COUNTRY REPORT ON THE STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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COUNTRY REPORT ON THE STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE IN MALAYSIA (1997-2007)

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GLOSSARY OF ABBREVIATIONS

AARNET	ASEAN-AVRDC Regional Network
ABS	Access and Benefit Sharing
ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Countries
AVRDC	Asian Vegetable Research and Development Centre
BGCI	Botanic Gardens Conservation International
BRCS	Bario Rice Certification Scheme
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
COGENT	International Coconut Genetic Resource Network
DOA	Department of Agriculture
EPU	Economic Planning Unit
FAMA	Federal Agriculture Marketing Authority
FAO	Food and Agriculture Organization
Felcra	Federal Land Consolidation And Rehabilitation Authority
Felda	Federal Land Development Authority
FRIM	Forest Research Institute of Malaysia
GDP	Gross Domestic Product
GPA	Global Plan of Action
IBPGR	International Board for Plant Genetic Resources
ICDUP	International Council for Development of Underutilised Plants
ICT	Information and Communication Technology
IFS	International Federation of Scientists
INGENIC	International Group for Genetic Improvement of Cocoa
INGER	International Network for Genetic Evaluation of Rice
INIBAP	International Network for the Improvement of Banana and Plantain
IPGRI	International Plant Genetic Resources Institute, Regional Office for Asia, the Pacific and Oceania (Bioversity International)
IPPC	International Plant Protection Convention
IRRDB	International Rubber Research and Development Board
IRRI	International Rice Research Institute
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
MAHA	Malaysia Agriculture, Horticulture and Agrotourism Show
MARA	Majlis Amanah Rakyat (Council of Trust for the Bumiputera)
MARDI	Malaysian Agriculture Research and Development Institute
MBBN	National Biodiversity-Biotechnology Council
MCB	Malaysian Cocoa Board
MEPIS	Medicinal Plant Information System
MLS	Multilateral System
MOA	Ministry of Agriculture
MOA-ABI	Ministry of Agriculture and Agro-based Industries
MP	Malaysia Plan
MPOB	Malaysia Palm Oil Board

MRB	Malaysian Rubber Board
NAP 3	Third National Agriculture Policy
NCCBD	National Committee on the Convention on Biological Diversity
NGOs	Non-governmental organizations
NISM	National Information Sharing Mechanism
PAS	All-Malaysia Islam Party
PFE	Permanent Forest Estate
PGR	Plant Genetic Resources
PGRFA	Plant Genetic Resources for Food and Agriculture
PMV	Penyakit Merah Virus
PORIM	Palm Oil Research Institute of Malalysia
PROSEA	Plant Resources of South-East Asia
PVP	Plant Variety Protection
R&D	Research & Development
RECSEA-PGR	Regional Cooperation in Southeast Asia on Plant Genetic Resources
RGBIS	Rice Genebank Information System
RISDA	Rubber Industry Smallholders Development Authority
RRIM	Rubber Research Institute Of Malaysia
SEDC	State Economic Development Corporations
SMTA	Standard Material Transfer agreement
TANSAO	Taro Network for Southeast Asia and Oceania
TRIPS	Trade Related Aspects of Intellectual Property Rights
UiTM	MARA University of Technology, Malaysia
UKM	National University of Malaysia
UM	University of Malaya
UMNO	United Malays National Organization
UMS	Sabah University of Malaysia
UNDP	United Nations Development Programme
UNIMAS	University of Sarawak, Malaysia
UPM	Universiti Putra Malaysia
USM	Science University of Malaysia

PREFACE

This report was written to provide an overview of the activities relating to Plant Genetic Resources for Food and Agriculture (PGRFA) which are executed within the country. The contents of the report were partially based on the information and active responses from the participation of 28 stakeholders of the FAO/Government cooperative project, GCP/RAS/186/JPN, entitled 'The Establishment of National Information Sharing Mechanism for the Monitoring of the Implementation of Global Plan of Action (GPA) on the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture in Malaysia'. The recognized stakeholders are listed under Acknowledgements.

In all, there are nine chapters in this report. It has been a great pleasure to make the information in this report available to policy/decision makers, funding agencies, research administrators, the private sector, civil society groups involved in biodiversity issues, the media and the local public.

CHAPTER 1

INTRODUCTION

1.1 Background

1.1.1 Geography

Malaysia is located between 2° and 7° north of the equator and longitudes 100° and 119° east. This South-east Asian sovereign nation covers an area of about 329 758 square kilometers, consisting of Peninsular Malaysia, and the states of Sabah and Sarawak as well as the Federal Territory of Labuan in the north-western coastal area of Borneo Island. Peninsular Malaysia comprises the states of Johor, Kedah, Kelantan, Melaka, Negeri Sembilan, Pahang, Pulau Pinang, Perak, Perlis, Selangor and Terengganu, and the Federal Territories of Kuala Lumpur and Putrajaya. Pahang is the largest state in Peninsular Malaysia with an area of 35 965 square kilometers. Sabah consists of five divisions, namely Tawau, Sandakan, Kudat, West Coast and Interior. The Federal Territory of Labuan, covering an area of 91 square kilometers, is situated off the west coast of Sabah. Sarawak comprises nine divisions, namely Kuching, Sri Aman, Sibu, Miri, Sarikei, Limbang, Kapit, Bintulu and Kota Samarahan.

The two regions (Peninsular Malaysia and the Borneo states) are separated by about 531.1 kilometers of the South China Sea. Peninsular Malaysia, covering 131 598 square kilometers, has its frontiers with Thailand in the north and Singapore in the south, while Sabah with an area of 73 711 square kilometers and Sarawak of about 124 449 square kilometers border the territory of Indonesia's Kalimantan province.

1.1.2 Climate

Malaysia experiences a tropical climate. The year is generally divided into the South-West and the North-East Monsoon seasons. The temperatures in the lowlands range from 21°C (70°F) to 32°C (90°F). Humidity is high at 80%. The highlands are cooler with temperatures ranging between 15°C (59° F) and 25°C (77°F). Annual rainfall varies from 2 000 mm to 2 500 mm.

1.1.3 Administration and politics

Malaysia is a federal constitutional monarchy, consisting of 13 states and three federal territories (Kuala Lumpur, Labuan and Putrajaya). The King is elected among the nine hereditary sultans of the traditional Malay states (*viz.* Johor, Kedah, Kelantan, Negeri Sembilan, Pahang, Perak, Perlis, Selangor and Terengganu) for a five-year term. Each of the 13 states has an Executive Council dealing with non-federal matters and is headed by a chief minister. The Federal Parliament has an upper chamber (Senate) with 70 members and a lower chamber (House of Representatives) with 193 members. National elections are held every five years. The government is sustained by Barisan Nasional or the United Front, a coalition consisting of 14 parties led by Malay nationalist UMNO. Barisan Nasional holds a two-thirds majority in the House of Representatives, as is required to pass constitutional amendments. The country's Prime Minister and UMNO President is YAB Dato' Seri Abdullah bin Haji Ahmad Badawi. The opposition is gathered in a front formed by four parties, the most important of which is PAS.

1.1.4 Population and races

According to the 2000 census by the Statistics Department, Malaysia has a population of 26.9 million. Malaysia is a multi-racial, multi-cultural and multi-religious country, with Malay, Chinese, Indian, Dayak, Kadazan (Dusun), Bajau, Melanau, Murut and various other ethnic groups and indigenous people. In religious terms it is predominantly Islamic, but with strong Christian, Buddhist and Hindu communities. The Malaysian constitution provides for a system of privileges favoring the Bumiputra (Malays and aborigines) which is reflected in the country's national development plans.

1.1.5 Economy

The Malaysian economy has performed remarkably well over the years due to the country's political stability, the sound financial and economic policies adopted by the government, and the efficient management of its natural resources which include oil and gas. Even more impressive is the fact that economic growth in Malaysia has been achieved within an environment of relatively low inflation.

Agriculture has played a vital role in the development of modern Malaysia, and continues to make a significant contribution to the national economy. The plantation sector, especially oil-palm, still leads the world in terms of vegetable oil production as well as in research and development.

1.2 New agriculture

Malaysia's agriculture sector was accorded renewed and extra importance by the government after the economic crisis of 1997, with a particular drive to reduce the food importation bill. In the year 2002, Malaysia's import and export of food was RM13 billion and RM7 billion, respectively, representing an import deficit bill of RM6 billion. Meeting the challenge of enhanced and more efficient agricultural production is one of the primary objectives to increase the exports and reduce the imports of agricultural commodities.

Agriculture has been treated with more importance in the Ninth Malaysia Plan or 9MP (2006-2010), starting with the revitalizing of the sector as one of the key aims of the Plan. The sector itself features strongly in each of the five key thrust areas of the National Mission. Following from the restructuring and renaming of the Ministry of Agriculture (MOA) as the Ministry of Agriculture and Agro-based Industries (MOA-ABI) in 2004, the agriculture sector will be revitalized to become the third engine of economic growth. Emphasis will be on new agriculture which will involve large-scale commercial farming, the wider application of modern technology, the production of high quality and value-added products, unlocking the potential in biotechnology, increased convergence with information and communications technology (ICT), and the participation of entrepreneurial farmers and a skilled workforce.

The value-added of agriculture grew at 3.0 per cent per annum over the Eighth Malaysia Plan (8MP) period, higher than the targetted 2.0 per cent. Agriculture and agro-based industries grew at 3.6 per cent. Over the 9MP period, agriculture is expected to grow at 5 per cent per annum, while agriculture and agro-based industries are expected to grow at 5.2 per cent. In 2005, the value added of agriculture was RM21.6 billion (at 1987 constant prices) or 8.2 % of GDP. When taken together with agro-based industries, the value added in 2005 was RM38.5 billion or 14.7% of GDP. This is targeted to increase to RM49.7 billion or 14.2% of GDP in 2010.

In terms of export earnings, agriculture and agro-based exports are expected to grow from RM74.9 billion in 2005 (14% of total exports) to RM115.7 billion (14.5% of total exports) in 2010. In terms of employment, agriculture and agro-based industries employed 2.39 million workers (21.9% of total employment) in 2005, and this is expected to increase to 2.43 million workers (20.3% of total employment) in 2010.

1.3 Farming systems

Although rice (paddy) cultivation is the major food crop enterprise in Malaysia, accounting for about 0.67 million hectares for all seasons in 2001 (Ministry of Agriculture, 2003), oil palm, rubber, coconut and durian also occupy large areas in the agricultural cropping systems. In 2001, there were 3.63, 1.57, 0.15 and 0.12 million hectares of oil palm, rubber, coconut and durian, respectively. Together with paddy, these crops covered almost 97 percent of the total cultivated agricultural land in Malaysia.

Three farm categories exist for crop production, namely the smallholders, the new land development schemes and the large commercial (estate or plantation) holdings. The new land development schemes (namely, Felda, Felcra and various State Economic Development Corporations or SEDC) are initiated by the public sector. The Felda schemes have holding sizes of 4.04 hectares of agriculture area (planted with oil palm or rubber) and a 0.10 hectare house lot for each farm family.

The smallholdings are those with an area is less than 40 hectares each, the majority having on average between 0.5 and 3.0 hectares. These smallholders usually practice some form of mixed cropping, involving mostly food crops. Small farm sizes have been a major cause of the low incomes of many smallholders, due to diseconomies of scale. The government of Malaysia, through the Ministry of Agriculture, is committed to overcoming this problem by grouping small farms into mini-estates and "group-farming" in order to achieve economies of scale, better farm resource management and

production sustainability. This is one of the government's policies for improving the living standards of the rural poor and small farmers.

Large holdings (>40 hectares) are those of the commercial plantations. Their production is well-organized for both local and overseas markets. In almost all cases, mono cropping practices are applied.

1.4 Biodiversity

1.4.1 Flora

Malaysia's rainforest is considered as the oldest in the world. It is estimated that over 15 000 flowering plant species (9 percent of the world's tota l) are found in Malaysia. Malaysia's flora includes some 2 500 species of trees, 200 different palms and 3 000 species of orchids. The diverse species of animal and plant life continue to excite a great deal of scientific attention research. Many believe that some as yet undiscovered plant or plants may hold cures for many of the currently incurable human diseases. The world's largest flower, the Rafflesia, is unique to the region. Another record-breaker is the towering Tualang tree, tallest of all tropical trees. It can reach up to 80 meters (260 ft) in height.

1.4.2 Fauna

The Malaysian rainforest holds hundred of thousands of animal species (some 185 000 species or 16 percent of the world's total), many of which are unique to the region and the world. A total of 286 species of mammals, 736 species of birds, 406 species of amphibians and reptiles, and more than 100 000 species of insects have been recorded in the country. Among the mammals which live here are tigers, elephants, rhinoceros, tapirs, civet cats, leopards, bears and two kinds of gibbons and monkeys. Sabah and Sarawak are homes to the extraordinary orang utan. The important areas for migratory birds include Kuala Gula in Perak, Pulau Bruit in Sarawak and the coastal areas of Sabah.

There are only two species of crocodiles in Malaysia, the estuarine crocodile and gharial. Crocodiles are known to inhabit large rivers, especially in Sarawak. The fresh water fish which is most abundant in Malaysia is the carp. Other types are *kelisa*, *sebarau*, *toman* and *haruan* River terrapins are found in the major river systems in the peninsula, such as the rivers of Perak, Kedah, Terengganu and Pahang. The east coast of Peninsular Malaysia provides one of the most important landing sites for marine turtles, especially the leatherback turtle. Rantau Abang in Terengganu is the main landing site in the country for these turtles. The Turtle Islands off the coast of Sabah are also important for the conservation of marine turtles in the region.

The government formulated a strategic agricultural development master plan, referred to as the Third National Agricultural Policy or NAP3 to cover the period 1998-2010 (Ministry of Agriculture, 1999). The projected sales target for food crops between the years 2001 and 2005 was set at RM27 billion (US$7.1 billion).

Based on the Eight Malaysia Plan, the projected increases in production of some crops up to the year 2005 are shown in *Table 1*. An inevitable result of this policy for enhanced agricultural growth is the expansion and/or further intensification of land use for agriculture. Between 1995 and 2000, agricultural land use increased from about 5.7 million hectares to about 6.0 million hectares.

TABLE 1
Crop production from 1995-2005 ('000 tonnes)

Commodity	1995	2000	2005
Agricultural industrial commodities			
Rubber	1 089	616	560
Crude palm oil	7 811	10 840	12 416
Palm kernel oil	2 396	3 220	3M 774
Cocoa	31 842	23 898	18 864
Pepper	131	70.0	115
Pineapple	13.0	24.0	30.0
Tobacco	140	184	264

Commodity	1995	2000	2005
Flowers	10.0	11.0	15.0
Food commodities			
Padi	2 127	2 235	2 813
Fruits[1]	1 020	1 376	1 982
Vegetables[1]	718	1 019	1 390
Coconut[2]	1 389	550	824

Notes:
[1] Refers to commercial cultivation
[2] Data in million nuts

CHAPTER 2

THE STATE OF DIVERSITY

2.1 Introduction

Malaysia is rich in biological diversity. It harbors some 185 000 species of fauna, more than 15 000 species of flowering plants. Of about 1 500 genera to be found are over 2 500 tree species, 3 000 species of orchids, 500 species of ferns, 60 species of grasses and bamboos, and many others. However, only a handful of the 15 000 species have been utilized for food production. It has been reported that only about 300 species native to the country have been exploited and utilized. The remaining species are still growing wild or semi-wild in various forest types and their economic potential has not been realized or investigated in greater detail. As an example, there are 24 species of *durian* (*Durio*) and its relatives in Malaysia. All with the exception of *D. zibethinus* are wild. The mango is equally species-rich, with 22 species, but only three or four of these are being utilized. There are 49 species of mangosteen and its wild relatives in Peninsular Malaysia but only mangosteen (*Garcinia mangostana)* is popularly eaten. Other examples of large genera with edible fruits include cempedak (*Artocarpus*) and *rambutan (Nephelium)*.

Based on data collected from stakeholders through the recently concluded National Information Sharing Mechanism (NISM) project, thirty four projects were recorded on inventorization of species in the last ten years.

2.2 Value of plant genetic resources for food and agriculture (PGRFA) in Malaysia

Apart from rubber, oil palm and cocoa, other crops of importance are rice, fruits such as papaya, pineapple, banana and starfruit, and some vegetable crops like chilli pepper and eggplant.

Much of the PGRFA used in rice breeding are from IRRI in the form of advanced breeding lines or accessions which contain certain desirable traits for use in breeding for disease resistance or eating quality. In vegetable crops, much of the improvement was made through selecting superior plants out of local land races. Several open-pollinated varieties of chilli pepper, long bean, luffa and several others have been developed using this method.

Similarly, noticeable progress has been made in improving *durian* and *rambutan*, again through selecting superior genotypes from the existing indigenous land races. Some introduced PGRFA were used to improve mango, *ciku* and starfruit. Both local and foreign PGRFA were used to improve the current cultivated banana.

Introduced advanced lines especially from AVRDC have also been used to improve certain vegetable types like tomato. Introduced PGRFA from CIP and CIAT together with local germplasms were used to improve sweetpotato and cassava. In general, an increasing trend was observed over the last ten years on the use of PGRFA in crop improvement research.

2.3 State of diversity of fruit genetic resources

2.3.1 Durian

With a total of 24 indigenous species recorded, Borneo together with Peninsular Malaysia is considered a major center of diversity for the genus. A total of 16 species are recorded in Peninsular Malaysia, of which nine are endemic while 12 species are found in Sabah, of which two are endemic. Sarawak has 13 species, three of which are endemic. *Durio zibethinus* is the only species that is cultivated commercially. A few other *Durio* species such as *D. lowianus*, *D. graveolens*, *D. oxleyanus, D. kutejensis* and *D. dulcis* also produce edible fruits. They are semi-cultivated and have local economic importance, while providing useful traits for durian breeding programs. Wild species such as *D. grandiflorus* and *D. testudinarum* are also producing fruits with a thin aril which is neither sweet nor having a distinct flavor. The cryptic biodiversity can be even more important in contributing such traits as pest and disease resistance and adaptability. Wild *D. carinatus* for example adapts well to peat swamps, *D. lanceolatus* to sandy soils and *D. kinabaluensis* to altitudes of > 1 000 meters.

2.3.2 Citrus

The citrus, for which Malaysia is believed to be the center of diversity, is represented in Malaysia by both wild and cultivated species. Eight species of citrus are cultivated widely in the country. Two species, *limau kedut kera* (*Citrus halimii)* and *limau hantu* (*Citrus macroptera)* grow wild, particularly in the sub-montane forests and is seldom found in the lowlands. *C macroptera* is somewhat gregarious and *C. halimii* is restricted to the hill forests of about 900 meter above sea level. Citrus species appear to be very rare in occurrence outside cultivation, and are gradually threatened.

2.3.3 Pulasan (*Nephelium* ramboutan-ake)

Pulasan adapts to a wide range of temperatures and rainfall regimes in the country. More than 80% of *pulasan* is cultivated at low elevations ranging from 10-500 m. Tremendous variation was observed in pulasan for fruit parameters such as fruit weight, size, shape, colour, rind thickness, sarcotesta thickness, fruit texture, taste, peeling ability, testa adherence, juiciness and flavour. Recently, MARDI selected three elite accessions with superior quality traits.

