagation. Targeted species were mango, avocado and citrus species. NAREI's propagation nurseries at Mon Repos, Timehri, Charity and Pouderoyen, despite several decades in orchard propagule production are still grappling to meet an ever increasing demand from homesteaders for saplings. Private plant propagators fared none the better. This deficit may be of a positive value because it allows NAREI to assess, in real time, the fluctuations in demand for crop species planted in homesteads. Therefore, the *in situ* diversity within community homesteads can be monitored from plant nursery distribution records. A strategy to alleviate the pressure on NAREI's management resources is suggested in Section 7.6.

3.2.3.7 Documentation of evaluation data

Based upon research conducted by staff in the Horticultural Department, several 'how to' booklets, planting guides, and brochures were produced. These were in the main, specifically edited for use by farmers and field extension agents (Chesney, 1996, 1998; Sookdeo, 2007). Innovative management strategies are documented for field gene banks of targeted crop species (Paul, 2007c), for maize (CR Paul, 1996) and coconut (Paul, 1999c). Absence of known documentations is an artifact of gaps in the NISM database.

In summary, barring technical capability, field gene banks do not face constraints that cannot be overcome with administrative will. The greatest constraints were with maintenance of orthodox and recalcitrant seeds. The undue delay in restoring the national seed depository facility, coupled with the

[27]The arrangement between NAREI and IAEA was essentially a shuttle breeding initiative to derive up with mutants resistant to mocha disease. Germplasm exchange was not part of this agreement.

unreliability of electricity supplies, frustrated research and improvement efforts, and deprive farmers of a requisite service to sustainably intensify crop production. This critical infrastructure is currently under restoration, but the technical competence would still be wanting. An immediate stop gap measure would be for policy-makers to engage international collaborators to intervene with assistance to restore a sustainable system (please see Section 6.7).

Chapter 4. The State of Use

4.1 Utilization strategy

Over the latter decades, Guyana's agriculture has evolved into two seemingly independent sub- sectors. There is the traditional 'rice and sugar' sector from whence we have derived the terminologies 'traditional crop agriculture' and 'non-traditional crop agriculture'. We have largely stuck to traditional methods in the use of PGRFAs in the non-traditional sector, but we have transformed the traditional sector with ever changing modern technologies. This is another of several parodies to be encountered in this study. [28]Barring only recent setbacks in the sugar industry, the contrasting use of PGRFAs in the two sectors have combined to guarantee food security for all and provide an income for more than [29]20 percent of the Guyanese population that obligately must depend upon agriculture for a sustainable livelihood. Guyana has very little experiences in responding to disasters that threaten national food security. During the reporting period there have been some menacing episodes but none has had cause to activate any emergency *food security plan*. It should be more obvious than apparent that the stability of our national food security status is directly related to our tradition of sustainable use of PGRFAs. Conventional plant breeding programmes have been the only source of varietal diversity in rice and sugar. On a seven-year basis, the 'rice and sugar' sector uses a succession of a combined average of five modern varieties in commercial production. The varieties used at a given point in time are few but their genetic base is ever widening. The non-traditional sector attempts to apply modern agricultural systems to optimize productivity using an unwieldy diversity of landrace varieties for commercial gains. At this comma after a few recommendations, it would temptingly suffice to conclude this chapter on the *Status of Use*.

4.2. The state of use in the sugar industry

GARC has a seasonal schedule of continuous crop performance evaluations. In a collaborative shuttle-breeding programme with other national programmes and coordinated by networks such as WICSBS and WISBEN, GARC's breeding clones are evaluated at multiple locations under diverse ecological conditions. A combination of pedigree and bulk conventional breeding methods is applied across national programmes. On a seasonal basis, GARC pedigrees are generated from hundreds of parental clones used in experimental, bi-parental, and open poly-crosses, and their breeding objectives are met through programmes for high quality, multipurpose varieties and base broadening. WICSBS is the main source of fuzz used in the pollination schemes. Family selection, adopted as the first step in the GARC varietal selection programme, is imposed on up to 90 000 single plant clones each season. Recurrent selection is used in advanced stages in the high quality programme. GARC's breeding programme, referred to in the WICSBS Network as the 'D crossing programme', sustained its great potential for extracting high quality clones. At the end of the 'breeding season' national programme leaders meet to evaluate nursery performance and collate data. Results of these cross-programme multi-location data

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[28]The current issues and controversies in the sugar industry indicate that sugarcane is (metaphorically writing) not an under-utilized crops species in Guyana. But it does have a potential to generate 'diversity-rich' products and a propensity to adapt to different agricultural systems. Paradoxically, what most sees as a 'crisis' this report sees as an opportunity (summarized in Box 4.5).

[29]In 1995 employment in the agriculture industry accounted for about 35 percent of the Guyanese labour force (NARI, 1995). This estimated downward revision is an indication of the extent the labour force has diverted towards the swelling mining and construction sectors.

are used to update entries in the core collections. Updated core collection records form the basis upon which about 32 clone populations are characterized and evaluated by multiple national programmes. Because the number of populations are relatively small, characterization activities are often superimposed upon evaluation plots; a time-saving and cost-effective strategy. Secondary pure-stand field nurseries, established on most estates, serve as the main source of 'seed clone' cuttings. In one reported instance, these field nurseries were used at Wales Sugar Estate as demonstration plots for private sugarcane farmers; introducing them to newer sugarcane varieties. To date, GARC has not acquired capability in molecular genetic marker or biochemical analysis technologies, but biochemical traits such as juice quality are inferred indirectly. GARC field research is focused upon practices that reduce impacts on the environment. Strongly emphasis is placed on evaluations for tolerances to biotic and abiotic stresses. Following upon research that saw the adoption of high-density plantings in the mid-90s, agronomic evaluations for cropping systems adaptability, tolerance to abiotic stresses and crop nutritional ecology studies contributed substantially towards diversifying agricultural field production systems (Dey et al., 2002). The industry is largely insecticide-free. The deployment of resistant commercial varieties and prudent biological control interventions were largely successful in suppressing upsurges of major insect pests.

The impact of nutritional ecological research conducted over several years brought about changes in the fertilization policies for sugarcane production, some resulting in considerable cost savings for the industry. In 2003 the fertilization policy was changed to reflect a 15% reduction in Nitrogen application to the plant cane crop. Similar 'reduced-impact' fertilizer interventions were successfully implemented for Sulphur and Potassium fertilization (GUYSUCO 2001; A Dey and H Davis, personal communication, 2012).

In addition to routine evaluations for varietal milling quality, *juice analysis* and sugar recovery rates, GARC's Central Laboratory Unit collaborated with the Plant Breeding Department in 1996 to initiate laboratory screening of 16 commercial and promising sugarcane varieties for their potential to produce *Yellow Crystal Sugar* as a diversity-rich product (GARC, 1996). Varieties were evaluated against the industry standard, D14146. Two commercial varieties, DB 7047 and DB 7661 gave results that were superior to the industry standard, while another three were comparable. Later in 2003, a project involving GARC and Factory Operations Departments initiated a number of studies to critically examine the technical feasibility in Guyana of utilizing sugar cane for products of value in addition to sugar. Out of this initiative was a proposal to examine the potential for fuel ethanol as a diversity-rich product of sugarcane (Davis and Stuart, 2003). One supportive component of this project was Homer's (2004) preliminary investigation into the physio-chemical characteristics of a wild relative of sugarcane (*Gynerium sagitatum*) found near Uitvlugt Estate. Analyses were conducted on both foliage (leaves) and stalks. The aim was to explore the potential of this species as an alternative to wood for the factories. However, gaps in GARC's Agricultural Research Reports precluded a follow-up on the outcome of this project. GARC research data are accumulated in a database *akin* to a Varietal Resource Management System.

One significant intervention of GARC during the reporting period was the 2007 extension of their research programme into the Ebini savannahs in an attempt to acclimatize sugarcane varieties to savannah ecologies (NARI, 2010). This research project was a collaborative arrangement among GUYSUCO, NAREI and WISBEN. Seven varietal clones were evaluated to determine the nutritional requirements in a sugarcane-legume fallow cropping system on brown soils. Another six were evaluated for their adaptation to cultural management practices appropriate for savannah ecologies. Impressive performances were recorded for high cane yields and superior juice quality (brix values). A second phase of this intervention initiated the establishment of a quarantine facility at Ebini for breeding clones involved in a shuttle-breeding arrangement between GARC, NAREI and WISBEN. Incomplete records

could not confirm to what extent sugarcane varietal evaluations for potential fuel alcohol production were pursued. Unfortunately, for reasons that are still neither clear nor logical, this collaborative research project in the Ebini savannahs was curtailed by the lead agency, GUYSUCO.
All of the entries in GARC's sugarcane core collection have been characterized. Rigorous evaluations carried out by local and overseas collaborating programmes have continued to guarantee stable field performance of GUYSUCO commercial varieties. The adaptability and commercial potential of varieties released through GARC are captured, among others, in the documentations of AD Dey *et al.* (2002), and MJ Mangal *et al.* (2002a, 2002b).
GARC, however, and by extension GUYSUCO, needs to urgently reassess the status of its critical mass of researchers. Crop protection seems to be the most proactive. But records gleaned from this study indicate dwindling competencies in sugarcane breeding, plant protection, soil and plant tissue laboratory analysis, and especially crop nutritional ecology. The current staff compliment may be capable of maintaining the minimum of research services, but unless there is a strategic upgrade of its professional staff, GARC would be unable to elevate its research competence to the next level.

4.3 The state of use in the rice industry

The nucleus of BRRS research is its plant breeding programme. To date BRRS has not acquired molecular genetic marker analysis technology. Some is strategic use of bulk breeding, but pedigree selection is the main breeding method used. Pedigree nurseries are generated on-station, but in each season, additional pedigree nurseries are shuttled from FLAR, IRRI, CIAT and the national rice breeding programmes of India. BRRS nurseries are shipped mainly to FLAR for reciprocal evaluations. On a reduced scale, BRSS also has similar collaborative exchanges with ADRON of Suriname. Cross-programme data collated, analyzed and exchanged are used to upgrade the characterization of BRRS 43 entries in its core collection. Between 2007 and 2008, ten released commercial varieties were comprehensively characterized. These characterization data were used to aid pedigree selection. More than 3000 pedigree line selections are evaluated each season. Line performance is selected for high grain yields, biotic stress tolerances, superior grain quality and high milling recovery. In the mid-to-late 90s, an accelerated breeding strategy facilitated the annual release of an average of 2 varieties. In the latter years efforts were concentrated on stability in varietal performance. Advanced candidate lines underwent longer rigorous evaluation, such that the released rate is currently 1-2 varieties every three years. In 2008, for example there were 10 released varieties under commercial cultivation. BRRS currently has a reservoir of several candidate lines that can be evaluated and advanced to varietal status in a much shorter time.
In 2009, as part of a rice and beans project in the Central Rupununi, BRSS ventured into the evaluation of rice varieties for adaptation to savannah ecologies in the Rupununi. Despite the growing conditions at Moco Moco, where the weather conditions were extremely dry with only three significant rainfall events, the first demonstration plots were harvested in 2009. Gaps in BRRS records did not allow a follow-up on the progress of this intervention. During the period 2008-2009, submergence-tolerance lines were evaluated under local rice industry standards. Five breeding lines obtained from FLAR were evaluated against two local industry standards *on-station*. The three FLAR entries FG 05-259, GO4-08, FG 05-298 were promising, but not significantly better than Rustic and G98-30-3. Efforts have been made to acclimatize aromatic varieties, sourced from the national programme of India, in Guyana. But no significant progress has been reported as yet.
The main scope of surveys at BRRS is to monitor the threats posed by biotic and abiotic stresses to cultivated varieties. Monitoring pest incidences in the industry was vigourous. Paddy bug is still an ever-menacing threat. Several interventions in paddy bug management served to gain knowledge of the biology of the insect. Surveying and monitoring on-station helped to improve seed quality. Industry-

wide surveys and monitoring helped to suppress surges in infestations through advanced warnings to the farming community. Towards the end of the reporting period not much progress had been made to manage this menace, but on-station interventions were effective in maintaining seed quality. Rice blast continued to be the most important disease in the rice industry. Monitoring and surveying have helped to give timely advice to rice farming communities on appropriate management interventions. Resistance to rice blast is a major objective of varietal development of rice in Guyana. From a very early stage all pedigreed lines are evaluated for blast resistance. The main sources of genetic blast resistance are local lines such as Diwani and 6039.

