COUNTRY REPORTS

THE STATE OF **MALAYSIA'S** BIODIVERSITY FOR FOOD AND AGRICULTURE

MALAYSIA'S COUNTRY REPORT ON THE STATE OF BIODIVERSITY FOR FOOD AND AGRICULTURE

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EXECUTIVE SUMMARY

As one of the rich-biodiversed countries, Malaysia houses to about 9% of the world's flowering plants, has great diversity of flora and fauna estimated about 15,000 species while that of Sabah and Sarawak is estimated to be 12,000 species (Saw *et al.,* 2009). Plant genetic resources are conserved as *in situ* in the protected areas. These protected areas served as refugee for threatened plants. In the last two decades Malaysia has had a resilient and impressive economic growth. This growth has contributed tremendously toward achieving almost all the MDGs and Malaysia is well position to achieve SDGs target. Compared to many countries Malaysia has a positive environmental records, however Malaysia is facing daunting challenges and threat to its rich natural resource capital. Malaysia's global biodiversity values are under continued pressure.

Studies have shown land use change and deforestation are associated with huge disturbances in landscape integrity, degradation of environment and environmentally sensitive area in Malaysia. Among major drivers of biodiversity loss; land degradation, urbanization, watershed pollution, climate change and invasive alien species have been identified to have the greatest impact on both terrestrial and aquatic ecosystems in Malaysia. Increasingly, climate change and land degradation is threatening Malaysian biodiversity and has exacerbated other environmental stresses already experienced by these ecosystems. In Malaysia, agricultural practices are becoming increasingly intensified and ecologically inappropriate. It is timely that a much more sound approach via ecosystem management to be implemented. This is important to make sure that all ecosystem services/provision that are important for the sustainability of production system will continue giving its services. Malaysia have already kick start this by launching the new National Policy on Biological Diversity 2016-2025 that one of the 5 overarching goal is to safeguarded all our key ecosystems, species and genetic diversity.

The major gap in information and knowledge on the trends and conservation of associated biodiversity and ecosystem services would be because less priorities being given to this group of

biodiversity. Only a few species that recently highlighted such as pollinator (stingless bee) that gaining its popularity for stingless bee honey production. Conservation and utilization of associated biodiversity could only be achieved with support for inventories and bio prospection of associated biodiversity. Funding by the government or other source of funding is critically needed.

In order to make use of available biodiversity resources for food and agriculture, slow adoption of management practices or actions that favour or involve the use of biodiversity for food and agriculture would be because farmers choose farming practices intensification and monocropping that usually have negative impact to associated biodiversity. Incentive should be given to farming practices that promotes eco-friendly approaches that will in turn improve productivity, food security and nutrition, livelihoods, ecosystem services, sustainability, resilience and sustainable intensification. Other than that government should give priorities and emphasize to such practices through mainstreaming of ecosystem services.

Recognizing the importance of biodiversity, Malaysia has continued to safeguard its natural resource capital by improving and strengthening existing provisions of policy, legal and institutional frameworks. Conservation and sustainable use of biodiversity has always been addressed within the context of sustainable development in Malaysia. Conservation of biodiversity has been mainstreamed in various Malaysia Plans as well as in several national and state's policies. Furthermore, its policy to retain at least 50% of its land under permanent forest cover in perpetuity and designated sites has contributed to the maintenance and enhancement of global biodiversity values, GHG emission reduction and GHG sequestration. While all the national documents and action plan including the retention of 50% of land as forest cover in perpetuity nationwide appears to provide a degree of confidence that important ecosystems and biodiversity will be maintained.

CHAPTER 1: INTRODUCTION

1.1 Malaysia Country Overview

Malaysia is a tropical country that belongs to the Sundaland bio-geographical region. Malaysia covers an area of about 33.27 million hectares, consisting of Peninsular Malaysia, the states of Sabah and Sarawak in the eastern region and the Federal Territory of Labuan in the northwestern coastal area of Borneo Island. The two regions are separated by about 540 kilometers of the South China Sea. Malaysia lies entirely in the equatorial zone and the average daily temperature throughout Malaysia varies from 21^0 C to 32^0 C. Malaysia's multi-racial and multi ethnic population is estimated at 31.7 million in 2016.

Map 1: Malaysia comprising of Peninsular Malaysia, Sabah and Sarawak

Malaysia practises a system of Parliamentary democracy with a constitutional monarchy. The country has three branches of government, namely the Executive, the Legislature and the

Judiciary. The Malaysian Parliament is made up of His Majesty the Yang di-Pertuan Agong (the King), the Upper House of Senate with 70 members and the House of Representatives (lower house) with 222 members. The general election for the 222 members of the lower house is held every five years. The Supreme Law of the country is the Federal Constitution of Malaysia, where it provides that the authority to legislate for matters relevant to biological diversity falls under the jurisdiction of the Federal and State Governments. Some subject matters pertaining to natural resources such as land and forests fall under the responsibility of the State Governments.

The agriculture sector plays an important role in Malaysia's economic development by providing rural employment, uplifting rural incomes and ensuring national food security. As Malaysia is recognised as megabiodiversity country which holds different varieties or diversity of genetic resources, efforts to conserve and utilise these resources, which are endemic and localised in distribution, are continued to be enhanced. The efforts have been taken by several agencies in Malaysia such as MARDI, Department of Agriculture (DOA), FRIM, Sarawak Biodiversity Centre, Sabah Biodiversity Centre and local universities. The activities are one of the main priorities in the national policies such as National Policy on Biodiversity (1998, amended 2015), National Food Security (2011-2020) and National Strategies and Action Plans (NSAP) on Agrobiodiversity Conservation and Sustainable Utilisation (2010-2020).

Farming system

Malaysia has dedicated a sizable proportion of land area to agriculture. As of 2010, Malaysia had more than 6.50 million hectares planted with oil palms and more than 1.5 million hectares planted with rubber tree. In addition, Malaysia dedicated more than 681,000 hectares to rice cultivation and more than 141,000 hectares to coconut plantations. In total, more than 6.2 million hectares or 19 % of Malaysia's total land area is dedicated to the production of 11 major crops. When other minor crops and pasture and rangeland are taken into account, Malaysia's total land area dedicated to agriculture approaches 30 %. Malaysia relies heavily on

its agriculture sector for foreign revenue as well as for domestic consumption and therefore places strong emphasis on monitoring and preserving agricultural biodiversity.

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, monocropping practices are applied (Ramli & Wong 1989).

1.2 Biodiversity for food and agriculture and the delivery of ecosystem services

Agrobiodiversity has long been recognized as the most valuable part of our national resources for sustainable agricultural development. It is the fundamental feature of farming systems that encompasses many types of biological resources for food and agriculture including edible plants and crops, livestocks, microorganisms, arthropods and agro-ecosystem components. Agriculture sector continued to expand in 2015 with a contribution of 8.9 per cent to the Gross Domestic Product (GDP). Oil palm was a major contributor to the GDP of agriculture sector at 46.9 per cent

followed by other agriculture (17.7%), livestock (10.7%), fishing (10.7%), rubber (7.2%) as well as forestry & logging (6.9%) in 2015.

In Malaysia, agrobiodiversity is managed by the Ministry of Agriculture and Agro-based Industry (MOA) and implemented by various agencies under the ministry such as MARDI and DOA. As for PGRFA, these largely consist of various plantations, rice fields, fruit orchards and vegetable farms as well as wild crop relatives conserved *in situ* or *ex situ* and further utilised sustainablely. As an important subsector, the National Strategies and Action Plans on Agrobiodiversity Conservation and Sustainable Utilisation was published in 2010, improved and launched in 2020 to guide the national stakeholders to conserve and sustainably utilised agrobiodiversity resources until 2020.

Assessment and monitoring of biodiversity for food and agriculture

Table 1. Production systems present in the country.

	Production system	**Indicate if present in the country (Y/N)**	**Description**
1	Livestock grassland-based systems	Y	
2	Livestock landless systems	Y	
3	Naturally regenerated forests	N	
4	Planted forests	Y	Overall more than 136,000 ha planted with indigenous timber tree species
5	Self-recruiting capture fisheries	Y	
6	Culture-based fisheries	Y	Importance of the production system to the incomes, livelihoods and well-being of rural communities
7	Fed aquaculture	Y	Importance of the production system to the incomes, livelihoods and well-being of rural communities. Overall 12,600 ha of total area production
8	Non-fed aquaculture	Y	Importance of the production system to the incomes, livelihoods and well-being of rural communities. Total area 15,400 ha
9	Irrigated crops (rice)	Y	Importance of the production system to the incomes, livelihoods and well-being of rural communities. Total area production of rice 674,000 ha with 2.6 million metric tonnes in 2013

10	Rainfed crops	Y	Share of smallholders, Importance of the production system to the incomes, livelihoods and well-being of rural communities
11	Mixed systems (livestock, crop, forest and/or aquatic and fisheries)	Y	Share of smallholders, Importance of the production system to the incomes, livelihoods and well-being of rural communities.

CHAPTER 2: DRIVERS OF CHANGE

Table 2.1. Effect of drivers on sector biodiversity within production systems in the country, by animal (AnGR), Plant (PGR), aquatic (AqGR) and forest (FGR) genetic resources

Production Systems	Drivers	Effect of drivers on sector biodiversity for food and agriculture			
		PGR	FGR	AnGR	AqGR
Livestock grassland-based systems Livestock landless systems	Changes in land and water use and management			-2	
	Pollution and external inputs			NK	
	Over exploitation and overharvesting			-1	
	Climate Change			NK	
	Natural Disaster			-1	
	Pest, diseases, alien invasive species			-2	
	Market, trade and the private sector			1	
	Policies			2	
	Population growth and urbanization			1	
	Changing economic, socio political and cultural factors			1	
	Advancement and innovations in science and technology			1	
Planted forests	Changes in land and water use and management		-2		
	Pollution and external inputs		-1		
	Over exploitation and overharvesting		-2		
	Climate Change		NK		
	Natural Disaster		-1		
	Pest, diseases, alien invasive species		-1		
	Market, trade and the private sector		1		
	Policies		2		
	Population growth and urbanization		1		
	Changing economic, socio political and cultural factors		1		
	Advancement and innovations in science and technology		1		
Self-recruiting capture fisheries Culture-based fisheries Fed aquaculture Non-fed aquaculture	Changes in land and water use and management				-2
	Pollution and external inputs				-2
	Over exploitation and overharvesting				-2
	Climate Change				-1
	Natural Disaster				-1
	Pest, diseases, alien invasive species				-2
	Market, trade and the private sector				1
	Policies				2

	Population growth and urbanization				1
	Changing economic, socio political and cultural factors				1
	Advancement and innovations in science and technology				1
Irrigated crops (rice) Rainfed crops	Changes in land and water use and management	-2			
	Pollution and external inputs	-1			
	Over exploitation and overharvesting	-1			
	Climate Change	-1			
	Natural Disaster	-1			
	Pest, diseases, alien invasive species	-2			
	Market, trade and the private sector	1			
	Policies	2			
	Population growth and urbanization	1			
	Changing economic, socio political and cultural factors	1			
	Advancement and innovations in science and technology	1			
Mixed systems (livestock, crop, forest and/or aquatic and fisheries)	Changes in land and water use and management	-2	-2	-2	-2
	Pollution and external inputs	-1	NK	NK	-2
	Over exploitation and overharvesting	-1	-2	-1	-2
	Climate Change	-1	NK	NK	-1
	Natural Disaster	-1	-1	-1	-1
	Pest, diseases, alien invasive species	-2	-1	-2	-2
	Market, trade and the private sector	1	1	1	1
	Policies	2	2	2	2
	Population growth and urbanization	1	1	1	1
	Changing economic, socio political and cultural factors	1	1	1	1
	Advancement and innovations in science and technology	1	1	1	1