2.3.4 Kuini (*Mangifera odorata*)

Kuini can be found in the areas with annual mean temperatures of 25-28°C and an annual rainfall distribution pattern ranging from 1 680 mm to 3 267 mm. Variation was observed in fruit shape, aroma, taste, color of flesh and flavour. MARDI has identified three accessions which possess good quality fruits.

2.3.5 Species diversity of other *Mangifera (Anacardiacea)*

There are 30 species (cultivated and wild) of *Mangifer*a in Malaysia; three are endemic (*M. gracilipes, M. khoonmengiana and M. pajang*). Eight of the 12 species cultivated in the villages in Malaysia are found in the wild and they are *binjai/ beluno* (*M. caesia)*, *bacang* (*M. foetida)*, *rawa* (*M. griffithii)*, *lanjut* (*M. lagenifera)*, *sepam/topah* (*M. longipetiolata)*, *pauh (M. pentandra)*, *asam kumbang (M. quadrifida)* and *binjai* (*M. caesia)*. *Mangga kasturi (M. casturi)*, *mangga (M. indica)*, *kuini (M. odorata)* and *bambangan (M. pajang)* are the exotic species cultivated in this country. In Peninsular Malaysia, 12 species of *Mangifera* are found in the Pasoh Forest Reserve and eight species in the Krau Wildlife Reserve. Eight and six species of *Mangifera* are found wild or cultivated in Sabah and Sarawak, respectively.

2.3.6 Species diversity of other *Nephelium (Sapindaceae)*

There are 20 species (cultivated and wild) of *Nephelium* in Malaysia, 10 of which are endemic (*N. aculeatum, N. compressum, N. costatum, N. daedaleum, N. hamulatum, N. havilandii, N. macrophyllum, N. meduseum, N. papillatum and N. reticulatum*). Most of them are located in lowland and hill dipterocarp forests. The trees are small to medium in size, 10-20 m tall and usually forming the understorey layer of the forest. Cultivated *Nephelium*, such as *kalambuko/ rambutan gergasi (N. cuspidatum*), *rambutan (N. lappaceum*) and *pulasan (N. ramboutan-ake*), can also be found in the wild, and these produce edible fruits with a sweet *taste.* Other species such as *kalas (N. daedaleum*), *geringgong (N. laurinum*), *buah sungkit (N. maingayi*) and *mertapang (N. melanomiscum*) produce edible but sour fruits. Six taxa of *Nephelium* are found in the Pasoh Forest Reserve and seven in the Krau Wildlife Reserve. Three and five species of *Nephelium* are found wild or cultivated in Sabah and Sarawak, respectively.

2.3.7 Species diversity of *Garcinia (Clusiaceae or Guttiferae)*

About 80 species of *Garcinia* are found in Malaysian forests over a wide range of habitats – from seashores to the tops of the highest mountains. The trees are small to medium in size, and occur in the forest as understorey trees. *M*angosteen *(Garcinia mangostana*) is not found the wild, but two wild species, *beruas (G. hombroniana*) and *manggis burung (G. malaccensis*), resemble the cultivated mangosteen. The other cultivated *Garcinia* are *asam gelugor (G. atroviridis*), *kandis (G. cowa*) and *kechupu (G. prainiana*), all of which can be found in the forest. Other wild species such as *tengkawan (G. bancana), bunau (G. caudiculata*), *gelugur (G. costata*), *mundu (G. dulcis*), *kandis gajah (G. griffithii*), *lulai (G. merguensis*), *kandis (G. nitida*) and *kundong (G. parvifolia*) also produce edible fruits. Thirteen species of *Garcinia* are found in the Pasoh Forest Reserve and 17 in the Krau Wildlife Reserve. Five species of *Garcinia* are found wild or cultivated in Sarawak.

2.3.8 A Case Study in Belum Forest Reserve

Belum Forest Reserve in Hulu Perak, Malaysia is known to be rich in fruit tree species. Thirty-two edible species were recorded in the forest reserve. Thirteen of these were considered common. The genus *Garcinia* was represented by five species, while the genera *Artocarpus* and *Baccaure*a were represented by four species each. The genera *Citrus*, *Durio, Scaphium, Nephelium* and *Bouea* were represented by two species each. Other genera, *Mangifera, Castanopsis, Dialium, Lansium, Reinwardtiodendron, Pometia, Xerospermum, Flacourtia* and *Elateriospermum*, were each represented by a single species.

2.4 State of diversity of aromatic plant species

Malaysia is also richly endowed with aromatic plants. There are more than 600 species of aromatic plants in Malaysia, belonging to at least 21 different families. The largest groups are from the families *Annonaceae*, *Dipterocarpaceae*, *Lauraceae*, *Meliaceae* and *Zingiberaceae*. Of the selected examples of 133 species of dicotyledonous aromatic plants, about 21% are endemic, 18% are non-endemic but rare, 51% are non-endemic and widespread, and only about 10% have been domesticated and cultivated in home gardens, roadsides, parks and small-scale commercial plantations. In the *Zingiberaceae*, about 75% of the 308 known species are endemic, and about 25% are non-endemic and widespread in South-east Asia.

2.4.1 Diversity of fruits in the average home garden (general on-farm fruit diversity)

Observations made by MARDI in a village in Pahang showed that traditional fruit species are grown in the orchards and also in the home gardens. A total of 21 fruit species were identified with the main fruit being *dokong* (*Lansium domesticum*). Of these, 67% of the fruit species are consumed fresh, 29% can be prepared as dishes, while 14% need to be processed. Shoots from *Garcinia atroviridis* is eaten fresh as *ulam* or vegetable. Three fruit species possess medicinal value. The most important species are *Garcinia atroviridis, Mangifera odorata* and *Parkia speciosa* because they provide a steady income to the farmers.

A typical home garden in Beaufort, Sabah, contains about 40 fruit species of which 67% are consumed fresh, 21% are prepared into dishes, and 10% processed. Two species are used in making drinks, and shoots from *Garcinia atroviridis* can be eaten fresh. Four species have medicinal uses, one species can be used in handicraft, and yet another species is used as shampoo. The most important fruit species are *Artocarpus odoratissimus*, *Mangifera pajang* and *Nephelium ramboutan-ake*. In another homegarden near Kota Kinabalu, tradition fruit species are also grown. A total of 24 fruit species were identified. About 75% of the fruits are consumed fresh, 17% processed, and 30% are used in dishes. About 30% of the fruit species have medicinal value. Important fruit species are *Mangifera pajang, Nephelium ramboutan-ake* and *Parkia speciosa.* The traditional fruits not only contribute to the nutrition of the family but also provide an important source of income to the family.

Traditional fruit species are also grown in home gardens in Bandar Sri Aman, Sarawak. Fifty-two fruit species were identified in the village, of which 54% are consumed fresh, 13% can be used for cooking, and 2% processed. The citrus fruits are used to make drinks. The stem of *senggang* (Zingiberaceae) is made into handicraft. Important fruit species in those homegardens are *Dialium* sp.*, Dipterocarpus* sp.*, Canarium odontophyllum, Dacryodes rostrata, ijuk, senggang, sabung, Dimocarpus longan var. malesianus, Litsea graciae*, and *Mangifera* sp. Among the highly priced fruit species in the home gardens are *Dialium* sp.*, Dimocarpus longan* var. *malesianus, Canarium odontophyllum, Parkia speciosa* and *Xanthophyllum amoenum* with average retail prices ranging from RM2.00 to RM8.00 per kg.

2.4.2 State of diversity of other indigenous cultivated fruit species

The other major indigenous cultivated fruit species include banana, *belimbing manis* (*Averrhoa carambola*), *cempedak* (*Artocarpus integer*), *duku* and *langsat* (*Lansium domesticum*), and mangosteen (*Garcinia mangostana*). Other minor indigenous cultivated species include *asam gelugor* (*Garcinia atroviridis*), *keranji (Dialium* spp.), *larah* (*Baccaurea griffithii*), *nam-nam* (*Cynometra cauliflora*), *rambai* (*Baccaurea motleyana*), *rukam manis* (*Flacourtia rukam*), *salak* (*Salacca edulis*) and *sentul* (*Sandoricum koetjape*),

2.5 Medicinal plant genetic resources

Many plants from the forest which can produce a large variety of phytochemicals or secondary metabolites are widely used in traditional medicine in Malaysia. Some of the important medicinal plant species are:

- **Gambir (*Uncaria* sp., *Rubiaceae*):** Several alkaloids have been isolated which show cardio-vascular effects in rats.
- **Neem (*Azadirachta indica*):** The tree is reported to be completely free of insect pests, and almost every part of the tree is known to have some use. The fruit and leaves of the tree contain potent anti-feedant compounds (*azadirachtin, salanin*). There are efforts to develop neem into a cheap source of insecticide for field use. The neem tree grows well in Malaysia, especially in the northern part of the Peninsula.

2.6 State of diversity of vegetable crops genetic resources

Inventorization work conducted in 2003 and 2004 on traditional vegetables of the country showed the following genus and species diversity:

TABLE 2
Traditional vegetables collection

Family	Genus	Species	No. of accessions
Umbelliferae	*Centella*	*asiatica*	5
Labiatae	*Ocimum*	*Basilicum*	2
Leguminoseae	*Psophocarpus*	*tetragonolobus*	12
	Ipomoea	*aquatica*	1
	Ipomoea	spp.	1
	Phaseolus	*vulgaris*	1
	Vigna	*sinensis*	3
	Vigna	*unguiculata*	2
	Vigna	spp.	1
	Canavalia	*gladiata*	3
	Cassia	*occidentalis*	5
	Dolichos	*lablab*	2
Capparidaceae	*Cleome*	*gynandra*	8
Compositae	*Cosmos*	*caudatus*	9
Malvaceae	*Hibiscus*	*sabdariffa*	1
	Hibiscus	*esculentus*	2
	Abelmoschus	*esculentus*	1
Moringaceae	*Moringa*	*oleifera*	2
Cucurbitaceae	*Cucumis*	spp.	1
	Cucumis	*sativus*	2
	Lagenaria	*siceraria*	1
	Momordica	*charantia*	12
	Momordica	spp.	2
	Cucurbita	*moschata*	3
	Luffa	*aegyptiaca*	9
	Luffa	*acutangula*	7
	Luffa	spp.	1
	Melothria	*affinis*	4
Solanaceae	*Solanum*	*melongena*	25
	Solanum	*tarvum*	10
	Solanum	*ferox*	10

Family	Genus	Species	No. of accessions
	Solanum	*nigrum*	5
	Solanum	*indicum*	3
	Solanum	*xanthocarpum*	2
	Solanum	*sarmentosum*	1
	Solanum	spp.	9
	Capsicum	*frutescens*	48
	Capsicum	*annuum*	7
	Capsicum	spp.	15
	Lycopersicum	*esculentum*	1
Passifloraceae	*Passiflora*	*foetida*	2
Chenopodiaceae	*Basella*	*alba*	1
	Basella	*rubra*	1
Amaranthaceae	*Amaranthus*	spp.	9
	Amaranthus	*viridis*	4
	Amaranthus	*tricolor*	11
	Amaranthus	*blitum*	2
	Amaranthus	*spinosus*	4
	Amaranthus	*gracilis*	1
Euphorbiaceae	*Sauropus*	*androgynus*	2
Dioscoreaceae	*Dioscorea*	*esculanta*	1

The number of accessions may indicate the population size of the respective species

2.7 Rice genetic resources

In Malaysia, four wild *Oryza* species occur – *O. rufipogon, O. officinalis, O. ridleyi,* and *O. meyeriana*. Of these only *O. rufipogon* has the same genome as cultivated rice, *Oryza sativa,* and can readily intercross under natural conditions. From them, a total of at least nine farmer varieties or land races have developed *viz*. *Siam 29*, *Mayang Ebos 80*, *Tangkai Rotan*, *Pulut Sutera*, *Radin Goi*, *Engkatek*, *Secupak*, *Pongsu Seribu* and *Padi Siam*. Some of them have been used to develop the currently used modern varieties.

As example, *Radin Goi* was used to develop varieties MR84, MR211, MR185 and MR219, *Pongsu Seribu* to produce MR73, *Mayang Ebos 80* to produce *Mahsuri*, *Tangkai Rotan* to produce *Bahagia*, and several others. *O. rufipogon* has been shown to possess genes resistant to *Penyakit Merah Virus* (PMV) disease or tungro and has been contributing genes for vigor in hybrid rice development.

2.8 Threats to PGRFA

At present PGRFA are threatened directly or indirectly by human activities that interfere with their habitats. Response to a survey of the NISM project showed that land development which involves the conversion of agriculture areas into non-agriculture areas and non-selective harvesting are the major threats to PGRFA.

The introduction of new crop varieties, natural disasters, natural rarity and biotic and abiotic stresses are also important factors that cause the decreasing numbers of PGRFA. Others include over-exploitation (wild fruit trees), population growth, immigration, negative market influence, lack of funds for biodiversity conservation, current global popularity of herbal medicines and several others.

2.8.1 Species under threat

Some wild fruit species are under threat. Examples are *cerapu* (*Baccaurea griffithii*), *binjai* (*Mangifera caesia*), *Castanopsis inermis*, *Artocarpus integer* var. *sylvestris* and *terap (Artocarpus lowii*), *redan (Nephelium maingayi*) and *Scaphium linearicarpon*. Most of the landraces of vegetable and rice are under threat due to the introduction of more uniform

modern varieties. Aromatic and medicinal plants that are under threat include some of the *medang* (*Lauraceae* species) and some of *gaharu* species. Others reported under threat by the stakeholders to the NISM project include most of the *Nepenthes* species, *Paphiopedilum rothschildianum*, *Phalaneopsis gigantean*, a few of the banana landraces such as *pisang tanduk* and *pisang nipah*, *kuini*, local *salak*, and popular medicinal plants such as *tongkat ali* (*Eurycoma longifalia*).

CHAPTER 3

THE STATE OF *IN SITU* MANAGEMENT

3.1 Inventories and surveys

About 34 activities have been reported which are related to the surveying and inventorization of PGRFA in Malaysia. The projects were implemented by various agencies, research institutes and institutions of higher learning throughout the country. Currently, the surveying and inventorization activities of PGRFA are being carried out continuously, but not all the plant genetic resources have been covered within the activities listed out. There are still a lot of species and land races to be collected and identified. In the early years, surveys and inventorys of PGRFA were not the main priority of the country. However, specific action plans have been lined out in the National Action Plan and Strategy for PGRFA to promote and strengthen the surveying and inventorization of PGRFA *in situ* and on-farm. This was put into force to support the National Policy on Biological Diversity.

Table 3 lists the area in Malaysia which have been surveyed and inventoried for PGRFA.

TABLE 3
Areas surveyed and inventoried in Malaysia

Stakeholder	Title of survey/inventory	Name of area surveyed/inventoried	Threatened species/ ecotypes/populations
Sabah Parks	Kinabalu Ethnobotany Project	Dusun communities around Kinabalu Park and Crocker Range Park	Not available
Sabah Parks	Distribution, Ecology and Conservation of Rafflesia	Sabah	Not available
Sabah Parks	Poring Orchid Conservation Centre	Sabah	Paphiopedilum rothschildianum, Phalaneopsis gigantea
Sabah Parks	Nepenthes Garden at Mesilau Nature Resorts, Kinabalu Park	Kinabalu Park	Nepenthes rajah, Nepenthes burbidgeae
Sabah Parks	Kinabalu Mountain Botanical Garden	Mount Kinabalu area	Not available
Strategic Resources Research Centre, MARDI	Biodiversity study, conservation and information management of cooking banana	Klang; Kuala Selangor; Sabak Bernam; Kuala Langat; Hulu Langat; Hilir Perak; Kuala Kangsar; Raub; Jerantut; Bentong; Kuala Lipis; Johor Bahru; Pontian; Batu Pahat; Muar; Segamat	*Pisang tanduk, pisang nipah, pisang kapas, pisang nangka, pisang awak*
Strategic Resources Research Centre, MARDI	Biodiversity, socio-economic studies and information management of binjai, bacang and cerapu	Alor Gajah; Batang Padang; Batu Pahat; Besut; Dinding; Dungun; Hulu Langat; Jasin; Jerantut; Kangar; Kemaman; Kluang; Kota Bharu; Kuala Berang; Kuala Kangsar; Kuala Krai; Kuala Muda; Kuala Pilah; Kuala Selangor; Kuantan; Kubang Pasu; Lansgkawi; Larut Matang; Lipis; Machang; Marang; Melaka Tengah; Muar; Parit; Pasir Mas; Pasir Putih; Pekan; Petaling; Pontian; Raub; Rembau; Segamat; Sepang; Seremban; Tanah Merah; Tangkak; Temerloh; Yan	*Cerapu* and *binjai*
Strategic Resources Research Centre, MARDI	Biodiversity, socio-economic studies and information management of pulasan and kuini	Alor Gajah; Arau; Batu Pahat; Dungun; Jelebu; Jempol; Jerantut; Johol; Kangar; Kemaman; Kluang; Kuala Kangsar;Kuala Lipis; Kuala Pilah; Kuala Selangor; Kuantan; Kubang Pasu; Langkawi; Larut Matang; Marang; Mersing; Muar; Parit; Pasir Mas; Pasir Putih; Pekan; Petaling; Pontian; Raub; Rembau; Rompin; Segamat; Seremban; Tampin; Tanah Merah; Tangkak; Temerloh; Yan	*Nephelium ramboutan-ake*; *Mangifera odorata*
Strategic Resources Research Centre, MARDI	Biodiversity, socio-economic studies and information management of *Salacca* species in Peninsular Malaysia	All states in Peninsular Malaysia	*Salacca* sp.
Strategic Resources Research Centre, MARDI	Biodiversity of edible *Durio* species	Hulu Langat; Jerantut; Kuala Berang; Miri; Kemaman	*Durio* sp.
Strategic Resources Research Centre, MARDI	Bioprospecting of rice genetic accessions for important agronomic traits	Batu Berendam; Baram; Beluran; Besut; Bintulu Town District; Cameron Highland; Daerah Kota Marudu; Daerah Kudat; Daerah Pensiangan; Daerah Pitas; Endau Rompin; Gerik; Gua Musang; Kuala Lipis; Lubuk Antu; Telupid; Temerloh	Wild rices and upland rice (*padi huma*)