Coastal rice ecologies in the rice belt would appear homogenous for the fact that they are all characteristic front-land clays. However, this observation did not distract from research to diversify rice production systems. From potassium supplemental fertilization to deep placement of urea, a gamut of fertilizer studies contributed towards new agronomic packages for rice. Available records would preclude an analysis of the effective cost savings. However, many of the packages were adopted by farmers.

BRRS is by far the largest certified producer of commercial seeds sold to farmers in Guyana. Owing to the standard required, and the cost of inputs and intensity of production procedures, BRRS has been filling a void in assisting farmers by subsidizing the cost of procuring seeds. In the earlier years between 1997 and 2002 production of basic and certified seeds more than doubled, and ever since has been able to satisfy farmer demands. Farmers are always free to produce their own seeds, but BRRS seeds are generally preferred. Dedicated seed production plots are managed on-station. Every growing season, field days are held on-farm where varietal demonstration plots would usually double as seed production demonstration plots.

This study ascertained that the system used to archive research data was akin to a Varietal Resource Management System . Records indicate that there was a gamut of research studies conducted by all Departments. The most publishable results were recorded in the Annual Rice Research Report of 2008. The results can be easily edited for peer-reviewed publication. Yet it is likely that this 2008 report is the only documentation of that year's research results. Apart from Annual Reports in which there are gaps, the paucity of references in BRSS database would suggest that filling publication gaps would be hard to come by.

Research and field extension staff work closely with farmers' group. This strategy keeps research staff in sync with the needs of farmers. BRRS is the only agricultural research institution in the country that has a dedicated policy on farmer-participatory breeding. These interventions are accommodated through frequent on-station and in-field farmers' field days. On-farm demonstration plots and on-station seed production fields are the preferred media of this exercise. The on-station varietal museum is a source of edification for new BRRS staff, GRDB extension staff, farmers and students alike.

Stability in varietal performance and improvement in cropping systems diversity have yielded some significant results and continue to be a strong component of the rice improvement programme in Guyana. Despite the successful interventions listed above, paddy production increased incrementally over the years but yields remained at the same plateau level; an indication that farmers were increasing the acreage of marginal lands. As a result, a major lingering concern may be reduced export grain quality.

Records of phytosanitary certification gleaned between 1997 and 2009 revealed an extremely wide range of grades for export quality grains (Squires *et al.*, 2009). The number of grades increased towards the latter years when poorer industrial-grade rice was entering the market. Whole, discoloured and broken grains comprised a spectrum of no fewer than eight grades. The major shift from grain export to paddy export in 2010 is no doubt an artifact of this lingering rice quality issue. But would the reluctance to give up on the new lucrative paddy market exacerbate this quality issue at the field level? Not really!

[30]This is an important development, because once rice quality demands are relaxed a preponderance of higher yielding lower quality varieties will become available, and BRRS breeding efficiencies would increase. The genetic base of commercial varieties would be widened in tandem with increased yields, and these varieties with wider genetic base would be better able to buffer both abiotic and biotic stresses; a dream result many breeding programmes would wish to emulate.

4.4 [31]The state of use in the non-traditional sector

4.4.1 The status of promoting sustainable crop production systems

Diversification of crop growing systems has historically been the main focus of Guyana's agricultural research interventions. NAREI'S strongest research capability has traditionally been in the area of *crop nutritional ecology*. During the last 15 years NAREI has emphasized this trend. The notion is that it is possible to adapt a wide range of crop species to any local growing conditions by modifying the nutritional environment in which the crop grows. An accompanying intervention is premised upon another notion that commercial value can be increased by 'purifying' crop stands of locally adapted crop varieties. On these bases, there have been a deluge of agricultural systems imposed upon the cultivation of landrace varieties to increase their productivity (NARI, 1997b; NARI, 2001a). So far, NAREI has to its credit the successful purification and adaptation of one pineapple (*Ananas comosus*) land race cultivar (Montserrat) to growing ecologies in the west Demerara areas of Canals Polder and the Parika-Salem Farming Communities, and another (Sugarloaf) in the Tri-lakes community inland of the Essequibo Coast (Craig *et al.*, 2006; Blair, 2006). Recently in 2005, similar adaptation studies were successfully completed for sweet potato (*Ipomoea batatas*) in the white sand ecologies on the Soesdyke-Linden Highway. Meanwhile, local farmers' varieties of Boulanger (*Solanum melongena*), bora (*Vigna sesquipedalis*) and ochro (*Hibiscus esculenta*) with their strong adaptability to extreme conditions, continue to excel. Fertilizer use in coconut (*Cocos nucifera*) cultivation is not popular. But NAREI's preliminary investigation (as recent as 2010) of the response to fertilizer applications on coconut plantations in the Lower Pomeroon River reported some encouraging results. Oppositely, farmers have reported responses from fertilizer applications on local landrace strains of plantain and banana. Nonetheless, the response to synthetic nutritional amendments of most land race crop species has been generally recalcitrant. Landraces of roots (cassava), aroids (eddo) and rhizomes (ginger), the single landrace corn variety (Charity), cucurbits (pumpkin) and hot peppers are recognized examples. Low fruit set of orchard crops continues to be a persistent challenge to both researchers and farmers.

> ***Box 4.1 Resilience of landrace varietal diversity***
> *Populations of landrace varieties are usually heterogeneous (comprising a mixture of plant types). Purification will almost always remove component plant types that contribute, for example, towards overall yields, stable adaptation to abiotic stresses and tolerance to a complex of biotic pressures. For this reason, the resilience of landrace diversity cannot be easily overcome by the imposition of even the simplest of modern production systems. There have been a few surprising successes, but those have been more an artifact of chance rather than science.*

This acclimatization strategy decreases 'unwanted' crop heterogeneity. But with the loss of responsive components within these landrace varietal complexes, the results are often contrary to those intended. It is apparent therefore, that with current resources and local capabilities, the possible gainful

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[30]Rice grain quality is known to be negatively correlated with yields.

[31]The section specifically pertains to NAREI, the focal point for plant science research in Guyana.

interventions to make landraces varieties responsive to modern agricultural practices have been exhausted.

4.4.1.1 A case for manuring

An important outcome of the experiences in crop nutritional requirements in Guyana is the recognition of the benefits of manuring. The main manure sources have been livestock-based. While alley cropping continues to linger at the field research stage, use of compost in homesteads is very popular. Manuring, for example, is the single most important source of crop nutritional needs in homesteads. Small-scaled commercial vegetable farmers have a very good working knowledge of the tolerance levels of various vegetable crops for manuring, synthetic fertilizer applications and combinations of both. Researchers are wont to caution about the disadvantages of bulk and variable nutrient composition of animal manures. The most successful intervention in sustainable farming systems for non-traditional crops in the country may be considered manure-based and farmer improvised. Swamp cultivation of eddoes (*Colacasia esculenta*) in the white sand swamp ecologies along the Soesdyke-Linden highway is a very good example of farmer-based improvisation. Commercial swamp eddo production is not only the largest manure-based farming system in Guyana, but is undoubtedly the most efficient of farming systems in the country.

> ***Box 4.2 Manure-based commercial swamp eddo***
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> *[32]From a mega-environment perspective, and contrary to popular belief, the production center for eddoes is not the North West District. Eddo production holdings in the relatively small 150 acres of cultivated swamp ecologies along the Soesdyke-Linden highway has the potential to absorb more than triple the current commercial output of poultry manure sold by the accompanying poultry enterprises. Incidentally, this same eddo farming community is the heart of Guyana's poultry production industry. Eddo production in these ecologies is perhaps the most efficient among all crops. Together with the proximity to export facilities, the sustainability of swamp eddo production must therefore be attributed to its profitability. Yet, findings from the gamut of research activities on marginal soils of the Soesdyke-Linden Highway have over several decades, failed to document the scientific or commercial basis of swamp eddo production (MA Livan, personal communication, 2011).*

This example gives credence to the notion that non-traditional PGRFAs should perform much better using traditional production techniques.

Associatively, using poultry manure as a crop nutrient source, Paul *et al.* (2009a) reported the successful acclimatization of local sweet potato accessions to these white sand ecologies on the Soesdyke-Linden Highway. There have been similar crop research studies (pepper, passionfruit and green vegetables, for example) but the scarcity of manure and the paucity of research information on crop manuring nutritional ecology are making these interventions unsustainable. In another approach, acclimatization of putative drought-tolerant cassava accessions to these ecologies has recently been initiated by NAREI. The above limitations notwithstanding, it is obvious that the potential of manuring has sufficient merit to revisit the notion of 'marginal soils'. Accordingly, a *situational analysis* of the Poultry Industry on the Soesdyke-Linden Highway is imperative.

4.4.2 Status of introduced improved crop exotics

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[32]Results of surveys and research studies going way back to the 1970s unto present-day have suggested that the North West District has the greatest potential for commercial aroid production.

The material basis for Guyana's non-traditional crops has historically been farmers' landrace varieties. Exotic introductions have been the primary plant breeding intervention for broadening the genetic base of these crops. Recently, vegetable cultivations have seen a preponderance of these exotic introductions. But for quite different reasons, the efforts to adapt improved exotic garden vegetables and field crops to local ecologies have been generally disappointing. Brassicas, tomatoes, hot peppers, cucurbits, carrot, soybean and cowpea have been some examples. The current efforts to acclimatize potato (*Solanum tuberosum*) are amusing, to say the least. The paucity, and more often the absence of characterization and evaluation data support this observation. An analysis of introductions of vegetable crop species showed that the application of this plant breeding method has been found wanting for lack of knowledge about its scientific principles and applicability.

The research work of the Vegetables and Agronomy Departments at NAREI has been commendable in so far that they were cognizant of the need for characterization and evaluation data. The initiative of Ralph *et al.* (2006) to broaden the crop diversity of local accessions of bora produced some positive results. Unfortunately both sets of efforts were not sustainable. Farmers do have access to a reliable commercial source of imported vegetable crop seeds from local agro-chemical companies. The basis for recommending these exotic varieties is apparently more for their *commercial potential* rather than their adaptability to sustainable commercial production systems (Kharb and Homenauth, 2003). This uncertainty is further exacerbated when the majority of these exotics bypass the scrutiny of plant quarantine systems and characterization and evaluation procedures of NAREI. Inevitably, a few of these exotic 'escapees' do become successfully established on-farm and in homesteads. Sweet pepper, tomatoes and cabbage are some examples of successful exotics entering into commercial production through this avenue. For the most part, except for a few (tomato varieties Heatmaster, Calypso and Mongol, and Cabbage varieties Salvation and Tropicana, for example) of those exotic vegetables for which NAREI has been able to intervene, this loophole of varietal succession has been largely unsustainable.

4.4.3 Status of germplasm characterization and evaluation

Except for sugar and rice that are in very good standing, the traditional crop species have been largely disregarded in this priority area. NAREI, the focal point of plant science research in the country, has only two records documenting a comprehensive characterization of crop species: sweet potato and a group of seven green vegetable crop species.