Effects of drivers of change on ecosystem services

Table 3. Effects of drivers of change on ecosystem services

Production systems	Drivers	Effect of drivers on ecosystem services								
		Pollination	Pest and disease regulation	Water purification and waste	Natural hazard regulation	Nutrient cycling	Soil formation and protection	Water cycling	Habitat provisioning	Production of oxygen/gas regulation
Livestock grassland-based systems Livestock landless	Changes in land and water use and management	0								
	Pollution and external inputs	0	-1	-1	-1	-1	-1	-1	-1	-1

systems	Over exploitation and overharvesting	0	-1	-1	-1	-1	-1	-1	-1	-1
	Climate Change	0	-1	-1	-1	-1	-1	-1	-1	-1
	Natural Disaster	0	-1	-1	-1	-1	-1	-1	-1	-1
	Pest, diseases, alien invasive species	0	-1	-1	-1	-1	-1	-1	-1	-1
	Market, trade and the private sector	0	-1	-1	-1	-1	-1	-1	-1	-1
	Policies	0	-1	-1	-1	-1	-1	-1	-1	-1
	Population growth and urbanization	0	-1	-1	-1	-1	-1	-1	-1	-1
	Changing economic, socio political and cultural factors	0	-1	-1	-1	-1	-1	-1	-1	-1
	Advancement and innovations in science and technology	0	-1	-1	-1	-1	-1	-1	-1	-1
Planted forests	Changes in land and water use and management	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Pollution and external inputs	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Over exploitation and overharvesting	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Climate Change	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Natural Disaster	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Pest, diseases, alien invasive species	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Market, trade and the private sector	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Policies	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Population growth and urbanization	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Changing economic, socio political and cultural factors	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Advancement and innovations in science and technology	-1	-1	-1	-1	-1	-1	-1	-1	-1
Self-recruiting capture fisheries Culture-based fisheries Fed aquaculture Non-fed aquaculture	Changes in land and water use and management	0	-1	-1	-1	-1	0	-1	-1	-1
	Pollution and external inputs	0	-1	-1	-1	-1	0	-1	-1	-1
	Over exploitation and overharvesting	0	-1	-1	-1	-1	0	-1	-1	-1
	Climate Change	0	-1	-1	-1	-1	0	-1	-1	-1
	Natural Disaster	0	-1	-1	-1	-1	0	-1	-1	-1
	Pest, diseases, alien invasive species	0	-1	-1	-1	-1	0	-1	-1	-1
	Market, trade and the private sector	0	-1	-1	-1	-1	0	-1	-1	-1
	Policies	0	-1	-1	-1	-1	0	-1	-1	-1
	Population growth and urbanization	0	-1	-1	-1	-1	0	-1	-1	-1
	Changing economic, socio political and cultural factors	0	-1	-1	-1	-1	0	-1	-1	-1
	Advancement and innovations in science and technology	0	-1	-1	-1	-1	-1	-1	-1	-1
Irrigated crops (rice) Irrigated crops Rainfed crops	Changes in land and water use and management	-1	NK	-1	NK	-1	-1	-1	-1	-1
	Pollution and external inputs	-2	-2	-2	NK	-2	-2	-2	-2	-2
	Over exploitation and overharvesting	-1	-2	-2	-2	-2	-2	-2	-2	-2
	Climate Change	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Natural Disaster	NK	NK	-1	-1	-1	-1	-1	-1	NK
	Pest, diseases, alien invasive species	-1	-1	NK	NK	NK	NK	NK	NK	NK

	Market, trade and the private sector	1	1	1	1	1	1	1	1	1
	Policies	1	1	1	1	1	1	1	1	1
	Population growth and urbanization	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Changing economic, socio political and cultural factors	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Advancement and innovations in science and technology	1	1	1	1	1	1	1	1	1
Mixed systems (livestock, crop, forest and/or aquatic and fisheries)	Changes in land and water use and management	-1	NK	-1	NK	-1	-1	-1	-1	-1
	Pollution and external inputs	-2	-2	-2	NK	-2	-2	-2	-2	-2
	Over exploitation and overharvesting	-1	-2	-2	-2	-2	-2	-2	-2	-2
	Climate Change	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Natural Disaster	NK	NK	-1	-1	-1	-1	-1	-1	NK
	Pest, diseases, alien invasive species	-1	-1	NK	NK	NK	NK	NK	NK	NK
	Market, trade and the private sector	1	1	1	1	1	1	1	1	1
	Policies	1	1	1	1	1	1	1	1	1
	Population growth and urbanization	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Changing economic, socio political and cultural factors	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Advancement and innovations in science and technology	1	1	1	1	1	1	1	1	1

Effects of drivers of change on wild foods

Table 4. Drivers affecting the availability, knowledge and diversity of wild foods

Drivers	**Effect of drivers**		
	Availability of wild foods	**Knowledge of wild foods**	**Diversity of wild foods**
Changes in land and water use and management	-2	-2	-2
Pollution and external inputs	-1	-1	-1
Over exploitation and overharvesting	-2	-2	-2
Climate Change	-2	-2	-2
Natural Disaster	NK	NK	NK
Pest, diseases, alien invasive species	-1	-1	-1
Market, trade and the private sector	-1	-1	-1
Policies	1	1	1
Population growth and urbanization	-2	-2	-2
Changing economic, socio political and cultural factors	1	1	1
Advancement and innovations in science and technology	1	1	1

Changes in land and water use and management, over exploitation and overharvesting, climate change and population growth have negatively affecting the availability, diversity and knowledge of wild foods in Malaysia for the last 10 years.

Effects of drivers of change on traditional knowledge, gender and rural livelihoods

Policies plays the most significant effect on the involvement of women in the maintenance and use of biodiversity and traditional knowledge relating to biodiversity for food and agriculture. To improve food security and sustainability drivers such as market, trade, policies, changing economic, socio political and cultural factors with advancement and innovation in science and technology are necessary to be addressed.

Lesson learned and best practices

Biodiversity conservation and management in Malaysia in the past have focused on segmented/ by sector (PGR/AqGR/AnGR/FGR) approach. It is timely that a much more sound approach via ecosystem management to be implemented. This is important to make sure that all ecosystem services/provision that are important for the sustainability of production system will continue giving its services. Malaysia have already kick start this by launching the new National Policy on Biological Diversity 2016-2025 that one of the 5 overarching goal is to safeguarded all our key ecosystems, species and genetic diversity.

CHAPTER 3: THE STATE AND TRENDS OF BIODIVERSITY FOR FOOD AND AGRICULTURE

3.1 Plant, animal, forest and aquatic genetic resources for food and agriculture

Plant genetic resources for food and agriculture (PGR)

Plant genetic resources comprised of indigenous as well as the exotic crops which include rice, cocoa, coconut, vegetables, fruits, field crops, industrial crops, ornamentals and medicinal plants are conserved or maintained as in situ, ex situ either in the seed genebanks or in the field genebanks/ germplasms. Currently, most of plant genetic resources for food and agriculture are located in their natural habitat or in the farmers field. However, the genetic resources of crop plants and their wild relatives at in situ areas have been collected and conserved ex-situ at various institutions or departments. MARDI, being the key agency under the MOA in agrobiodiversity conservation and sustainable utilization, has the largest *ex situ* collections of crop plants such as fruits, herbs and medicinal plants, roots and tubers in the field genebanks and also maintains the largest collection of rice accessions in the seed genebank as well as some accessions of indigenous vegetables species. In addition, DOA Sarawak, Sabah and Peninsular Malaysia also maintain a sizeable plant genetic resources of fruits and medicinal plants in their *ex situ* collection.

Aquatic genetic resources (AqGR)

The information gathered indicates that the farmed aquatic species in Malaysia comprise of the genetic of native species as well as introduced types. In general, the trend in the production of most farmed species is either increasing or stable. The majority of the aquatic organisms farmed in Malaysia are still dependent on the wild seed or brood stock. The genetic improvement of

aquatic species is mostly through traditional selective breeding and to a lesser extent, hybrids and mono-sex with major (70%) effort being supported by the public sector. Although the genetic data for some farmed aquatic species is quite extensive, it is not being fully utilized in their resource management. Only a few of the farmed aquatic species particularly live specimens have been transferred or exchanged with other countries over the past 10 years mostly as brood stocks or for research purposes. The information gathered suggests that sustainable management of AqGR can best be achieved by encouraging continued diversification of fish species throughout the country.

In aquaculture, the main drivers and trends that are shaping aquaculture and their consequences for AqGR are cause by the increased wealth and demand for fish, governance, competition for resources especially freshwater and changes in values and ethics of consumers are foreseen to positively affect the AqGR of farmed aquatic species and their wild relatives. Human population increase and climate change on the other hand will have a negative effect on AqGR.

Animal genetic resources (AnGR)

In relation to animal genetic resources, conservation of these resources comes within the purview of the DVS and MARDI for the improvement of new varieties. Malaysia has a National Animal Embryo Centre (NAEC) and National Institute of Veterinary Biodiversity (NIVB), which to conduct farm animal research and development (R&D) in collaboration with national and international agencies. Market demand strongly influences the development of different farm animal genetic resources. High priority is given to inventory and characterization of AnGR, monitoring trends and risks, and establishing country-based early warning and response mechanisms.

Overall, production system in Malaysia shared common trend which show increasingly intensified and ecologically inappropriate. For example, there has been a corresponding increase in fertilizer

use by the agricultural sector. Potassium fertilizers have shown the largest increase. For period 2010-2011, it's estimated that 1.75 tons of chemical fertilizer per hectare was applied. In 2010 approximately 60 thousand tons of pesticides and pesticides related product was used. Within the last 10 years the use of pesticides and pesticides related product and fertilizers nearly doubled, thus increasing agricultural nitrous oxide emission from 8.4 million tons of CO_2 eq in 2000 to 10.38 million tons CO_2 eq 2010, resulting in degradation of soil structure, loss of biodiversity and changes in the pH value of soil. In 2005, a study conducted by National Hydraulic Research Institute of Malaysia showed that 62% of lakes and fresh water ways were suffering from eutrophication stresses. Rampant NPK fertilizer applications readily washed out by heavy rains has led to eutrophication on a grand scale in watershed throughout Malaysia. The resulting increase in algal blooms quickly strips rivers of their dissolved oxygen, with knock on effects on invertebrate and fish species and ultimately the rural communities that rely on them for their livelihoods and food security.

State and trends of associated biodiversity and ecosystem services

Table 3.1. Trends in the state of components of associated biodiversity within production systems

Production systems	**Trends in last 10 years**			
	Micro-organism	Invertebrates	Vertebrates	Plants
Livestock grassland-based systems	-1	-1	-1	-1
Livestock landless systems	-2	-2	-2	-2
Planted forests	1	1	1	1
Self-recruiting capture fisheries	1	1	1	1
Culture-based fisheries	0	0	0	0
Fed aquaculture	-1	-1	-1	-1
Non-fed aquaculture	0	0	0	0
Irrigated crops (rice)	-2	-2	-2	-2
Rainfed crops	-2	-2	-2	-2
Mixed systems (livestock, crop, forest and/or aquatic and fisheries)	-1	-1	-1	-1

3.2 Pollination and pollinators

Malaysia is known as one of the world mega biodiversity country. One of the indicators of the high diversity in Malaysia is the pollinator species in the country. The diversity of stingless bee in Peninsular Malaysia in previous reports was 29 species 1, 17 species on stingless bee species in virgin jungle forest and 32 species (Mohd Fahimee, 2012). Since 2012, stingless bees has become popular to beekeeper for it's honey and it is a prolific pollinator species in agroecosystems. Since 2012, four species of stingless bees (*Heterotrigona itama, Geniotrigona thoracica, Lepidotrigona terminata, and Tetragonula laeviceps*) were promoted as pollinator species for many important crops in Malaysia and among this four, two species was succesfully domesticated (*Heterotrigona itama* and *Geniotrigona thoracica*) in agroecosystem as meliponiculture. However this number of domesticated species will be increase in future due to shortage of pollinator species in agricultural area.