Stakeholder	Title of survey/inventory	Name of area surveyed/inventoried	Threatened species/ ecotypes/populations
Strategic Resources Research Centre, MARDI	Safeguarding and preservation of the biodiversity of the rice genepool	Batu Berendam; Baram; Beluran; Besut; Bintulu Town District; Cameron Highland; Daerah Kota Marudu; Daerah Kudat; Daerah Pensiangan; Daerah Pitas; Endau Rompin; Gerik; Gua Musang; Kuala Lipis; Telupid; Temerloh	Wild rices and upland rice (*padi huma*)
Strategic Resources Research Centre, MARDI	Rice genetic resources conservation and management	Batu Berendam; Baram; Beluran; Besut; Bintulu Town District; Cameron Highland; Daerah Kota Marudu; Daerah Kudat; Daerah Pensiangan; Daerah Pitas; Endau Rompin; Gerik; Gua Musang; Kuala Lipis; Lubuk Antu; Telupid; Temerloh	Wild rices and upland rice (*padi huma*)
Strategic Resources Research Centre, MARDI	Ethnobotanical study, conservation and information management of *ulam* species.	Batu Kikir; Baling; Bahau; Seberang Perai; Gurun; Kangar; Kota Setar; Kuala Krai; Kuala Pilah; Kuala Terengganu; Machang; Marang; Pasir Puteh; Titi Tinggi; Tumpat; Muar; Dungun; Jelebu	Edible plant species
Strategic Resources Research Centre, MARDI	Ethnobotanical study and information management of plant species utilised by ethnic Malay in West Malaysia	Sempang Pelangai; Bentong; Bentong; Jerantut; Kuala Lipis; Kuantan; Maran; Muadzam Shah; Raub; Rompin; Temerloh; Lanchang	Some of the popular species are threatened.
Strategic Resources Research Centre, MARDI	*In situ/ex situ* conservation of medicinal/aromatic plant species.	MARDI Jerangau	Medicinal and edible plants species
Strategic Resources Research Centre, MARDI	Collection, characterization and utilization of indigenous vegetables of Malaysia	Bayan Lepas; Batu Kikir; Balik Pulau; Bachok; Seberang Perai; Besut; Kota Bharu; Kuala Berang; Kuala Pilah; Kuala Terengganu; Machang; Marang; Parit Buntar; Tanah Merah; Tumpat; Muar; Setiu; Jelebu	Indigenous vegetables
Strategic Resources Research Centre, MARDI	*In situ* conservation of medicinal plants/aromatic plant species used by the ethnic Malay in Pahang	Sempang Pelangai; Bentong; Jerantut; Kuala Lipis; Kuantan; Maran; Muadzam Shah; Raub; Rompin; Temerloh; Lanchang	Medicinal plants
Strategic Resources Research Centre, MARDI	Studies on biosystematics and biodiversity of Tongkat Ali (*Eurycoma* spp.) for use in effective and sustainable management, conservation, and exploitation of its genetic resources in Malaysia	Baling; Bukit Tangga; Sintok; Tanjung Tuan; Air Keroh; Durian Tunggal; Gerik; Kota Tinggi; Kuala Kangsar; Masjid Tanah; Port Dickson; Seremban; Taiping; Tapah; Ulu Langat; Muar; Langkawi; Hulu Selangor	*Eurycoma* spp.
Strategic Resources Research Centre, MARDI	Prospecting, collection, genetic diversity studies, exploitation and conservation of genetic diversity of chilli (*Capsicum* spp.), eggplant (*Solanum* spp.) and tomato (*Lycopersicon* spp.) in Malaysia and prospects for genetic enhancement	Alor Gajah; Bentong; Bota; Cameron Highland; Gua Musang; Johol; Kuala Lipis; Kuala Pilah; Raub; Serdang; Tampin; Perak Tengah; Jelebu; Jempol	*Capsicum* spp., *Solanum* spp., and *Lycopersicon* spp.
Strategic Resources Research Centre, MARDI	Collection and conservation of *Zingiber* sp., *Derris* sp., *Labisia* sp.and Citrus sp.	Baling; Tanjung Tuan; Air Keroh; Durian Tunggal; Gerik; Jitra; Kota Tinggi; Kuala Kangsar; Masjid Tanah; Port Dickson; Pulai; Segamat; Seremban; Sungai Petani; Taiping; Tapah; Ulu Langat; Muar; Langkawi; Larut dan Matang;Hulu Selangor	*Zingiber* sp., *Derris* sp., *Labisia* sp.and Citrus sp.
Strategic Resources Research Centre, MARDI	Ethno-botanical study, conservation and information management of medicinal plant species utilised by the orang asli community	Cameron Highlands	*Eurycoma* spp.
Golden Hope Research PTE	Conservation of Herbal Plants	Golden Hope Research Centre Banting;West Estate Carey Island, Selangor	Herbal plants
Golden Hope Research PTE	Conservation of Rubber	Bukit Pilah Estate, Negeri Sembilan	Not available
Department of Forestry, Kelantan	Survey of Virgin Forest Reserve (28A) at Ulu Sat Permanent Forest Reserve	Permanent Forest Reserve Ulu Sat	Not available
Department of Forestry, Kelantan	Application of GPS and GIS to fix external borders of Permanent Forest Reserves	Lebir Permanent Forest Reserve Stong Utara Permanent Forest Reserve Ulu Sat Permanent Forest Reserve	Not available
Department of Forestry, Sabah	Inventory of ethnobotanical resources in Sabah	All forested areas and rural areas with local communities in Sabah	Not available
Department of Forestry, Sabah	Phenology of trees in Sabah	All forested areas and forest plantations in Sabah	Not available
Department of Forestry, Sabah	The Taxonomy of *Rothmannia* (*Rubiaceae*) in Borneo	Borneo	Not available
Department of Forestry, Sabah	Tree Flora of Sabah & Sarawak (TFSS)	Borneo	Not available
Department of Forestry, Sabah	Tree Flora of Sabah and Sarawak Project: Taxonomic study of Theaceae in Sabah and Sarawak (Borneo)	Borneo	Not available

Stakeholder	Title of survey/inventory	Name of area surveyed/inventoried	Threatened species/ ecotypes/populations
Department of Agriculture, Peninsular Malaysia	Collection of fruit clones	Stesen Pembangunan Komoditi, Hulu Paka, Terengganu	Not available
Malaysian Cocoa Board	Introduction, Assessment and Conservation of Cocoa Germplasm	Hilir Perak, Perak, Peninsular Malaysia; Madai, Kunak, Sabah; Mile 10, Tawau, Sabah	Not available
Malaysian Cocoa Board	Conservation and Evaluation of Genetic Diversity of Cocoa Germplasm	Hilir Perak, Perak, Peninsular Malaysia; Jengka, Pahang, Peninsular Malaysia; Madai Baturong, Kunak, Tawau, Sabah	Not available

Some constraints that have been identified as interfering with the surveying and inventorization of PGRFA activities in the country are as follows:

- National priorities have not been established
- It is not clear which organization is responsible to conduct surveys and inventories
- Financial support is insufficient
- Number of staff is insufficient
- Staff does not have sufficient skills

In addition, some information is lacking, such as the status of certain populations leading to difficulties in determining which species are really under threat and need to be collected and conserved urgently. The information on the areas covered also was not specific and inadequate to determine any gaps.

The inventories and surveys of plant genetic resources are considered as the most crucial steps in the *in situ* management. Therefore, areas which have been identified which face major threats to the PGRFA are ranked higher priority (*Table 4*).

TABLE 4

Priority areas for surveys and inventories

Name of priority area for survey/inventory of PGRFA	Priority rank for survey/inventory	Major threats to PGRFA in the area
Kinabalu Park: Northern area and Mount Tombuyukon	Medium-High	Not available
Crocker Range Park:Core area	Medium-High	Not available
Tawau Hills Park	Medium	Not available
District of Klang, Sabak Bernam, Hulu Langat, Kuala Selangor, Sepang and Kuala Langat (Selangor), Hilir Perak and Kuala Kangsar (Perak), Bentong, Kuala Lipis, Temerloh and Jerantut (Pahang), Muar, Segamat, Batu Pahat, Pontian and Johor Bharu (Johor)	Medium	Disease incidence and planting of more profitable crops
Alor Gajah and Jasin (Melaka), Muar (Johor), Jerantut (Pahang), Batang Padang (Perak), Langkawi	High	Land development
Sabah, Sarawak and all rice growing states in Peninsular Malaysia.	High	Fast replacement of traditional varieties.
Pahang, Kelantan, Terengganu	High	Land development
Negeri Sembilan, Johor, Kelantan, Terengganu, Perak, Pulau Pinang, and Kedah	Medium-High	Land development
Kedah, Perak, Johor dan Selangor	High	Land development, over harvesting by collectors and no replanting.
State of Pahang	Medium-High	Non-selective harvesting, land clearing for development
Sungei Wangi Estate	Low-Medium	Pests and diseases threats
Bukit Pilah Estate Negeri Sembilan	Medium-High	Conservation area will be planted with oil palm
Golden Hope Research Centre Banting	Medium	Pests and diseases threats
West Estate Carey Island, Selangor	Medium	Pests and diseases threats
Permanent Forest Reserve Lebir	Medium-High	None
Permanent Forest Reserve Chiku	Medium-High	None
Permanent Forest Reserve Gunong Basor	Medium-High	None
Permanent Forest Reserve Stong Utara	Medium-High	None
Permanent Forest Reserve Ulu Sat	Medium-High	None

Name of priority area for survey/inventory of PGRFA	Priority rank for survey/inventory	Major threats to PGRFA in the area
All forested areas and rural areas with local communities in Sabah	Medium-Hig	Not available
All forested areas and forest plantations in Sabah	Medium-High	Not available
UKM	High	Peninsular Malaysia, Sabah and Sarawak (for traditional rice varieties and wild rices)
Forest Reserves	High	Human activities
Hilir Perak, Perak, Peninsula Malaysia, Malaysia	High	Cocoa Pod Borer (Conopomorpha cramerella) and Vascular Streak Dieback Disease

There is a need for assistance from international organizations in capacity- building, especially for human and financial resources, to support inventories and surveys of plant genetic resources, crop-associated biodiversity and wild plants for food production. As an example, the majority of traditional rice varieties and a few endemic wild rices have been collected and conserved in the MARDI Rice Genebank and in the Agricultural Research Centers of Sabah and Sarawak. This germplasm collection totals approximately 9 000-10 000 accessions. However, their characterization and evaluation have only been carried out modestly due to technical and budget constraints. Many of these traditional varieties can contribute towards varietal improvement programmes to fulfill many of the current breeding objectives. For wild rices, there were only a few collection efforts and negligible utilization. Thus, all the survey and inventory activities carried out need secure and sustainable funds to be maintained successfully.

3.2 On-farm management and improvement of PGRFA

Initiatives on on-farm conservation activities started since early 2000 and have increasing from time to time. A number of activities have been reported (*Table 5*), such as the ethno-botanical study in West Malaysia and the biosystematics and biodiversity studies of *tongkat ali* (*Eurycoma longifolia*) which were carried by MARDI to improve and enhance the on-farm management of PGRFA. Meanwhile, the Science University of Malaysia (USM) also conducted a project called Agrobiology to assist the farmers in their on-farm management. Others, such as on-farm conservation of rubber and rattan have been carried out by the Department of Forestry in state of Kelantan, followed by an initiative by the Malaysian Cocoa Board on the cocoa germplasm conservation. However, the level of integration into national programme and the level of priority within national programme for on-farm management of PGRFA are very low. Therefore, these matters need a better forum for discussion and implementation to overcome the difficulties.

TABLE 5
On-farm conservaton activities

Stakeholder	Project
Strategic Resources Research Centre, MARDI	Ethno-botanical study and information management of plant species utilized by ethnic Malay community in West Malaysia
	Studies on biosystematics and biodiversity of Tongkat Ali (*Eurycoma* spp.) for use in effective and sustainable management, conservation, and exploitation of its genetic resources in Malaysia
Science University of Malaysia	Agrobiology
Department of Forestry, Kelantan	On-farm conservation of rubber
	On-farm conservation of rattan
Malaysian Cocoa Board	Introduction, assessment and conservation of cocoa germplasm

Thus, a National Strategy and Action Plan have been developed and will be used to promote on-farm management of PGRFA in the country. For the time being, there is no national or regional forum for stakeholders involved in on-farm conservation.

The government strongly supports on-farm participatory plant breeding programmes in the country. The main reason is to develop and to give to the farmers their rights and opportunities to improve their own livelihood. Bario rice is one good example of on-farm conservation which has become one of the best products of Malaysia. Bario rice is grown in the cooler climates at elevations above 1 200 meters. Cultivated by the natives or *Orang Ulu* in the highlands of Sarawak, Bario rice has long been regarded as one of the finest rice grains of the world. Because of its soft texture, fine and elongated grains, pleasant and mild aroma and exquisite taste, Bario rice is well-accepted locally and across many countries. The uniqueness of Bario rice is its production without the use of pesticides and chemical fertilizers, and that it is grown using

traditional methods that make it distinguishable from any other rice variey. The Department of Agriculture, Sarawak had launched a scheme named Bario Rice Certification Scheme (BRCS) to ensure the quality and production of the rice, right from seed certification to end-product retailing and distribution. In 2002, Bario rice was awarded an International Presidia Award by the Slow Food Foundation of Italy, and this will enhance the Malaysian rice industry.

There are many actions taken to increase the development of local small-scale seed production in Malaysia. For example, in rice seed production, the government has initiated a seed certification programme to ensure the supply of certified seed for purposes of planting. The government also encourages the participation of the private sector in producing certified seed. Farmers are encouraged to participate as contract seed growers to supply planting materials under the scheme.

In addition, action is also being planned and the plans will be implemented to support on-farm management in the country. Some of the actions are as follows;

- Seminars for public awareness in on-farm management
- Development of market niches to promote new products – e.g. Bario rice
- Facilitation of access to a wider range of planting materials
- National strategies and action plan to be put into place

Some of the limitations to on-farm management and improvement of PGRFA in the country are as follows:

- Inadequate incentives provided to farmers
- Insufficient skills and staff training
- Insufficient financial support
- On-farm management and improvement of PGRFA are not a national priority

3.3 Restoring agricultural systems after disasters

There is a mechanism to replace plant genetic resources for food and agriculture following disasters, but the mechanism excludes farmers. In addition, information on the local seed supply system is not adequate to identify and facilitate germplasm reintroduction following disasters. The country has never had the experience of a big disaster which created the need to reintroduce and restore the agricultural system, especially to ensure the availability of traditional seed varieties. Therefore, there are no official organizations or committees to oversee the problems caused by natural disasters. However, some efforts have been made by various research agencies and institutions of higher learning or universities, such as MARDI, DOA, FRIM and UPM, to establish a genebank community that would facilitate the reintroduction of germplasm following disasters. So far, there has been no request from local farmers to the genebank community for seed to replant any traditional varieties in their farms.

The greatest constraint to establishing an effective plant genetic resources disaster response mechanism in the country is that not all PGRFA have not been collected and inventoried before the disaster. Besides, the lack of farmer involvement and unavailability of germplasm that have all the needs for restoration will also contribute to the failure of a disaster response mechanism. Therefore, there is a need for priority to improve the effectiveness of any PGRFA disaster response mechanism planned in the future. There is at present an information system for rice which has been recognized to assist in the identification of appropriate germplasm for reintroduction following disasters. This information system named as the Rice Genebank Information System (RGBIS) is being developed by MARDI with assistance from IRRI.

3.4 *In situ* conservation of wild crop relatives and wild plants for food production

There have been few activities related to *in situ* conservation of wild crop relatives and wild plants for food production in the last few years. Most of them were focused on medicinal and herbal plants, indigenous vegetables including those species suitable for *ulam, Clematis* species*, Litsea* species and fruits species. However, many of the research institutes are now more aware of the importance and potential of wild crop relatives and wild plants, and are increasing their efforts in studying and promoting these species to local farmers and also to the general public.

In general, *in situ* conservation of plant genetic resources in Malaysia is effectively carried out in certain protected areas. An overview and a summary of these legally protected areas have been given in Table 6 The total protected area amounted to 5.8% (763 300 ha), 8.9% (658 824 ha) and 2.3% (288 806 ha) of the total land area of Peninsular Malaysia, Sabah and Sarawak respectively. With respect to Sarawak, It also noted that the state authorities have strong intentions of expanding the protected areas to 1.14 million hectares which will represent about 8% of the total land area.

TABLE 6
Existing protected forest habitats in Malaysia

Type of habitat	Area (hectares)			
	Peninsular Malaysia	Sabah	Sarawak	Total
National/ State Parks	434 300	245 172	113 955	793 427
Virgin jungle reserves	19 000	88 304	-	107 304
Wildlife reserves/bird sanctuaries	310 000	143 682	174 851	628 543
Other protected forests/ conservation areas	-	181 666	-	181 666
Total protected areas	763 300	658 824	288 806	1 710 930
Total land area	**13 160 000**	**7 400 000**	**12 300 000**	**32 860 000**
Total remaining forests	**6 150 000**	**4 520 000**	**8 700 000**	**19 370 000**
Total permanent forest estate	**4 750 000**	**3 350 000**	**6 000 000**	**4 100 000**

The total protected areas of the forest habitats comprise the gazetted National and State Parks, virgin jungle reserves, wildlife reserves and bird sanctuaries as well as protected forests (in the case of Sabah). Among the more important and bigger areas where probably an extensive fruit biodiversity occurs are *Taman Negara* (434 000 ha), Endau-Rompin Park and wildlife reserves (90 000 ha), and the Krau Wildlife Reserve (63 000 ha) in Peninsular Malaysia, Gunung Mulu Park (53 000 ha), Lanjak Entimau Wildlife Sanctuary (169 000 ha) and Batang Ai Park (24 000 ha) in Sarawak, and Kinabalu Park (73 000 ha), Crocker Range Park (140 000 ha) and Tabin Wildlife Reserve (141 200 ha) in Sabah.

Some studies have been conducted on the inventories of wild fruit species in some of these protected forest areas. Work conducted at *Taman Negara*, Pasoh Forest Reserve and Krau Wildlife Reserve have found that there is on the average five individuals of wild fruit trees per hectare with a trunk diameter of 10 cm or more, and it was also noted that the species remain as understorey trees and will not exceed 30 m in height or greater than 30 cm in trunk diameter. Extensive studies at Pasoh Forest Reserve further indicated that the densities of adult trees also vary greatly between species. For example, within the genus *Mangifera* which is represented by 12 species, the adult density is 0.1 trees per hectare as compared to 180 trees for *Xerospermum noronhianum*. This may lead to a different strategy for conserving the two species as a small area may be enough to capture sufficient diversity of the plants of *X. noronhianum* while a much bigger area will be needed for *Mangifera*.

CHAPTER 4

THE STATE OF *EX SITU* MANAGEMENT

4.1 Sustaining and expanding *ex situ* collections

A tremendous effort has been made to sustain *ex situ* collections of plant genetic resources in Malaysia. Many research institutions, including governmental and private agencies, have developed and maintained related programmes and projects which were relevant to their crops of interest. Most of all the accessions are conserved in field genebanks. There are a few organizations that have seed genebanks, *in vitro* conservation and cryopreservation facilities. The Forest Research Institute of Malaysia (FRIM) has the additional capability of conserving its germplasm materials in a DNA genebank. In addition, the existence of botanical gardens, such as Rimba Ilmu, Medicinal Plant Garden in UPM, MRDI Orchid Collection and the Penang Botanical Garden, also plays an important role in conserving wild species and their wild relatives. Rimba Ilmu is a tropical botanical garden set up in the University of Malaya campus in Kuala Lumpur. It gives emphasis to the flora of the Malaysian and Indonesian region. In the garden, there are several main show collections, including those of medicinal plants, palms, bamboos, rare plants, orchids, citrus and citroids, all of which comprise living accessions of over 1 600 species. Rimba Ilmu also houses the University of Malaya herbarium, and has its own Environmental Education Programme. Rimba Ilmu is a member of the Botanic Gardens Conservation International (BGCI) and the Southeast Asia Botanic Gardens Network.

The *ex situ* collections which cover a very large number of accessions and species are kept by Sabah Parks, MARDI, Putra University of Malaysia, Science University of Malaysia, Sabah University of Malaysia, MARA University of Technology Sabah Campus, National University of Malaysia, Golden Hope Research PTE, Department of Forestry Sabah, Department of Agriculture Peninsular Malaysia, Department of Agriculture Sarawak, the Malaysian Rubber Board and the Forest Research Institute of Malaysia (*Table 7* and *Table 8*).