[33]In the department of Plant Biotechnology and Genetic Resources of NAREI, characterization and evaluation activities on PGRFA are captured in ongoing projects for coconut, hot pepper, sweet potato avocado and cassava. Due to limited research resources, significant progress is reported only for sweet potato and cassava. Using Bioversity International crop morphological descriptors, all 63 sweet potato accessions in the field gene bank towards the end of 2001 were characterized (Paul et al., 1999; Roberts et al., 2001). This data, accumulated within a three-year period, is archived in NAREI's sweet potato database. No other characterization record for non-traditional crops in the country comes close to

[33]It is apposite to note that by early 2011, NAREI had acquired the critical mass of technical competencies, materials and equipment, and laboratory housing facilities to initiate DNA molecular analysis research for the first time in the country's agricultural history. But at the point when the new biotechnology programme should have commenced in June 2011, it was strategically decided to take advantage of an opportunity to upgrade the laboratory infrastructure to a substantive biotechnology facility.

sweet potato. Characterization work on cassava commenced more than five years ago but progress has been painfully slow.
On the other hand, data from an overwhelming number of agronomic evaluations have not been consolidated and therefore it is difficult to migrate data into a retrievable database. Redundant evaluations are therefore not inconsequential. In short, in the absence of even a semblance of a plant breeding strategy, evaluations are not premised on a concerted crop improvement effort, and hence the pressure to characterize and evaluate is diminished by a lack of recognition of their relevance and necessity.
For these and more reasons, attempts to broaden the genetic diversity of crops in agricultural systems have a familiar semblance to *travesty*. There has been a plethora of instances where exotic varieties were 'released' (escaped) to farmers without documented passport, characterization, or evaluation data. There are also, several examples where reactions to abiotic and especially biotic stresses of improved imported accessions were not pre-evaluated prior to varieties 'escaping' to farmers. Also quite often, passport and characterization data accompanying imported germplasm have been irretrievably dislodged. In a majority of instances, whenever experimental data were accumulated, results of a single trial or plot demonstration were considered sufficient to release a variety for commercial cultivation (NARI, 2007b) . During the reporting period, for example, only two multi-location trials were reported. Those were for sweet potato and peanut, and summarized in Section 4.4.4. As a consequence, several promising accessions may have been inadvertently discarded, and those that have entered farming systems soon became commercially unsustainable (NARI, 2007a). Butternut squash, broccoli, cauliflower, the bullnose hot pepper variety, spices, potato and wheat are classic examples (NARI, 2007a; Kharb *et al.*, 2004; Kharb and Homenauth, 2004b). The treatment of soybean and cowpea accessions was less abusive, but the results were nonetheless disheartening (NARI, 2004a). NAREI will do well to correct the impression that 'stability performance trials' is an alien concept to its research policy. The realized consequences of these missteps are generally unknown or undocumented, but there are quite a few suspected cases in the glaring public. Hot pepper, brassicas and garden beans, for example, may have been the inadvertent targets. Apart from NAREI, the private agro-chemical companies, with their plethora of exotic improved varieties, cannot honesty be exonerated (Kharb and Homenauth, 2003). Much time, cost and tedious efforts are required to produce modern varieties, and farmers do show their appreciation to toiling researchers by investing in quality seeds. For these and more reasons, there are *legal* requirements prior to commercial release of plant varieties. The National Seeds Act 2011 and National Plant Quarantine Act 2011, for example, contain provisions to bring *in-line* those seed distributors who are oblivious to consequences of releasing unproven exotic varieties to unsuspecting farmers.

4.4.4 Status of crop improvement and seed distribution systems

The Department of Plant Biotechnology and Genetic Resources of NAREI has the lead role for research on PGRFA. In reality, other departments are also very actively involved in PGRFA research. The Department manages a number of on-going strategic projects for coconut, hot pepper, cassava, mango, sweet potato and avocado. Utilization of PGRFA in plant tissue culture is covered under Section 3.1. Use of PGRFA focused on the thematic research area of yield and yield component inter-relationships. To this end, pioneering research was completed for peanut for savannah ecologies in the north Rupununi savannahs in association with NRDAPA (Paul *et al.*, 2009c), and for sweet potato in the white sand ecologies along the Soesdyke-Linden Highway (Paul *et al.*, 2009b).

4.4.4.1 Peanut

Results for peanuts demonstrated how to optimize yields and kernel quality by manipulating sub-sets of yield components. Unfortunately, the project did not include a peanut marketing component. As a result, the increased production created a glut that made peanut farming in the community unprofitable. A government-sponsored school feeding programme utilizing products from peanut value-added processing has partially allayed farmers' risks.

4.4.4.2 Sweet potato

Characterization data were used to select an initial 10 candidate varieties for evaluation. Several on-station, on-farm and multi-location trials conducted over a six year period, confirmed the absence of the threats of sweet potato weevil in the white sand ecologies along the Soesdyke-Linden highway. Five varieties were selected for their adaptability and high yields, including one for unusual extended field persistence.

4.4.4.3 The status of varietal evaluations and seed supply systems

Unlike the Department of Plant Biotechnology and Genetic Resources, other research departments at NAREI do not strictly follow any of the standard varietal evaluation procedures established for non-traditional crops. Consequently, the maintenance of stability in varietal performance has been difficult to impossible. It is not surprising therefore that the breeding gains from crop introductions have failed to significantly increase vertical production in non-traditional crops. For this reason, any realized increase in production is expected to be derived from increasing the area under cultivation of existing low-performance cultivars. Failure to realize the genetic gains expected from introductions of improved varieties is therefore inadvertently degenerating the productivity base of non-traditional crop species.[34] This parody exists, in part, because of the absence of a formal commercial seed industry and substantively, the failure to enact timely seed legislation. This absence is depriving NAREI of its obligation to provide quality seed to farmers (Kharb and Homenauth, 2004a; GFA Consulting Group S.A., 2010). The implementation and enforcement of the recent *National Seeds Act 2011* would go a far way towards jump-starting a formal seed industry. Delaying the accompanying plant seed industry legislation will continue to be a major constraint to agricultural modernization in Guyana. Accordingly, some additional relevant appendages to the National Seeds Act of 2011 would be Seed Certification, Seed Standards, National Performance Trials, Commercial Release of Plant Varieties, Farmers' Rights and Plant Breeders' Rights.

Until only in recent months, the nontraditional crop sector has endured the absence of a formal centralized system for orthodox seed storage for close to eight years. In the main, this short coming has precluded collecting of crop species with orthodox seeds. During this period, commercial and subsistence farming communities as well as homestead cultivations have had to withstand quite a few episodes of extended unseasonal floods and droughts (Paul, 2009b). The numerical loss of crop species diversity has escaped the scrutiny of this documentation, but we can safely surmise that there were significant depletions in crop varietal diversity. Nonetheless, there have been a plethora of national events involving government-aided distribution of seeds in these emergency situations. These supplies

[34] It should be noted here that a formal seed industry has always been existent in Guyana. But government policies do not encourage its commercialization.

may have been recorded but were not captured in the records of the NISM database. Absence of adequate passport, characterization and evaluation data (related to their adaptability to biotic and abiotic stresses) of these distributed seed materials are not without caution.

The access by farmers and researchers to quality 'seed' material is an important gauge of how well research programmes and seed distribution systems are functioning. In this connection, government has often reiterated its commitment to ensure users are provided with quality seeds. The government-funded NAREI do have records for the sale of vegetable seeds and nursery saplings. There is need for a centralized system that documents planting materials distribution. In contrast to those of BRRS, the current disjointed format of orthodox seed distribution documented in NAREI's annual reports is very tedious to summarize. Agro-chemical companies, private commercial vegetable seedling nurseries, and a number of NGOs may have more accountable systems but these records could not be evaluated in time for this documentation.
In summary, without any standard scientific guidance, the current untenable status of non-traditional crop seed supply systems may continue for some time to be an artifact of the lack of seed legislation enforcement and accompanying regulations, as well as dramatically dwindling technical competences in seed science technology and gene bank management.

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

4.4.5.1 Promoting the value of under-utilized crops

The parody of landrace varietal diversity and marketability of their harvests have been revealed in Section 2.4.1.2. The capability of producers to supply sufficient product of a specific or the smallest number of landrace varieties are restrained by their low productivity. The demand for uniformity in the industrial processing industry cannot cope with this limitation of diversity in quality and quantitative fluctuations in supply. In an assessment of the risk management and finance along the cassava vale chain, Blair (2010a, 2010b) further lamented the prevalence of poor storage, and observed that generally postharvest handling constitute a significant source of risk for traders. GFA Consulting Group S.A (2010), in their strategic plan for fruits and vegetables concurs with the findings of Blair (ibid). One way NAREI has addressed these quality deficiencies was research on small-scale agro-processing. Most of this research component was conducted at NAREI's Mon Repos Post-harvest and Agro-processing laboratory. Between 1995 and 2009 a multitude of research interventions were executed in the field of Agro-processing and Post-harvest technology and commendable work and findings have been reported (Faroze, 1998, 1999).
Green vegetables, roots and tubers and fruits were targeted. There were several and various research studies including waxing, blanching, freezing, solar drying and desiccation, among others. The development and evaluation of several of these were instigated by industry. It is not explicit, but it can be implied that some research outputs may have been adopted by the local agro-processing industry. Notwithstanding, commercialization of value-added diversity rich products has been spearheaded by the local industry itself. These would range in the use of local hot pepper varieties in the condiment and spices sector, and the use of a wide assortment of fruits in the local beverage industry. The local food-grade oil processing industry is noted to sustainably depend 100 percent upon local varieties of coconut. But it is not clear to what extent cassava contributes to the demand for starch at the single local cardboard container manufacturing plant.
There were a number of results that aided NAREI's in-house researchers. A number of these investigative efforts took cognizance of challenges in agro-commodity marketing. Value-added studies specifically investigated the storage and processing potential of underutilized crop by-products. One

successful product of post-harvest technology research was a solar dryer designed by NAREI. One recipient of this technology was the Pomeroon Women Small Cottage Association (PWSCA) at Charity in the Pomeroon River District. Reports gleaned for this documentation could not determine to what extent other research findings were applied to targeted small-scale agro-processors.
In 2009, when the lead post-harvest research scientist left NAREI, the Post-harvest department was moved out of NAREI to GSA to take advantage of that institutions apparent greater technical capability. However, GSA is not a research-oriented institution. The consequence is the void we see in post-harvest research in the country.
This study was unable to explore the nexus between cost of on-farm production and export marketing returns. Cost of production studies of all crops, especially those in the export sector will go a far way to give some focal direction to research efforts. Complementary to cost of production studies would be schemes to promote access of financial assistance to small-scale farmers and cottage agro-processors. This need for financial assistance to agro-producers and marketers is currently pursued through the ADP (C Anthony, personal communication, 2011). There has been some progress but anticipated lending targets were not fully realized. With the increasing excess liquidity in the banking system Government would do well to use its influence to restore an agency akin to the former Guyana Agricultural and Industrial Development Bank.

4.4.5.2 The status of marketing non-traditional crop commodities

4.4.5.2.1 Local marketing of agro-commodities

A perusal of commodities at municipal and rural markets will reveal a wide assortment of crop produce on daily display. From fruits of the notorious weedy shrub (antidesma, *Antidesma ghaesembilla*), to the wild swamp palm (kukarit, *Attalea maripa*), monkey apple (*Annona glabra*), chiganet (*Bellucia grossularioides*) and sumotoo (Bell Apple, *Passiflora maliformis*) to the craved rambutan, together comprise a minimum estimate of about 200 botanical taxons. Except for hot pepper, Guyanese seem to have a strong preference for fresh rather than processed plant-derived foods. This is the predominant form that PGRFAs are offered for sale. It should be obvious therefore that marketing of PGRFAs should be conditioned by seasonal scarcity and abundance. Prices of green vegetables, pumpkin and several ripened fruits have the greatest price fluctuations. In recent years, prices of tender coconut have shown a continuous rising trend. The ever popular tender fruits of breadnut are hard to come by at all market places. On the other hand, breadfruit chip, akin to plantain chip, is gaining popularity. But its sapling has always been in high demand. Except for when large unscheduled volumes are exported, prices and supply of pineapple, ginger and eddo are stable all year. The pricing feud between the locally produced plantain and the imported potato (*Solanum tuberosum*) makes for an interesting observation about commodity substitute dynamics. Consumers often prefer the cheaper choice.
These pricing dynamics relate an even more important phenomenon in that they indicate those crop species that are (or not) most resilient or prone to the vagaries of our farming systems; of recent, implicated in climate change phenomena. The increasing prices for tender coconut for example, are an indication that farmers need to replace their plantations of aged late-maturing palms with plantings of the '3-year' short duration dwarf varieties. Scarcity of breadnut may be an artifact of its great demand. There is no denial that the '7-curry' menu served at hundreds of religious functions and ceremonies held monthly across the country are deprived of this venerable vegetable. Both breadnut and breadfruit are

easily propagated. [35]NAREI would do well to find a research solution. Extreme weather conditions aside, the fluctuating prices of vegetables is probably an artifact of varietal instability of unproven newly introduced hybrid cultivars. On the other hand, ginger has excellent field persistence, and pineapple and eddo have a fairly established farm production and marketing system.