Stingless bee has been found as a major pollinator of lowland dipterocarp species in Malaysia. Pollination service from insect pollinator has been described by Kamke et al. (2011), the valuation of pollination service provided by insect pollinator mainly from honey bees was about USD 14 billion in USA. In Malaysia, stingless bee was estimated to have a service value of about 66 million per year. Since 2012 stingless bees in Malaysia became a phenomenon due to the high nutrition value in their honey and the pollen also high on market demand. However excess used of pesticide, changing of land title, illegal logging and others are the reasons of declination of pollinator.

Microorganism is one of the important component of biodiversity that been given attention in Malaysia. As its play important role in servicing ecosystem by degrading waste, recycling nutrient from soil and indirectly, balancing the adverse effect of excessive usage of chemical inputs,

especially in agriculture. Introduction of several microbial-based inputs such as biopesticide and biofertilizer are among the main focus given in agriculture.

Ori-X is Metarhizium spp based biopesticide products that have been used to control *Oryctes* sp in oil palm plantation. Beside that exploration of its use to control several pest affecting *Eurycoma sp* is still on going. Meanwhile several biofertilizers, have been developed using microbial as the active ingredients such as *Trico-gold* (*Trichorderma* sp based) and *Myco-gold* (mychorriza based). By introducing biofertilizer and compost, the chemical fertilizer inputs can be reduce. Theoretically the reduction will reduce the greenhouse gases (nitrous oxide) and indirectly reduce the impact on climate change. Malaysia is aiming to reduce the chemical fertilizer input by at least 3-5% in 2020. Besides that, Malaysia also looking at the over harvest issues related to medicinal mushrooms. Hence afford to grow *Lignosus rhinoceros* or more commonly known as *Tiger Milk Mushroom* have been done. So far the afford showed promising results, but whether the knowledge in cultivating the mushroom reduce the harvesting activities from the forest yet need to be prove. Table 3.2 show the some associated biodiversity species.

Conservation of associated biodiversity

Table 3.2. *Ex situ* conservation or management activities or programmes for associated biodiversity for food and agriculture

Components of associated biodiversity	**Organisms, species and subspecies conserved**	**Size of collection**	**Conservation conditions**	**Objectives**	**Characterization and evaluation status**
Microorganism	Food processing micro organism	505 cultures	MARDI	Food processing	Characterized
	Microbial collection	2053 strain	MARDI	Biofertiliser, biocompost, biocontrol, bioremediation, food safety and animal feed	Characterized
Invertebrates	Pollinator/ Stingless bee (Meliponini)	11 species	Live colonies (MARDI)	Pollination/stingless bee honey production	Characterized
	Insects	30,0000 specimen	Insect museum (MARDI)	Referral center for arthropod related to agriculture	characterized

3.3 Pest and disease regulation

Listed below are some of related pest and disease regulation in Malaysia:

1.Plant Quarantine Act 1976

To the control, prevention and eradication of agricultural pests, noxious plants and plant diseases and to extend co-operation in the control of the movement of pests in international trade for matters connected there with.

2.Plant Quarantine Regulations 1981 (amendment 1986)

These Regulations stipulate the requirements which must be met for the importation of plants, plant products, growing media/rooting compost, beneficial organisms, plant pests and carrier of plant pests into Malaysia in order to prevent the entry and spread of noxious plants and pests. The importation of any plant shall be allowed only if in possession of a permit issued by the Director and if accompanied by a phytosanitary certificate. The Regulations further provide for: restrictions on the importation of various plants as specified in the text; importation, eradication and control of dangerous pests; inspection, quarantine, treatment or destruction of plants imported into a component region; powers of Plant Quarantine Inspectors; penalties; etc.

3.MAQIS Bill 2011

Malaysian Quarantine Inspection Services (MAQIS)

Established in 2008 under the Ministry of Agriculture and Agro-Based Industry Malaysia (MOA) as a Department. Integrated services relating to quarantine, inspection and enforcement at entry points for the import and export of plants, animals, carcasses, fish, agricultural produce, soils, microorganism and food; Currently, all entry points at Peninsular Malaysia are under the management of MAQIS.

4. Convention on International Trade in Endangered Species of Wild Fauna & Flora (CITES) Act 2008

3.4 Building and maintaining healthy soils.

Soil is the basis for sustainable food production for mankind. Thus, soil science is a long term requirement to feed the increasing world population. Currently, in Malaysia most soils are changed by weather, human activities etc which have become the largest environmental factor influencing soils and their processes. For many areas, soils and their relationships and spatial sequences of occurrence and properties will be determined by the economic relationships of plots. New relationships of soils are not restricted to a landscape but can exist over all continents. In the future with an advanced economy, the extent of anthropogenic soils will increase drastically. Soil science will continue to be important when its focus is on soil use as main future factor of soil environment, soil development, soil properties and soil functions. Demands to soils are too different that there could be a unique and universal soil quality concept as there is for construction materials for example. Immediately after the deposition of a natural or man-made soil, the environment starts its action by chemical, physical, mechanical and biological processes. Soil development is always a natural process. The high dynamics of destruction, replacement and sealing of soils results in new processes, for example, such for human life fundamental ones as CO_2 accumulation in the topsoil free of humus, change of evapo-transpiration and groundwater renewal. Development of new compounds and organisms, and dispersal of both all over the world is risky. Soils with highly diverse properties have a higher capacity to buffer and to resist adverse effects for a longer time. Such soils give us the chance to detect potential future catastrophe, and to reduce risks.

Organic Farming

In Malaysia, the local organic food industry is still small, as more than 60% of organic food products are imported. Most of the organic products are sold domestically, while some are

exported to Singapore. The perception and understanding of organic food production is based mainly on not using synthetic fertilizers and pesticides. In general, there is a lack of awareness among producers, retailers, and consumers of the wider extent of organic production and processing standards in local markets. The organic food industry is facing several challenges in Malaysia. Although the demand for organic food in Malaysia is growing, the supply of local organic products is not able to keep up with the increased demand. In addition to the inconsistent supply, the variety of local organic food is also limited. Another problem faced by local organic food consumers is the price difference between organic and conventional food. Hence, to match the recent increases in demand, the Malaysian Agricultural Research and Development Institute is actively developing the organic farming sector through various programs and activities.

BioRiCHAR: Biochar based organic fertilizer for improved soil health and sustainable organic crop production

In general, organic fertilizers are low in its nutrient content. Solid organic fertilizers such as compost and manures have slow release rates, requiring soil microorganisms to break down the material into chemical forms that plants can use. Approximately only half or less of the nutrients are released for crop use and others are loss through various mechanisms in the field. This causes the farmers to use organic fertilizers in significantly larger quantity especially for fruity vegetables crops which requires sufficient potassium and phosphorus nutrients for high yield production. Apart from that, current organic fertilizers found in market with high nutrient rates are uncertain of their organic status and resources which is required by MyOrganic guidelines. Malaysia is importing organic fertilizer in high volume to cater the need of high yield crop production and certified organic sources. As to overcome this constraints, an environmental friendly, highly efficient and cost effective solid organic fertilizer namely 'BioRiCHAR' was developed to achieve better crop production through higher nutrient supply and retention for more efficient crop uptake under organic farming system. In addition, the fertilizer was developed following the list of materials allowed by MyOrganic guidelines.

Biochar based solid organic fertilizer 'BioRiCHAR', was developed through the combination of rice husk biochar and empty fruit bunch biochar with selected high nutrient substrates and enhanced with effective microbes, zeolite and plant enzymes. The fertilizer was developed through a composting process. Biochar which is used as a fertilizer base has many advantages such as high in pH, water holding capacity, absorption and nutrient holding capacity and act as microbial carrier which enhances crop growth and yield production. Biochar addition in the developed organic fertilizer, functions mainly to hold the nutrients inside the macro and micropores and will release them slowly in the soil with the presence of water. It was found that composting process of nutrient substrates was accelerated by the addition of biochar through the increase in microbial population and faster in maturity period. Moisture content in the compost with biochar was found higher throughout the composting period as compared to compost without biochar . This helps in reducing compost leachates. Laboratory leaching test and field verification of the developed organic fertilizer showed significantly lesser leaching rates (10-15%) when compared to organic fertilizer without biochar. Higher and more sustainable crop yield production(15-20%) higher than current fertilizer practice

The soils in Malaysia are highly weathered soil as they exist under tropical environment with high rainfall and temperature throughout the year resulting in leaching of plant nutrients and reduced pH. Most of the ultisols and Oxisoils here is lacking in organic matter which is essential to improve the soil quality to supply the nutrient for plants more effciciently. 'BioRiCHAR' which has lesser leaching rates and >65% of organic matter provides more available nutrients sources for crop uptake in the soil. Sufficient amount of NPK especially for fruits vegetables crops and most importantly will be delivered to crops in a more efficient way. High surface area of biochar aslo helps to improve soil structure in relation to porosity (5%) after repeated applications of fertilizer in the field. Application in long term is expected to improve soil physico-chemical properties such as pH, porosity and water holding capacity as well as soil microbial properties

3.5 Natural hazards regulation

Malaysia is geographically located outside the Pacific Ring of Fire. Therefore, it is relatively free from certain severe crises found in neighboring countries. However, Malaysia is vulnerable to natural hazards including floods, forest fires, tsunami, cyclonic storms, landslides, epidemics, and haze. Additionally, the effects of climate change have resulted in an increasing amount of climate related disasters, resulting in a newfound threat to Malaysia's health and development.

Relevant laws are as follows below, such as:

1. Government Standard Operating Procedure (SOP)
2. SOP in Handling Flood Disaster (Volume I)
3. SOP in Handling Industrial Disaster (Volume II)
4. SOP in Handling Forest Fire/Open Burning and Haze (Volume III)
5. SOP in Handling Oil, Gas and Petrochemical Disasters
6. SOP in Handling Earthquake Disaster
7. SOP in Handling Tsunami Disaster
8. SOP in Handling Drought Disaster
9. Police Act 1967
10. Fire Services Act 1988
11. Civil Defense Act 1951
12. SOP on Pandemic/ Endemic Preparedness Plans - MOH
13. Malaysian Maritime Enforcement Agency Act 2004
14. Land Conservation Act 1960
15. Environment Quality Act 1974
16. Local Government Act 1976 ADRC Visiting Researcher_FY2011A Country Report of MALAYSIA
17. Street, Drainage and Building 1974
18. Occupational Safety and Health Act 1994
19. Uniform Building By-Laws 1984
20. Public Order Manual (POMAN)
21. National Contingency Plan for Oil Spill Combat

3.9 State and trends of wild resources used for foods

In Malaysia, many of the wild crop relatives and wild plants for food and agriculture are still found in the forest. Wild fruits require effective protected large areas of undisturbed forests having, ideally, maximum species diversity and high intra-specific diversity for different species to be conserved as *in-situ.* A study on the wild fruit tree species in the National Park or *Taman Negara* showed that only 9% of the wild fruit trees are known, mostly underutilised and need further study (Mohd Shukor *et al*. 2011).

Curently, many of the current plant genetic resources for food and agriculture are mostly located in the their natural habitat or in the farmers field. However, the genetic resources of crop plants and their wild relatives at *in situ* areas have been collected and conserved *ex-situ* at various institutions or departments such as MARDI, DOA, universities and also private sectors in the country.