TABLE 7

Listing of types of activities at existing *ex situ* collections

***Ex situ* conservation programme/ project/activity**	**Type of activity**	**Stakeholder**
Kinabalu Mountain Botanical Garden	Botanical garden Field genebank	Sabah Park
Poring Orchid Conservation Centre	Seed genebank (short- term collections) Botanical garden *In vitro* conservation Field genebank	Sabah Park
Tawau Hills Park Lowland Garden	Botanical garden Field genebank	Sabah Park
Nepenthes Garden at Mesilau Nature Resorts, Kinabalu Park	Seed genebank (short- term collections) Botanical garden Field genebank	Sabah Park
Poring Rafflesia Farm	Seed genebank (short- term collections) Botanical garden Field genebank	Sabah Park
Poring Ethnobotanical Garden	Botanical garden Field genebank	Sabah Park
Fernarium at Crocker Range Park	Botanical garden Field genebank	Sabah Park
Biodiversity study, conservation and information management of cooking banana	Field genebank	Strategic Resources Research Centre, MARDI
Biodiversity, socio-economic studies and information management of binjai, bacang and cerapu	Arboretum Field genebank	Strategic Resources Research Centre, MARDI
Bioprospecting of rice genetic accessions for important agronomic traits	Seed genebank (long- term collections) Seed genebank (medium-term collections) Seed genebank (short- term collections)	Strategic Resources Research Centre, MARDI

Ex situ conservation programme/ project/activity	Type of activity	Stakeholder
Low temperature storage of rice and *ulam* accessions	Seed genebank (long- term collections) Seed genebank (medium term collections) Seed genebank (short term collections)	Strategic Resources Research Centre, MARDI
Rice genetic resources conservation and management	Seed genebank (long term collections) Seed genebank (medium term collections) Seed genebank (short term collections)	Strategic Resource Research Centre MARDI
Safeguarding and preservation of the biodiversity of the rice genepool	Seed genebank (long- term collections) Seed genebank (medium-term collections) Seed genebank (short- term collections)	Strategic Resources Research Centre, MARDI
Biodiversity, socio-economic studies and information management of *Salacca* species in Peninsular Malaysia	Field genebank	Strategic Resources Research Centre, MARDI
Biodiversity, socio-economic studies and information management of pulasan and kuini	Arboretum Field genebank	Strategic Resources Research Centre, MARDI
Biodiversity of edible *Durio* species	Arboretum Field genebank	Strategic Resources Research Centre, MARDI
Ethnobotanical study, conservation and information management of *ulam* species.	Seed genebank (long- term collections) Seed genebank (medium-term collections) Seed genebank (short- term collections) Field genebank	Strategic Resources Research Centre, MARDI
Ethnobotanical study and information management of plant species utilised by ethnic Malay community in West Malaysia	Field genebank	Strategic Resources Research Centre, MARDI
Collection, characterization and utilization of indigenous vegetables of Malaysia	Seed genebank (long- term collections) Seed genebank (medium-term collections) Field genebank	Strategic Resources Research Centre, MARDI
Ethno-botanical study, conservation and information management of medicinal plant species utilised by the *orang asli* community	Field genebank	Strategic Resources Research Centre, MARDI
Studies on biosystematics and biodiversity of Tongkat Ali (*Eurycoma* spp.) for use in effective and sustainable management, conservation, and exploitation of its genetic resources in Malaysia	Field genebank	Strategic Resources Research Centre, MARDI
Prospecting, collection, genetic diversity studies, exploitation and conservation of genetic diversity of chilli (*Capsicum* spp.), eggplant (*Solanum* spp.) and tomato (*Lycopersicon* spp.) in Malaysia and prospects for genetic enhancement	Seed genebank (long- term collections) Seed genebank (medium-term collections)	Strategic Resources Research Centre, MARDI
Collection and conservation of *Zingiber* sp., *Derris* sp., *Labisia* sp., *Citrus* sp.	Field genebank	Strategic Resources Research Centre, MARDI
In situ/*ex situ* conservation of medicinal/aromatic plant species.	Field genebank	Strategic Resources Research Centre, MARDI
Genetic and elite planting material of *Andrographis paniculata* for development of variety for antidiabetic effects	Field genebank	Putra University of Malaysia
Genetic diversity and conservation of *Phyllanthus* spp. genetic resources for development of variety for anti-cancer	Field genebank	Putra University of Malaysia
Germplasm Collection and Breeding of Taro	Field genebank	Putra University of Malaysia
Rationalization of Sweetpotato germplasm	Field genebank	Putra University of Malaysia
Agrobiology	Seed genebank (medium-term collections)	Science University of Malaysia
Collection and characterization of Mas Cotek	Field genebank	Rice and Industrial Crops Research Centre, MARDI
Collections and evaluation of dukung anak (*Phyllanthus niruri*) varieties/lines for commercial production on bris soil.	Seed genebank (medium-term collections) Field genebank	Rice and Industrial Crops Research Centre, MARDI
Coffee Clonal Garden	Seed genebank (medium-term collections) Field genebank	Rice and Industrial Crops Research Centre, MARDI
Coconut Germplasm Collection	Seed genebank (long- term collections) Field genebank	Rice and Industrial Crops Research Centre, MARDI
Collection of sweetpotato and cassava accessions	Seed genebank (medium-term collections) Field genebank	Rice and Industrial Crops Research Centre, MARDI
Tapioca varieties (*Manihot esculenta* Crantz) and its potential industrial uses in Sabah	Field genebank	Sabah University of Malaysia

***Ex situ* conservation programme/ project/activity**	**Type of activity**	**Stakeholder**
Conservation of Herbal Plants	Seed genebank (medium-term collections) Seed genebank (short- term collections) Arboretum Field genebank	Golden Hope Research PTE
Conservation of Rubber	Seed genebank (long- term collections) Seed genebank (medium-term collections) Seed genebank (short- term collections) Field genebank	Golden Hope Research PTE
Development of Ethnobotanic Garden	Seed genebank (long- term collections) Botanical garden Field genebank	Department of Forestry, Sabah
Yield performance of cassava (*Manihot esculenta* Crantz) for starch and snack production	Field genebank	MARA University of Technology, Sabah Campus
Collection of fruit clones	Arboretum Field genebank	Department of Agriculture, Peninsular Malaysia
Clonal depository of registered fruit tree varieties as reference collection	Arboretum Field genebank	Department of Agriculture, Peninsular Malaysia
Collection and evaluation of rare fruits, herbs and medicinal plants	Arboretum Field genebank	Department of Agriculture, Peninsular Malaysia
Linekeeping of Varietal Collections	Seed genebank (short- term collections)	Department of Agriculture, Sabah
Tapioca (*Manihot esculenta)*	Field genebank	Department of Agriculture, Sabah
Yam (*Dioscorea* spp.)	Field genebank	Department of Agriculture, Sabah
Sweet potato (*Ipomoea batatas*)	Field genebank	Department of Agriculture, Sabah
Sugarcane (*Saccharum* cv.)	Field genebank	Department of Agriculture, Sabah
Sweet Shoots (*Sauropus androgynus*)	Field genebank	Department of Agriculture, Sabah
Bambangan, beluno and tampoi germplasm collection	Field genebank	Department of Agriculture, Sabah
Coconut Germplasm Collection	Field genebank	Department of Agriculture, Sabah
Collection and Evaluation of Bamboo for Shoots Production	Field genebank	Department of Agriculture, Sabah
Collection, Maintenance and Utilization of Avocado Germplasm	Field genebank	Department of Agriculture, Sabah
Collection, Maintenance and Utilization of Papaya Germplasm	Field genebank	Department of Agriculture, Sabah
Collection and Evaluation of Durian Germplasm	Field genebank	Department of Agriculture, Sabah
Collection and Evaluation of Pineapple Germplasm	Field genebank	Department of Agriculture, Sabah
Collection and Evaluation of Star Fruit Germplasm	Field genebank	Department of Agriculture, Sabah
Collection and Selection of *Artocarpus* spp. – Breadfruit	Field genebank	Department of Agriculture, Sabah
Collection and Selection of *Artocarpus* spp. – Cempedak	Field genebank	Department of Agriculture, Sabah
Collection and Selection of *Artocarpus* spp. – Jackfruit	Field genebank	Department of Agriculture, Sabah
Collection and Selection of *Artocarpus* spp. – *Tarap*	Field genebank	Department of Agriculture, Sabah
Fruits, Nuts and Spices Germplasm Collection	Field genebank	Department of Agriculture, Sabah
Germplasm Collection	Field genebank	Department of Agriculture, Sabah
Temperate Fruits Germplasm Collection	Field genebank	Department of Agriculture, Sabah
Conservation, evaluation and utilization of *Hevea brasiliensis* germplasm	Field genebank	Malaysian Rubber Board
Conservation, evaluation and utilization of different *Hevea* species genetic resources	Field genebank	Malaysian Rubber Board
Mixed Orchard Teluk Teduri, Baling	Field genebank	Kedah Regional Development Authority
Durian Orchard Kampung Rambong, Baling	Field genebank	Kedah Regional Development Authority
Cocoa farm Charuk Kelubi, Baling	Field genebank	Kedah Regional Development Authority
Rubber farm Sungai Tengas, Kulim	Field genebank	Kedah Regional Development Authority
Durian Orchard Bukit Relau, Bandar Bahru	Field genebank	Kedah Regional Development Authority
Collection, Conservation and Utilization of Rice in Sarawak	Seed genebank (long- term collections)	Department of Agriculture, Sarawak
Conservation, evaluation and selection of indigenous vegetables of Sarawak	Field genebank	Department of Agriculture, Sarawak

Ex situ conservation programme/ project/activity	Type of activity	Stakeholder
General germplasm, collection and evaluation of indigenous and exotic fruits	Arboretum	Department of Agriculture, Sarawak
Germplasm collection, Selection, Evaluation and Propagation of Indigenous Herbs and Medicinal Plants of Sarawak	Field genebank	Department of Agriculture, Sarawak
Introduction, collection, maintenance and characterization of starfruit germplasm	Field genebank	Horticulture Research Centre, MARDI
Introduction, collection, maintenance and charaterization of guava germplasm	Field genebank	Horticulture Research Centre, MARDI
Introduction, collection, maintenance and characterization of cempedak germplasm	Field genebank	Horticulture Research Centre, MARDI
Introduction, collection, maintenance and characterization of citrus germplasm	Field genebank	Horticulture Research Centre, MARDI
Introduction, collection, maintenance and characterization of mango germplasm	Field genebank	Horticulture Research Centre, MARDI
Introduction, collection, and characterization of mangosteen germplasm	Field genebank	Horticulture Research Centre, MARDI
Introduction, collection, maintenance, and characterization of melon germplasm	Seed genebank (long- term collections) Seed genebank (medium-term collections)	Horticulture Research Centre, MARDI
Introduction, collection, maintenance and characterization of watermelon germplasm	Seed genebank (medium-term collections) Seed genebank (short- term collections)	Horticulture Research Centre, MARDI
Introduction, collection, and characterization of germplasm of papaya	Seed genebank (medium-term collections) Seed genebank (short term collections)	Horticulture Research Centre, MARDI
Introduction, collection, maintenance and characterization of pineapple germplasm	Field genebank	Horticulture Research Centre, MARDI
Introduction, collection, maintenance and characterization of banana germplasm	Field genebank	Horticulture Research Centre, MARDI
Introduction, collection, maintenance and characterization of ciku germplasm	Field genebank	Horticulture Research Centre, MARDI
Introduction, collection, maintenance and characterization of rambutan germplasm	Field genebank	Horticulture Research Centre, MARDI
Introduction, collection, maintenance and characterization of nangka germplasm	Field genebank	Horticulture Research Centre, MARDI
Introduction, collection, maintenance and characterization of chilli germplasm	Seed genebank (medium-term collections) Seed genebank (short- term collections)	Horticulture Research Centre, MARDI
Introduction, collection, maintenance and characterization of tomato germplasm	Seed genebank (long- term collections) Seed genebank (medium-term collections)	Horticulture Research Centre, MARDI
Introduction, collection, maintenance and characterization of orchid germplasm	*In vitro* conservation Field genebank	Horticulture Research Centre, MARDI
Breeding of roselle (*Hibiscus sabdariffa*) for morpho-agronomic traits	Seed genebank (short- term collections)	National University of Malaysia
Soy bean improvement for high yield and stability	Seed genebank (short- term collections)	National University of Malaysia
Conservation genetics of *Nephelium* and *Citrus* species	Seed genebank (short- term collections) Arboretum *In vitro* conservation Cryopreservation	National University of Malaysia
Plant collections in FRIM	Seed genebank (long- term collections) Seed genebank (medium-term collections) Seed genebank (short- term collections) Botanical garden Arboretum *In vitro* conservation Field genebank Cryopreservation DNA gene bank	Forest Research Institute of Malaysia

TABLE 8
Number of accessions of selected species conserved *ex situ*

Local Name	Scientific name	Number of accessions
Akar butang baju	*Ardisia* sp.	1
Alek tembaga	*Smilex calophylla*	5
Bacang	*Mangifera foetida*	30
Batu jin	*Strobilanthus cripsis*	1
Bebuas	*Premna foetida*	4
Beka	*Oroxylum indicum*	1
Belimbing	*Averrhoa carambola*	95
Belimbing tanah	*Tacca cristata*	13
Beluntas	*Pluchea indica*	4
Betik	*Carica papaya*	52
Binjai	*Mangifera caesia*	72
Cekur	*Kaempferia* sp.	10
Cekur	*Kaempferia galanga*	7
Cemamar	*Micromelum minutum*	4
Cempedak	*Artocarpus champeden*	11
Cenderai	*Grewia tomentosa*	1
Cerapu	*Garcinia prainiana*	3
Chili	*Capsicum annuum*	30
Ciku	*Achras sapota*	19
Cili api kampung	*Capsicum frutescens*	56
Cili besar	*Capsicum annuum*	20
Cooking banana	*Musa* sp.	200
Daun kari	*Murraya koenigii*	3
Dukung anak	*Phyllanthus amarus*	1
Dukung anak	*Phyllanthus niruri*	5
Durian	*Durio zibethinus*	271
Gajah beranak	*Goniothalamus* sp	10
Gelenggang kecil	*Cassia obtusifolia*	1
Gelenggang nasi	*Senna* sp.	1
Geli-geli	*Lasia spinosa*	1
Getah	*Hevea* sp.	50 000
Getah	*Hevea brasiliensis*	10 004
Halia	*Zingiber* sp.	77
Halia	*Zingiber officinale*	2
Halia bara	*Zingiber officinale*	1
Hempedu bumi	*Andrographis paniculata*	92
Jambu air	*Eugenia* sp.	1
Jambu batu	*Psidium guajava*	23
Jambu batu liar	*Psidium* sp.	1
Jambu bol	*Syzygium malaccense*	1
Janggus	*Anacardium* occidentale	3
Jering	*Pithecellobium jiringa*	9
Kacang kelisa	*Psophocarpus tetragonolobus*	4
Kacang soya	*Glycine max*	10
Kacip fatimah	*Labisia pumila*	78

Local Name	Scientific name	Number of accessions
Kaduk	*Piper sarmentosum*	3
Kantan	*Phaeomeria speciosa*	4
Kantan	*Etlingera elatior*	2
Kantan merah	*Phaeomeria speciosa*	1
Keladi	*Colocasia esculenta*	162
Kelapa	*Cocos nucifera*	30
Keledek	*Ipomoea batatas*	182
Keranji	*Dialium cochinchinense*	1
Kerdas	*Pithecellobium* sp.	1
Kerian	*Syzygium cumini*	1
Kopi	*Coffea Arabica*	15
Kuini	*Mangifera odorata*	100
Kundang	*Bouea macrophylla*	1
Kunyit	*Cucurma* sp	20
Labu	*Cucurbita moschata*	3
Langsat	*Lansium domesticum*	18
Lemuni	*Vitex negundo*	1
Lengkuas	*Alpinia* sp.	10
Lengkuas merah	*Alpinia galangal*	5
Limau	*Citrus* sp.	174
Limau bali	*Citrus maxima*	20
Limau purut	*Citrus hystrix*	5
Maman pasir	*Cleome rutidosperma*	1
Mangga / mempelam	*Mangifera indica*	171
Manggis	*Garcinia mangostana*	200
Mas cotek	*Ficus deltoidea*	35
Mata pelanduk	*Ardisia elliptica*	1
Melinja	*Gnetum gnemon*	4
Mengkudu	*Morinda citrifolia*	5
Naga buana	*Phyllanthus pulcher*	35
Nanas	*Ananas comosus*	72
Nangka	*Artocarpus heterophyllus*	43
Nepenthes	*Nepenthes burbidgeae*	10
Nepenthes	*Nepenthes fusca*	10
Nepenthes	*Nepenthes rajah*	500
Nepenthes	*Nepenthes tentaculata*	50
Nepenthes	*Nepenthes lowii*	10
Nepenthes	*Nepenthes stenophylla*	10
Orkid	*Dendrobium* sp.	50
Orkid	*Mokara* sp.	20
Orkid telinga gajah	*Phalaneopsis gigantea*	30
Pegaga kampung	*Centella asiatica*	20
Peria katak	*Momordica charantia*	12
Peria pantai	*Colubrina asiatica*	2
Petai	*Parkia speciosa*	1
Pink guava	*Psidium guajava*	2
Pisang	*Musa x paradisiaca*	217
Pulasan	*Nephelium ramboutan-ake*	50

Local Name	Scientific name	Number of accessions
Putat	*Barringtonia racemosa*	20
Rafflesia	*Rafflesia keithii*	20
Rafflesia	*Rafflesia pricei*	10
Rambutan	*Nephelium lappaceum*	152
Rice, cultivated	*Oryza sativa*	30 478
Rice, wild	*Oryza rufipogon*	200
Rice, wild	*Oryza officinalis*	52
Roselle	*Hibiscus sabdariffa*	17
Setawar hutan	*Costus speciosus*	5
Slipper orchid	*Paphiopedilum rothschildianum*	200
Tembakau	*Nicotiana tabacum*	50
Tembikai	*Citrullus lanatus*	20
Tembikai wangi	*Cucumis melo*	10
Temu	*Curcuma aeruginosa*	8
Terung	*Solanum wrightii*	5
Terung	*Solanum melongena*	11
Terung	*Solanum incanum*	6
Terung asam	*Solanum ferox*	9
Terung belanda	*Solanum torvum*	16
Terung manggul	*Solanum torvum*	10
Terung ranti	*Solanum nigrum*	4
Terung telunjuk	*Solanum melongena*	25
Tomato	*Lycopersicon esculentum*	20
Tongkat ali	*Eurycoma longifolia*	1 556
Tongkat rasul	*Siphonnenthus indicum*	1
Tuba	*Derris elliptica*	20
Tuba	*Derris* sp.	20
Tutup bumi	*Elephantopus scaber*	1
Ubi jaga	*Smilex mysotiflora*	7
Ubi kayu	*Manihot esculenta*	31
Ubi kayu (Green Twig and Tuaran cvs.)	*Manihot esculenta*	2
Ulam kacip fatimah	*Labisia pumila*	1
Ulam raja	*Cosmos caudatus*	9
White ginger	*Hedychium coronarium*	2

As the *ex situ* collections in Malaysia hold large numbers of accessions and species, there have been many publications made available to assist and distribute information on the strategic management for *ex situ* conservation. For example, an agroforestry approach provides the opportunity for integrating herbs under a rubber ecosystem (as reported in the Proceedings of a National Seminar on Agroforestry: The Way Forward.) Other examples are the handling of rice seeds for germplasm conservation, and the use of herbarium and genebank survey data in mapping out strategies for future collections of eggplant genetic resources in Malaysia (as reported in the Proceedings of the Third National Seed Symposium and the Proceedings of the Symposium on Genetic Resources of Borneo, respectively).