> ***[36]Box 4.3 Marketing information is valuable***
> *Then there was this farmer from a remote community… was so fed up with the consistently low prices she was receiving from huskers, decided to market her shipment of 142 pumpkins directly at one of the Georgetown municipal markets. At the end of the second day that mid-December evening, the farmer had managed to sell only 27 fruits. Fed up at the futility of her efforts, the farmer succumbed to a husker's 'rescue offer' and accepted the cost of her return ferry passage in exchange for the remaining 115 fruits. The husker promptly hoarded the 'gift' in storage until when the prices peaked three months after.*

Guyana, perhaps more than any other country, offers a special example of the challenges of marketing commodities of non-traditional crop species. Extended to export markets, it is a daunting task for even the most enterprising expert on agro-commodity (market) futures. This study takes cognizance of the invaluable contribution of local landrace varieties to our agricultural industry and food security. Small farms, homesteads and foraging grounds shall continue to evolve along with its people counterpart. But for the specific purpose of commercialization, Guyana's gamut of landrace varietal diversity, for the most part, may at best be relegated to crop improvement programmes.

4.4.5.2.2 Promoting the export potential of local PGRFAs

This documentation summarized the study of Squires et al. (2009) in which more than 6000 plant quarantine export certificate records between 2004 and 2009 were analyzed. Exports were made to 61 countries. Excluding alcohol, more than two-thirds of these records were for non-traditional agro-commodities exported to 25 countries. Records available at the time could not capture exports through frontier ports to Brazil, Venezuela or Suriname. The ports of exit used in the study were Georgetown and Timehri. There were indicators for both realized and potential markets.

4.4.5.2.2.1 Potential markets

The potential commodity markets were indicated by un-valued samples mostly air-lifted and specifically targeting Guyanese in the diaspora. More than 80 percent of these samples were gifted to relatives in North America. The remainder was destined for the wider Caribbean and the United Kingdom. Dried herbal spices, hot pepper sauces, achar, cassareep and fragrant herbs for religious uses were quantitatively the most demanded commodity samples. Fruits were restricted to only what were allowed to be imported in the recipient country. Cassava bread, pickled mango and tamarind balls were also popular. But in general, most exports were accompanied by both dried and liquid concoctions of medicinal and neutraceutical herbals. This study was unable to access previous SWOT analyses of these potential marketing niches, and as such could not ascertain to what extent these sampling trends could be commercialized.

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[35]http://ntbg.org/breadfruit/breadfruit/propagation1.php), for example has information on a number of vegetative methods.

[36]Vegetables are at their lowest demand during the Christmas season.

It is obvious that non-traditional agro-commodities require special treatment. Inventorying the distribution, productivity, and consumption trends of non-traditional crops with commercial potential will go a long way to assess the capability of suppliers to meet export demands.

4.4.5.2.2.2 [37]Realized markets

The realized markets were mainly in the wider Caribbean. Barbados, Trinidad and Tobago, Antigua, Grenada and St Lucia were the main importers for all commodity groups. Sea-freighted consignments of aroids, pumpkins, watermelon, cassava, bora, cabbage, hot pepper and coconuts targeted the fresh commodity markets. Other ripened and 'green' fruits were not as popular in the Caribbean as they were in North America. Shipments to North America were restricted to small but frequent shipments expanded to include a broader assortment of fruits, cassava bread and cassareep. Consignments to other destinations in the wider Caribbean serviced the territorial arch from The Bahamas, The Netherland Antilles, St Maarten, Jamaica and The Dominican Republic, to The British Virgin Islands, Antigua, St Lucia, Grenada, and back to Suriname. Of significant note were brand name herbal teas processed and packaged by a local enterprise, and exported to a niche market in the United Kingdom.

> ***Box 4.4 Commercial foraging of herbals***
> *Contrary to popular beliefs the foraging of traditional medicinal and neutraceutical herbals may be sustainable; although not necessarily on a commercial scale. Despite their ubiquitous presence the distribution is wide and scarcely ever concentrated in any easily predictable and accessible ecology. These ecological built-in safeguards are apparently serving to insulate herbal diversity from commercial foraging. Even if over-harvesting should threaten species depletion, open and closed foraging seasons, akin to wild life species under CITES convention, can be imposed. Ban carilla (wild relative of Momordica charanta L.) is a good example. Venture capitalists interested in commercializing the forest succession species, Congo Pump (Secropia spp.) will do well to first consult with the GFC. In the meantime, we await the results from the industrial foraging of manicole.*

In 2002, the value of all non-traditional crop commodities was valued at US$3 605 000. The quantity of imports by Canada was the highest for Guyana and from the wider Caribbean. In this year the lead commodities were mangoes, bora, hot pepper, pineapples, genip, squash, eggplant, sapodilla, awara, bananas, poi callaloo, mammey and dried thyme.
Documentation compiled by NAREI for the basal year 2005, estimated the value of non-traditional commodity exports at US$6 221 103 (NARI, 2007c). Intra-regional exports of 49 agro-commodities were US$1 285 485. Extra-regional exports for 15 agro-commodities were valued at US$4 935 618. Hot pepper, pineapple, pumpkin, plantain, watermelon and bora were the top exports for the 11 years leading up to 2005.
In 2009 the total value of non-traditional agro-commodity exports was US$ 5.2 million. The major processed commodities exported regionally were copra, crude coconut oil, copra meal and tender coconut water. The major fresh commodities exported regionally were dried coconuts, pumpkins, watermelons, plantains and eddoes. The major importing countries extra-regionally, were Dominican Republic, Canada, France, Lebanon and Belgium. The major fresh commodities exported extra-regionally were dried coconuts, mangoes, wiri wiri hot peppers and eddoes. The major processed commodities exported extra-regionally were heart of palm, pineapple chunks and coconut crude oil.

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[37]Export-earning values were distilled, in the main, from Annual Report data published at the web portal of the NGMC (http://www.newgmc.com/index.php?option=com_phocadownload&view=category&id=4&Itemid=53)

In summary, the value of exports may be relatively small, and supply of individual commodities may have been erratic. Except for a few vegetable species, Guyana should stand out as a source of origin where sizable exports of non-traditional agro-commodities were obligately derived from very close to 100 percent farmer's cultivars and foraged botanicals (Kharb and Homenauth, 2003). We can therefore draw a nexus with the observation that an audit of homesteads should capture at least 80 percent of the entire diversity of PGRFAs in Guyana (please see Section 2.2.1).

4.4.5.2.2.3 Promoting the export marketing of non-traditional commodities

Government policy strongly advocates value-added processing, but the industry has been largely unresponsive. This tardiness was reviewed in Section 4.4.5.1 and is summarized in Section 6.1. In 2007, government entered into a number of agreements on protocols for export compliance of agro-commodities. Agreements with Barbados, Trinidad and Tobago, Antigua and St Lucia were effected. Government later spearheaded an initiative to bring the industry of farmers and exporters into compliance with import standards of targeted countries. This export diversification thrust was supported by an Agricultural Diversification Programme (ADP), the Rural Enterprise and Agricultural Development Project (READ), Conservancy Adaptation Programme (CAP) and an Agricultural Support Services Programme (ASSP). In 2008, Guyana Agricultural Producers Association (GAPA), an umbrella entrepreneur NGO of agro-commodity traders and producers, was re-established to mobilize small farmers and to aid them in the compliance process. One group that benefitted substantially was the Pomeroon Women's Small Cottage Association (PWSCA). Their operational capacity was boosted with financial and technical support. There may have been some technical and logistical issues with the export diversification thrust; one being logistical difficulties in accessing remote farms. These farmers endured long waits before certification. But in the main, most of the compliance pressures were placed upon resource poor farmers. As a consequence, some farmers could not keep up with the rigorous inspection routines and the preparation of produce for marketing became tedious.

4.4.5.2.2.4 NGMC and Ministry of Agriculture

Meanwhile, NGMC continued to give commendable support to the farming communities and agro-commodity marketing sector. The NGMC assumed an active role in export promotion. A refrigerated trucking service was provided at a subsidized rate to farmers and exporters. Another significant infrastructural input was the strategic establishment of packaging houses at major ports of exit. These facilities operated on a daily basis and also responded to special requests by exporters. The notion was that by producing high quality produce, exporters, and by extension farmers, would be able to tap into lucrative export market niches. The services offered by packaging houses were upgraded and the compliance system had improved because more farmers were aware of the need for compliance. At their comprehensive web portal, NGMC posted information on commodity export procedures, potential market niches and weekly commodity price movements. A monthly newsletter debuted in 2011, but it is not clear if this source of information is still functional. In 2009, the NGMC, in association with the Ministry of Agriculture, implemented a market facilitation and information dissemination service. A wireless component kept stakeholders in the industry informed about critical issues and marketing opportunities. Farmers and commodity traders could receive cell phone, radio and TV updates on current commodity price trends, weather and pest risk alerts, and notices of community flash meetings. By 2009, this information system had appended NGMC's Agricultural Market Information Service (AMIS).

4.4.6 Stimulating commercial non-traditional crop enterprises

Commercial production of corn and soybean has long been a researcher's dream choice for agricultural production in the Intermediate savannahs. A high infusion of fertilizers would be required, together with the attenuated increased use of fuels that mechanization requires. In this latter regard an agro-industrial biofuel production component using cassava and sugarcane would be the natural supportive complement to agricultural mechanization; from whence we may derive a compatible corn-soybean-fuel sugarcane and cassava production system.

> ***Box 4.5 The new agriculture frontier***
>
> *Researchers in Guyana have long since conceptualized a vision of a new frontier for local Agriculture. The settings for a logical scenario are still the inland ecologies of the intermediate and Rupununi savannahs. Information within and outside the scope of this compilation supports the view that the time has long past for local researchers to extend or migrate some relevant components of their research programmes into these inland ecologies. Relatedly, we know that stakeholders in the agriculture sector are not oblivious of threats to the future of coastal agriculture. A cursory look around the country would reveal that the population density is concentrated within and close to the agricultural industries. From* ***Chapter 2*** *we should be able to understand this inseparable coexistence. It is therefore logical to deduce that if the future of agriculture is threatened, so too should be the Guyanese people. And if agriculture moves to safety, so too should its 'people' counterpart.* [38]*The point here is that in the light of inevitable debilitating climate change scenarios on coastal agriculture we would need to ease the population pressure on coastal resources by encouraging people to move inland. Easier said than done? This study posits that if the least of logical reasons was used, it would have been easier to secure the livelihood of coastal dwellers than to curtail GARC's 2007 innovative research projects on sugarcane adaptation at NAREI's Ebini Research Station in the intermediate savannahs. As if that were not to be enough, we have Stine Seed Company (disclosed publically in Guyana for the first time in 2008) of the United States of America, just across the Berbice River from Ebini.* [39]*An idea can be gleaned from the internet, but the technological fortitude of Stine Seed Company is better known at the United States Patent Office (USPO). The multimillion-dollar-revenue company of GM corn-and-soybean fame has an MOU with NAREI; the fourth clause which reads (quotes inserted): 'MS and Stine will expand operations in the Intermediate Savannahs to include the Ebini Station currently managed by NARI'.* [40]***Reliable information at hand exonerates Stine Seed Company of inaction****. In the parlance of one of our popular TV programmes, we should: Stop the suffering of coastal people, because anything less would be criminally negligent.*

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[38]Flooding seems to be the single most serious threat to coastal livelihood. Coastal agriculture cannot withstand the perils of unseasonal floods, but the intermediate savannahs have proven it can. Predictions from the scientific notion of rising sea levels have become increasingly credible. The few millimetres of unseasonal rains, currently reaping havoc in coastal ecologies, pale in comparison with rising sea level scenarios.

[39]Stine Seed CO (http://www.stineseed.com/) in Adel, Iowa, is a private company categorized under Seeds and Bulbs. Current estimates show this company has annual revenue of US$20-50 million and employs a staff of approximately 100 to 249.

[40]This study could not document any evidence that NAREI has activated its side of the four clauses in this agreement.

Chapter 5. The State of National Programmes, Training and Legislation

We may have a shortage of adequate legislation, but Guyana is not short on policies, strategies, initiatives, programmes and projects relating to agriculture. It is not the task to consolidate these documentations, but several of these initiatives have helped to shape the focus of this study. Between a National Development Strategy and the Jagdeo Initiative, we have a National Biodiversity Action Plan, a National Food Security Strategy, an Agricultural Diversification Programme and a Strategic Research and Development Agenda. Not even a summary would do justice to these well illuminated documentations, but they do clearly indicate that Guyana had continued its long standing policy on agricultural education and food security. These policies have invigorated government's grow more food campaigns. The significance of some of these programmes and policies has been documented in Section 2.2.1. One of the most enduring impacts of agriculture has been in the education system from Kindergarten to University. Such has been the results that the second best pass rates at the regional examinations have been for the courses offered in the Agricultural Sciences.

