COMMONWEALTH
FORESTRY INITIATIVE

Sustainable Forest Management in Malaysia

by
Haron Abu Hassan
and
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Commonwealth
Secretariat

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FOREWORD

This report is the fourth in the series published by the Commonwealth Secretariat. Each volume traces the development of tropical forest management in a Commonwealth country and illustrates the range of experience that has been gathered during the past century and more of Commonwealth forestry. Forest management is no longer the concern of forest managers alone, and the wise use of tropical forest increasingly depends on the understanding of interested people outside the profession, such as politicians, the general public, and the media. This series is intended to assist in a wider understanding of the historical basis which forms the point of departure for many of the new approaches and policy directions which are now being tried.

This series of reports is part of a Commonwealth Forestry Initiative which aims to foster linkages between countries which are actively developing new programmes in natural forest management. Brief reports have been published for Karnataka, India; Ghana; Uganda; and Sri Lanka. In addition, a more specialist volume dealing with timber utilisation has been published for Uganda.

This text has been prepared by the Director of the Asean Institute of Forest Management, based in Kuala Lumpur and provides an easily understood introduction to the characteristics of Malaysian forests and their importance to the economy and the environment. There are important chapters on the development of forest management since the beginning of the century and a review of present approaches to sustainable forest management. Finally, there is a look ahead to the challenges facing Malaysia and the role that the country is playing on the international forestry scene.

The views expressed in the publication do not reflect the position of the Commonwealth Secretariat or Commonwealth member countries.

Brian Kerr
Chief Programme Officer
Commonwealth Secretariat

PREFACE

Forests may be a familiar site in Malaysia but forest management could be as alien as the name of commercial trees to non-botanists or foresters, despite all that has been done in this field. Perhaps concerted educational promotion will bring the public into the forest, not so much to see the dollar signs on the big trees but to experience the serenity of God's creation away from the dust and noise polluting the cities and towns. Being in the forest, doubtlessly one would soon be conscious of the 'compactness' and complexity of the forest ecosystem emanating a glorious feeling and sense of peacefulness. We must keep alive this feeling. We must conserve the forest and preserve the complete ecosystem, not only to sustain biodiversity of the flora and fauna but also the spiritual earthly sense of belonging.

The Commonwealth Forestry Initiative: Malaysia Volume provides a summary of sorts regarding forestry in Malaysia, specially written in conjunction with the 15th Commonwealth Forestry Conference held in Zimbabwe in May 1997. A lot more could be written but it would be out of context for this exercise. The writing of this Volume actually started in October 1995 but due to unforeseen circumstances and the fact that the Conference is in May 1997 (perhaps more the latter), the facts and figures became outdated as it was being written. Further research was made to reflect the latest situation, though the authors wish to apologise if some references may still appear obsolete. Things change, as they normally do, but be rest assured that the latest available information has been used in the analysis of situations and potentials.

The theme of this Volume is Sustainable Forest Management in Malaysia. It befits past endeavours and current practice, trends and inspirations of foresters and environmentalists alike. Sustainable Forest Management has enjoyed centre-stage in numerous fora, especially since the 1980s, and it is sure to be basking in the full light of the coming 15th Commonwealth Forestry Conference and other major events across the globe, as it should. Our lives are at stake if we become too careless in managing our forests, and the greenness of the world with high forests, in particular, could be the only saviour.

It is hoped that this Volume will be useful as an update on the forestry initiatives in Malaysia, and enable readers to perceive the expectations and inspirations of a people fast moving into a developed nation through vision 2020.

ACKNOWLEDGEMENTS

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Our special gratitude is due to a long list of the ASEAN Institute of Forest Management (AIFM) staff who gave their full support in getting together the materials and information needed. Dahlan Taha, Shah Rani Ahmad Zailan, Zulkifli Mukni, Baidrul Hisham Shaari must top the list for their diligence in helping to compile the basic information required and for the field work, including taking the photographs. Many others had contributed in one way or another. To all, thank you very much. Your diligent assistance will be reflected in the following pages.

Finally we wish to thank the Director General of Forestry, Peninsular Malaysia for having the AIFM involved in this publication.

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1.0 INTRODUCTION

Malaysia is endowed with lush, humid, tropical rainforest, often referred to as the wet equatorial rainforest. However, not all the forests in Malaysia have similar texture and structure. They differ with location and altitude and it would be a great mistake to have a single management procedure for all the forests in Malaysia, or to expect a forest to response similarly to a particular management practice. The mangroves, for instance, certainly behave differently from the high forest which in turn differs from the lowland and the hill forests.