Not all the *ex situ* collections have been duplicated. At this moment, only a few organizations have established safety duplication for certain accessions (*Table 9*). These are due to several constraints. Amongst the major constraints that need to be overcome to establish safety duplication are adequate funding and skilled human resources.

TABLE 9
Listing of safety duplications

Stakeholder	Name of taxon	Crop	Number of accessions	Number of accessions with safety duplication at other genebanks	Genebank holding safety duplicates
Strategic Resources Research Centre, MARDI	*Mangifera odorata*	Kuini	100	58	Jerangau Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Nephelium ramboutan-ake*	Pulasan	50	10	Bukit Tangga Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Barringtonia racemosa*	Putat	20	10	Seberang Perai Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Oryza sativa*	Cultivated rice	11 470	2 800	International Rice Research Institute
Strategic Resources Research Centre, MARDI	*Oryza sativa*	Cultivated rice	11 470	2 800	International Rice Research Institute
Strategic Resources Research Centre, MARDI	*Oryza rufipogon*	Wild rice	100	20	International Rice Research Institute
Strategic Resources Research Centre, MARDI	*Oryza officinalis*	Wild rice	26	5	International Rice Research Institute
Strategic Resources Research Centre, MARDI	*Oryza rufipogon*	Wild rice	100	20	International Rice Research Institute
Strategic Resources Research Centre, MARDI	*Oryza officinalis*	Wild rice	26	5	International Rice Research Institute
Strategic Resources Research Centre, MARDI	*Solanum melongena*	Eggplant	25	10	Seberang Perai Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Capsicum frutescens*	Chili pepper	48	24	Seberang Perai Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Capsicum annuum*	Chili	7	10	Seberang Perai Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Solanum torvum*	Turkey berry	10	2	Seberang Perai Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Cosmos caudatus*	Ulam raja	9	9	Seberang Perai Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Momordica charantia*	Bitter gourd	12	3	Seberang Perai Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Zingiber* sp.	Ginger	50	50	Seberang Perai Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Eurycoma longifolia*	Tongkat ali	48	48	Jerangau Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Ardisia* sp.	Akar butang baju	1	1	Jerangau Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Strobilanthus cripsis*	Batu jin	1	1	Jerangau Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Tacca cristata*	Belimbing tanah	3	3	Jerangau Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Kaempferia galanga*	Ginger	2	2	Jerangau Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Grewia tomentosa*	Cenderai	1	1	Jerangau Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Phyllanthus amarus*	Dukung anak	1	1	Jerangau Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Senna* sp.	Gelengga-ng nasi	1	1	Jerangau Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Psidium guajava*	Guava	1	1	Jerangau Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Psidium* sp.	Guava	1	1	Jerangau Research Station, MARDI
Strategic Resources Research Centre, MARDI	*Labisia pumila*	Kacip fatimah	14	14	Jerangau Research Station, MARDI
Universiti Putra Malaysia	*Andrographis paniculata*	Hempedu bumi	92	92	Strategic Resource Research Centre, MARDI
Sabah University of Malaysia		Tapioca (cassava)	6	3	MARA Technology University
Department of Agriculture Sarawak	*Oryza sativa*	Rice	3 938	980	Rice and Industrial Crops Research Centre, MARDI
Horticulture Research Centre, MARDI	*Averrhoa carambola*	Starfruit / carambola	95	95	Faculty of Agriculture, Universitl Putra Malaysia
National University of Malaysia	*Nephelium lappaceum*	Rambutan	100	20	Kemaman Research Station, MARDI

Several information systems are employed to store and manage the information and documentation on the plant genetic resources. For example, the Rice Genebank Information System (RGBIS) has been used for rice conservation at Seberang Perai Research Station of MARDI.

Beside RGBIS, MARDI has also developed an information system for agrobiodiversity as a tool towards information sharing. The system is a pioneer information system for management of information on agrobiodiversity in MARDI, and was started in 2003. Through this system, researchers or scientists will gain benefits in their research work by keeping systematic and efficient records of important data and findings. At present, the databases on the system are for rice, indigenous fruits and vegetables, medicinal plants, an arthropod collection and a microbial culture collection.

Few organizations have initiated work on regeneration, but the number will increase with time. There are about 3 000 accessions of cultivated rice and 20 accessions of tobacco that need to be regenerated. At present, 1 000 accessions of cultivated rice have already been regenerated according to established standards (*Table 10*). For tobacco, all accessions have been regenerated completely. There are still many other type of crops which need to be regenerated, such as cassava, sweetpotato, *tongkat ali*, yam, sugarcane, sweet shoots, coconut, bamboo, avocado, papaya, *durian*, pineapple, starfruit, breadfruit, cempedak, jackfruit, *tarap*, and indigenous fruits and vegetables, as have been identified by the respective organizations. All these crops are listed as the main priority, and relevant activities are underway to achieve the target of regeneration.

TABLE 10
Management practices to reduce genetic loss or loss of genetic integrity

Stakeholder	Management Practice
Strategic Resources Research Centre, MARDI	Timely viability testing Appropriate sampling strategies Proper handling of regenerated material
Rice and Industrial Crops Research Centre, MARDI	Timely viability testing Suitable regeneration environment Appropriate sampling strategies Adequate population size
Department of Forestry, Sabah	Suitable regeneration environment Appropriate sampling strategies Adequate population size Proper handling of regenerated material
Department of Agriculture, Sabah	Timely viability testing Proper handling of regenerated material
Department of Agriculture, Sarawak	Appropriate sampling strategies Adequate population size Proper handling of regenerated material
Horticulture Research Centre, MARDI	Suitable regeneration environment Adequate population size Proper handling of regenerated material

4.2 Planned and targeted collections

Table 11 lists the collecting missions which had been conducted with the purpose of establishing germplasm collections for *ex situ* conservation.

TABLE 11
Collecting missions related to *ex situ* conservation

Stakeholder	Loaction of collection area	Crop	Number of collected accessions	Number of collected accessions secured in long-term conservation
Strategic Resources Research Centre, MARDI	District of Klang, Sabak Bernam, Hulu Langat, Kuala Selangor, Sepang and Kuala Langat (Selangor); Hilir Perak and Kuala Kangsar (Perak); Bentong, Kuala Lipis, Temerloh and Jerantut (Pahang); Muar, Segamat, Batu Pahat, Pontian and Johor Bharu (Johor)	Cooking banana	200	200
Strategic Resources Research Centre, MARDI	Batang Padang; Dinding; Hulu Langat; Jasin; Jerantut; Kangar; Kluang; Kota Bharu; Kuala Berang; Kuala Kangsar; Kuala Krai; Kuala Pilah; Kuantan; Kubang Pasu; Machang; Parit; Pasir Mas; Pekan; Petaling; Pontian; Rembau; Segamat; Sepang; Seremban; Tanah Merah; Temerloh; Yan; Batu Pahat; Langkawi; Kuala Muda; Alor Gajah; Kemaman; Lipis	*Bacang*	30	30

Stakeholder	Loaction of collection area	Crop	Number of collected accessions	Number of collected accessions secured in long-term conservation
Strategic Resources Research Centre, MARDI	Hulu Langat; Besut; Dungun; Kota Bharu; Kuala Berang; Kuala Krai; Kuala Selangor; Kubang Pasu; Machang; Pasir Mas; Pasir Puteh; Pontian; Tangkak; Batu Pahat; Muar; Melaka Tengah; Alor Gajah; Kemaman	*Binjai*	36	36
Strategic Resources Research Centre, MARDI	Batang Padang; Dungun; Jerantut; Kota Bharu; Kuala Krai; Kuala Pilah; Machang; Pasir Puteh; Petaling; Raub; Tanah Merah; Temerloh	*Cerapu*	10	3
Strategic Resources Research Centre, MARDI	Dungun; Hulu Terengganu; Yan	Salacca	25	25
Strategic Resources Research Centre, MARDI	Hulu Langat; Bentong; Jerantut; Kluang; Kota Tinggi; Muadzam Shah; Pontian; Serdang; Muar; Hulu Selangor; Miri	*Pulasan*	50	50
Strategic Resources Research Centre, MARDI	Arau; Larut dan Matang; Dungun; Jerantut; Johol; Kangar; Kluang; Kuala Kangsar; Kuala Lipis; Kuala Pilah; Kuala Selangor; Kuantan; Kubang Pasu; Mersing; Parit; Pasir Mas; Pasir Puteh; Pekan; Petaling; Pontian; Raub; Rembau; Rompin; Segamat; Seremban; Tampin; Tanah Merah; Tangkak; Temerloh; Yan; Batu Pahat; Muar; Langkawi; Alor Gajah; Kemaman; Jelebu; Jempol	*Kuini*	100	100
Strategic Resources Research Centre, MARDI	Sabah, Sarawak and Peninsular Malaysia	Cultivated rice	1 000	1 000
Strategic Resources Research Centre, MARDI	Sabah, Sarawak and Peninsular Malaysia	Wild rice	25	0
Strategic Resources Research Centre, MARDI	Sabah, Sarawak and Peninsular Malaysia	Wild rice	6	0
Strategic Resources Research Centre, MARDI	Sabah, Sarawak and Peninsular Malaysia	Ginger	100	100
Strategic Resources Research Centre, MARDI	Negeri Sembilan, Johor, Kelantan, Terengganu, Perak, Pulau Pinang and Kedah	Eggplant	25	25
Strategic Resources Research Centre, MARDI	Negeri Sembilan, Johor, Kelantan, Terengganu, Perak, Pulau Pinang and Kedah	Chili pepper	48	48
Strategic Resources Research Centre, MARDI	Negeri Sembilan, Johor, Kelantan, Terengganu, Perak, Pulau Pinang and Kedah	Pumpkin	3	3
Strategic Resources Research Centre, MARDI	Negeri Sembilan, Johor, Kelantan, Terengganu, Perak, Pulau Pinang and Kedah	Chili	7	7
Strategic Resources Research Centre, MARDI	Negeri Sembilan, Johor, Kelantan, Terengganu, Perak, Pulau Pinang and Kedah	Turkey berry	10	10
Strategic Resources Research Centre, MARDI	Negeri Sembilan, Johor, Kelantan, Terengganu, Perak, Pulau Pinang and Kedah	*Ulam raja*	9	9
Strategic Resources Research Centre, MARDI	Negeri Sembilan, Johor, Kelantan, Terengganu, Perak, Pulau Pinang and Kedah	Bitter gourd	12	12
Strategic Resources Research Centre, MARDI	Negeri Sembilan, Johor, Kelantan, Terengganu, Perak, Pulau Pinang and Kedah	Asiatic pennywort	5	5
Strategic Resources Research Centre, MARDI	All states in Peninsular Malaysia	Chili pepper	8	8
Strategic Resources Research Centre, MARDI	All states in Peninsular Malaysia	Chili	13	13
Strategic Resources Research Centre, MARDI	All states in Peninsular Malaysia	Giant potato tree	5	5
Strategic Resources Research Centre, MARDI	All states in Peninsular Malaysia	Turkey berry	16	16
Strategic Resources Research Centre, MARDI	All states in Peninsular Malaysia	Black nightshade	4	4
Strategic Resources Research Centre, MARDI	All states in Peninsular Malaysia	Eggplant	11	11
Strategic Resources Research Centre, MARDI	All states in Peninsular Malaysia	Bitter apple	6	6
Strategic Resources Research Centre, MARDI	All states in Peninsular Malaysia	Hairy-fruited eggplant	9	9
Strategic Resources Research Centre, MARDI	Cameron Highlands	Ubi jaga	2	2
Strategic Resources Research Centre, MARDI	All states in Peninsular Malaysia	Tongkat ali	48	48

Stakeholder	Loaction of collection area	Crop	Number of collected accessions	Number of collected accessions secured in long-term conservation
Strategic Resources Research Centre, MARDI	Cameron Highlands	Tongkat ali	3	3
Strategic Resources Research Centre, MARDI	Cameron Highlands	Kacip fatimah	4	4
Strategic Resources Research Centre, MARDI	State of Pahang	*Akar butang baju*	1	1
Strategic Resources Research Centre, MARDI	State of Pahang	*Batu jin*	1	1
Strategic Resources Research Centre, MARDI	State of Pahang	*Belimbing tanah*	3	3
Strategic Resources Research Centre, MARDI	State of Pahang	Ginger	2	2
Strategic Resources Research Centre, MARDI	State of Pahang	*Cenderai*	1	1
Strategic Resources Research Centre, MARDI	State of Pahang	*Dukung anak*	1	1
Strategic Resources Research Centre, MARDI	State of Pahang	*Gelenggang nasi*	1	1
Strategic Resources Research Centre, MARDI	State of Pahang	Guava	1	1
Strategic Resources Research Centre, MARDI	State of Pahang	Guava	1	1
Strategic Resources Research Centre, MARDI	State of Pahang	Kacip fatimah	14	14
Sabah University of Malaysia	UiTM Sabah	Tapioca	6	2

Table 12 lists the methods used to identify any gaps in the *ex situ* collections.

TABLE 12

Methods used to identify gaps in *ex situ* collection

Stakeholder	Name of collection	Name of information system	Gaps detected	Methods used to detect gaps
Strategic Resources Research Centre, MARDI	Collection, characterization and utilization of indigenous vegetables of Malaysia	Agrobiodiversity information system	Incomplete coverage of targeted taxa; Incomplete geographical coverage	Comparison of stored material against geographical references
Strategic Resources Research Centre, MARDI	Ethnobotanical study and information management of plant species utilised by ethnic Malay in West Malaysia	MS Excel	Incomplete geographical coverage	Comparison of stored material against geographical references
Strategic Resources Research Centre, MARDI	Prospecting, collection, genetic diversity studies, exploitation and conservation of genetic diversity of chilli (*Capsicum* spp.), eggplant (*Solanum* spp.) and tomato (*Lycopersicon* spp.) in Malaysia and prospects for genetic enhancement	Agrobiodiversity information system	Incomplete geographical coverage	Comparison of stored material against geographical references

4.3 Constraints in implementing *ex situ* conservation

The major constraints in implementing *ex situ* conservation activities are as follows:

- Lack of funding
- Insufficient staff
- Lack of training
- Insufficient equipment
- Lack of facilities
- Insufficient or irregular electrical supply

- Risk-prone environments
- Lack of a focused approach
- Occurrence of pests and diseases

More funds are needed to support and maintain the existing *ex situ* collections. In addition, efforts should be made to implement on-farm conservation as well as alternative long-term conservation strategies, such as cryopreservation. In the next five years, activities have been planned to collect targeted PGRFA such as fruits and vegetables that possess good agronomic traits and are resistant to pests and diseases.

There is a need for priorities to not only sustain but also to expand the existing *ex situ* collections of plant genetic resources, especially for rice, indigenous fruits and vegetables, and herbs and medicinal plants. Collection activities need to be increased and extended throughout the country.

CHAPTER 5

THE STATE OF USE OF PGRFA

5.1 The importance of utilization

Plant genetic resources have been defined under the national programme for plant variety protection, conservation and utilization. The definition is based on the Plant Variety Protection (PVP) Act in respect to access and benefit-sharing for those who wish to acquire local and wild varieties of PGR for research and commercial purposes. Characterization and evaluation of PGR as well as utilization of molecular technologies allowing identification represent the main improvements in information-gathering and documentation which contribute significantly to facilitating germplasm utilization. Available plant materials together with characterization and evaluation data are the main indicators of PGR usability. Characterization of genetic resources is being broadened, particularly using morpho-agronomic traits and genetic evaluation traits, as well as agronomic characters such as high yield, resistance to diseases and stress, characteristics of storage proteins and isoenzymes, mainly to aid in the development of molecular techniques and DNA markers.

5.2 Utilization and enhancing the use of plant genetic resources

5.2.1 Under-utilized crops

There are many crops and plant species with potential value but are currently under-developed and under-utilized. Among the most important are *kuini*, *pulasan*, *binjai*, *peria pantai*, taro and sweetpotato which have low to medium research priority. The selection process of elite accessions with good characteristics in terms of production and consumer preference is important. This will ensure the feasibility of introducing new crops to farmers and consumers.

Other under-utilized crops include orchids, hill paddy, *ulam* and some medicinal plants. The new trend of using medicinal plants as food supplements, alternative medicine and bio-products has created niche markets for these crops. The high demand for such products has encouraged some state governments to take initiatives to introduce the one medicinal plant - one district approach that will generate additional income to farmers. Wild orchids fetch good prices and are useful for generating new varieties of orchids. Some of the activities related to developing or commercializing under-utilized crops or species are given in *Table 13*.

Although the potential of exploiting under-utilized crops is very promising, the lack of effort in promoting their development and commercialization has resulted in slow acceptance by the public. Strategies and action plans should be put forward by the authorities to promote the widespread use of these crops, by creating public awareness as to their nutritional, medicinal and other commercial value.

TABLE 13

Activities related to the development or commercialization of under-utilized crops or species

Name of programme/project/activity	Target	Name of taxon
Poring Orchid Conservation Centre	Under-ultilized crops or species;'Diversity-rich' products	*Paphiopedilum rothschildianum;Phalaneopsis gigantea;Dimorporchis rossii*
Development of screening method and selection criteria for non-flooded rice	Local varieties	*Oryza sativa*
Ethnobotanical study, conservation and information management of ulam species.	Local varieties	*Gnetum gnemon;Barringtonia racemosa;Premna foetida;Pluchea indica*
Collection, characterization and utilization of indigenous vegetables of Malaysia	Local varieties	*Centella asiatica;Cucurbita moschata;Momordica charantia;Cosmos caudatus;Solanum ferox;Solanum torvum;Solanum melongena*

Name of programme/project/activity	Target	Name of taxon
Prospecting, collection, genetic diversity studies, exploitation and conservation of genetic diversity of chilli (*Capsicum* spp.), eggplant (*Solanum* spp.) and tomato (*Lycopersicon* spp.) in Malaysia and prospects for genetic enhancement	Local varieties	*Capsicum frutescens;Capsicum annuum;Solanum ferox;Solanum wrightii;Solanum torvum;Solanum nigrum;Solanum melongena;Solanum incanum*
Studies on biosystematics and biodiversity of Tongkat Ali (*Eurycoma* spp.) for use in effective and sustainable management, conservation, and exploitation of its genetic resources in Malaysia	Under-ultilized crops or species	*Eurycoma longifolia*
Genetic and elite planting material of *Andrographis paniculata* for development of variety for antidiabetic effects	'Diversity-rich' products	*Andrographis paniculata*
Genetic diversity and conservation *Phyllanthus* spp. genetic resources for development of variety for anti-cancer	'Diversity-rich' products	*Phyllanthus pulcher*
Germplasm Collection & Breeding of Taro	'Diversity-rich' products	*Colocasia esculenta*
Rationalization of Sweetpotato germplasm	'Diversity-rich' products	*Ipomoea batatas*
Collection & characterization of Mas Cotek	Under-ultilized crops or species	*Ficus deltoidea*
Development of sweet potato genotype with high starch yield and quality, and resistant to pest in particular *Cylas formicarius* and *Elsinoe batatas*.	Under-ultilized crops or species;Local varieties	Ipomoea batatas
Conservation of Herbal Plant	Under-ultilized crops or species;Local varieties;'Diversity-rich' products	Eurycoma longifolia
Conservation of Rubber	Local varieties;'Diversity-rich' products	*Hevea brasiliensis*
Pharmacological and phytochemical screening of potential medicinal and bioactive plants in Sabah.	Under-ultilized crops or species;Local varieties;'Diversity-rich' products	Not available
Yield performance of cassava (*Manihot esculenta* Crantz) for starch and snack production	Local varieties	*Manihot esculenta*
Introduction, collection, maintenance and charaterization of guava germplasm	Local varieties	Psidium guajava
Introduction, collection, maintenance and characterization of starfruit germplasm	Local varieties	*Averrhoa carambola*
Collection and Selection of Jackfruit (*A. heterophyllus* Lamk)	Local varieties	*Artocarpus heterophyllus*
Introduction, collection, maintenanceand characterization of banana germplasm	Local varieties	*Musa* sp.
Collection, Maintenance and Utilization of Papaya Germplasm	Local varieties	*Carica papaya*
Collection and Evaluation of Pineapple Germplasm	Local varieties	*Ananas comosus*
Conservation genetics of *Nephelium* and *Citrus* species	Under-ultilized crops or species;Local varieties	*Nephelium lappaceum;Nephelium ramboutan-ake*
Evaluation of antioxidant activity in nine species of ulam	Under-ultilized crops or species	*Centella asiatica;Piper sarmentosum;Oenanthe javanica;Morinda citrifolia;Micromelum pubescens;Cosmos caudatus;Solanum ferox;Polygonum minus;Pluchea indica*
General germplasm collection, conservation and evaluation of indigenous and exotic fruits	Under-ultilized crops or species	Indigenous fruits

5.2.2 Capacities and improved training in plant breeding

The current trend in the plant breeding programmes of certain crops in Malaysia is either stable or increasing. Continuity in these plant breeding programmes is important as it promotes and facilitates the use of greater diversity of plant genetic resources. Plant breeding is also important in developing superior varieties that are resistant or tolerant to stress as well as pests and diseases.