5.1 Agricultural curricula at tertiary institutions

Among tertiary educational institutions in Guyana, there is no curriculum that specifically teaches PGRFA contents as a course. Ecosystems services and management and species diversity in natural ecosystems incorporated in courses taught in the Faculty of Agriculture and Forestry, Faculty of Natural Sciences and in the School of Earth and Environmental Sciences at UG are about the closest we get. There is no doubt that more could be done in the Department of Agriculture to promote awareness of the relevance of PGRFA to agriculture. In this Department for instance, the Seed Science and Plant Breeding courses taught in earlier years as electives only in alternate years, are currently not offered. These courses should be upgraded to third- and fourth-year 4 credit-hour courses incorporating extended components on PGRFA subject matter.

PGRFA-related content in courses taught at GSA is more implied than measured. Some elements of biodiversity subject matter in natural ecosystems are incorporated in the forestry programme. As the preferred entry requirement to the undergraduate agriculture degree at UG, the Diploma programme at GSA, and for that matter, all three plant science-based programmes, would do well to upgrade the curriculum with courses that specifically incorporate PGRFA-related content.

In Section 2.4.1.2., this study noted some unique challenges in marketing nontraditional agricultural commodities. It would be instructive for curricula of both UG and GSA to be upgraded to included course contents on *Agro-commodities trading and Market futures*. Efforts under way to incorporate PGRFA subject content at the GSA and UG are commendable.

5.2 Training and information services at BRRS and GARC

The BRRS is the research arm of GRDB that has overall responsibility for the rice industry. GARC and GUYSUCO have a similar relationship. In the latter years, GARC hosted a number of projects for UG final year students of Agriculture with several projects done in soils and nutritional ecology and general sugarcane agronomy. Several research papers emanating from work at GARC were presented at various sugarcane conferences and workshops, including the WIST, ISSCT and NAREI conferences. The skills base of BRRS is well complemented by a team of junior research staff. Substantial assistance was received through the ITEC scientific exchange programme of India. This BRRS-ITEC collaborative arrangement was not renewed in 2003. Through other accommodations, post-graduate studies could still be pursued by BRRS staff. Since 2004 the senior staff complement has gradually been reduced and some voids for post-graduate training in all areas have presented an opportunity to elevate the technical competence of junior research staff.

Towards the end of this reporting period the senior complement of GARC staff was strategically diminished. This documentation was unable to discern a succession plan to maintain or upgrade to a critical mass of research staff. The training needs of GARC were summarized in Sections 1.1.1.3 and 4.2. This study gives due importance to current issues affecting Guyana's foremost agricultural industry. It is more real than apparent that erosion of the very research base that maintains its economic viability would have long lasting negative consequences.
An area of concern is publication of PGRFA-related information. Virtually all of the training interventions of BRRS and GARC have not specifically addressed PGRFA content. Project records, for example, extracted from both BRRS and GARC reveal a paucity of published research results. These should have been forth-coming in view of the great number of completed projects.
There were regular TV and radio programmes that specifically targeted farmers. NGMC, GRDB and NAREI features were integrated in a farmers' round-up hosted on TV by the Ministry of Agriculture. GUYSUCO hosted their separate weekly TV roundup. These mainly government-sponsored interventions are generally devoid of specific PGRFA content. Additional information services of the Ministry of Agriculture and NGMC are captured in Section 4.3.2.2.4.

5.3 The contribution of IICA (Guyana)
IICA has been involved in several PGRFA-related training interventions (IICA, 2008). These have in large part been limited to diversifying agricultural production systems (IICA, 2006). In particular, IICA's training programmes served to compliment other efforts of a wide cross-section of institutions involved in research, agri-business, agro-processing and agricultural education. The strongest PGRFA-related impact would have been in the areas of good agricultural practices (GAP), phytosanitary inspection, and pest surveying and monitoring (IICA, 2002). This latter training area has been commendable in the way it strategically complemented activities of NAREI and especially the Ministry of Agriculture's plant quarantine programme. IICA's promotion of agricultural education in secondary schools was laudable in its sponsored school gardening competition (IICA, 2009).

5.4 NAREI Information Services and Training
NAREI has been involved in and executed a wide range of research activities. These interventions ranged from PGRFA-related training workshops, cross-country scientific attachments, short academic courses, symposia, international fellowships and technical training *in-house*. Almost all of NAREI's international collaborative research activities incorporated a significant training component. In one recorded instance assistance was requested from the pool of NAREI research scientists to train Surinamese counterparts to suppress the surge of pink mealeybug disease complex in that country (NARI, 2005). NAREI does have to its credit, sponsorship and hosting of a few PGRFA-related courses and workshops. These were on national systems and conservation management (2001), documentation and training in the use of documentation software (2001), tissue culture propagation (2008), biochemical and bio-molecular analyses (2000, 2001), aquatic weed management (2004), and several on promoting sustainable agriculture through diversification of production systems (2000, 2002).
A special local component of NAREI's training activities was carried out in collaboration with the crop extension services of the Ministry of Agriculture (Chandranauth et al., 2007). In these interventions, hundreds of participants attended farmers' field schools. With its alumni numbering in the hundreds, the staple of NAREI's agricultural training has been its Pest Management Training Courses.
NAREI is the focal point for plant science research and the national depository for information on Agriculture. The outcomes of these training interventions are revealed in project results but stop short of published documentations. Nevertheless, NAREI has to its credit, an assortment of brochures and 'how to' booklets. These were specifically compiled to benefit farmers and field extension staff.

Probably the most significant educational output from NAREI Library and Documentation Unit is a Farmers' Manual (Homenauth, 2007). From homesteaders and commercial farmers to students and researchers, the manual is frequently referenced by all strata of agriculturists. The *PPPPC Series* of farmer-friendly brochures documented by Homenauth and Dwarka (2011a, 2011b), Homenauth and P-DeSouza (2011), and Homenauth and Adrian (2003) have filled some gaps on insect pests and disease management of pepper, pineapple, plantain, pumpkin, manicole and cassava. A second edition of the Farmers' Manual is overdue.

This study has been unable to find a majority of reports that should have been submitted following training activities. Perhaps much more could have been accomplished in the field of research if these publications were forthcoming. Taking cognizance of the gamut of research work undertaken by NAREI, the paucity of scientific publications is not without cause for concern. [41]NAREI needs to re-institute its highly regarded Annual Agricultural Research Review Conference and become more proactive in publishing technical information and peer-reviewed research results. It is not without a parody therefore that the learned scientific community has failed to draw a nexus between their PGRFA-related work and the concerted efforts of *in situ* homesteads to conserve and use PGRFA.

5.5 [42]Technical Competencies of NAREI

Since 1995, when the last NAREI-sponsored post-graduate student returned, NAREI had employed only three government-sponsored post-graduate scientists. Two-self sponsored post-graduates have returned to NAREI and one has since left in 2005. Amid a steady exodus of research scientists, NAREI has attracted into its employ fewer than three research scientists over the last 15 years; a prominent issue that has not been given the attention and remedy it so deserves. In the absence of immediate post-graduate training opportunities and to complement its current capability, NAREI will do well to take advantage of hosting the projects of final year students of UG's Departments of Agriculture and Faculty of Natural Sciences. Another recommended approach is to invigorate existing international collaborations such as the MOU with, among others, Stine Seeds Inc., USDA, CIAT, CARDI, FAO and GCDT.

Box 5.1 Plant Breeding in Guyana

NAREI's strategic research agenda (SRDA) is documented in two versions, 2007-2011 and 2006-2015 for a total of 86 pages. The term 'crop improvement' is used four times in headers. But to its credit, the strategy did *mention* in a sole sentence the 'Identification and introduction of suitable varieties…'. Is it not conceivably accidental though, that the two-word phrase 'plant breeding' is absent from these documents. And the 18 times that 'breeding' were used they all refer to livestock. The term 'crop development' was absent from the documents. But generally, outside rice and sugarcane, the status of crop breeding interventions at NAREI is inexplicable. The agricultural field extension programme at NAREI comes with the most apposite label 'Crop Development Support Services'. But NAREI has no

[41]In 2008, NAREI revived its tradition of research review with its Annual Agriculture Conference. The last was held in 2009. Current efforts are underway to resuscitate this annual research review in 2012.

[42]The critical mass of 37 Research Scientists at NAREI peaked in 1996. This core of research scientists has gradually reduced to currently 5. At the same time, the recent formation and restructuring of NAREI has significantly expanded its research mandate amid decreasing technical capabilities and sources of funding. Collaborative research with local and international agencies is a potentially immediate fix for this situation. NAREI's apparent reluctance to enter into these accommodations must be urgently reviewed.

research programme specifically targeting plant breeding interventions. During the reporting period agricultural research in the country enlisted only four formally trained plant breeders–one an ITEC consultant in rice breeding; one each dedicated to rice (BRRS) and sugarcane (GARC); and the third inconspicuously relegated to NAREI.

[43]In short, over the last 15 years NAREI did not sponsor the training of even a single staff at the post-graduate level, and now has to depend upon a new crew of budding undergraduates. Filling a void by this intervention has become necessary but it is not sufficient. Concerted and immediate considerations must be given to elevating the technical competences of this promising core of researchers to post-graduate status. Specifically, all research-related agencies, but NAREI in particular, need to adopt deliberate policies, programmes, and actions that would help them advance the careers of young professionals through, *inter alia*, re-establishing a culture of mentoring and professional development.

5.6 Dissolving NAREI's responsibilities

NAREI is overburdened with too many responsibilities, and therefore has been unable to focus on research priorities. With the depletion of its senior research specialists, NAREI's needs to include a more focused approach towards promoting sustainable agriculture. There is need for interdisciplinary thematic research teams. Crop nutritional ecology and cropping systems diversification are two examples. In conjunction, NAREI must embrace a proactive crop breeding programme for vegetables and root and tuber crops. For this purpose, a number of currently unwieldy research responsibilities should be consolidated into thematic research units, outside of NAREI, to focus on priorities. The currently diminished management capability will logically suggest that we prioritize by relevance of crop species. The idea is that thematic crop research field stations, akin to those for rice and sugar, would be better positioned to promote the development and commercialization of under-utilized crops species. Field Research Stations for Root and Tuber Crops and for Plantain are deserving of this elevated status. With the acquisition of biotechnology research capability in late 2010, NAREI can now elevate its *in-house* research capability to molecular genetic analyses. Molecular tools would accelerate characterization and evaluation of core collections, and application of marker-aided selection is indispensable to meet demands of industry for improved cultivars.

5.7 Catalyzing the seed industry

Complementary to the demand for stable performing cultivars, is the need to formalize the seed industry. Most supportive were the recent expedited approval of the National Seeds Act of 2011 and the National Plant Quarantine Act of 2011. In order to give effect to this legislative support, a formal and sustainable *ex situ* seed conservation system encompassing storage, regeneration, purification, evaluation and standardization must be re-established. An important appendage to the Seeds Act of 2011 could provide for an authority to coordinate PGRFA conservation responsibilities in the country. The commission of a National Crop Genetic Resources Centre incorporating responsibilities for a national seed bank is most apposite. Typical of agricultural-based economies, government, private agricultural-based enterprises, export traders and commercial farmers' groups need to embrace this seed security assurance strategy. In this regard, the significant progress made so far in the refurbishment of NAREI seed technology facility at Mon Repos is hopeful and reaffirms government's commitment to strengthen research capability and seed supply systems.

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[43]Government bounded graduates have in recent years, numerically boosted the complement of NAREI's technical staff.

In summary, NAREI should adopt a PGR Management System as the nucleus of its research agenda. Key components of this system would see the allotment of more trained staff towards management of *ex situ* collections and initiate a programme of PGRFA improvement.

5.8 The status of realized threats in the agriculture industry and early-warning systems

Generally, efforts have been limited to the surveillance and monitoring of agricultural pests as both a preventive measure and to suppress surges in infestations. Successes have been reported for the surges of the pink Mealeybug disease complex in the latter half of the 1990s (NARI, 1997, 1998). Since that time, surveillance and monitoring continued and control measures were applied for the following pests with **active threat** status: hibiscus pink Mealeybug, papaya Mealeybug, Carambola fruit fly, black Sigatoka disease and yellow Sigatoka disease. The most recent update by the NPPO assigned the status of **passive threat** to the following pests: red palm mite, Mediterranean fruit fly, and giant African snail. The activities of the NPPO were coordinated in collaboration with IICA (Guyana). This study was unable to capture the documented reports of surveillance and monitoring activities of the NPPO covering the last three years.