As the genetic materials are importance for further utilisation, characterization and evaluation of all the accessions are the main activities of the germplasm collections. Most of the accessions are characterized and evaluated using morpho-agronomic characters. Characterization and evaluation will provide diagnostic descriptors for the accession as well as identifying accessions with desirable traits for crop improvement. Evaluation of the materials is carried out by multidiciplinary team consisting of breeders, entomologists, pathologists, agronomist and others. Mohd Shukor *et al.* (2007) reported that in most of the germplasm holdings in the country, the accessions are partially (75-90 %) characterized or evaluated. It is also important to characterize the diversity present in the genepool or genebank collections. Some of the germplasm collections are characterized using molecular markers to determine the genetic diversity in the country e.g. *Durio zibethinus, Ipomoea batatas, Phyllanthus pulcher,* oil palm, *Theobroma cacao* and *T. augustum.* Some collections such as *Andrographis paniculata, Phyllanthus pulcher, Colocasia esculenta, Ipomoea batatas, Averrhoa carambola* and *Ananas comossus*, biochemical markers are used as to characterise and standardise the materials. Only a small portion of the total collections in the country has been evaluated for biotic and abiotic

stress reactions. Therefore, characterisation and evaluation of genetic resources need to be enhanced.

Photo 3.1 *Salacca affinis*

Photo 3.2 *Mangifera pajang*

Photo 3.3*Garcinia hombroniana*

Photo 3.4 *Nephelium lappaceum*

Photo 3.5 Wild *Musa*

Photo 3.6 Wild *Musa*

Photo 3.7 *Spondias pinnata*

Photo 3.8 *Ficus roxburghii*

Photo 3.9 *Dioscorea hispida*

Photo 3.10 Edible aroids conservation plot

Photo 3.11 *Baccaurea polyneura*

Invasive alien species and biodiversity for food and agriculture

Increasing travel, trade, and tourism associated with globalization and expansion of the human population have facilitated intentional and unintentional movement of species beyond natural biogeographical barriers, and many of these alien species have become invasive. Invasive alien species (IAS) are considered to be one of the main direct drivers of biodiversity loss at the global level. It is clear that IAS can produce substantial environmental and economic damage, and their negative effects are exacerbated by climate change, pollution, habitat loss and human-induced disturbance. Increasing domination by a few invasive species increases global homogenization of biodiversity, reducing local diversity and distinctiveness.

IAS can change the community structure and species composition of native ecosystems directly by out-competing indigenous species for resources. IAS may also have important indirect effects through changes in nutrient cycling, ecosystem function and ecological relationships between native species. IAS can also cause cascading effects with other organisms when one species affects another via intermediate species, a shared natural enemy or a shared resource. These chain reactions can be difficult to identify and predict. Furthermore, aggregate effects of multiple invasive species can have large and complex impacts in an ecosystem. A checklist of invasive of organisms in Malaysia could be retrieved from the http://www.chm.frim.gov.my/About-CHM/CBD-Cross-Cutting-Issues/Invasive-Alien-Species.aspx.

National Action Plan for Prevention, containment, Eradication and Control of Invasive Alien Species

The members of this working group consist of agencies working with agriculture, fisheries, veterinary services, environment, irrigation and drainage, wildlife, forestry, public health, medical, research, maritime, transportation, aviation, customs, research institutions and also universities. This working group is headed by the Director General of the Department of Agriculture Malaysia and the Director of Crop Protection and Plant Quarantine Division was elected as the secretariat.

Gap and Priorities

The major gap in information and knowledge on the trends and conservation of associated biodiversity and ecosystem services would be because less priorities being given to this group of biodiversity. Only a few species that recently highlighted such as pollinator (stingless bee) that gaining its popularity for stingless bee honey production being farm. Conservation and utilization of associated biodiversity could only be achieved with support for inventories and research and development through funding by the government.

CHAPTER 4. THE STATE OF USE OF BIODIVERSITY FOR FOOD AND AGRICULTURE

Biodiversity contributed to the production of food for food security and nutrition and agriculture plays a main role in poverty reduction.

4.1 Status of utilization of PGR, AnGR and AqGR

In order to make use of available plant genetic resources for food and agriculture, genetic enhancement and base broadening are being undertaken in a number of crops including rice, sago palm, pepper, selected vegetables and coconut through extensive breeding programme. These crops are economically importance as well as being the staple crop for the country. As far as consumer demand is concerned, some of the tropical fruits have been identified as economically potential through the identification of elite accessions. There were selected based on their yield, superior quality of taste and texture, juiciness and sweetness. With all this consideration, these might increase market demand, farmers income and create new market for economic development.

Lack of information on nutritional values has become one of the causes of less consumption of traditional vegetables and *ulam* species. Therefore, to promote these indigenous and wild species of vegetables and *ulam*, nutritional evaluations and phytochemical analysis were carried out on selected underutilised fruits and traditional vegetable species in searching for high nutritional, high vitamins and high in antioxidant properties. *Ceri terengganu (Lepisanthes sp)*, *jambu ceri (Psidium sp), kundong (Garcinia sp), kerkup (Flacourtia sp), belimbing buloh (Garcinia sp)*, and *cerapu* (*Garcinia sp*) exhibited very high antioxidant activities even higher to that of synthetic antioxidant agent and commercial fruits such as guava and orange. While for traditional vegetables and *ulam* species, *bebuas (Colubrina asiatica)*, *beluntas (Pluchea indica)* and *gajus (Anacardium occidentale)* showed high antioxidant activity (FRAP assay) more than 70% radical scavenging effect and can be potentially promoted to farmers for plantation. Currently, cultivation, pre-breeding activities and development of product have also been carried out extensively.

Malaysian AqGR is composed of genetic of native species as well as introduced types. Majority of the AqGR still relies on the collection of brood stock or seed from natural populations because of the low domestication levels in fisheries in contrast to animal farming and agriculture. At present, there is a very limited broodstock development program for fish species with major efforts mostly by the government. Sustainable management of AqGR can best be achieved by encouraging continued diversification of fish species throughout the country. Biotechnologies are only used in some extent for genetic improvement of farmed aquatic organisms. Nevertheless, simply having a domesticated species or genetically improved species is not sufficient to guarantee optimum production from an aquaculture facility. There are many other factors that are responsible in the aquaculture production and management.

4.2 Associated biodiversity species managed for the provision of ecosystem services

Table 4.1. List of associated biodiversity species that are actively managed in production systems for the provision of ecosystem services.

Associated biodiversity species	**Ecosystem functions and services provided by the species in the production system**
Heterotrigona itama (stingless bee)	Provide ecosystem service as pollinating agents in agriculture ecosystem in many fruits/herbs/forest species
Geniotrigona thoracica (Stingless bee)	Provide ecosystem service as pollinating agents in agriculture ecosystem in many
Metarhizium spp	Control *Oryctes* sp in oil palm plantation

4.3 Management practices promoting the conservation and sustainable use of biodiversity for food and agriculture

Table 4.1. Management practices that are considered to favor the maintenance and use of biodiversity for food and agriculture

Production system	**Management/ diversity based practice**	**Trends in the application of the practice over the past ten years**
Farm animal Production	Feedlot Management System and Free Range Rearing	Utilization of local genetic resources adapted to environment for meat, milk and eggs
Agriculture production	Integrated Pest Management (IPM)	Crop rotation; inter-cropping; seedbed sanitation, sowing dates and densities, under-

		sowing, conservation tillage, pruning and direct sowing; where appropriate, use of pest resistant/tolerant cultivars, push-pull strategies and standard/certified seed and planting material; balanced soil fertility and water management, making optimum use of organic matter; prevent spreading of harmful organisms by field sanitation and hygiene measures; protection and enhancement of important beneficial organisms.
	Sustainable Soil Management Practices	Monitoring soil erosion losses on various soil types on different slope conditions; Erosion Risk Map of Peninsular Malaysia and Sloping Land Development Guidelines were established
	Home Gardens	Increasing trend. Promoting edible home gardens and kitchen garden, use of green kit, fertikit with self-watering system
	Landscape management	Eco-engineering approach
	Organic agriculture	SALM and MyOrganic certification
Aquatic production	Conservation hatcheries	Tagal/Tagang system- Community based fisheries management in Sabah/Sarawak Tagal System in Sabah [252 villages in 13 districts encompassing more than 100 rivers]
		Fish Sanctuary in Kuala Kubu Baru,
		Kelah (Tor sp.) sanctuary in: •Lubuk Tenor, Sungai Tahan, Taman Negara, Pahang, Malaysia •Sungai Relau, Merapoh, Pahang, Malaysia •Sungai Petang in Tasik Kenyir, Terengganu, Malaysia

4.4 The use of food-processing micro- organisms

It is well known that lactic acid bacteria (LAB) have been widely used as starter culture for the manufacturing of various fermented foods such as dairies, beverages, meat and vegetables etc. They are a group of related bacteria that produce lactic acid as a result of carbohydrate fermentation. LAB are important in the food and dairy industries because the lactic acid and other organic acids produced by these bacteria act as natural preservatives as well as flavor enhancers.

LAB find increasing acceptance as probiotics which aid in stimulating immune responses, preventing infection by enteropathogenic bacteria, and treating and preventing diarrhea (Reid, 1999). Beside lactic acid and other organic acids, LAB also produce many other metabolites such as enzymes, phenolic compound, amino acids, vitamins and many more based on their genetic information. This criterion leads to its functional properties such as anti-cancer, anti-tumor, anti-inflammatory, anti-cholesterol etc.

Development of Collection of Functional Food Cultures (CFFC) by MARDI is in line with Malaysian effort to establish National Culture Collection with the initiatives to conserve, manage and utilize agro-biodiversity resources as national heritage for future generation. It is a center of collection for functional food cultures with the aim to preserve functional food microbes which consist of bacteria, yeast and fungi with systematic database profiling of Malaysian fermented foods such as fermented fish, fermented vegetables, 'tapai', soy sauce, nata, vinegar, yogurt, tempeh and other fermented foods.

A total of 505 functional food cultures from indigenous fermented foods such as fermented fish, fermented vegetables, 'tapai', soy sauce, nata, vinegar, yogurt, tempeh and other fermented foods have been screened, isolated, characterized and identified. These fermented food samples were collected from all over Malaysia. The cultures were determined for their tolerance towards high temperature, acidity, salinity and tested for antimicrobial and protease activity. Identification of these cultures was done using polymerase chain reaction method. Proper preservation techniques were applied to maintain its viability and quality assurance in the production of our authentic fermented food cultures. All functional food cultures were stored and preserved *via* 3 preservation techniques i.e glycerol stock, freeze-dried and cryo preservation. A catalogue system has been set up and database with detail information of functional food cultures was uploaded for reference. A standard operating procedures (SOPs) is applied to ensure the proper storage and authentic functional starter cultures.

The main core business of CFFC is to supply reliable and specialized starter cultures demanded by local entrepreneurs and private sectors. CFFC development will ensure the continuous supply of pure starter cultures for production of fermented foods, while improving its quality and productivity to ensure its competitiveness with international fermented food products such as kimchi, sauerkraut, nato and kefir. It also serves as a depository center for functional starter cultures acquired by any research institutes or universities. Systematic database system can be potentially to be adopted in research institution, universities and private sectors whereby it acts as a platform for extended development of future functional products using our pure starter cultures collection.

To date, a few starter cultures have been commercialized and successfully supplied to hundred entrepreneurs for the production of fermented food products including nata, tempeh, yogurt, tapai, soy sauce, and etc. to improve livelihood of low-income earner. CFFC has become one stop center and serves as a role model for local and foreign visitors to learn and seek advice on the use of good microorganisms. Many universities student and private sectors have been visiting our culture center for consultation and technical support guidance. CFFC also provides few industrial training on the production of fermented foods for local SMEs twice a year as an effort to improve SMEs incomes and opportunities to exploiting our local agro resources. Specific skills on the handling and microbial preservation always been conducted “in-house” to ensure the proper maintenance of our culture collection and give our best servicing to the public.