Table 14 lists the current capability of various R&D agencies in conducting the breeding of specified crop groups.

TABLE 14
Capability of various agencies to perform breeding of specified crop groups

Stakeholder	Crop group
University of Sarawak, Malaysia	Sago
Sabah Park	Roots and tubers; Fruits
International Islamic University Malaysia	Vegetables
Strategic Resources Research Centre, MARDI	Cereals; Fruits; Vegetables
Rice and Industrial Crops Research Centre, MARDI	Cereals; Grain legumes; Roots and tubers; Fiber crops; Oil crops; Sweetener plants
Malaysian Institute for Nuclear Technology Research	Cereals; Grain legumes; Fruits; Forages; Oil plants
Department of Forestry, Peninsular Malaysia	Oil plants
Department of Agriculture Sabah	Cereals; Oil plants
Malaysian Rubber Board	Rubber; Tree crops
Horticulture Research Centre, MARDI	Fruits; Vegetables
National University of Malaysia	Fruits
Malaysian Cocoa Board	Cocoa

5.2.3 Increased pre-breeding activities

Efforts in genetic enhancement and genetic base broadening are important for maintaining sustainable agriculture and for food security. With increasing realization of the importance of PGRFA in crop improvement, the capability of the country in carrying out the breeding of specified crops, including the enhancement and broadening of the genetic base, has also increased. It is important to improve such crops as cultivated and wild rice, sago palm, pepper, and coconut in terms of their adaptation to various agroecological zones or farming systems as this will ensure food security. Most of the activities are concentrated on genetic enhancement by introgression for specific traits. The rational was mainly due to the poor gains achieved through conventional methods. The assessment of genetic diversity is made mostly through molecular markers, pedigree studies or other methods. As rice and vegetables are important food crops, priority has been given to genetic enhancement efforts in these crops. It seems that activities tend to focus more on annual crops such as rice and vegetables. Wider crop coverage is limited by constraints such as funding, facilities and human resources. On-the-job training for the current staff is suggested in the area of gene mining. Roselle has been singled out as a crop species that needs genetic enhancement due to its narrow genetic base and breeding difficulty.

Table 15 provides some examples of genetic enhancement programmes using PGRFA.

TABLE 15
Genetic enhancement programmes

Name of programme/project/activity	Name of taxon	Type of activity
Genetic assessment of pepper germplasm using DNA markers for improvement and variety identification	*Piper nigrum*	Population improvement through incorporation or base broadening
Breaking yield ceiling of rice through Gene/Genome manipulation	*Oryza rufipogon*	Genetic enhancement by introgression for specific traits
Breaking yield ceiling of rice through Gene/Genome manipulation	*Oryza sativa*	Genetic enhancement by introgression for specific traits
Varietal improvement of rice under minimal water conditions.	*Oryza sativa*	Genetic enhancement by introgression for specific traits
Bioprospecting of rice genetic accessions for important agronomic traits	*Oryza sativa*	Genetic enhancement by introgression for specific traits
Sustainable Production of High Yielding Irrigated Rice Under Minimal Water Input	*Oryza sativa*	Genetic enhancement by introgression for specific traits
Development of new varieties of papaya with resistance to papaya ringspot virus disease and delayed fruit ripening.	*Carica papaya*	Genetic enhancement by introgression for specific traits
Development of new varieties of pineapple for fresh fruit and canning industry	*Ananas comosus*	Genetic enhancement by introgression for specific traits
Gamma Irradiation Induced Mutation and molecular breeding for the improvement of *Citrus sinensis* (Limau Madu)	*Citrus sinensis*	Genetic enhancement by introgression for specific traits
Induce Mutation Breeding of Fragrance rice for blast resistance	*Oryza sativa*	Genetic enhancement by introgression for specific traits

Name of programme/project/activity	Name of taxon	Type of activity
Breeding Hevea for enhanced latex and timber yield	*Hevea brasiliensis*	Genetic enhancement by introgression for specific traits; Population improvement through incorporation or base broadening
Pembiakan roselle (*Hibiscus sabdariffa*) untuk ciri-ciri morfo-agronomi	*Hibiscus sabdariffa*	Genetic enhancement by introgression for specific traits
Development of Superior Cocoa Hybrids, Clones and Stock Plants	*Theobroma cacao*	Population improvement through incorporation or base broadening
Introduction, Assessment and Conservation of Cocoa Germplasm	*Theobroma cacao*	Genetic enhancement by introgression for specific traits

5.2.4 Germplasm characterization and evaluation

Characterization and evaluation of accessions have been given focus as the main activities in establishing a PGRFA collection. Much of the efforts under the 37 projects, covering 90 plant species, have so far been spent mainly on collecting data on morphological characters and agronomic traits.

In organizations holding germplasm collections, 21.5% of the collections have been totally characterized morphologically. Many others have been partially characterized (75-90% morphological characterization). Some collections were characterized based on their biochemical (*Andrographis paniculata, Phyllanthus pulcher, Colocasia esculenta, Ipomoea batatas, Averrhoa carambola* and *Ananas comosus)* and molecular properties (*Durio zibethinus, Ipomoea batatas, Phyllanthus pulcher, Theobroma cacao* and *Theobroma augustum)*. Only a small portion of the total collections in the institutions has been evaluated for biotic and abiotic stress reactions (*Table 16*).

As indicated by the percentages above, the country needs to vigorously carry out characterization and evaluation activities. However, the main problem would be getting financial support and trained personnel. This in turn will manifest in limiting the establishment of core collections.

TABLE 16

Germplasm collections held by various institutions with percentages of accessions already characterized and/or evaluated for various types of descriptors

Name of taxon	% accessions characterized for morphological traits	% accessions characterized based on molecular markers	% accessions evaluated for biochemical traits	% accessions evaluated for abiotic stresses	% accessions evaluated for biotic stresses
Musa sp.	100	0	0	100	100
Mangifera foetida	90	0	0	0	0
Mangifera caesia	90	0	0	0	0
Garcinia prainiana	90	0	0	0	0
Nephelium ramboutanake	90	0	0	0	0
Mangifera odorata	90	0	0	0	0
Salacca glabrescens	100	0	0	0	0
Durio zibethinus	100	70	0	0	0
Oryza sativa	40	0	0	10	40
Zingiber sp.	5	0	0	0	0
Capsicum frutescens	80	0	0	0	0
Capsicum annuum	75	0	0	0	0
Solanum melongena	24	0	0	0	0
Solanum melongena	64	0	0	0	0
Capsicum frutescens	38	0	0	0	0
Cucurbita moschata	80	0	0	0	0
Capsicum annuum	42	0	0	0	0
Derris sp.	5	0	0	0	0
Labisia pumila	5	0	0	0	0
Zingiber sp.	46	0	0	0	0
Goniothalamus sp	0	0	0	0	0
Labisia pumila	30	0	0	0	0

Name of taxon	% accessions characterized for morphological traits	% accessions characterized based on molecular markers	% accessions evaluated for biochemical traits	% accessions evaluated for abiotic stresses	% accessions evaluated for biotic stresses
Derris elliptica	13	0	0	0	0
Tacca cristata	1	0	0	0	0
Cucurma sp	13	0	0	0	0
Alpinia sp.	4	0	0	0	0
Kaempferia sp.	5	0	0	0	0
Smilex mysotiflora	1	0	0	0	0
Smilex calophylla	0	0	0	0	0
Eurycoma longifolia	60	0	0	0	0
Premna foetida	2	0	0	0	0
Pluchea indica	3	0	0	0	0
Andrographis paniculata	100	60	60	0	100
Phyllanthus pulcher	100	20	50	0	100
Colocasia esculenta	100	0	100	0	0
Ipomoea batatas	100	60	100	0	100
Costus speciosus	40	0	0	0	0
Alpinia galanga	20	0	0	0	0
Curcuma aeruginosa	20	0	0	0	0
Etlingera elatior	20	0	0	0	0
Hedychium coronarium	20	0	0	0	0
Kaempferia galanga	20	0	0	0	0
Zingiber sp.	20	0	0	0	0
Ficus deltoidea	100	0	0	0	0
Phyllanthus niruri	100	0	0	0	0
Nicotiana tabacum	100	0	0	0	0
Durio zibethinus	100	0	0	100	100
Nephelium lappaceum	100	0	0	100	100
Lansium domesticum	100	0	0	100	100
Artocarpus champeden	100	0	0	100	100
Hevea brasiliensis	10	0	0	0	0
Averrhoa carambola	40	0	5	1	1
Artocarpus heterophyllus	10	0	0	1	5
Artocarpus champeden	50	0	0	1	5
Psidium guajava	0	0	0	0	5
Citrus maxima	30	0	0	0	0
Mangifera indica	30	0	0	0	0
Cucumis melo	0	0	0	0	0
Citrullus lanatus	10	0	0	0	0
Durio zibethinus	40	0	0	0	5
Achras sapota	50	0	0	0	0
Nephelium lappaceum	50	0	0	0	5
Carica papaya	90	0	0	20	20
Ananas comosus	80	0	20	10	10
Musa x paradisiaca	80	0	0	20	20
Garcinia mangostana	20	0	0	0	0
Capsicum annuum	20	0	0	10	10
Lycopersicon esculentum	10	0	0	5	5
Dendrobium sp.	20	0	0	5	5
Mokara sp.	20	0	0	5	5
Theobroma cacao	80	30	0	50	100
Theobroma augustum	100	50	0	50	100

5.2.5 Core collections

Only 10 core collections have been established in Malaysia to date (*Table 17*). Obstacles that exist include the lack of financial support and trained personnel, inadequate information on accessions, and the complexity of the methodology, and this has resulted in only a limited number of established core collections. Characterization and evaluation data were documented mostly in databases but not all the holding institutions use a systematic database.

TABLE 17
Core collections existing in Malaysia

Stakeholder	Name of core collection	Total number of accessions	Number of accessions that have been distributed at least once
Strategic Resources Research Centre, MARDI	Biodiversity, socio-economic studies and information management of binjai, bacang and cerapu	100	0
Universiti Putra Malaysia	Rationalization of Sweetpotato germplasm	152	30
Universiti Putra Malaysia	Germplasm Collection & Breeding of Taro	162	162
Universiti Putra Malaysia	Genetic and elite planting material of Andrographis paniculata for development of variety for antidiabetic effects	92	26
Rice and Industrial Crops Research Centre, MARDI	Development of disease (Fusarium wilts) resistant Malaysian flue-cured tobacco varieties	50	0
Rice and Industrial Crops Research Centre, MARDI	Development of sweet potato genotype with high starch yield and quality, and resistant to pest in particular *Cylas formicarius* and *Elsinoe batatas*	10	5
Rice and Industrial Crops Research Centre, MARDI	Collection of sweetpotato and cassava accessions	30	5
Rice and Industrial Crops Research Centre, MARDI	Coconut Germplasm Collection	15	0
Rice and Industrial Crops Research Centre, MARDI	Coffee Clonal Garden	15	0
Malaysian Cocoa Board	Cocoa	181	Not available

5.2.6 Diversity-rich products

Local varieties/landraces and diversity-rich products have often been neglected in the past. However with the realization of the need to protect local varieties as well as diversifying the PGRFA, the government has given incentives for such efforts. Premium price has been given for indigenous vegetables, niche variety-registration systems and labelling of products that use non-standard crop varieties. The increasing trend in the utilization of indigenous vegetables has been due to the perception of consumers that not only minimum pesticide levels were applied during their cultivation, but also that they have high nutriceutical value such as containing vitamins and antioxidants.

The existing policies and legal framework that cover local varieties and diversity-rich products are:

- 3rd National Agricultural Policy (1998-2010)
- National Policy on Biological Diversity
- Protection of New Plant Varieties Act 2004
- Plant Quarantine Act
- National Biological Diversity Policy
- Sanitary and Phytosanitary Scheme
- Malaysian Scheme for Farm Accreditation
- Malaysian Organic Scheme

Many efforts have been made towards developing value-added processing of 'diversity-rich' products for commercial purposes. The government encourages smallholders to embark on small-scale production, e.g. the processing of fried banana chips and dried banana, the processing of bitter gourd into dietary supplements, and the processing of chilli into sauce and pickles. Development of new processing methods and formulation of active ingredients towards specific end-products will also diversify the use of local varieties.

Promotion of these diversity-rich products is important in creating awareness among the public in the utilization of the lesser known PGRFA. Annual fairs, street fairs and exhibitions such as the Malaysia Agriculture, Horticulture and Agrotourism (MAHA) show would be the main platforms for these varieties to find new markets, either locally or internationally. *Table 18* lists some species for which local varieties are currently or have the potential of being exploited in the market.

TABLE 18

Species with local varieties currently in the market as well as those identified with great economic potential for developing new markets

Stakeholder	Name of taxon
Strategic Resources Research Centre, MARDI	*Solanum melongena* *Capsicum frutescens* *Cucurbita moschata* *Capsicum annuum* *Solanum torvum* *Cosmos caudatus* *Momordica charantia* *Centella asiatica*
Rice and Industrial Crops Research Centre, MARDI	*Ficus deltoidea* *Manihot esculenta* *Ipomoea batatas* *Coffea arabica*
Golden Hope Research PTE	*Hevea brasiliensis* *Eurycoma longifolia* *Psidium guajava*
MARA University of Technology, Sabah	*Manihot esculenta*
Department of Agriculture, Peninsular Malaysia	*Nephelium lappaceum* *Artocarpus champeden* *Durio zibethinus* *Lansium domesticum*
Horticulture Research Centre, MARDI	*Averrhoa carambola* *Carica papaya* *Ananas comosus* *Psidium guajava* *Musa* sp. *Mangifera indica* *Durio zibethinus*
Malaysian Cocoa Board	*Theobroma cacao*

5.2.7 Seed supply systems and the role of markets

Seed production and distribution are functions of both the public and private sectors. Projects include the production of rice seeds, mixed orchards project in Bendang, Kedah, and various seed production activities carried out by MARDI, Departments of Agriculture and several other agencies in Peninsular Malaysia, Sabah and Sarawak. For crops like rice, vegetables, corn, groundnut and fruit crops, the government reseach institutions like MARDI and local universities generate breeder and/or foundation seeds or planting materials. Subsequently, the Department of Agriculture undertakes the production and distribution of the seeds and planting materials to the public. For industrial crops that include rubber, oil palm, coconut and cocoa, both private and government agencies are involved with crop improvement as well as seed and planting material distribution.

Improving the crop seed production and supply systems is still problematic in Malaysia due to numerous factors, notably the lack of resources and budget to produce new hybrids or clones, inappropriate subsidies, and inadequate participation from the farmers and also the private sector. Although farmers are paid premium prices if they participate in the rice seed production programme, this is not practiced for the seed production of other crops. Moreover, production of PGRFA planting materials is mostly handled by private nurseries, except for rice and to some extent fruits and vegetables – these being produced by DOA and MARDI. Development of propagation procedures and transfer of improved cultivation techniques for some fruit and traditional plants will help in promoting the conservation and sustainable use of PGRFA, as well as in encouraging crop seed production and supply.

Basically, some form of incentive is needed for growers to produce quality planting materials of local clones or varieties and land races especially those of under-utilized crops. To some extent, this is happening. Organized local seed producers are almost non-existent. The problem of poor seed storage has been highlighted. Except for tobacco for which variety registration is needed, others are still on a voluntary basis or non-existent. Seed quality standards are practiced for rice and plantation crops such as oil palm, rubber and cocoa. A big proportion of the seeds used for planting is from modern

or improved varieties (60-95%). Only for rice and plantation crops do policy and a regulatory framework exist for the purpose of seed production. Incentives are also in place for the production of better rice seeds.

5.2.8 Crop improvement programmes and food security

Products of crop improvement programs have boosted agricultural yield. The volume of production for rice is mainly contributed by modern varieties. At present, many activities carried out for indigenous vegetables are important in selecting for elite accessions to be introduced to public and in helping to diversify the use of PGRFA.

Breeding programs have also developed plants that are more resistant to stress as well as to pests and diseases. In rice, an improved variety of fragrant rice with blast resistance has been developed. Another example is an improved papaya variety which has resistance to ringspot virus and shows delayed fruit ripening. Other examples are also listed in *Table 19*.

TABLE 19
Crops which will benefit from breeding programs at various institutions

Stakeholder	Name of taxon	Trait(s)/characteristic(s) addressed
University of Sarawak, Malaysia	*Metroxylon sagu*	Starch synthase gene
	Metroxylon sagu	Gene encoding for starch branching enzyme
	Metroxylon sagu	Identification and characterization of adh enzyme
	Piper nigrum	Genetic assessment of pepper germplasm
Strategic Resources Research Centre, MARDI	*Oryza sativa*	Morpho-agronomic traits and genetic evaluation traits (GEU Trait).
	Oryza sativa	Yield traits under environment water stress.
	Oryza rufipogon	Morpho-agronomic traits and genetic evaluation traits (GEU Trait).
Rice and Industrial Crops Research Centre, MARDI	*Nicotiana tabacum*	Resistance to wilt diseases
	Cocos nucifera	High yield
Malaysian Institute for Nuclear Technology Research	*Oryza sativa*	Tolerance to minimal water input
	Carica papaya	Dwarfism; disease resistance
	Ananas comosus	Disease resistance; flesh quality
	Citrus sinensis	Resistance to greening disease; taste quality
	Oryza sativa	Resistance to blast disease; high yield
Malaysian Rubber Board	*Hevea brasiliensis*	Latex yield, wood volume production and other secondary characters
Horticulture Research Centre, MARDI	*Averrhoa carambola*	Self-compatibility; fruit quality
	Psidium guajava	Nematode resistance; fruit quality for processing
	Artocarpus heterophyllus	Resistance to bacterial wilt
	Musa sp.	Resistance to Fusarium wilt
	Carica papaya	Resistance to papaya ring spot virus
	Ananas comosus	Resistance to bacterial heart rot (BHR)
National University of Malaysia	*Hibiscus sabdariffa*	Desirable plant types; anthocyanin content; yield; short maturity
Malaysian Cocoa Board	*Theobroma cacao*	High yield hybrid; tolerance to major pests and diseases.