Weeds, in general and aquatic weeds in particular, pose a special problem in coastal Guyana. By far, the most successful weed control programme in the country was conducted by the field management teams of GUYSUCO. Their successes were spearheaded by close supervision of GARC that imposed a rigourous routine of monitoring and surveillance. The problem of wild (red) rice in the rice industry is apparently still ignored. Red rice has clearly achieved the status of invasive species. NAREI was given the mandate for weed research for the rest of the agricultural industry. In a joint NARI-FAO- ERDC collaborative survey and deployment programme conducted over recent years, capabilities for the release of insect biological control agents for the management of aquatic weeds in Guyana were developed. Surveys along coastal Guyana revealed the presence of one species each of weevil capable of colonizing and destroying the floating waterhyacinth (*Eichhornia crassipes*), waterlettuce (*Pista stratiotes* L.), and *Salvinia* species. No control agent affecting the submersed fanwort (*Cabomba aquatica*) was encountered. In their updated progress report, Chardranauth and Nanku (2009) documented more than 60% weevil destruction at the site of release of these floating weeds. The bulk of government subvention for maintenance of drainage and irrigation systems in the country is allotted to regional development councils.

There was need for a number of alerts of the threats of paddy bug (*Obaelus poecilis*.) in the rice industry. The interventions of GRDB, BRRS, and GARC have been effective in averting any tangible economic impact due to the threats of pests in the rice and sugar industries, respectively. On the other hand, efforts led by NAREI and the Crop Extension Services of the Ministry of Agriculture, with support from IICA (Guyana), have been unable to arrest ravaging pests affecting cucurbits as early as 2003 in the West Demerara and Essequibo Islands (Chandranauth and McAllister, 2007). For the better part of more than seven years, we have been embattled against the 'still to be confirmed' Sigatoka pests in the plantain and banana industry. Help was offered from IICA (Guyana) (Power, 2009) and through NAREI research colleagues at the USDA (T Kisha and K Williams, personal communication, 2009), but it was not clear to what extent the partnering agency, NAREI, was able to cooperate. The current status of the Musa industry was summarized in Box 3.1.

What is notably missing, however, are concerted efforts to monitor the threats to *in situ* diversity among non-traditional crop species. In support of early warning systems, this component of PGRFA research needs to be spread across NAREI's research departments. With the increasing number of recent emergencies imposed by unpredictable weather patterns, an authoritative mechanism for early warning systems supporting the agricultural industry must be elaborated at the level of the CDC. A molecular genetic analysis of crop species diversity is suggested in Section 2.2.1. A related superimposed ethno-

botanical assessment of the economic and social value of PGRFA in homesteads and foraged grounds can serve as a catalytic incentive to enforce recognition of the need for such an authority. In this regard, a national surveying and monitoring authority on PGRFA, expanded upon the proposal by IICA (IICA, 2003), should be appended to the logistic structure of the CDC. In the absence of existing national PGRFA networks, the objective here is to consolidate the surveying and monitoring efforts of, *inter alia*, NAREI, the national plant protection authority and the national hydro-meteorological service.

> ***Box 5.2 A note on disaster preparedness in the rice and sugar industries***
> *During the reporting period and from records available there were no major disasters in the sugar industry, nor did we expect any, because GARC continuous surveillance is aimed at averting disasters. GARC also shares with regional and international breeding agencies gene bank collections with a wide diversity of sugarcane varieties readily adaptable to Guyana's sugarcane industry. All of BRRS commercially-released varieties are stored in duplicate collections at IRRI and CIAT as well as at the participatory Breeding Nurseries managed by FLAR. Besides, BRRS has a reservoir of several hundreds of breeding line under advanced evaluations. Threats of disasters posed by biotic stresses may be debilitating, but current preparedness to respond to these challenges could not be on better tracts.*

5.9 The International Treaty on PGRFA

Early warning systems for PGRFA are naturally complementary to the recent implementation of the NISM for the sustainable management of PGRFA. The preparation of the Second Guyana Country Report on the Status of PGRFA would effectively serve to generate baseline information to guide food security assurance policies. Part of this food security policy will depend upon the access or exchange of local and external sources of PGRFAs. Benefits accruing to Guyana would entail some collaboration with other national and international agencies. [44]For this reason, Guyana's 2008 ratification of the Cartegena Protocol on Biosafety, the passage of legislation for the National Plant Quarantine Act of 2011 and National Seeds Act of 2011 are strategically supportive of the National Policy on the Access to Plant Genetic Resources and the Sharing of the Benefits Arising from their Use (EPA (Guyana), 2007). A draft regulatory appendage to this policy document has been submitted in 2005, but its current approval status has been unclear. Accordingly, the way could not be clearer for Guyana to ratify the International Treaty on PGRFA.

5.10 Technocracy

This study has noted the recurring paucity of technocratic representation for agriculture at the policy and legislative levels of government. Elaboration is outside the scope of this documentation. But the implications for agricultural research, as exemplified in the tone of this documentation, are not sustainable. Government policies are well intentioned, but in a country that is not short of logically sensible ideas, there is need for a paradigm shift towards a more inclusive approach in formulating agricultural research strategies and policies. This study has identified a few policy miss-steps; the strategy on seed distribution systems not being the least. Government, for example, should support the advocacy of stakeholders to re-establish a broad-based consultative and advocacy body akin to the currently dormant Society of Professional Agriculturalist of Guyana and further commit to give the due recognition it deserves.

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[44]The ABS policy, (EPA (Guyana), 2007), adopted by Cabinet in 2007, specifically addresses the *protective access* of all crop wild relatives and wild food plants by foreign academic researchers and for commercial uses. It emphasizes prior-inform-consent but strategically stops short of farmers' rights.

Chapter 6: The State of Regional and International Collaboration

Regional and International collaboration is critical for the conservation and sustainable use of PGRFA in so far that responsibilities for network activities are shared, technical expertise are exchanged, national programme scientists are trained, financial resources are accessed through network participation and information about the importance of PGFRA is disseminated. Accordingly, Guyana's collaborative initiatives are commendable for the number of engagements it pursued.

6.1 ITEC scientific exchange programme with BRRS and NAREI

A scientific exchange agreement for technical assistance to NAREI and GRDB with the government of India came into effect in 1996. The International Programme for Indian Technical and Economic Cooperation (ITEC) facilitated the exchanges. Expertise in plant protection, breeding and agronomy were received by BRRS, and those in agricultural economics (crop planning), seed technology, coconut processing and spice crop breeding were received at NAREI. By 2004, when their BRRS engagement came to an end, the rice industry had already been upgraded to the strong foundation we continue to build upon today. In an exit strategy that has not seen any parallel, the exchange also facilitated the post-graduate training in India of GRDB's current scientists in the 'replacement' fields of plant breeding, plant protection, and agronomy.

NAREI's programme engaged the experts for shorter 2 to 3-year periods. Their bench mark contributions are captured in case studies of marketing systems for non-traditional commodities (Mathur and Homenauth, 2004a; Mathur and Homenauth, 2004b; Mathur, 2003a, 2003b; Kharb and Homenauth, 2003) and seed certification standards for popular vegetable crops (Kharb, 2004a, 2004b; Homenauth et al., 2004). Perhaps the most significant expert engagement was that in the field of spice crop breeding. Research interventions in this area accumulated NAREI's first germplasm bank of local and exotic spice crop diversity. Details of these accessions were summarized in Section 3.2.3.3. Consequent research, captured in the documentation of Sasikumar (2010), and Sasikumar and Sukhna (2009, 2010a, 2010b), effectively established the material basis for spice research in Guyana. NAREI's programme also included a training component. These were restricted only to very short courses in India. Except for one in spices, those who received short-term training have long since left NAREI.

During the reporting period the ITEC programme exchanges have been one of the most generous and enduring. A Mobile Agro-processing Unit gifted to NAREI was used to demonstrate small-scale value-added processing to farmers and local engineering firms. The objective was to locally fabricate the processing machinery and adapt them to the cottage industry of small scale entrepreneurs and farmers. While this intervention continues to evade the attention of local engineering firms, the agro-processing industry is experiencing a significant setback.

While the positive impact on the rice industry is very commendable, the effectiveness of the engagements with NAREI could not be fully evaluated at this time. The expertise and experiences in Indian agriculture are legend. Two areas in which NAREI will benefit tremendously are in seed technology and plant breeding. The absence of an effective seed gene bank management system is a major constraint to agricultural modernization in Guyana. Guyana will therefore do well to re-activate these recently halted scientific exchanges.

6.2 NAREI-USDA collaborative research programme

A collaborative research programme to strengthen NARI's scientific capacity and infrastructure for effective conservation and use for PGRFA was effected in 2004. The United States side of the

programme was facilitated by the USDA-ARS, USDA-FAS, and USDA-PEO. The 11 projects were adopted as the official work programme of the department of Plant Biotechnology and Genetic Resources. USDA and Bioversity International scientists visited with the programme in Guyana on four occasions. A strong training component, pre-empted in 2001, upgraded *in house* competences of 37 technicians from research and agricultural extension agencies in the fields of PGR conservation management, and PGR documentation and training in the use of the pcGRIN software. In 2006, the programme awarded four Bourlag Fellowships, and USDA-ARS funding facilitated further training in 2009. These scholarships were pursued at the University of Washington at Seattle, and University-based USDA-ARS centers at the University of Florida at Gainesville and Washington State University at Pullman. Fellows received training in statistical genetics, DNA molecular analysis, biotechnology laboratory management, vegetable seed production and pasture agronomy. By late 2010, NAREI had acquired the critical mass of technical competencies, materials and equipment, and laboratory housing facilities to initiate DNA molecular analysis research for the first time in the country's agricultural history. The programme further equipped the department with an online information system, acquired an off-road vehicle for PGRFA field work, allotted funds for PGRFA public awareness and for upgrading the national policy on access and benefit sharing of PGRFA. The project for the establishment of out-station crop depositories is on-going, but the joint NAREI-USDA exploration for plant genetic resources in Guyana is still out-standing.

Guyana crop genetic diversity is grossly under-represented in national, regional, and international PGRFA depositories. Pepper, sweet potato, and cassava, for example, are absent from the plant germplasm system in the USDA (K Williams and T Kisha, USDA, personal communication, 2009). NAREI's efforts to initiate a research programme in plant biotechnology have been in gestation for the last 11 years. NAREI needs to elevate and expand its level of characterization and evaluation, and to establish a number of crop core collections for use in crop improvement. For this purpose, molecular tools, such as marker-aided selection, are especially warranted. Pre-empting an early start to this programme, the department of Plant Biotechnology and Genetic Resources had initiated collaborative work with the USDA-ARS laboratory at Washington State University for joint characterization and evaluation of germplasm. Towards this end, molecular profiling was accomplished for 27 of NAREI's sweet potato accessions. Molecular genetic analysis of homestead *in situ* plant genetic diversity was set to follow. In this regard, NAREI-USDA-ARS efforts are continuing but progress has been lagging at NAREI's end. At the point that we have acquired the necessary competencies and infrastructural capability in Plant Biotechnology, the perceived reluctance of NAREI to bring this milestone to fruition continues to frustrate both sides.

6.4 NAREI-CIMMYT maize improvement initiative

In 1996, CIMMYT afforded an opportunity of one NAREI scientist to undergo extensive training in conventional maize breeding. An important objective of the training was to identify national programmes that could add to CIMMYT's several international testing centers. A maize breeding strategy was one outcome of this scientific engagement (Paul, 1996). A germplasm exchange agreement was initiated, and the first evaluation of CIMMYT tropical hybrids was conducted at GSA during the El niño period of 1997 (Paul, 1998). The results identified three promising hybrids. Research emphasis may have suddenly shifted, because NAREI mysteriously terminated the project in early 1998. CIMMYT has since developed and extensively tested a wider range of tropical lowland maize germplasm suited for targeted agro-ecologies in Guyana. By 1996, results of CIMMYT tropical wheat trials were also promising. NAREI scientists still maintains cordial contacts with CIMMYT research scientists. With the restart of an initiative to promote commercial maize cultivation, NAREI would do well to re-engage CIMMYT for germplasm exchange, and anchoring a few international trials.