Gap and priorities

Major gap with respect to the use of management practices or actions that favor or involve the use of biodiversity for food and agriculture would be because farmers choose farming practices intensification and monocropping that usually have negative impact to associated biodiversity. Incentive should be given to farming practices that promotes eco-friendly approaches that will in turn improve productivity, food security and nutrition, livelihoods, ecosystem services, sustainability, resilience and sustainable intensification. Other than that government should give priorities and emphasize to such practices through mainstreaming of ecosystem services.

CHAPTER 5: THE STATE OF INTERVENTIONS ON THE CONSERVATION AND USE OF BIODIVERSITY FOR FOOD AND AGRICULTURE

5.1 The state of the characterization

Table 5.1: Summary of Malaysia's overall biodiversity richness

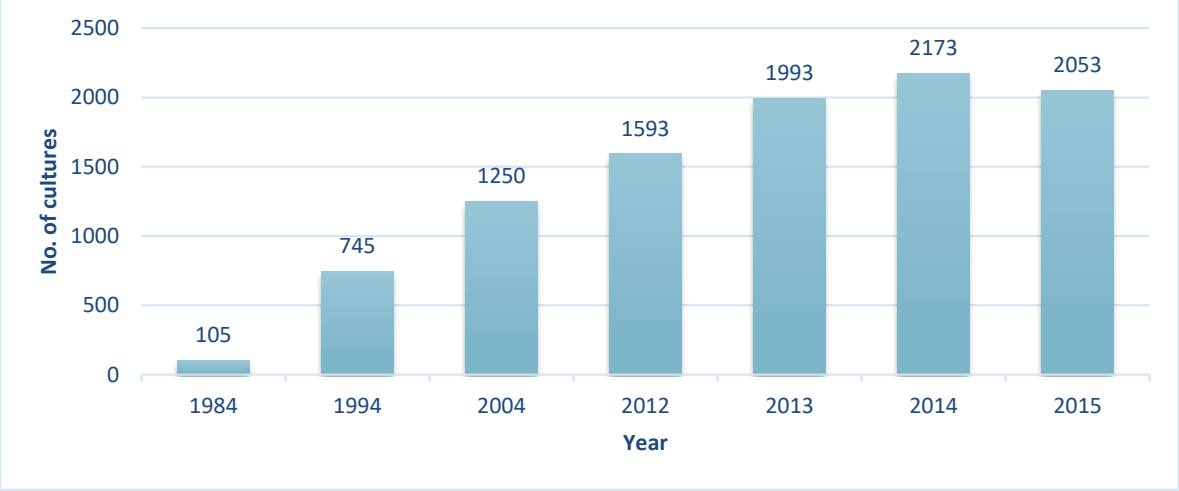
Mammals	306
Birds	742
Reptiles	567
Amphibians	242
Marine Fishes	1,619
Freshwater Fishes	449
Invertebrates	150,000
Vascular Plants	15,000
Fungi	4,000
Mosses	522
Hard Coral	612

Source: Ministry of Natural Resources and Environment, 2013

5.2 The state of characterization of microorganism

Characterization of microorganism being carried out by various agencies and institution and mostly on species of interest of specific use. In MARDI the collections activities has started between 1980's to 1990's. The oldest cultures in MARDI were dated 1984 and most of the cultures with duplicated ID. MARDI Microbial Culture Collection (MMCC) in MARDI is consist of 2 main centres; Agrobiodiversity & Environment Research Centre and Biotechnology Research Centre.

Table 5.2. Number of strain in MARDI Microbial Culture Collection (MMCC) based on year



5.3 Conservation of Genetic Resources for Food and Agriculture

5.3.1 Conservation of Plant Genetic Resources (PGR)

In situ and ex situ conservations are the important area that is highlighted in the National Strategies and Actions Plan on Agrobiodiversity Conservation and Sustainable Utilization (2011-2020). It is also being importantly highlighted in Malaysian Biodiversity Policy (1998, revised in 2015). Many of the wild crop relatives and wild plants for food and agriculture are still found in the forest. Wild fruits require effective protected large areas of undisturbed forests having, ideally, maximum species diversity and high intra-specific diversity for different species to be conserved as *in-situ.* A study on the wild fruit tree species in the National Park or *Taman Negara* showed that only 9% of the wild fruit trees are known, mostly underutilised and need further study (Mohd Shukor *et al*. 2011). A total of 820 species in 294 genera and 78 families of trees measuring more than 1 cm diameter at breast height were enumerated in a 50-ha plot in Pasoh Forest Reserve, a lowland Dipterocarp forest recognized as an excellent example of *in situ* conservation. Of these, 76 species are known to bear edible fruit and the most diverse species are the mango species (12 *Mangifera* spp.), mangosteen (13 *Garcinia* spp.) and rambutan (5 *Nephelium* spp.). Generally, the most common fruit tree genera found in the forests are *Artocarpus, Baccaurea, Durio, Garcinia, Lansium, Sandoricum, Bouea, Mangifera, Cynometra, Dialium, Parkia, Nephelium* and *Xerospermum* (Chung *et al.*, 2005). Many medicinal plant species are also found in the protected forests of Malaysian rainforest and about 1,200 plant species have been estimated to have medicinal value (Saw *et al.*, 1991). Scientific studies on these medicinal plants are very limited and only 22% of the flora of Malaysia or less than 15% of the total flora of Malaysia were studied for their phytochemical properties (Soepadmo, 1999).

Malaysia has participated in regional in situ conservation initiative under Global Environmental Facility through UNEP starting in the year 2009 to 2013 for the conservation and sustainable use of underutilized tropical fruits species (*Mangifera, Garcinia* and *Nephelium*). The main objective is to conserve *in situ* and on farm of tropical fruit tree genetic resources through strengthened capacity of farmers, user groups, local communities and institutions to sustainably

apply good practices and secure benefits. For the ex situ conservation of PGR, more than 13,000 accessions of rice, cocoa, coconut, vegetables, fruits, field crops, industrial crops, ornamentals and medicinal plants are conserved or maintained as ex situ either in the seed genebanks or in the field genebanks in various institutions (Table 5.3).

Table 5.3. Seed and field genebanks of plant genetic resources in various institutions

Crop	MARDI[1]		DOA PM[2]		DOA Sabah[3]		DOA Sarawak[4]	
	No. of Sp.	No.of Acc.	No. of Sp.	No.of Acc.	No. of Sp.	No.of Acc.	No. of Sp.	No.of Acc.
Rice	12	12,883	-	-	-	-	2	1,651
Fruits	168	2,831	109	900	75	7,118	204	997
Vegetables	69	2,042	5	5	4	11	20	648
Medicinal plants	307	532	95	95	105	200	240	240
Aromatic plants	1	40	-	-	-	-	-	-
Biopesticidal plants	9	15	-	-	-	-	-	-
Spices		300	-	-	-	-	-	-
Roots and tubers (Taro)	2	120	-	-	-	-	-	-
Ornamental plant	1	1000	-	-	-	-	-	-
Sugar cane			-	-	-	-	-	-
Coconut	1	45	-	-	-	-	-	-
Coffee	2	74	-	-	-	-	-	-

[1]Malaysian Agricultural Research & Development Institute [2]Dep. of Agriculture of Peninsular Malaysia
[3]Dept. of Agriculture Sabah [4]Dept. of Agriculture Sarawak

Malaysia has a regional project entitled “Enhancing understanding and implementation of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) in Asia” under the Treaty which was funded by the Government of Japan. In the project, ex situ conservation and implementation of high international genebank standard are amongst the important priority commitments needed from the member countries. Another on-going GCDT project is the collection of crop wild relatives (CWR) in Malaysia, with the objectives to conserve and duplicate crop wild relatives of commercially important cultivated rice, banana, sweet potato, pigeon pee and eggplant seeds to the Millennium Seed Bank, RBG Kew.

5.3.2 Conservation of AqGR

It is essential to prevent unlimited exploitation of wild germlasm resources and put in place a strategy for sustainable utilization of resources. Realizing the importance of this, Malaysia has

taken strategic steps in the in situ conservation of aquatic genetic resources using appropriate approaches. The most effective in situ conservation technique practised in Malaysia is Tagal/Tagang system i.e. a simple yet effective approach to good stewardship of the river based on community management which not only helps to conserve biodiversity but also rejuvenates fish. Other in situ conservation measures adopted are marine and freshwaters protected areas, fish sanctuaries, fish inventorisation, “state fish” initiatives, close-season, capture fisheries zonation, CITES implementation and captive propagation of threatened and endangered fish.

The ex-situ programs are through the establishment of a repository of marine and fresh waters fish biological materials (living specimens, DNA and cryo-preserved semen). In addition species specific semen cryopreservation protocols are established to support the ex situ conservation works. Besides that, live breeding organisms were also cultured and maintained at various centers to contribute to the ex situ conservation of aquatic genetic resources.

5.3.3 Conservation of Animal Genetic Resource (AnGR)

Agriculture is crucial to the Malaysia economy especially in term of food production and food security. It is important to our life and our future generation. Agriculture forms an integral part of the rural infrastructure, is a significant employer particularly in rural areas and has a vital role in conserving biodiversity and the natural environment. However, Malaysia currently in the process of transformed the agriculture industry to the more modern industry. Under Malaysia's Agro-food policy (2011-2020), the key thrusts are high-value agriculture development, sustainable agriculture development, private sector investment to modernize the sector and knowledgeable and informed human capital. Livestock development is one of the specific strategies to achieve the policy's objectives.

Gene flow mainly moving from developed countries into Malaysia. Government implemented a policy of importing exotic breeds. A quite large exotic breeds have been imported, which are beef cattle from Australia, Jersey-Friesian dairy cattle from Australia and New Zealand, and commercial poultry (broiler and layer breeders) from USA and Europe. Importation of these

breeds are predicted to continually increase. Malaysia has also imported small ruminants (sheep and goats) from neighboring countries and Middle East. Malaysia, also involved in further development of our local dairy and beef breeds. Under government initiative, Dairy Belt Valley has been initiated to further develop the dairy industry which also involved enhancement of local dairy breed, Mafriwal. The local beef breed, Kedah Kelantan will be further enhanced through proper breeding program conducted by the Department of Veterinary Services (DVS) and Malaysian Agriculture Research and Development Institute (MARDI). However, the swamp buffalo population is slowly decreasing mainly because buffalo are no longer used as draft animals but they are still in demand for beef. Swamp buffalo are not crossed with other breeds and kept pure and under an extensive management system. Murrah buffalo are kept for milk production. More recently, Dorper and Damara breeds have been imported. However no specific breeding program in place for the breeds.

Only the public sector is involved in *in-situ* conservation. Breeds conserved include the Kedah-Kelantan cattle, Katjang goats, Barbados Blackbelly sheep and Kampong (local) chicken. However, for specific breed such as Kedah Kelantan and Mafriwal, special program and incentive has been planned to develop the multiplier farmers. This will involve in distribution of the selected breeding stock, herd management software and expertise service and consultation. At the same time, the proper breeding program will be enhanced in the government farms through proper data collection and management. National Data Center for farm animal genetic resources (FAnGR) is planned to be developed and will be managed by the national focal point. This will overcome our main weakness which is the absence of an improved, automated, cost effective database supporting more regular monitoring and evaluating of breeds.