MARDI has been successful in releasing improved varieties of fruits, vegetables, rice and root crops. Listed below are some of improved varieties of crops resulting from these breeding programs:

- *Eksotika* and *Eksotika II* papaya varieties suitable for export markets
- MDUR 78, MDUR 79 and MDUR 88 hybrid *durian* with good fruit quality and tolerance to canker disease
- Josapine pineapple hybrid with attractive fruit cosmetics, good eating qualities and improved storage characteristics
- MC 11 and MC 12 chilli varieties with good fruit qualities and high, stable yield
- MRQ 50 and MRQ 74 aromatic rice varieties
- *Sri Pontian* – a new edible cassava variety for snack food processing
- *Sri Kanji 1* and *Sri Kanji 2* – two new cassava varieties for starch processing

- *Telong* and *Jalomas* – two sweetpotato varieties suitable for processing into food products
- *Gendut* – a sweet potato table variety suited to processing into french fries

5.3 Major constraints and needs to improve the utilization of conserved PGR

Obstacles to the utilization of conserved PGR include:

- Lack of continuous financial support
- Lack of technical facilities, especially for a National Genebank.
- Lack of trained personnel in germplasm management.
- Lack of local, national or regional networking in germplasm conservation and utilization
- Lack of capacity building in gene mining of the genetic resources

These can be translated to some of the needs considered important in improving the utilization of conserved PGR:

- The need to acquire continuous financial support from the government or other sources, including international agencies.
- The need to develop technical facilities especially National Genebank.
- The need to train enough numbers of personnel in germplasm management.
- The need to establish networking in germplasm conservation and utilization among stakeholders.
- The need to develop R&D programmes for germplasm conservation and utilization

CHAPTER 6

THE STATE OF NATIONAL PROGRAMS, TRAINING AND LEGISLATION

6.1 National programs for plant genetic resources

Malaysia ratified the Convention on Biological Diversity in 1994. A National Committee on the Convention on Biological Diversity (NCCBD) was established to plan, co-ordinate and implement follow-up actions as required under the Convention. On 16 April 1988, the NCCBD formulated the National Policy on Biological Diversity to provide the direction for the nation to implement strategies, action plans and programs on biological diversity for the conservation and sustainable utilization of its resources. In addition, the Malaysian government prepared a National Conservation Strategy while the Ministry of Science, Technology and the Environment published a country report on the Assessment of Biological Diversity in 1997.

There are quite a number of national entities (agency, committee, etc.) functioning as a governance structure responsible for coordinating and/or facilitating PGRFA activities in the country. Among them are MARDI, Putra University of Malaysia (UPM), Ministry of Agriculture and Agro-Based Industries (MOA-ABI) and Malaysian Cocoa Board (MCB). These agencies will facilitate the establishment of committees that usually involve national stakeholders (public and private sectors, educational and research institutions, civil society organizations, local communities, etc.) in the planning and implementation of programs related to PGRFA.

Consequently, efforts are underway to establish national strategies and action plans for PGRFA. Workshops and meetings have been organized for information sharing and exchange as well as training and consultations have been provided for capacity building in the institutions involved. The participation of communities and of state and district agencies has also been improved. Other steps to be taken would be setting up of a National Seed Genebank and an Agrobiodiversity Information System, as well as the establishment of a committee on agrobiodiversity.

6.2 Networks

In addition to an increased national budget for PGR conservation and sustainable use, the government of Malaysia has undertaken numerous measures to promote the PGRFA network. For example, Malaysia has been an active member in the international arena in promoting liaisons between regional or international PGRFA networks (*Table 20*), especially for important crops such as rice, coconut, cocoa, banana, cassava and sweetpotato. Malaysia has also facilitated the implementation of various activities, such as organizing training courses and workshops, information dissemination, etc. The fact that we have supported financially and technically many networks in the past, such as COGENT, RECSEA-PGR and INIBAP, shows that Malaysia is very serious and believes that networking plays an important role in facilitating effective conservation and sustainable utilization of PGRFA. Through IBPGR and RECSEA Malaysia has participated in a highly successful program on PGR with Indonesia, Papua New Guinea, Philippines and Thailand.

TABLE 20
PGRFA network activities

Name of network	Network activity description
Regional Co-operation in Southeast Asia for Plant Genetic Resources	The establishment of a National Information Sharing Mechanism (NISM) in a Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture (PGRFA) in Malaysia
International Coconut Genetic Resources Network	Coconut Germplasm Utilization and Conservation to Promote Sustainable Coconut Production
International Network for the Improvement of Banana and Plantain	Assessment of Tissue Culture-Derived Banana (Musa AAA, cv. Pisang Berangan)
Consultative Group on International Agricultural Research	On-Farm Studies on the Adaptability of Food Crop Varieties (Zucchini & Potato)
International Network for Genetic Evaluation of Rice	Pilot project on accession level information system for rice.
Asian Network for Sweet Potato Genetic Resources	Asian Network for Sweetpotato Genetic Resources
Taro Network for South East Asia and Oceania	Taro Network for South-East Asia and Oceania
Asian Cassava Research Network	Asian Cassava Research Network
International Group for Genetic Improvement of Cocoa	International Cocoa Germplasm Database

Major benefits to the country from networking activities are:

- Transfer of technology
- Back-up safety duplication of germplasm
- Exchange of germplasm
- Increased stakeholder participation
- Access to financial resources through participation
- Sharing of responsibilities for network activities
- Exchange of technical expertise
- Training for national program scientists
- Exchange of information
- Access to advanced research results
- Joint characterization and evaluation of germplasm
- Increased awareness of PGRFA
- Avoiding duplication of efforts

Major constraints to the effective participation of Malaysia in regional and/or international PGRFA networks include:

- There is a lack of financial resources
- Bilateral relations are found to be more beneficial than multilateral
- Benefits of participation in the networks are not clear.

6.3 Education and training

The Third National Agricultural Policy (1998-2010) underlines education and training as an important aspect in developing the human capital that will determine the success of conservation and utilization of PGRFA. There is a trend towards decreasing numbers of technical experts working in the national programs due to staff retirements. Even though training at the university level exists, the technology gap between the retired staff and the new staff in terms of knowledge and experience is quite disturbing. In order to overcome this problem the young officers are encouraged to attend short courses to fill the knowledge gaps and also to understudy the senior officers as fast as they can.

Even though there is no national strategy yet in place, adequate training is provided at the universities where training in PGRFA is offered to interested students. Among the lead universities are Putra University of Malaysia (UPM), University of Malaya (UM), National University of Malaysia (UKM), Science University of Malaysia (USM), Sabah University of Malaysia (UMS) and MARA University of Technology (UiTM). Training is also offered by research institutes, the Department of Agriculture and various Park Managements (*Table 21*).

However, there are training priorities presently not covered by any training program in Malaysia and the region, namely, on genetic enhancement and cryopreservation of crops with recalcitrant seeds.

Due to inadequate budget and training facilities, the training and education quality and quantity remain insufficient to meet the actual requirements for well- educated and trained staff. To partly overcome this problem, staffs have been encouraged

to take opportunities to study abroad. Nevertheless, as already mentioned, there is an urgent shortage of well-trained staff for implementing successfully all the activities necessary for the country's PGRFA conservation and sustainable use.

TABLE 21
Training in PGRFA management by various organizations and institutions

Organization/Institution	Name of training course
Sabah Park	Nepenthes Garden at Mesilau Nature Resorts, Kinabalu Park
Sabah Park	Kinabalu Mountain Botanical Garden
Sabah Park	Poring Ethnobotanical Garden
Sabah Park	Poring Rafflesia Farm
Sabah Park	Tawau Hills Park Lowland Garden
Sabah Park	Fernarium at Crocker Range Park
Strategic Resources Research Centre, MARDI	Training on characterization and evaluation methodology for indigenous vegetables
Universiti Putra Malaysia	Genetic and elite planting material of *Andrographis paniculata* for development of variety for antidiabetic effects
Universiti Putra Malaysia	Genetic diversity and conservation *Phyllanthus* spp. genetic resources for development of variety for anti-cancer
Universiti Putra Malaysia	Germplasm Collection & Breeding of Taro
Universiti Putra Malaysia	Rationalization of Sweetpotato germplasm
Science University of Malaysia	Plant Pathology
Science University of Malaysia	Plant physiology and development
Science University of Malaysia	The collar rot of *Citrus sinensis* and its biological control using mycorrhiza and beneficial microbes
Science University of Malaysia	Healthy Campus Programme
Science University of Malaysia	Entomology
Science University of Malaysia	Agrobiology
University of Sabah, Malaysia	Industrial crop management 1
MARA University of Technology, Sabah Campus	Yield performance of cassava (*Manihot esculenta* Crantz) for starch and snack production
MARA University of Technology, Sabah Campus	Planting Management
MARA University of Technology, Sabah Campus	Major Crops
Department of Forestry Peninsular Malaysia	Medicinal Plants
MARA University of Technology	International Plantation Conference 2006
MARA University of Technology	National Seminar on Plantation Industry 2006
National University of Malaysia	MSc in conservation of plant genetic resources
Malaysian Cocoa Board	Development of Superior Cocoa Hybrids, Clones and Stock Plants

Suggestions to improve education and training include:

- Universities need to be equipped with more technical expertise in the area of PGRFA conservation.
- More post-graduate courses in the area of PGRFA conservation should be offered to students pursuing tertiary education.
- More short-term training in PGRFA should be provided to those working in the area of PGRFA.
- Education and training in PGRFA should be one of the components of the national PGRFA program.
- The government should recognize the importance of PGRFA in the national agenda when formulating the national education policy.
- Professionals in genetic conservation and utilization should be increased in number through specific training programs at the university level.
- More laboratories on soil and plant analyses are needed to facilitate research.

6.4 National legislation

Before 1996 there was no policy or legislative framework that specifically addressed the conservation and utilization of plant genetic resources. Currently, the policies and development plans that are relevant to biodiversity of plants include:

- The National Forestry Policy 1978 Amendment 1993
- The National Agricultural Policies (1992-2010)
- The Five-Year Development plans
- The Second Outline Perspective Plan (1991-2000)

The two legal frameworks regulating the establishment of the national strategy, plan and program on conservation and sustainable use of PGRFA are the Third National Agricultural Policy (1998-2010) and the National Policy on Biological Diversity 1998.

The Third National Agricultural Policy or NAP3 (1998-2010) was formulated to ensure that the capability of the agricultural sector's strategic role in national development is sustained and enhanced in the light of new and emerging challenges facing agricultural development. Towards this end, NAP3 will focus on new approaches for increasing productivity and competitiveness, strengthening linkages with other sectors, venturing into new frontier areas as well as conserving and utilizing natural resources on a sustainable basis. The policy aims to set in place the enabling and supportive measures as well as to provide a conducive environment for promoting growth in the agricultural sector. The policies and strategies formulated will continue to emphasize productivity and market-driven growth.

Meanwhile, the National Policy on Biological Diversity sets the vision of transforming Malaysia into a world centre of excellence in conservation, research and use of tropical biological diversity by the year 2020. To attain this vision, 15 strategies and 87 action plans are outlined in the policy. Further, in 2005 Malaysia initiated the National Biotechnology Policy with the aim of making Malaysia a regional and international centre for biotechnology which relies upon the country's rich biodiversity. The central achievements in these policy areas are the access and benefit-sharing (ABS) requirements. Malaysia along with other member States supported the promulgation of the 2004 ASEAN framework Agreement in access benefit-sharing (ABS). It has yet to ratify the agreement.

Other than that, the National Biodiversity-Biotechnology Council (MBBN) was established in 2002 to strengthen biodiversity management in Malaysia. The council which comprises of 10 cabinet ministers and 13 state chief ministers is the highest body in decision-making for biodiversity management in Malaysia. The draft of the Biosafety Bill which will form the legal framework for biosafety regulations in the country has undergone public consultation with various stakeholders and was approved by the cabinet in February 2004. At the fifth meeting of the council in September 2006, the Biosafety Bill was directed to be tabled in Parliament. The Biosafety Bill aims to ensure that biotechnology products are safe to use and do not pose any danger to humans, animals and the environment. Also at the fifth meeting of MBBN, it was agreed that a Natural History Museum be established in order to strengthen the knowledge base on biodiversity conservation and management in the country.

Two of the most significant international conventions or agreements relevant to PGRFA that have been signed and/or ratified by Malaysia are the Convention of Biological Diversity (CBD) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).

ITPGRFA entered into force on 29 June 2004. The first meeting of the Governing Body of the Treaty held on 16 June 2006 adopted the Standard Material Transfer agreement (SMTA) for the Multilateral System (MLS) of Access and Benefit-Sharing (ABS).

The New Plant Variety Protection Act 2004 provides for protection of the rights of breeders of new plant varieties, gives recognition and protection to contributions made by farmers, local communities and indigenous people towards the creation of new plant varieties; encourages investment in and development of the breeding of new plant varieties in both public and private sectors; and provides for other related matters. This Act comes into force in January 2007. The enforcement of the Act fulfills Malaysia's obligation as a signatory to the Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement which provides the intellectual property rights protection of new varieties of plants either by a patent or by an effective *sui generis* (class of its own), or a combination of both.

6.5 Information systems

Malaysia has not in the past developed any national information management system to support her efforts to sustainably use, develop and conserve PGR. Although certain attempts have been made before to establish the National Information System, it was never materialized. Each institute maintains its own database which is not in the same standard format as those of other institutes, thus making exchangeable information very limited.

The implementation of GCP\RAS\186\JPN – a project to establish the National Information Sharing Mechanism (NISM) for the implementation of the Global Plan of Action (GPA) for the conservation and sustainable utilization of plant genetic resources for food and agriculture – was the first effective step towards constructing a comprehensive information system for PGRFA in the country. Through using the "Common Tables" and Reporting Formats provided by the project, data collected can be better standardized, systematized and managed.

Apart from adopting the NISM-GPA database, Malaysia has a few information systems developed to maintain plant genetic resources. At the moment, MARDI is coordinating the establishment of an information system for PGRFA. In fact, MARDI itself has been and is implementing projects leading to the establishment of agrobiodiversity information systems for certain crops (see *Table 22*).

TABLE 22
Development of PGRFA information systems

Stakeholder	Name of project/activity
Strategic Resources Research Centre, MARDI	Pilot project on accession level information system for rice.
Strategic Resources Research Centre, MARDI	Ethno-botanical study and information management of plant species utilised by ethnic Malay community in West Malaysia
Strategic Resources Research Centre, MARDI	*In situ/ex situ* conservation of medicinal/aromatic plant species
Strategic Resources Research Centre, MARDI	The establishment of a National Information Sharing Mechanism (NISM) of Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture (PGRFA) in Malaysia.
Strategic Resources Research Centre, MARDI	Collection, characterization and utilization of indigenous vegetables of Malaysia
Strategic Resources Research Centre, MARDI	Ethno-botanical study, conservation and information management of medicinal plant species utilized by the orang asli community
Strategic Resources Research Centre, MARDI	Prospecting, collection, genetic diversity studies, exploitation and conservation of genetic diversity of chilli (*Capsicum* spp.), eggplant (*Solanum* spp.) and tomato (*Lycopersicon* spp.) in Malaysia and prospects for genetic enhancement
Strategic Resources Research Centre, MARDI	Studies on biosystematics and biodiversity of Tongkat Ali (*Eurycoma* spp.) for use in effective and sustainable management, conservation, and exploitation of its genetic resources in Malaysia
Strategic Resources Research Centre, MARDI	Ethno-botanical study and information management of plant species utilised by ethnic Malay in West Malaysia
Strategic Resources Research Centre, MARDI	Ethno-botanical study, conservation and information management of *ulam* species.
Department of Forestry, Sabah	Set up a phytochemical/pharmaceutical/herbal unit at FRC – Herbal Technology Unit

However, only three of the information systems above are being used actively by for PGRFA and/or seed stock data management. They are the Rice Genebank Information System (RGBIS), Medicinal Plant Information System (MEPIS) and Agrobiodiversity Information System. The MEPIS is basically information about plants used for medicinal purposes in Malaysia, while the Rice and Agrobiodiversity Information Systems give information on the genetic resources collected, characterized and conserved in the respective genebanks.

6.6 Public awareness

The National Policy on Biological Diversity indicates strategies for tackling the problem of institutional and public awareness, as follows:

- Increase awareness within the civil service at federal, state and local government levels as well as in professional bodies and the private sector through courses and training programs
- Enhance mass media coverage on biological diversity issues
- Incorporate the study of biological diversity and related fields into the curricula of schools and institutions of higher learning
- Promote and support the biological diversity activities of nature clubs and societies

- Incorporate the notion of conservation of biological diversity and sustainable use of its components as an element of environmental awareness and training programs
- Recognize the role of non-governmental organizations (NGOs) in the conservation and sustainable utilization of biological diversity.

Several NGOs have proactive joint efforts with the government for raising public awareness on the related issues, especially through implementing projects for promoting *in situ* and on-farm conservation. Even so, the participation of NGOs is still limited in terms of number. The active NGOs are listed below:

- Third World Network
- Malaysian Nature Society
- North Borneo Starch Sdn. Bhd.
- Incorporated Society of Planters
- Golden Hope Plantations Limited
- Malaysian Association of Productivity
- ASEAN Cocoa Club
- Asia Pacific Regional Cocoa Breeding Group

The participation of regional or international organizations has provided Malaysia with financial support in carrying out quite a number of public awareness activities on PGRFA. Through this relationship, information could be disseminated to targeted communities more effectively. These organizations include:

- Regional Office for Asia and the Pacific, FAO-RAPA
- AVRDC-Asian Regional Center
- Asian Development Bank (ADB)
- International Plant Genetic Resources Institute, Regional Office for Asia, the Pacific and Oceania (IPGRI)
- United Nations Development Programme (UNDP)

Also, workshops and training courses organized under the GCP/RAS/186/JPN project have significantly contributed to promoting public awareness in the country for PGRFA conservation and sustainable use.

Even so, the obstacles in carrying out most PGRFA activities are due to limited efforts and concern spent in community training and raising awareness. Very limited numbers of forums were organized on the related issues, and only a small number of training courses has been offered to farmers and communities. Up to now, most of the awareness-raising activities have been carried out under projects funded by foreign donors; there have been no sustainable and strong national projects in this aspect. Also, very few information, education and communication materials have been produced and introduced or distributed to the public. Moreover, the PGR issues have seldom been mentioned in both the central and local governmental mass communication channels. Inadequate study and use of indigenous knowledge for PGRFA conservation is another important issue. This is not only problematic for raising public awareness, but in many cases is also an obstacle in the implementation of many other activities, as has already been mentioned before.