6.5 Evaluation of introduced legume varieties

During the reporting period, NAREI received nurseries of cowpea accessions from IITA and the USA, and soybean accessions from EMBRAPA (Brazil). An appraisal of research work on these nurseries was reviewed in Section 4.4.3. We are very appreciative of the continued support Guyana is receiving from these agencies. However, NAREI must take cognizance of the efforts and costs that goes into making these nurseries available to researchers around the world. Should NAREI observe the global protocol for varietal testing much breeding gains could be passed on to our local farmers.

6.6 [45]The Initiative on coconut genetic resources

NAREI officially joined COGENT in 1997.In that year, NAREI focal point scientist attended a workshop at CICY in Mexico, and later in 1999, participated in a training course in molecular typing of coconut lethal yellow disease. Guyana was instrumental in proposing the establishment of a multi-location trial in the COGENT-LAC region. Later in 2001, NAREI hosted a visit from the head of the COGENT secretariat (NARI, 2001b). These activities were specifically aimed to build technical competencies to mitigate the treats of coconut lethal yellow disease. These efforts continued with a joint NAREI-CIB (Jamaica) survey and monitoring expedition in 2011. Coconut processing interventions were made in collaboration with an ITEC expert as well as with a consultant from the FAO. This report has however, been unable to capture results of these initiatives. With the recent resuscitation of COGENT, NAREI should seek to renew its membership. In the meantime, NAREI must devise funding proposals to accelerate its lagging projects to safeguard our coconut genetic diversity against the threats of coconut lethal yellow disease.

6.7 NAREI's regional collaborative Initiative with GCDT and CIAT

In 2008, NAREI entered into a memorandum of understanding for the regeneration and safety-duplication of cassava. Eighty seven (87) accessions were made available. In collaboration with CLAYUCA, NAREI received 17 commercial clones of 'sweet' cassava from CIAT in late 2010. In mid-June 2011, after the tissue culture laboratory abruptly underwent an infrastructural upgrade, both projects were put on-hold.

NAREI's Mon Repos Research Station is the focal point for plant *in vitro* technology. For the purpose of international exchange, *in vitro* methods are critical for regenerating PGRFA. Increased physical capacity and the need for advanced training in *in vitro* methods are needed to bring more crops into micro propagation protocols. NAREI must consider an offer, currently extended through GCDT, to engage CIAT's scientists.

Formation of core collections to be used in crop improvement programmes is premised on the availability of accurate characterization and evaluation data and supportive systems for effective seed gene bank management. The relevance of molecular-aided characterization has been summarized in Section 6.2. International efforts into which these activities can tap are the International Treaty on PGRFA (ITPGRFA) for implementation of the Global Plan of Action (GPA), the Bioversity International (BI) and the Global Crop Diversity Trust (GCDT). All of these agencies focus on conservation and utilization of PGRFA at all levels from the community, national and regional to global. They facilitate safety-storage in the CGIAR gene banks, are well-funded and equipped to conserve germplasm till doomsday and beyond in gene banks such as the Svalbard Global Seed Vault in Norway.

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[45]NAREI in particular, has not adopted a proactive attitude towards the opportunity offered by networking. Quite often the choice of participation or not lacks logic and the follow-up on commitments has been less than serious.

6.8 International collaboration for rice and sugarcane improvement

GUYSUCO's arrangements on shuttle breeding with WISCBS and the related WISBEN are the most enduring and indispensable to the local and regional sugar industry. This collaboration gives GUYSUCO access to regional and international breeding programmes managing pools of a wide diversity of sugarcane varieties readily adaptable to Guyana sugarcane industry. A summary on rice and sugarcane networking is documented in Sections 8.2.1.

> ***Box 6.1 Take on absorbing technical expertise***
>
> *Guyana needs technical assistance. One avenue has been government's engagement in scientific exchanges through foreign volunteer expertise. Volunteer counterparts have always come to expect that we already have the physical amenities and the capability to absorb foreign assistance. Some local agencies, however, often lack this capacity to absorb technical assistance. NAREI represented some awkward cases: engaging expertise on seed conservation management without a functional seed storage system; spice breeding expertise without a plant breeding agenda; requested tissue-culture assistance knowing that there was no functional tissue culture laboratory; engaged specialists in DNA molecular analysis knowing that we had not yet developed that level of laboratory capability, are a few noted episodes that did not lend much for improvisations. In almost all instances, local collaborating counterparts had very minimal technical competence in the subject area of the volunteer expert. Consequently, many experts could not always be gainfully engaged. To absorb the skills of experts, agencies need to ensure, as far as possible, that they are endowed with the capacity to do so. We note however, that all of NAREI's foreign collaborating agencies were from resource-generous countries. And it still bewilders what would it cost for volunteer agencies to complement technical competence with material support.*

6.9 NAREI's tasks and roles of stakeholders

In summary, cognizant of technical challenges, NAREI should re-prioritize its myriad of responsibilities to focus on sustainably re-integrating into regional and international networks; strengthening its gene bank management systems and facilities; recognize PGRFA as the material basis of its research programmes and adopt a proactive crop improvement programme as the thematic core of its research agenda; elevate technical competencies in crop nutritional ecology, characterization and evaluation, molecular genetic analysis, and early warning systems.

Government, through its agencies, needs to enforce its policies on promoting the value, development and commercialization of under-utilized crops and crop wild relatives. [46]The following are *8 new* thematic initiatives distilled from this study:

1. Ethno-botanical assessment of homestead *in situ* diversity
2. Sustainable commercial foraging of herbals and crop wild relatives
3. Traditional management of cassava morphological and genetic diversity in community-based subsistence farming
4. Guyana herbal ontology
5. The Stine Initiative: Promoting an integrated commercial expansion into the New Agriculture Frontier.
6. Strategies to resuscitate the commercial plantain and banana industry by engaging inland riparian communities with this capability
7. Establishment of safe-depositories of threatened crop species diversity
8. Industrial 'bee foraging' on forestry concessions.

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[46]As part of a sub-project of the 2004 NAREI-USDA collaborative research agreement, Initiative 7 was initiated in 2005. In recent years, NAREI has relegated this project into obscurity.

Policy-makers and concerned stakeholders must support these initiatives by pursuing, more vigorously, funding and training options available under international and regional collaborations, and commercial opportunities under bilateral agreements.

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

7.1 National strategy, plan and programme on conservation and sustainable use of PGRFA

Guyana acceded to the CBD in 1992, and later in 2008 signed onto the Cartegena Protocol on Biosafety. The focal point for both multilateral agreements is the EPA (Guyana). The administration of the agreement on the Cartegena Protocol has generally been outside the scope of research on PGRFA. A 2010 agreement between FAO and NAREI facilitated the compilation of the Second Guyana Report on the state of PGRFA and the implementation of an accompanying National Information Sharing Mechanism (NISM) on the Global Plan of Action (GPA) for the conservation and sustainable use of PGRFA. This project was funded by NAREI and the FAO. Together with other relevant legislative instruments Guyana has fulfilled all the basic provisions to enable it to ratify the International Treaty on PGRFA. By being a signatory to the treaty, Guyana's legal framework regulating the establishment of the NISM, plans and programmes on conservation and sustainable use of PGRFA would enable it to benefit from interventions in all of the 20 priority areas of the GPA.

7.2 Policy on foreign access to Guyana's PGRFA

In 2007, cabinet approved the national ABS policy (EPA (Guyana), 2007). The ABS policy does place wide restrictions on wild species and some of these include crop wild relatives and wild food plants. The ABS document, however, is more focused on access by foreign partners for academic and commercial research on biodiversity. Accompanying regulations to be appended to the national ABS policy are at the approval stage. The Plant Protection Act of Guyana 2011 to contain the incidence of quarantineable pests addresses all plant species and the Seeds Act of Guyana 2011 to regulate the production, distribution and sale of breeder and commercial grade seed, specifically addresses all crop species. Access issues of *in situ* protection of crop wild relatives and wild food plants are therefore widely and legally covered in Guyana. Apart from the ABS policy on wild plants, there are no known obstacles granting reciprocal access to crop species in Annex I covered under the Multilateral System.

7.3 Policy supporting sustainable use and marketing for under-utilized species

The Plant Protection Act of Guyana 2011 and the Seeds Act of Guyana 2011 also support development and expansion of local seed supply systems for both farmers' landrace varieties and modern varieties, inclusive of vegetables, root and tuber crops, orchard crops and open row field crops important to small-scale and large-scale commercial farmers. Land race varieties however, in the near future, may require additional legislative treatment to ensure the right of farmers to save their seeds. Government has advocated several supportive policies promoting the marketing of underutilized species and diversity-rich products. Chief among these is a private sector entrepreneurship in agribusiness (GFA Consulting Group S.A, 2010). The ADP was entrusted to execute this initiative aimed to establish a well-structured food and vegetable sector capable of satisfying 60% of export markets by 2020. In addition to government's grow-more-food campaigns, supportive mechanisms to promote the marketing of non-traditional agro-commodities were summarized in Sections 4.3.2.2.3 and 4.3.2.2.4.

7.4 Formal networking agreements for the exchange of PGRFA

There are only three *competent authorities* (GUSUCO, GRDB, and NAREI) that engage directly with national programmes, regional and international networks for the exchange of PGRFA. Other agencies were allowed to import seeds of non-traditional crop species, but exports had to be sanctioned by NAREI and approved by the EPA.

7.4.1 Networking of GARC and BRRS

The formal PGRFA exchange protocols for rice with FLAR, CIAT, IRRI, and the national programmes of Suriname (ADRON) and India continue to be the important sources of advanced breeding lines to BRRS varietal improvement programme. Of BRRS's routine 4000-line pedigree nurseries, more than 75 percent were sourced from these international network systems. GARC networks with national sugarcane breeding programmes that pool their genetic resources into WICSBS and its varietal testing arm, WISBEN. GARC's routine 32 clone populations, synthesized from infusions of parental breeding clones from other national programmes, are comprehensively characterized and evaluated by WISBEN in a coordinated shuttle breeding strategy involving several national programmes.
Strategies for varietal restoration to agricultural systems following potential disasters are further summarized in Box 5.2 and Section 8.2.1.

7.4.2 Networking of NAREI

Being the focal point for plant science research, NAREI's research programmes have a specific mandate for the conservation of about 30 commercially important crop species and more than 40 under-utilized and diversity-rich crop species. During the reporting period, NAREI has executed an arrangement with GCDT, coordinated by CARDI, for cassava regeneration. A related MTA with CIAT, through CLAYUCA, has seen the exchange of cassava germplasm accessions (24 from NAREI and 17 from CIAT) between the two programmes. In an arrangement akin to shuttle breeding, in the later 1990s, germplasm materials comprising tissue cultured explants of plantain were sent to the IAEA for research on mutagenic induction, and mutated explants were returned to NAREI for evaluations. Much later in 2009, as part of a research collaboration effort with the USDA for joint characterization and evaluation of germplasm, dried leaf tissue samples of 27 sweet potato accessions were sent to the USDA-ARS laboratory at Washington State University (Pullman) for DNA profiling. In 1999, NAREI-CARDI successfully conducted a mission to collect hot pepper diversity in Guyana; 47 duplicate accessions being transferred to CARDI. No other record documenting the exports of PGRFA to national programmes or international networks could be cited in this study. Several other local collecting missions were spearheaded by NAREI. In recent years these were mainly restricted to clonally propagated landrace varieties conserved in field gene banks. These collecting activities were summarized in Sections 2.2.1, 2.4.1.2, 2.6.1, 3.2.3.2, and 4.1.
NAREI received copies of international trials for more than 40 cowpea lines from IITA. Ten advanced breeding lines of soybean were received from the USDA, and a consignment of 10 soybean accessions from EMBRAPA. Several accessions of green vegetables were accessed from AVRDC, but details on these introductions were not immediately available for this study.
Except for cassava and sweet potato, where the documentation is close to complete, an inadequately organized system for PGRFA conservation is preventing the transfer of local accessions to regional and international PGRFA networks. Consequently, NAREI may be constrained to be a proactive network participant because it is unable to meaningfully reciprocate in kind. But in reality, NAREI's very limitations in conservation, documentation, characterization and evaluation militates against exporting significant numbers of its own accessions, and reciprocally, introducing significant numbers of PGRFA accessions. Networking is important to assist NAREI in varietal replacement to restore agricultural systems following disasters and in cases of routine 'seed' shortages. Strategies for addressing these eventualities are summarized in Boxes 2.3 and 3.1, and in Sections 8.2.2.4 and 8.2.2.5. Other benefits of networking PGRFAs were summarized in Chapter 6.