The national focal point for animal genetic resources is the National Institute of Veterinary Biodiversity in Jerantut, Pahang. To further strengthen the management of the FAnGR in the country, a National Farm Animal Genetic Resources Technical Working Group has been established in 2015 under DVS. This is one of the action plan under National Strategies and Action Plans for Agrobiodiversity Conservation and Sustainable Utilization 2012.

There is a cattle artificial insemination (AI) service run by the DVS but limited coverage due to shortage of manpower. Further action need to be taken to spur the artificial insemination industry in Malaysia especially in dairy cattle. AI service in Malaysia is mostly utilized for the development of terminal beef breed and this focus need to be changed through education and awareness of proper genetic improvement program.

5.4 Information management

Table 5.4 National information systems on associated biodiversity in the country

National information system	Component of associated biodiversity addressed (list)	Concise description of information system
AgrobIS	The system once fully operational will contain germplasm information of more than 40,000 accessions of Plant Genetic Resource for Food and Agriculture (PGRFA) which includes fruits, rice, vegetables, and medicinal plants. The system also consists of information on 2,500 isolates of microbial genetic resources and more than 30,000 specimens of arthropods. -Biodiversity associated to agriculture -Also will include farm animal -Also include DNA Genebank database -Include Seed Management Information System (SMIS) for rice	AgrobIS is an information system developed by MARDI to provide the public direct access to data of all biological genetic resources conserved at MARDI. Agricultural biodiversity information system or AgrobIS was developed originally to fulfill the need for easy access to information on biological resources currently held at various genebanks, microbial resource collection centre and arthropod repository facility in MARDI
MePHIS	Medicinal Plant Information System	Information of plants used for medicinal purposes. System was developed by MARDI
Mybis	Biodiversity	Malaysia Biodiversity Information System (MyBIS) is an enhancement and rebranding of Malaysia Biological Diversity Clearing

		House Mechanism (MyCHM). This website aims to be a one-stop repository for biodiversity information in Malaysia. http://www.mybis.gov.my/
FishBOLD	DNA sequence Species names Distribution Level of endangerment	
FishBASE	Species names Distribution	
Fisheries Annual Statistic	Production figures	
Malaysian Genome Institute	DNA sequence Genes and genotype Species names	

Sarawak Biodiversity Centre is developing the traditional knowledge database related to biodiversity found in Sarawak. The main output will be a Bioinformatics Data Centre for biodiversity or biological resources databases, research and development; a natural product library and inventory system; traditional knowledge databases on the State's indigenous communities.

5.5 Initiatives in the country

Landscape based initiatives to protect or recognized areas of lands or water in the country with particular significance for biodiversity for food and agriculture

Landscape based initiatives	**Description of sites and their characteristics of relevance to biodiversity for food and agriculture**	**Extent (Area)**
Central Forest Spine Master Plan	The Central Forest Spine of Peninsular Malaysia is composed of four (4) main forest complexes, and an important natural landscape of Malaysia. The complex of forest supplies 90% of the	Covers an area of approximately 5.3 million hectares; over 40% of the total terrestrial area and over 91% of forest areas in Peninsular Malaysia. Roughly 80% of the CFS areas are PRFs,

	population's water supply through its numerous watersheds. Additionally the CFS also provides other services such as climate regulation, soil protection, and carbon storage and sequestration. The CFS also harbours the remaining population of Malayan tigers within its forests.	comprising mainly of production forests and protection forests. Of the remaining 20%, 12.4% consists of national and state parks, and the remainder is comprised of cultivated land, under both state and private tenure, including plantations of oil palm, rubber and planted forest.
The Heart of Borneo Initiative	The Heart of Borneo Initiative is a voluntary transboundary cooperation between Malaysia, Indonesia and Brunei, seated upon sustainable development foundations aimed at conserving and managing the contiguous tropical forests in the island of Borneo. The Declaration that endorsed the Initiatives was signed by the three governments in 2007.	The HoB area covers approximately 200,000 km2 of ecologically inter-connected rainforest in the provinces of Indonesia (Kalimantan), Malaysia, (represented by states of Sabah and Sarawak amounting to 61,000 km2), and Brunei Darussalam. The total of approximate area for the HoB is around 30% of the island's land area.
Conservation and sustainable use of cultivated and wild tropical fruit diversity: promoting sustainable livelihood, food security and ecosystem services	The five year project is funded by Global Environment Facilities (GEF) and United Nation of Environmental Programme (UNEP) and ended in December 2014. It was regionally coordinated by Bioversity International and implemented in India, Indonesia, Malaysia and Thailand. The project was started in 2009 with the cost of USD 663,000.	Six sites were selected for on-farm conservation i.e. Yan (Kedah); Bukit Gantang (Perak); Serian and Sibuti (Sarawak); Papar and Kota Belud (Sabah). In the country, MARDI is the coordinating agency with other national partners; Department of Agriculture (Peninsular), Department of Agriculture Sarawak and Department of Agriculture Sabah. This project was only focused on main, important and widest family of fruit trees from genus Mangifera, Nephelium and Garcinia.

The Coral Triangle Initiative-Coral Reefs, Fisheries and Food Security (CTI-CFF)	Malaysia commitment in ensuring marine ecosystem remains healthy transpire by became a part of the six (6) nations (CT6) Coral Triangle Initiative in 2009.	The boundaries of the Coral Triangle are defined as covering all or part of the exclusive economic zones of six (6) countries: Indonesia, Malaysia, Papua New Guinea, the Philippines, the Solomon Islands and Timor-Leste. These boundaries encompass only part of Malaysian waters i.e. Malaysian waters in the Sulu Sea and Sulawesi Sea that is premised mainly in the coasts of Sabah.

CHAPTER 6: FUTURE AGENDAS FOR CONSERVATION AND SUSTAINABLE USE OF BIODIVERSITY FOR FOOD AND AGRICULTURE

6.1 Stakeholders in the management of biodiversity for food and agriculture

The principal stakeholders with interest in GRFA include the farmers, private companies, government agencies, universities and academic communities, NGOs. There is no discrimination imposed on women or indigenous people/local community in any activities regarding farming, fishing, culturing, managing or conserving the genetic resources.

Table 6.1. List of stakeholders involved in the management of AqGR, PGR dan AnGR for food and agriculture

List Stakeholders for AqGR	Area of research
Fisheries Research Institute, Department of Fisheries Malaysia	• Basic knowledge on aquatic genetic resources • Characterization and monitoring of aquatic genetic resources • Communication on aquatic genetic resources • Conservation of aquatic genetic resources • Access and distribution of aquatic genetic resources
University of Science, Malaysia	• Basic knowledge on aquatic genetic resources • Characterization and monitoring of aquatic genetic resources • Communication on aquatic genetic resources
University of Malaya, Kuala Lumpur	• Basic knowledge on aquatic genetic resources • Characterization and monitoring of aquatic genetic resources • Communication on aquatic genetic resources
University of Malaysia, Sabah	• Basic knowledge on aquatic genetic resources • Characterization and monitoring of aquatic genetic resources • Communication on aquatic genetic resources
University of Malaysia, Terengganu	• Basic knowledge on aquatic genetic resources • Characterization and monitoring of aquatic genetic resources • Communication on aquatic genetic resources
University Putra Malaysia, Serdang, Selangor	• Basic knowledge on aquatic genetic resources • Characterization and monitoring of aquatic genetic resources • Communication on aquatic genetic resources
WorldFish Centre, Penang, Malaysia	• Basic knowledge on aquatic genetic resources • Communication on aquatic genetic resources•

	• Access and distribution of aquatic genetic resources
List Stakeholder for Plant Genetic Resources	Crop Group
University of Sarawak, Malaysia (UNIMAS)	Sago
Sabah Park	Roots and tubers; Fruits
International Islamic University Malaysia (UIAM)	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 (MINT)	Cereals; Grain legumes; Fruits; Forages; Oil plants
Department of Forestry, Peninsular Malaysia (DOF)	Oil plants
Department of Agriculture (DOA), Sabah	Cereals; Oil plants
Malaysian Rubber Board (MRB)	Rubber; Tree crops
Horticulture Research Centre, MARDI	Fruits; Vegetables
National University of Malaysia (UKM)	Fruits
Malaysian Cocoa Board	Cocoa
Malaysian Pineapple Industry Board	Fruits
List stakeholders for AnGR	
Department of Veterinary Services (DVS)	
Malaysian Agriculture Research and Development Institute (MARDI)	Research and development. Characterization and monitoring of animal genetic resources • Communication on animal genetic resources
University Putra Malaysia, Serdang (UPM)	Basic knowledge on Farm Animal genetic resources • Characterization and monitoring of animal genetic resources • Communication on animal genetic resources

6.2 State of cooperation

Collaboration between institutions and organizations

In Malaysia, from umbrella institutional view point on biodiversity governance, the previous National Biodiversity-Biotechnology Council is now known as the National Biodiversity Council

(NBC) with a more focused function on biodiversity related issues. Specifically the NBC would determine and endorse the direction, policy and strategies for conservation of biodiversity. The NBC is chaired by the Deputy Prime Minister and serves as a platform discussion and dialogue on biodiversity matters between the federal and state governments. The Ministry of Natural Resources (NRE) as the focal point to the CBD plays a major roles in coordinating matters related to biodiversity in Malaysia. Ministry of Agriculture and Agro based Industry (MOA) working together with NRE in monitoring and coordinating activities and planning biodiversity related to agriculture.

The new National Policy on Biological Diversity 2016-2025 (NBSAP) encompassed every aspect of sustainable development of biodiversity in the country. The NBSAP also integrated the National Strategies and Action Plans on Agricultural Biodiversity Conservation and Sustainable Utilization (NSAP) in the policy as to ensure that the agricultural sector in Malaysia uses its biological resources in sustainable manner.

Aspects covered under this document (NSAP) include:-

i. Plant genetic resources for food and agriculture, including pasture and rangeland species and forest genetic resources of trees that are an integral part of farming systems;
ii. Animal genetic resources for food and agriculture, including fisheries as part of the farming system, and insect genetic resources; and
iii. Microbial and fungal genetic resources.

The implementation of these National Policy on Biological Diversity 2016-2025 will contribute towards the achievement of the Aichi Biodiversity Targets.

Regional cooperation

Malaysia's participation in international collaboration on plant, aquatic and farm animal genetic resources, and their wild relatives. Having ratified to various conventions, Malaysia has

incorporated into the national policy, the set of commitments under the treaty including national strategies, legislations, bilateral research programs, plans of action, codes of practices or programmes. Malaysia recognized the importance to enhance implementation of international instruments including national policies and plan of actions and doing her best to ensure that specific consideration on the issues of conservation and management of PGR, AnGR, FGR and AqGR. This call for more collaboration especially on improving capacities for characterization and monitoring, genetic improvement, economic valuation and conservation of biodiversity genetic resources.