6.7 Major constraints in national programs, development, training and legislation

Several major constraints have been identified in curbing the national programs, development, training and legislation related to PGRFA:

- Insufficient financial support
- Insufficient number of staff
- National priorities have not been established
- Staff do not have sufficient skills and knowledge
- Unclear which organization is responsible for which activity
- Bilateral relations found to be more beneficial than multilateral
- Unclear benefits from participation in the networks
- Lack of expertise and technologies
- Lack of awareness in training needs within the country
- Lack of trained personnel in the country to provide training

6.8 Major needs for national programme, development, training and legislation

Thus, the major needs for the same may be stated as below:

- To conduct systematic studies on indigenous knowledge and the current role of farming communities in management, conservation and development of PGRFA. This is of vital importance for designing appropriate and feasible strategies, plans, programs, projects, and policies to promote on-farm conservation and sustainable use of PGRFA.
- To increase public awareness through the production and distribution of leaflets, videos and CDs, and through intellectual discourses addressing the issues on mass media.
- To gazette areas designated for PGRFA conservation.
- To develop a mechanism leading to a monitoring and warning system for loss of PGRFA.

CHAPTER 7

THE STATE OF REGIONAL AND INTERNATIONAL COLLABORATION

7.1 Regional collaboration

Malaysia is one of the countries under ASEAN and has been actively involved and cooperating in a number of regional activities related to PGRFA conservation, sustainable utilization, and access and benefit-sharing in the region. Malaysia is an active member of the Regional Cooperation in Southeast Asia on Plant Genetic Resources (RECSEA-PGR) since its establishment in mid-1978, and has participated in the recent consultation exercise held in Kuala Lumpur for the drafting of proposals for the conservation and sustainable use of PGRFA in the region. Before that, Malaysia has participated in a highly successful cooperative program in plant genetic resources with Indonesia, Papua New Guinea, Philippines and Thailand. National institutions like MARDI and PORIM were participants in the program.

Malaysia also has contributed to the development of an ASEAN framework agreement on access to, and fair and equitable sharing of benefits arising from the utilization of, biological and genetic resources, a recent proactive initiative of ASEAN in response to the Convention on Biological Diversity (CBD). The country has agreed to collaborate with other ASEAN countries to assist each other in developing capacity to formulate legislature and policy, as well as capacity in bioprospecting and sustainable utilization of PGRFA. In respect to vegetable crop genetic resources, Malaysia is also an active member of the ASEAN-AVRDC Regional Network (AARNET).

Malaysian scientists and other scientists in the region met in 1992 and produced the Manila Declaration which calls for the ethical collection and utilization of Asian biological resources. A code of ethics in biological prospecting was drawn up. A subsequent meeting in Malaysia produced the Melaka Accord (1994) which called for actions to be implemented within the region to control the movement of plant genetic materials.

7.2 International collaboration

Malaysia has been involved prominently in the international arena, and the Langkawi Declaration on the Environment and Development of 1989 by the Heads of Government of Commonwealth countries marks a significant step in this direction. With the ratification of the Convention on Biological Diversity (CBD) on the 24 June 1994, Malaysia was obliged to develop national strategies, plans or programs for the conservation and sustainable utilization of its biological resources. The National Policy on Biological Diversity was officially launched in 1998, four years after Malaysia ratified CBD. Malaysia is also a contracting party to the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) since 2004. Hence, where possible and appropriate, these features are integrated into sectoral or cross-sectoral plans, programs and policies.

IPGRI, now newly named Bioversity International, had at one time provided funds to MARDI to establish a medium-term seed storage facility and to collect coconut germplasm. PORIM and RRIM each have sizeable collections of oil palm and rubber germplasm funded by IPGRI and the International Rubber Research and Development Board (IRRDB).

Germplasm collection and conservation of minor and under-utilized crops are also undertaken by several local universities through the assistance of some international funding agencies. Winged bean germplasm was collected by UKM with financial assistance from IPGRI, the International Council for Development of Underutilised Plants (ICDUP) and the International Federation of Scientists (IFS), and also by UPM with assistance from the Asia Foundation and ICDUP. The IFS awarded grants to UPM and UKM for long bean and edible aroids germplasm collections, respectively. Since 1984, IPGRI has involved several Malaysian scientists in a regional collection mission of the genetic resources of *Citrus* species and related genera.

The PROSEA project was an example of a cooperation program at a regional level to gather, document and exchange information on plant genetic resources among countries in the region. As a result of this collaboration, Malaysian scientists have been able to contribute to the publications of PROSEA. The most recent international collaborations established by Malaysia are listed in *Table 23*.

TABLE 23
List of recent international collaborations

Network	Activity	Local Institution/ (Leader)
International Coconut Genetic Resources Network	Coconut germplasm utilization and conservation to promote sustainable coconut production	MARDI (Abdullah Othman)
International Network for the Improvement of Banana and Plantain	Assessment of tissue culture-derived banana (Musa AAA, cv. Pisang Berangan)	Mardi (Siti Hawa Jamaluddin)
Consultative Group on International Agricultural Research	On-Farm studies of adaptability of food crop varieties (zucchini and potato)	DOA Sabah and MARDI (Abd. Shukor Rahman)
International Network for Genetic Evaluation of Rice	Pilot project on accession level information system for rice.	MARDI (Abdullah Md. Zain)
Asian Network for Sweet Potato Genetic Resources	Asian Network for Sweetpotato Genetic Resources	MARDI (Tan Swee Lian)
Taro Network for South East Asia and Oceania	Taro Network for South-East Asia and Oceania	MARDI (Tan Swee Lian)
Asian Cassava Research Network	Asian Cassava Research Network	MARDI (Tan Swee Lian)
International Group for Genetic Improvement of Cocoa	International Cocoa Germplasm Database	MCB (Kelvin Lamin)

Collaboration is in the following projects:

- Pilot project on accession level information system for rice
- The establishment of a National Information Sharing Mechanism (NISM) of Global Plan of Action (GPA) for the conservation and sustainable use of plant genetic resources for food and agriculture (PGRFA) in Malaysia
- Conservation genetics of *Nephelium* and *Citrus* species
- Breeding of soybean
- Breeding of roselle (*Hibiscus sabdariffa*)
- Study of genetic variation of Malaysian rice varieties/advanced breeding lines and wide compatibility varieties/ advanced breeding lines and wide compatibility varieties using amplified fragment length polymorphism (AFLP)
- Cocoa productivity and quality improvement: a participatory approach

Based on the survey results submitted by the stakeholders in the NISM project, support provided by Malaysia to the various collaborations and networks include:

- Direct financial support through membership dues
- Travel costs to attend meetings
- Technical expertise in joint activities
- Organization and hosting of network meetings
- Institutional infrastructure to participate in joint activities
- Information management support

Based on the NISM survey, some of the benefits to the nation in collaborating are:

- Transfer of technology
- Back-up safety duplication of germplasm
- Exchange of germplasm
- Increased stakeholder participation
- Access to financial resources through participation
- Sharing of responsibilities for network activities
- Exchange of technical expertise
- Training for national program scientists
- Exchange of information
- Access to advanced research results
- Joint characterization and evaluation of germplasm
- Increased awareness of PGRFA
- Avoidance of duplication of efforts

Among the constraints in participating, as reported by stakeholders in the NISM survey, are:

- Lack of financial resources
- Bilateral relations are found to be more beneficial than multilateral
- Benefits of participation in the networks are not clear

CHAPTER 8

ACCESS TO PLANT GENETIC RESOURCES AND SHARING OF BENEFITS ARISING OUT OF THEIR USE, AND FARMERS' RIGHTS

8.1 Access to plant genetic resources

8.1.1 Acceding to the international legal framework

PGR form a distinct group in the entire concept of biodiversity. They are made up of species of cultivated plants and their wild relatives. Plant genetic resources for food and agriculture (PGRFA), however, include all species which contribute to people's livelihoods by providing food, medicine, fiber, clothing, shelter, energy and feed for domestic animals. For centuries, PGR have provided the basis for civilization and agriculture for life and prosperity around the globe. PGR, in the form of seeds, were the primary objects of earlier trade, dissemination and exchange. This free-flow of PGR has benefited a number of countries around the world, including Malaysia.

Development of modern technologies and political maneuvers at the international level, however, has added new dimensions, and consequently has altered the traditional pattern of exchange of PGR. These developments have significantly influenced the policy environment and laws relating to the management and control of PGR.

The main international legal frameworks that have a significant influence on the national policy and laws relating to management and control of PGR include the Convention on Biological Diversity (CBD), International Plant Protection Convention (IPPC), the agreement on Trade Related Aspect of Intellectual Property Rights (TRIPS) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). In this respect, Malaysia is currently either a party or signatory to the above mentioned international legal frameworks.

To facilitate regional cooperation, Malaysia, together with the other members of the States of the Association of South East Asian Nations (ASEAN) has agreed to adopt a broad framework for Access and Benefit Sharing (ABS) for the region. The member states recognize the importance of inter-country cooperation within the region with regard to access and benefit-sharing relating to plant genetic resources.

8.1.2 Organization system, national policy and legal framework

The organization framework system for access to genetic resources is structured around the Ministry of Agriculture and Agro-based Industries (MOA-ABI). Act as a national focal point, MOA-ABI plays an important coordinating role in ensuring continuity, consistency and complementary of functions between the various levels as well as at each level. This organization structure provides policy directions and plans of work on PGR through management networking involving several ministries, government agencies, research institutions and universities. Various technical committees have been formed to formulate policy and strategies. The system is supported by calls for research proposals, seminars and meetings to promote dialogue between researchers and those managing the PGR. The current organization structure has effectively laid down the right working environment dealing with policy matters relating to the management and control of PGR.

Currently, there is no specific national law which solely addresses the issue of managing and controlling PGR. However, there are applicable federal and state laws that regulate work pertaining to PGR in this country (*Table 24*).

TABLE 24
List of applicable federal and state laws and policies on PGR

Relevant policy	Applicable law
National Forest Policy 1978 National Policy on Biodiversity (1998)	Plant Quarantine Act 1976 Customs (Prohibition of Export) 1993 National Forestry Act 1984 National Park Act 1980 Parks Enactment 1984 Forest Enactment 1992 Fauna Conservation Ordinance 1963 Forest Ordinance 1954 Natural Resources Ordinance 1949 Sarawak Biodiversity Centre Ordinance 1997 Sabah Biodiversity Enactment 2000 Protection of New Plant Varieties Act 2004

The National Forestry Policy passed in 1978 promotes the maintenance of a permanent forest estate (PFE), managed in accordance with the principles of sound forest management. It also provides for thorough and efficient use of state forests outside the PFE earmarked for conversion. In 1993, the policy was revised to acknowledge the importance of biodiversity conservation and sustainable use of forest genetic resources, as well as the role of local communities in forest development.

The National Biodiversity Policy launched in 1998 further provides for a broader policy framework on issues pertaining to biological resources. The policy includes strategies and outlines action plans to conserve biological diversity and to ensure sustainable use of biological resources. The policy recognizes the importance of managing Malaysia's biological resources to provide long-term economic benefits, food security and environmental stability to the country.

With increased research and development work in biotechnology as well as bio-industry, the government recognizes that there is a surge in actual and potential value of the existing biological resources available in this country. The policy makers have been working on various legislative and administrative procedures and other measures to facilitate and promote bio-prospecting in this country. Subsequently, the National Biodiversity and Biotechnology Council was established by the government in 2001.

The process to develop legislation on access and benefit-sharing began in 1994. Subsequently, in 1999 the final text of the first draft was adopted. While the above process was taking place at the national level, the states of Sabah and Sarawak had their own processes underway, and these resulted in the enactment of the Sarawak Biodiversity Center Ordinance in 1997 and the Sabah Biodiversity Enactment in 2000. To further strengthen the governance of biological diversity in this country, the government passed the Protection of New Plant Varieties Act in the year 2004.

8.1.3 Gaining access to PGR

Malaysia continues to hold and establish technical cooperation with international institutions worldwide, as well as with other countries on a bilateral basis to gain access to PGR. *Table 25* provides a list of international cooperation on PGR in which Malaysian institutions are involved.

TABLE 25
International cooperation on PGR involving Malaysian institutions

Crop	Local institution	Collaborator	Activity
Banana	MARDI	INIBAP	Exchange of germplasm Sharing information Capactiy building
Rice	MARDI	IRRI INGER	Exchange of germplasm Testing of advanced lines Information sharing Capacity building
Sweetpotato	MARDI UPM	CIP	Exchange of germplasm Sharing information Capacity building
Cassava	MARDI	CIAT	Exchange of germplasm Sharing information
Maize	MARDI	CIMMYT	Exchange of germplasm Sharing information

Crop	Local institution	Collaborator	Activity
Coconut	MARDI	COGENT	Exchange of germplasm Sharing information
Vegetables/ Pulses	MARDI	AVRDC	Exchange of germplasm Sharing information Capacity building
Zucchini and potato	DOA Sabah	CGIAR	Exchange of germplasm Testing of advanced lines Capacity building
Taro	MARDI	TANSAO	Exchange of germplasm Testing of advanced lines Sharing information
Cocoa	MCB	INGENIC	Exchange of germplasm Testing of advanced lines Sharing information
Rubber	MRB	International Network	Exchange of germplasm Testing of advanced lines
Pepper	DOA Sarawak	International Network	Exchange of germplasm Testing of advanced lines

8.2 Fair and equitable sharing of benefits from the use of PGR

Malaysians will continue to exercise the *status quo* freedom of access to plant genetic resources for the purposes of recreation, collection, study and research. However, without a proper ABS regime in place at the national level, the Guidelines on Research implemented by the Economic Planning Unit (EPU) of the Prime Minister's Department will continue to be adopted as temporary measures to regulate access to genetic resources by foreign nationals, as well as the sharing of benefits derived from the utilization of PGR.

Despite notable progress made in the drafting of ABS regime for the country, there are still many challenges that need to be overcome before a national ABS legislation is in place. Some of these include issues on traditional knowledge and access licensing. Another major constraint is the federal-state jurisdiction over land and natural resources. In this regard, there exists a federal-state jurisdictional dichotomy over land and natural resources; this means that the implementation of the access regime needs the endorsement of the respective State Legislative Councils.

The Protection of New Plant Varieties Act 2004 passed by the Parliament provides a fair and equal protection of rights for the contribution made by breeders, farmers, local communities and indigenous people, and gives due recognition to their innovative efforts towards the creation of new plant varieties.

8.3 Implementation of Farmers' Rights

Article 9 of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) clarifies that the Contracting Parties recognize the contribution of farmers, but states that the responsibility for the realization of Farmers' Rights rests with national government. In this respect, *Articles 13(1)d* and *Article 14(2)* of the Protection of New Plant Varieties Act 2004 recognize the role of farmers and local communities. Thus, the farmers and local communities as well as indigenous people are given equal protection and rights as the breeders with regard to their innovative efforts.

Article 31(1)d, 31(1)e, and 31(1)f of the Act further recognize the needs of small farmers, and thus, a special privilege is granted to this group of people. These articles, in particular, recognize the traditional rights of small farmers to save and exchange a reasonable amount of materials from the variety/ies protected under the Act for their own use. The Act also permits the sale of farm-saved seeds of a protected variety arising from natural disasters or emergencies, or any other factors beyond their control, provided the amount sold is not more than what is required in his holding.

CHAPTER 9

THE CONTRIBUTION OF PGRFA MANAGEMENT TO FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

9.1 Introduction

In order for PGRFA to contribute to food security and sustainable development, an effective management system for local PGRFA has to be put in place. At the moment under the management of Ministry of Agriculture and Agro-based Industries (MOA-ABI), PGRFA are being monitored and managed by various agencies depending on their function – either as an extension agent, such as Department of Agriculture (DOA); as a marketing agency, such as FAMA; as a research and development institute, such as MARDI, FRIM, MCB, MRB, MPOB, etc.; or as a land development agency, such as RISDA, Felda, Felcra, etc.

Conservation efforts of PGRFA are important in maintaining traditional varieties, landraces, wild relative crops and other wild plant species. At the same time, advanced breeding lines of PGRFA that can produce high yield and generate more income to farmers are also important. Thus, equilibrium between conservation and development is essential for sustainable development.

9.2 Contributions to agricultural sustainability

Although at one time farmers only focused on getting maximum crop yield to the extent that they depended very much on chemical inputs and monoculture, the trend has been slowly changing these past 10 years. With knowledge for using more ecologically friendly methods they now manage to get the same amount of yield with less chemical inputs. Consumer preference for organic products, such as vegetables and fruits, also changed the farmers' paradigm, switching their focus to organic farming. Mixed farming and precision farming also contribute to more sustainable agriculture.

9.3 Contributions to food security and poverty alleviation

Food security is one of the important components of agricultural multi-functionality. Malaysia has been trying to reduce her dependence on imports of food products. Food security in Malaysia relates to the ability to produce domestically at least 65% of the country's rice needs. This has been the main focus of the agriculture sector in the past few years. Improved varieties of PGRFA that produce high yield, tolerance to stress such as extreme weather as well as pests and diseases have been developed. At the same time, improved varieties that adapt to local conditions and having resistance to pests and diseases are also being developed by farmers. Farmers also maintain home gardens planted with local fruits, vegetables, *ulam* and medicinal plants for their own use, but this practice at the same time also conserves the plant genetic materials for the future generations. The government through the land development agencies such as RISDA, Felda, Felcra, etc. provides land for poor farmers which helps alleviate their poverty through agriculture.

9.4 Contributions to economic development

The Malaysian government has identified agriculture as the third engine of growth for the country. Agriculture has been "rebranded" from its traditional way of life to a business that can generate good income for farmers. Apart from the income resulting from the yield of produce, agriculture can also be promoted through agro-tourism. Value-added products from

PGRFA are also being exploited as pharmaceutical or health food products. At the same time, the authorities can also manage sustainable land use through community agricultural projects to revive farming land abandoned due to lack of labor. At the moment only 6.4% of Malaysian labor works in the agricultural sector.

9.5 Needs and priorities to improve the contribution of PGR

In order to better understand the various roles of PGR in economy, culture and society, ecology, etc. we have to know what the nation has. There is an urgent need to educate the farmers and consumers on the importance of PGR in their lives. PGR have been an important element in mankind's livelihood by providing food, medicine, clothing, etc. PGR are also important in maintaining ecological balance.

However, the lack of information on PGR and their functions or benefits to the country has caused PGR to be exposed to genetic erosion as many *in situ* sites of PGR are being cleared for logging and land development.

A few factors that contribute to the lack of understanding of the roles and value of PGR include:

- Lack of comprehensive surveys and inventories. Work carried out thus far have not been synchronized and are isolated.
- Lack of an effective information system to enhance information sharing and exchange
- Priorities only on major crop varieties and commercial crops resulting in monoculture that is susceptible to pests and diseases
- Lack of personnel dealing with PGR for its conservation and utilization
- Lack of funds for the conservation of PGR
- Lack of capacity building in the local communities to enhance sustainable use of PGR

In order to have a better understanding of the contributions of PGR, a strong national program has to be in place. At the moment, the country are preparing the National Action Plan and Strategy for PGRFA. It will cover all the priority areas underlined by the global plan of action. This will be the country's benchmark to fulfill the national and international obligations on biodiversity conservation. Carrying out the strategy and action plan will give a better understanding to more people, not only those who work directly with PGR but also those formulating laws and those who have important executive powers.