7.5 [47]Local access to plant genetic resources and sharing of benefits arising from use

In Guyana plant genetic resources is regarded as the common wealth of all. The diversity of seeds and other propagules is derived mainly from local varieties. Because of demand, some of these planting materials have experienced seasonal scarcity, but generally they are easily accessible and freely shared among homesteaders and farmers. For all crops and plant species, no monopoly has ever known to exist in the history of the country. This custom of 'free' seeds is strongly encouraged by government's policy. This policy goes further to exempt taxation on imports of seeds of improved varieties. Government subsidizes the supply of planting materials produced by NAREI, GRDB, and GUYSUCO (distributed to private cane farmers). And in times of temporary crop failures, government would intervene with distribution of free seeds and other accompanying agricultural inputs. These relief efforts distributed mostly vegetable seeds of modern varieties and almost all were sourced from commercial agro-chemical companies. In their 2004 survey on vegetable seed marketing in Guyana, Kharb and Homenauth (2004) observed the comparable high prices for imported seeds. Despite the high but wide variations, prices for imported seeds were still far above those for locally produced substitutes. The study however, stopped short of assessing the affordability issue of buyers.

7.6 Farmers Rights

In the absence of a formal seed distribution system, government's interventions to bring in-expensive seeds to growers go largely un-noticed by the general public. It is not surprising that the seed industry has over the decades remained shy of Guyana. The Seeds Act of Guyana 2011 does not explicitly enshrine the right of farmers to save seeds and proposed regulations would be needed to enforce this right. But government's strategy to make seeds available in emergency situations is symptomatic of a number of issues:

1. The unsustainability of current seed supply systems for non-traditional crops (please see Section 4.4.2).
2. Recognition of the role the private sector can play and the strategic void it can fill in a formal seed industry (please see Section 7.5).
3. The need for an enhanced seed security management policy and system (please see Section 8.2.2.5).
4. The need for NAREI to adopt at least some semblance of a basic crop improvement programme for non-traditional crops.

Farmers' dependence on saved seeds and government enthusiasm to subsidize seed supplies may see the investment of seed companies diverted mainly towards 'high-tech seeds'.

[47]The agreement with MS and Stine (please see Box 4.5) is outside the scope of this Section.

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

8.1 Security in diversity

Guyana relies heavily upon the economic vitality of its Agriculture industry. It is the mainstay of the country's economy and the growth of the sector is crucial to the Country's overall economic and social development. Guyana has very little experiences in responding to disasters that threaten national food security. During the reporting period there have been some menacing episodes but none has had cause to activate any emergency *food security plan*. A cursory look around the country would reveal that the population density is concentrated within and close to the plant-based agricultural industries. It should be more obvious than apparent that the stability of our national food security status is directly related to our tradition of sustainable use of the plant species diversity for food and agriculture. For this reason, Guyanese have a traditional inseparable co-existence with agricultural systems. It is therefore logical to deduce that if the future of Guyana's agricultural diversity is threatened, so too should be its 'people' counterpart. 'Security in diversity' is therefore an appropriate thematic approach towards the sustainable management of food security.

8.2 Safeguarding the material basis of our food security

8.2.1 Securing the genetic diversity in the rice and sugar industry

GUYSUCO's collaboration with WISCBS and its related WISBEN on shuttle breeding has been the most enduring and indispensable to the local and regional sugar industry. This collaboration gives GUYSUCO access to regional and international breeding programmes that manage pools of a wide diversity of sugarcane varieties readily adaptable to Guyana sugarcane industry. This plant breeding strategy saliently addresses a varietal security issue because it allows rapid acquisition of replacements or supplementary cultivars from national and regional programs following crop failures or industry-related disasters. GRDB has over several decades, instituted a similar arrangement for rice with IRRI, CIAT, FLAR, USDA-ARS, and the national programmes of Suriname (FLAR) and India. Sugar and rice are the pillars of our agriculture industry. At the regional level, both GARC and BRRS should be capable of overcoming routine challenges of maintaining its *ex situ* gene banks. However, in order to respond to a pending disaster that seriously threatens the sustainability of our production base, the only recourse will be the access to replicated safety depositories of PGRFAs maintained at several international locations, inclusive of the Svalbard Global Seed Vault in Norway. Accordingly, the integral participation of GRDB and GUYSUCO in regional and international PGRFA networks must be sustained.

8.2.2 Securing the genetic diversity in the non-traditional agricultural sector

8.2.2.1 Regional and International Networking

As the focal point for plant science research, NAREI needs to revisit its priorities and obligations on PGRFA conservation. Unlike sugar and rice, the diversity of non-traditional species is grossly under-represented in regional and international crop germplasm depositories (K Williams and T Kisha, USDA, personal communications, 2009). Cassava, hot pepper, sweet potato, and coconut are just a few species that have been deprived of this privilege. This situation is indicative of the lack of sufficient prominence NAREI gives PGRFA conservation. The perceived reluctance to accelerate an initiative to safeguard targeted crop species was mentioned in Section 6.2. NAREI in particular, has not adopted a proactive attitude towards the opportunity offered by networking. NAREI depends upon an infusion of PGFRAs transferred to its programmes through regional and international networks. A lack of outflow of local PGRFA is denying the networks the very benefits we are seeking.

8.2.2.2 Homestead depositories

The significance of homestead community depositories should be given prominence not only because it samples a large proportion (95 percent) of landrace varietal diversity, but also because it allows PGRFA diversity to evolve along with Guyanese folklore and cultural traditions. For this reason, the role of PGRFAs in shaping the agro-ecological land scape in coastal communities should be brought to prominence. The several components of homestead community depositories provide a range of ecosystem services, of which supplementing food needs is not the least. A realistic estimate is needed, but we may surmise that the 'food energy reserves' in coastal farms, homesteads and forage grounds, at any one point, should be capable of sustaining 50 percent of our population for an estimated two months. Its food security relevance notwithstanding, the diversity of coastal PGRFA is threatened by ever increasing episodes of flooding; potentially the single most serious threat to coastal livelihood.

> ***Box 8.1 A warning note on coastal flooding***
> *In its quest for increase productivity, GUYSUCO has reduced its acreages under cultivation in the Demerara estates. At the same time, rice cultivation has not yet expanded into these abandoned lands. Together with the relentless expansion of new housing communities within agro-ecologies, we face the consequences of a double dilemma. Since its engineering more than four centuries ago, the capacity of coastal drainage networks has been reduced significantly. Clogging drainage systems and increase run-off from expanding housing communities have out-striped the drainage capacity along the coast. With our being oblivious to the need for better drainage systems, it is plausible that disastrous episodes owing to rains may win the battle ahead of rising sea levels.*

The diversity of fauna is directly dependent upon the diversity of PGRFA. The diversity of both constitutes an agro-ecological ambiance and ecological balance that ideally supports a food chain from common insect pests and unusual parasitoids to mosquito-dependent amphibians and fishes, parasitizing fungi and birds; from estate rodents to roaming, browsing and grazing livestock and shade tolerant fruit-trees, to aquatic weeds and the reptiles with which they cohabitate. Without this synergy, potentially devastating climate scenarios and ecological episodes would likely make livelihood unbearable for human habitation. The social and commercial value of homestead depositories was further summarized in Section 2.3.

8.2.2.3 Coconut

Coconut represents an important component of coastal ecologies. The ecological threats to coconut diversity and a strategy for their mitigation have been summarized in Section 2.2.1.1.

8.2.2.4 Cassava

In recent years, the effect of unseasonal floods and droughts in remote hinterland communities should give pause to revisit our response strategies. Cassava value-added cottage products such as cassareep, cassava bread, and farine have two things in common. They are in-expensive dietary staples of hinterland Amerindian communities and they have a relatively long shelf life. We should note that food scarcity in these communities is synonymous with short supplies of these value-added foods. Yet, food aid to stricken hinterland communities seldom ever includes these value-added staples. In times of good harvests, community-based initiatives on food storage could mitigate the anxiety and insecurity commonly associated with relief efforts. The savings in costs absorbed by relief efforts will far exceed the costs required for storage infrastructure. The surplus money will allot more for medical and transportation interventions, and for government to purchase excess reserves. A strategy to safeguard cassava varietal diversity is summarized in Box 3.1. The food security significance of cassava for sustainable livelihood in hinterland communities was further summarized in Section 2.3.1.

8.2.2.5. Seed distribution systems

Government's dependence upon emergency bulk purchases of seed through locally-based commercial agro-chemical companies presents what has become an unsustainable seed security policy. Private commercial agricultural-based enterprises are a necessary forerunner for commercial agriculture; and especially so for investing in the local seed industry. But under the UN FAO policy on national food security, governments (not private businesses) are held responsible to protect this right of citizens. And to relegate a major component of this responsibility to private enterprise is contrary to Guyana's obligations. Seed security issues have been further summarized in Sections 3.2.3.7. This study sees a potential solution to this abnormality because there is a direct parallel between a plausible response to shortages of cassava value-added foods and this unsustainable seed security issue (please see Section 8.2.2.4). A National Crop Genetic Resources Centre would ably support 3-5 regional (satellite) seed banks.

8.3 A cultural dimension to food security in Guyana

> ***Box 8.2 Rice and food security***
> *On a daily basis, the material and social context of food security in Guyana is conditioned by two essential and inseparable value-added products; herein referenced as the two '**R**s'. On the one hand we have rice. In Guyana food connotes rice. It is the material basis of our mental food security. But contrary to the beliefs of a majority of Guyanese, a sudden depression of the local rice industry would not result in any food security disaster. Should Guyanese wake up one morning and realize that there would be no local rice supplies for one month, the establishment of a rice import industry would be guaranteed by the said afternoon. The economic cost would be high but not unbearable. And the estimated three-month 'food energy reserves' in coastal farms, homesteads and forage grounds, capable of sustaining 50 percent of our population for an estimated two months, would remain intact.*

[48]Barring only recent setbacks in the sugar industry, the contrasting use of PGRFAs in the rice and sugar sub-sectors has combined to guarantee food security for all and provide an income for more than [49]20 percent of the Guyanese population that obligately must depend upon agriculture for a sustainable livelihood. The rice and sugar industries are therefore, important indicators of Guyana's economic vitality. But sugar, in particular, has transcended into a niche of cultural neutrality.

> ***Box 8.3 Social stability and the sugar industry***
> *Then we have the other **R**. It denotes a 100 percent product that is distilled from our sugar factories and blends with a cultural custom that is in no small way, truly responsible for the tears, joys and gratifications of the daily Guyanese experience. Some are wont to associate the sugar industry with the mainstay of our entertainment industry. But from a social security perspective, the sugar industry is the most significant contributor to our cultural industry in so far that it continues to be instrumental in sustaining the unique Guyanese identity. A sudden or gradual depression of the local sugar industry, for example, would result in an unbearable suppression of our daily social norms. In response, it is logical to posit the resurgence of the local cottage distillation industry. And that would likely be a social disaster in the making, waiting. In short, a depression in the two pillars of Guyana's agriculture industry may have contrasting*

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[48]The current issues and controversies in the sugar industry indicate that sugarcane is (metaphorically writing) not an under-utilized crops species in Guyana. But it does have a potential to generate 'diversity-rich' products and a propensity to adapt to different agricultural systems. Paradoxically, what most sees as a 'crisis', this report sees as an opportunity (summarized in Box 4.5).

[49]In 1995 employment in the agriculture industry accounted for about 35 percent of the Guyanese labour force (NARI, 1995). This estimated downward revision is an indication of the extent the labour force has diverted towards the swelling mining and construction sectors.

implications, but the seriousness with which we take to our main social security issues automatically forces policy-makers to implement measures to guarantee the sustainability of these two pillars of agricultural production and by extension, the major components of our food security.

8.4 Securing the material basis for export markets

The volumes and recent trends of non-traditional crop exports is a strong indication of Guyana's ability to sustain food self-sufficiency. We have not yet, and possible will not in the near future, attain food self-reliance, but our food security platform is set to endure well into the coming decades. In short, Guyana must continue the thrust to increase exports of non-traditional agro-commodities, because exports will continue to serve as the pulling force for their production. The accompanying push from agricultural (and marketing) research needs to embrace a paradigm shift towards modern strategic and applied technologies to deliver the material foundation to assure food security.

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