Table 6.2. Regional and/or international initiatives targeting the conservation and sustainable use of biodiversity for food and agriculture, and in particular associated biodiversity

No.	Name of Networks	Description
1	International Coconut Genetic Resources Network (COGENT)	PGR
2	Asian Network for Sweetpotato Genetic Resources (ANSWER)	
3	International Network For Bamboo And Rattan (INBAR)	
4	Banana Research Network for Asia Pacific (BAPNET)	
5	Asia-Pacific Seed Association (APSA)	
6	International Seed Testing Association (ISTA)	
7	International Rice Research Institute (IRRI)	
8	The World Vegetable Centre (AVRDC)	
9	Consultative Group on International Agricultural Research (CGIAR)	
10	International Society of Horticulture Science (ISHS)	
11	CABI	
12	International Tropical Fruit Network (TFNet)	
13	Bioversity International	
14	Crops for the Future Research Centre (CFFRC)	
15	Global Crops Diversity Trust (GCDT)	
16	Royal Botanic Gardens, Kew, United Kingdom	
17	Institut Pertanian Bogor (IPB), Indonesia	
18	Filipina Tropical Fruit Commissions	
19	Inter-governmental Science-Policy Platform of Biodiversity and Ecosystem Services (IPBES)	Assiociated biodiversity
19	WorldFish	AqGR
20	Heart of Borneo (HoB) Initiatives	FGR
21	Indonesia and Malaysia Transboundary Conservation Area (TBCA)	

6.3 The state of education and training

Nowadays, there are many research institutes and universities providing a short course/trainings related to the conservation and sustainable use of biodiversity. In fact, several courses on long-term education such as Master of science and Doctor of Philosophy are now available in local universities. As example, Universiti Putra Malaysia, Universiti Malaya, Universiti Kebangsaan Malaysia, Universiti Malaysia Sarawak and Universiti Malaysia Sabah are well known for their capabilities and well-equipped facilities to provide proper education related to conservation. At present, the numbers of higher learning institutions which offered the programmes related to biodiversity conservation in this country are increasing including private institutions such as Universiti Malaysia Terengganu (UMT), Universiti Tun Hussein Onn Malaysia (UTHM), Universiti Selangor (Unisel) & Universiti Nottingham Malaysia.

Meanwhile, research institutes (RI) such as MARDI, FRIM, DVS, DOF, MCB, SBC and Sabah Parks are engaged with research and development capacity to enhance biodiversity conservation and sustainable utilization in the country. RI also provide short courses/training based on their needs and capacities to promote the biodiversity conservation activities. As mention in the NSAP, training for local communities to identify, catalogue and manage wild crop relatives and wild food crop are needed throughout the country to strengthen the conservation and sustainable use of PGRFA. As example, training course on collection, handling and quality seed processing of crop wild relatives (CWR) was held in MARDI with the collaboration and funding from Millennium Seed Bank, Royal Botanic Garden, Kew London. MARDI also has initiated an education programme named Green Shoots Tani Warrior (GSTW) for kids to encourage them in the agriculture and technologies used at young age. However, there are many things need be done and this include on farm and in situ management of PGRFA. As for animal genetic resources, KAP (Knowledge, Attitudes, Practices) study is required to identify and determine the awareness status of farm animal genetic resources. Meanwhile, trainings and fieldwork related to arthropod biodiversity (pollinators, parasitoids and predators, protein, food, medical and pharmaceutical applications) are needed in order to strengthen the biodiversity curriculum in schools and universities. Similar

to microbial genetic resources for food and agriculture, which also required proper trainings and better understanding to obtain economic benefits from its' sustainable use.

As in AqGR, the stakeholders with interest and their roles in AqGR of farmed aquatic species and wild relatives. The findings in this chapter point to the fact that the fish farmers, fishers, fish hatchery people and fishing/aquaculture associations and consumers in Malaysia are vague about AqGR and its importance, more so, their roles in AqGR conservation. Their technical knowledge on the application of modern genetic techniques in aquaculture is very minimal. Although they are concerned about the threatened resources, their priorities are more on production and marketing. On the other hand, the aquatic protected area managers, policy makers, non-governmental organisation and the donors are more enlightened about AqGR and play substantial roles with regards to AqGR. The communication between these two groups is very crucial in order for the implementation of conservation strategies and management plans of AqGR farmed aquatic species and their wild relatives to be successfully achieved. Increased awareness on conservation strategies and management plans, combined with building stronger capacities among most stakeholders should be a priority. Donors and intergovernmental organisation have indirectly helped Malaysia in the sustainable use and conservation of AqGR. The indigenous and local communities have shown an outstanding accomplishment in the community based management of AqGR. This is proven as indigenous knowledge reflects many generations of experience and problem-solving method. It represents valuable information on how previous communities have interacted with their changing environment including its floral and faunal resources

As summary, education programmes and trainings are essential to create and awareness among public and stakeholders especially policy makers and authorities for understanding of conservation and sustainable use of associated biodiversity.

6.4 The State of research

National research programmes very much support the conservation, sustainable use and development of GRFA and their wild relatives. However it lacks focus and coordination between the researchers and agencies involved. This could explain why some of the results obtained on GRFA have not been adopted for biodiversity management.

Generally, Malaysia has sufficient basic expertise needed for the sustainable management of its GRFA. However, new situations and challenges (such as climate change, increase in pollution level, competition for areas and waters, new diseases etc) result in a need for capacity building within those areas, in order to secure appropriate management of GRFA in the future.

6.5 The state of implementation of the ecosystem approach

Recognizing the importance of biodiversity, Malaysia has continued to safeguard its natural resource capital by improving and strengthening existing provisions of policy, legal and institutional frameworks. Conservation and sustainable use of biodiversity has always been addressed within the context of sustainable development in Malaysia. Conservation of biodiversity has been mainstreamed in various Malaysia Plans as well as in several national and state's policies. Furthermore, its policy to retain at least 50% of its land under permanent forest cover in perpetuity and designated sites as RAMSAR/MAB has contributed to the maintenance and enhancement of global biodiversity values, GHG emission reduction and GHG sequestration. While all the national documents and action plan including the retention of 50% of land as forest cover in perpetuity nationwide appears to provide a degree of confidence that important ecosystems and biodiversity will be maintained, however there remains a considerable pressures to overall maintenance of the nation's ecological homeostasis and critical biodiversity hotspots throughout the country.

6.6 Policy and legal frameworks

Recognizing the importance of biodiversity, Malaysia has continued to safeguard its natural resource capital by improving and strengthening existing provisions of policy, legal and institutional frameworks. Conservation and sustainable use of biodiversity has always been addressed within the context of sustainable development in Malaysia. Conservation of biodiversity has been mainstreamed in various Malaysia Plans as well as in several national and state's policies. Furthermore, its policy to retain at least 50% of its land under permanent forest cover in perpetuity and designated sites as RAMSAR/MAB has contributed to the maintenance and enhancement of global biodiversity values, GHG emission reduction and GHG sequestration. While all the national documents and action plan including the retention of 50% of land as forest cover in perpetuity nationwide appears to provide a degree of confidence that important ecosystems and biodiversity will be maintained, however there remains a considerable pressures to overall maintenance of the nation's ecological homeostasis and critical biodiversity hotspots throughout the country.

Few initiatives or programmes also were undertaken to support the biodiversity works in the country as mention in the 5th National Report to CBD, comprising The Central Forest Spine Master Pelan (CFS), The Heart of Borneo Initiative (HoB) and the Coral Triangle Initiative-Corall Reefs, Fishery and Food Security (CTI-CFF). The projects will be expected to produce measureable targets for biodiversity conservation and its sustainable use in our country. As example, one of the 5 pillars in the Sarawak Strategic Plan of HoB will focus on the sustainable agriculture and land use in order to improve the livelihood of local communities, ensure productivity and income without compromising the sustainability.

Table 6.3. Policies related to biodiversity conservation and sustainable utilization for food and agriculture

No	Policy	Description
1	A common vision on Biodiversity	• Adopted by National Biodiversity and Biotechnology Council of Malaysia 2009 • Use as a guiding tool for planners, decision makers and practitioners at all level of

		governments with respect to biodiversity planning and management • Implementation aim on three approaches i) Strengthening the Protected Areas System ii) Land/Seascape Management for Biodiversity iii) The Mainstreaming of Biodiversity
2	The National Agro Food Policy	• Adopted on 28 September 2011 • The main objectives are; i) To ensure adequate food supply and food safety; ii) To develop agrofood industry into a competitive and sustainable industry; and iii) To increase the income level of agricultural entrepreneurs
3	National Strategies and Action Plans on Agricultural Biodiversity Conservation and Sustainable Utilization	• Released in 2010 and revised in 2012 • The strategies and action plans (includes PGRFA, AnGR, Insect genetic resources with microbial and fungal genetic resources) are meant to ensure that the agricultural sector in Malaysia uses its biological resources in sustainable manner. • Four main components addressed; 1) Public awareness 2) Capacity building 3) Research and monitoring & 4) Legal and institutional framework
4	Malaysian Good Agricultural Practices (MyGAP)	• Launched in 2013 • Certification scheme for agricultural, aquaculture and livestock sectors based on the Malaysian Standard (MS) • Originated and combination of three schemes, namely the Malaysian Farm Certification Scheme for Good Agricultural Practices, the Livestock Farm Practices Scheme and the Malaysian Aquaculture Farm Certification Scheme
5	The Malaysian Organic Scheme (MOS)	• Certification programme to certify farms that are operated using organic methods • Based on the Malaysian Standard entitled 'MS1529:2001 The Production, Processing, Labelling and Marketing of Plant Based Organically Produced Foods' • Use of chemical fertilizer and pesticide are prohibited under the organic farming scheme
6	National Policy on Biological	• Revised National Policy 1998

	Diversity 2016-2025	• The revised policy will provide the direction and framework in conserving the nation's biodiversity and use it sustainably in the face of increasing challenges • Outlines 5 key principles on biodiversity management; 1) Heritage 2) Precautionary 3) Shared responsibility 4) Participatory & 5) Good governance • Has five overarching goals encompassing stakeholder empowerment, reducing pressure on our biodiversity, safeguarding our ecosystems, species and genetic diversity, ensuring equitable benefits from our biodiversity and building the capacity of all stakeholders. • The five goals are supported by 17 national biodiversity targets which include 57 action plans to be undertaken.
7	Fisheries Act 1985	• The Fisheries Act is supported by other acts, policies and plans for holistic approach in managing and conserving genetic resources in Malaysia including AqGR
8	National Forestry Act, 1984	• Administration, management and conservation of forests and forestry development within the states of Malaysia and for related purposes.
9	Plant Variety Protection Act	• Gazetted in 2004 • The main objectives are as follow; i) To provide for the protection of the rights of breeders of new plant varieties. ii) To provide recognition and protection of contribution made by farmers, local iii) communities and indigenous people towards the creation of new plant varieties. iv) To encourage investment in and development of the breeding of new plant varieties in both public and private sectors
10	Wildlife Conservation Act	• Into force on 2010 • An act to provide for the protection and conservation of wildlife and for matters connected therewith.
11	Environmental Quality Act, 1974	• DOE monitors 20 specific activities and parameters related to pollution and environmental standards. • Prescribed activities that affect forest e.g. logging >5 km²

		• EIA guidelines for forestry
12	National Forestry Act, 1984	• Act to provide for the administration, management and conservation of forests and forestry development within the States of Malaysia
13	Sabah Biodiversity Enactment, 2000	Sabah Biodiversity Enactment 2000 (SBE 2000) was enacted by the Sabah State Legislature in December 2000. Such an enactment provides a legal framework for the safeguarding of biodiversity and biological resources of the State. its mission is to ensure that Sabah biodiversity is sustainably managed.
14	National Agro-Food Policy, 2011-2020	to address food security and safety to ensure availability, affordability dan accessability; • to ensure the competitiveness and sustainability of the agrofood industry; and • to increase the income level of agropreneurs.
15	National Policy on Climate Change, 2009	mainstreaming climate change through the wise management of resources and enhanced environmental conservation. The policy also aims to strengthen institutional and implementation capacity to better harmonise opportunities to reduce negative impacts on climate change. The policy is based on the principles of sustainable development, coordinated implementation, effective participation and common but differentiated responsibilities.
16	National Biotechnology Policy, 2006	The NBP was enacted in 2005 and, the industry has developed a strong base and today Malaysia's biotechnology cluster has the potential to lead the Asia Pacific region.
17	National Environment Policy, 2002	• Aim at achieving development taking account the environmental carrying capacity and conserving the country's cultural and natural heritage, all within the concept of sustainable development.