Issues on forest management and the sustainability of the world's forests have been widely deliberated in recent years. Public concern on environmental quality and stability has been rising and the fact that forest use is central to this anxiety cannot be over-emphasised. Countries rich in forest, including Malaysia, have been looked upon as likely saviours in regard to climate deterioration such as global warming and thinning of the ozone layer. Deforestation and industrialisation have been seen as contributory toward environmental instability and must be addressed wisely for the security and sustainability of mankind, biodiversity of flora and fauna, and national development.

2.0 PHYSICAL FEATURES

2.1 Location

Peninsular Malaysia lies at the southern-most tip of mainland South-east Asia, while the states of Sabah and Sarawak lie to the east on the island of Borneo. The total land area is approximately 32.9 million hectares with 13.2 million hectares in Peninsular Malaysia, which comprises eleven states and the Federal Territory of Kuala Lumpur; 7.4 million hectares in Sabah (including the Federal Territory of Labuan), and 12.3 million hectares in Sarawak. Peninsular Malaysia is separated from Sabah and Sarawak by 720 km of the South China Sea, and the country as a whole has a coastline of about 4,830 km.

2.2 Topography

Peninsular Malaysia consists of east and west coastal plains and central mountain ranges running roughly north to south and reaching up to 2,130 m in some places. The two largest rivers, the Perak River and the Pahang River, flow towards the Straits of Malacca and the South China Sea respectively. At their sources and upper reaches, the rivers are fast-flowing but in the lower reaches those on the west coast often meander through swampy land, while the east coast rivers are sometimes impeded by sand bars.

Sabah and Sarawak consist of alluvial and often swampy coastal plains with hilly rolling country inland and mountain ranges in the interior. In Sabah, the central mountain ranges rise abruptly from the west coast to Mt. Kinabalu which, at 4,100 m, is the highest mountain in South-east Asia. It is the source of many rivers flowing north-west and east to the South China Sea and Sulu Sea respectively. The largest river is the Kinabatangan which is navigable for considerable distances and has an extensive plain. In Sarawak, the eastern

mountain ranges rise to more than 1,520 m and contain the largest cave in the world. The largest river, the Rejang, is 564 km long and is navigable for about 160 km.

2.3 Geological Aspects

Peninsular Malaysia is generally hilly or mountainous, with about 40 per cent of the total land area rising above the 310 m contour and 23 per cent above 155 m. The only low-lying areas are near the coasts on both flanks of the peninsular from where they extend inland for a few kilometres up to a maximum of 64 kilometres before becoming moderately undulating, mostly between 15 and 150 metres above sea level. Further inland the very steep main mountain ranges rise abruptly from the surrounding lowlands.

The mountains occur as a series of parallel ranges running approximately north-south. The largest of these ranges, the Main Range, is a continuous granite ridge extending from the Perak-Thailand border to the Negeri Sembilan-Malacca boundary near Tampin. This range is usually regarded as the backbone of the country, but it is certainly not a central axis, as the highly-developed lowland region to the west represents only about a fifth of the total land area, while three-fifths lies to the east of this ridge.

Basically, Peninsular Malaysia can best be pictured as a land mass built around an intrusive core of solid granite, the uneven roof of which reaches the surface in a number of places to from the principal mountain ranges. The sedimentary rocks older than the granite, of Palaeozoic and Mesozoic age, occur along the flanks of these ranges and in the intervening lower-lying areas, while Recent, Quaternary and Tertiary sediments, which have accumulated since the emplacement of the granite, are confined principally to the coastal areas and to the main basins and valleys of the interior.

The geology of East Malaysia (Sabah and Sarawak) is more complex and dominated by the Borneo Basement ancient rocks. In Sabah, younger rocks are the result of past volcanic activities, though volcanoes are unknown in recent times.

2.4 Climate

The climate of Malaysia is typically humid tropical or wet equatorial and is characterised by year-round high temperatures and seasonal heavy rain, especially during the North-east monsoon from October/November to February/March. The mean temperatures during the day and night are 32°C and 22°C respectively.

3.0 THE FOREST

3.1 Forest Cover

Malaysia has been fortunate to be endowed with extensive areas of valuable natural tropical rainforest which are extremely complex ecosystems and rich in tree species as in similar areas of Africa and South America. In fact, Malaysia has one of the most species-rich communities in the world. The flora is estimated to comprise 7,500 species of seed plants in which 4,100 are woody. An estimated 2,900 species reach a diameter of 10 cm at breast height (dbh)

while about 1,680 species in 375 genera are trees reaching a diameter of 30 cm dbh (Whitmore, 1975). About 890 of these species reach exploitable sizes of at least 45 cm dbh and 408 have been marketed to the international market under the Malayan Grading Rules.