6.7 Access and benefit sharing

In order to ensure that benefits arising from the utilization of biological diversity are shared in a fair and equitable manner which in line with the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their utilization, Malaysia is now in the final stage of presenting the Access and Benefit Sharing (ABS) Law to parliament which hopefully will be implement in 2017. The ABS law will cover all biological diversity including (AnGR, AqGR, PGR, microorganism, invertebrate, vertebrate etc).

With the National ABS laws in place, it will encourage the advancement of biotechnology and research on biological resources, which could lead to new discoveries and thereby supports the implementation of the New Economic Model 2010, which *inter alia* identifies biodiversity as a new source of wealth creation. The ABS Law also took into account farmers and indigenous peoples and local communities' rights under the Access and Benefit Sharing (ABS) processes. Annex 1 crops listed in the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) are to be governed by the ITPGRFA which exclude PGR listed as Annex 1 crops in the multilateral system from the scope of ABS law.

CHAPTER 7: THE WAY FORWARD

7.1 Synthesis of needs and priorities and the possible way forward

Efforts to assess and monitor GRFA activities have been initiated through the National Policies (National Strategies and Action Plans (NSAP)). The NSAP is also a complementary to the National Agro-food Policy (2011-2020) with the main priority of tackling the issues of food security, nutrition and climate change at national level. Based on these policies, Malaysian priorities and needs in 4 priority areas and the possible actions to be undertaken are as following:

Table 6.7. List of the country's needs and priorities, and possible actions to be undertaken, to conserve and use biodiversity for food and agriculture.

Priority areas	Needs and priorities	Possible actions to be undertaken
1. Assessment and monitoring	1. Enhance and improve the scientific knowledge base as the main trust in GRFA activities 2. Minimize impacts of human activities on the diversity of GRFA in Malaysia	• At national level, survey, collection, inventorisation and documentation of GRFA as well as to undertake studies to assess its direct and indirect values, identify the potential threats to GRFA diversity loss, and how they may be countered are essential and will continue to enhance. take mitigating measures to reduce the adverse effects of human activities on GRFA. Some of the resources are already and nearly extinct which we have to protect and conserve.
2. Conservation and sustainable use	1. Enhance sustainable utilization of the GRFA in the country 2.Develop a Centre of Excellence (COE) in GRFA	• At national level, the stakeholder will have to continue to identify and encourage the optimum use of the GRFA with the emphasis of ensuring fair distribution of benefits to the nation and to local communities. ○ Malaysia is at the final stage of establishment of the National Genebank with higher capacity, facilities and resources. This genebank will be the 'one stop centre' and coordinator of any

	3. Strengthen and integrate conservation programmes on GRFA 4. Encourage private sector participation	germplasms exchange in the country. On the other hand, Malaysia has already established National Biodiversity Centre under Ministry of Natural Resources and Environment (NRE) of which GRFA is under the responsibility of MOA and MARDI as the implementing agency. • Efforts to strengthen and integrate conservation programmes of GRFA in Malaysia will be increased through the national policies and funding. It will be further enhanced in the 11th Malaysian Plan (2016-2020). Malaysia will continue to facilitate contacts between private sector and public sector (public-private partnership) in order to improve design and transfer of appropriate technology, including biotechnology for GRFA.
3. Policies, institutions and capacity	1. Strengthen the institutional framework for GRFA management 2. Integrate diversity of GRFA considerations into sectoral planning strategies 3. Continuation in the development and enhancement of skill, capabilities and competence on GRFA	• Malaysia will continue to set up a high level policy formulation, coordination and advisory body with effective representation from all relevant federal ministries and agencies and state governments. Through the Steering Committee of the National Genebank, MOA will coordinate across ministries on all GRFA activities (conservation and sustainable utilisation as well as materials transfer or exchange) in the country. ○ It is important to continue reviewing current sectoral policies, plans and programmes to determine the extent to which use of GRFA reflect conservation needs and recommend appropriate measures there in. To date, the efforts already started with the review of 1998 National Biodiversity Policy, implementation of ABS law and implementation of NSAP until 2020. • Malaysia will continue to identify critical skill requirements and undertake programmes to develop the human resource base in the appropriate areas of GRFA. • Utilize research institutes and universities to build up competence in GRFA.

	4. Review legislation to reflect GRFA needs in Malaysia 5. Develop and strengthen policies, regulations, laws and capacity building on biosafety 6. Enhance institutional and public awareness 7. Establish funding mechanisms in the country	○ Malaysia has and will continue to identify areas where new legislation or major enhancements to existing legislation are needed for: ▪ Commitments under the Convention on Biological Diversity and Agenda 21; Regulating and managing biological resources including the introduction and implementation of codes of practice for collectors; ▪ Intellectual property and other ownership rights. • Introduce measures for the incorporation of biosafety principles and concerns, especially in relation to genetic engineering, and the importation, creation and release of genetically modified organisms. In addition, a new issue such as synthetic biology is internationally debated. Malaysia will have to be aware and ready for such issue in the future. ○ Malaysia will have to continue to promote and encourage the understanding and participation of the public and institutions for the effective conservation and protection of GRFA. Cooperation with NGOs and privates will also be enhanced. • Malaysia will continue to identify and establish appropriate funding mechanisms for GRFA conservation and management. At present, Science Fund, TechnoFund, NKEA and FRGS are some of the funding for R&D on GRFA as well as under development fund applied by each agencies to the Ministry of Finance (Ec onomic Planning Unit, EPU).

4. Regional and international cooperation	1. Promote international cooperation and collaboration 2. Exchange of information	• Malaysia will have to continue to identify areas of research and technology requirements where cooperation and collaboration are needed in the area of GRFA. ○ Systems for the exchange of such information at national and international levels through networking, and by establishing databases and information centres will need to be established or strengthened through: ▪ information centres and networks to disseminate relevant information prepared by government, research and educational institutions, industry, non-governmental organizations (NGOs) and individuals; ▪ central directories of relevant data sets, information centers and networks

REFERENCES

Abdullah MZ, Mohamad O, and Saad A (2005). Rice genetic resources: conservation and utilisation in Malaysia. Jurnal Biosains. 16 (1): 139-153

Azmi, M., Abdullah, M.Z. and Fuji, Y. (2000). Exploratory study on allelopathic effect of selected malaysian ricevarieties and rice field weed species. J. Trop. Agric. And Fd Sc. 28 (1).

Anon. (1998). Malaysia's National Policy on Biological Diversity, Ministry of Science, Technology and Environment (MOSTE)

Anon. (2005). MARDI leads the way in agriculture and food industries. MARDI, Serdang.

Anon. (2006). Biodiversity in Malaysia, Ministry of Natural Resources & Environment, ISBN 983-42860-1-5 .

Anon. (2010). National Strategies and Action Plans (NSAP) on Agrobiodiversity Conservation and Sustainable Utilisation. MARDI Publication.

Anon. (2011). Dasar Agro-Makanan Negara, Kementerian Pertanian dan Industri Asas Tani (MOA).

Chung, R.C.K., Soepadmo, E. and Saw, L. G. (2005).Good practices in *in situ* conservation of tropical fruit trees genetic resources for sustainable livelihoods, food security and ecosystem services in Malaysia. Paper presented at the International Good Practice Workshop, 4-5 April 2005, Bangkok, Thailand

Mohamad, O., Abdullah, M.Z. and Abd. Rahman, M. (2005). Molecular markers as a breeding tool in rice breeding: New paradigm and opportunities. Plenary paper. Proceeding of the 6th national Congress on Genetics, 12-14 May 2005. Kuala Lumpur.Pp. 10-22.

Mohd Shukor, N., Zulhairil, A., Rosliza, J., Wan Darman, W.A. and Mohammad Gaddafi, D. (2011). Conservation and utilisation of plant genetic resources for food and agriculture in Malaysia. MARDI Publication: 9-15.

Mohd. Shukor, N., Zulhairil, A., Jeffry Lim, S.H., Razean Haireen, M.R., Erny Sabrina, M.N., Rosliza, J. And Sabki, S. (2007). Final report on the establishment of the national information sharing mechanism (NISM) on the implementation of the global plan of action (GPA) for the conservation and sustainable utilization of plant genetic resources for food and agriculture in Malaysia. FAO, MARDI, MOA.pp 177.

Mohd Shukri, M.A., A.H.S. Mirfat, M.N. Erny Sabrina, M. Razali, I. Salma, 2013. Nutritional Value and Potential of Malaysian Underutilised Fruits and Traditional Vegetables (Eds: F. Massawe, S. Mayes & P. Alderson) Acta Horticulturae 979(1): 173-185 (ISBN 978-90-6605-279-6), Drukkerij Geers, Germany.

Murray, H. (2015). Ethno-botany Behind the Malay Herbal Industry. http://www.slideshare.net/Murray58/ethnobotany-and-the-malaysian-herbal-industry?related=1 (Accessed on March 2015)

Nazir Khan, N.K. and Mohd. Yunus, Z. (2005). Forest resources trend and sustainable forest management in Peninsular Malaysia. Paper presented at Seminar on the status of biological diversity in Malysia 28 -29 June, 2005. FRIM, Kepong, Kula Lumpur

Ramli, M.N. and Wong, L.J. 1989. Rainfed agriculture in Malaysia. In: Rainfed Agriculture in Asia and the Pacific Region. RAPA, FAO Publication. Pp. 139-144.

Reid, G.(1999). The scientific basis for probiotic strains of Lactobacillus. Applied Environmental Microbiology 65: 3763–3766.

Salma, I. (2009). Research Theme Report presented at Project Monitoring.Strategic Resource Research Centre. MARDI, Serdang. 2 Feb. 2009.

Saw, L.G., LaFrankie, J.V., Kochummen, K.M and Yap. S.K. (1991). Fruit trees in Malaysia rain forest. *Economic Botany.* 45 (1): 120-136.

Saw, L.G.,Chua, L.S.L. and Abdul Rahim, N. (2009). Malaysia National Strategy for Plant Conservation. Ministry of Natural Resource and Environment and Forest Reseach Institute of Malaysia.

Soepadmo, E. (1991). Conservation status of medicinal plants in PeninsularMalaysia. Proceeding of the Medicinal products. Tropical Rain Forest Conference. 13-15 may 1991. FRIM, Kuala Lumpur.

Kamke, R., Schmid, S., Zillikens, A., Lopes, B. C. & Steiner, J. The importance of bees as pollinators in the short corolla bromeliad Aechmea caudata in southern Brazil. *Flora - Morphology, Distribution, Functional Ecology of Plants* **206**, 749-756, doi:http://dx.doi.org/10.1016/j.flora.2010.12.004 (2011).

Schwarz, H. F. The Indo-Malayan Species of Trigona. *Bulletin of The American Museum of Natural History* **LXXVI**, 83-141 (1939).

Salim, H. M. W. *et al.* STINGLESS BEE (HYMENOPTERA: APIDAE: MELIPONINI) DIVERSITY IN DIPTEROCARP FOREST RESERVES IN PENINSULAR MALAYSIA. *The Raffles Bulletin of Zoology* **60**, 213-219 (2012).

Mohd Norowi, H., Sajap, A. S., Rosliza, J., Mohd Fahimee, J. & Suri, R. in *Proceeding of International Seminar on Enhancement of Functional Biodiversity Relevant to Sustainable Food Production in ASPAC.* (NIES).

Fahimee, M. in *Regional Agrobiodiversity Conference (RAC1)* (Langkawi, Kedah, 2012).

Momose, K. *et al.* Pollination Biology in a Lowland Dipterocarp Forest in Sarawak Malaysia. I. Characteristics of the Plant Pollinator Community in a Lowland Dipterocarp Forest. *American Journal of Botany* **85**, 1477-1501 (1998).