The total area of forests in Malaysia is estimated to be 18.91 million hectares or nearly 58 per cent of the total land area. The extent of the forest cover is shown in Figure 1. The proportion of forested land is higher in Sabah and Sarawak than in Peninsular Malaysia, as shown in Table 1 (Ahmad Zainal, 1996). In the ASEAN region, Malaysia lies third in terms of amount of forested areas after Indonesia and Thailand, but fourth with regard to percentage to total area of the country (Haron, 1996).

Table 1: Distribution and Extent of Forests in Malaysia, (million ha)

Region	Land Area	Natural Forest			Plantation Forest	Total Forested Land	% Total Forested Land
		Dipterocarp Forest	Swamp Forest	Mangrove Forest			
Peninsular Malaysia	13.16	5.38	0.30	0.10	0.07	5.85	44.45
Sabah	7.37	3.83	0.19	0.32	0.11	4.45	60.40
Sarawak	12.33	7.20	1.20	0.20	0.01	8.61	69.73
Malaysia	32.86	16.41	1.69	0.62	0.19	18.91	57.55

While most plantation forest originated from areas used to be covered by natural stands with forest reserves there have been encouraging developments recently to replant neglected alienated land with fast-growing commercial timber species of *Azadirichta excelsa* (Sentang) and the high quality but slower growing *Tectona grandis* (Teak), besides the earlier favoured *Acacia mangium* (Akasia), *Paraserianthes falcataria* (Batai), *Gmelina arborea* (Yemane) and *Swietenia macrophylla* (Mahogany). This development, coupled with likely reforestation of agricultural lands, now planted with *Hevea brasiliensis* (rubber), into forest plantation may in the long-run increase the area of forests, although the net increase will depend on the reduction of the current annual deforestation rate of 2.6% in Peninsular Malaysia alone, ironically, mainly for conversion to agriculture. Although the deforestation rate for the whole country is 2.10%, it is still higher than the ASEAN average 1.08% per annum (Haron,1996). However, if the tree agricultural crops of rubber and oil palm are regarded as forest plantations since both can be utilised for wood (timber), then the total tree (forest) cover in Malaysia is about 75% of the total land area, not 58% (see Table 1).

Areas under shifting cultivation and degraded land status in the Peninsular are small. However, they are being rehabilitated, wherever necessary. In Sabah and Sarawak, such areas can be quite extensive, covering about 4.62 million hectares, but concerted efforts are being undertaken to re-forest them with fast-growing species, particularly *Acacia mangium*.

3.2 Permanent Forest Estate

Most of the forests in Malaysia are managed on a sustainable basis. Some forests, however, are licensed for logging without any minimum girth limits, particularly those forested areas demarcated for conversion to other land-uses including agriculture, housing and other land developments. Such forests are known as the Stateland forest.

More than 75% of Malaysian's forests have been gazetted as forest reserves, also known as Permanent Forest Estate (PFE) in the National Forestry Act. This also constitutes about 43% of the country's total land area. The distribution of these forests are shown in Table 2. Actually, another 185,000 ha of Stateland forest in Peninsular Malaysia are in various stages of being gazetted as PFEs which will further increase the size of the latter. The PFEs are sustainably managed either for production, protection or amenity purposes. Harvesting of timber from the production forest is regulated according to the recognised system of the day. So too, are the protection and amenity forests which have special management procedures quite different from that of a normal production forest. The security of tenure is guaranteed under the National Forestry Act (NFA) except perhaps for certain PFEs lying in the remaining lowland Dipterocarp forest. If de-gazettement does occur, there is a commitment in the NFA that for every hectare of PFE dissolved, the same amount of suitable area in the Stateland forest must be gazetted to replace it, wherever possible. However, Aiken and Leigh (1992) did not see how the rainforest would not keep on vanishing, but certainly every effort is being made by Malaysia to conserve its forest in the light of rapid economic development.

Table 2: Permanent Forest Estate in Malaysia (million ha)

Region	Land Area	Total Forested Land	Total PFE	Forested Land Stateland Forest	Percentage of PFE to Total Land Area	Total Forested Land
Peninsular Malaysia	13.6	5.85	4.68	1.17	34.41	80.00
Sabah	7.37	4.45	3.60	0.85	48.85	80.90
Sarawak	12.33	8.61	6.00	2.61	48.66	69.69
Malaysia	32.86	18.91	14.28	4.63	43.46	75.52

There are no significant private forests in Malaysia. However, there may be tiny pockets of reserved forested land alienated to certain organisations for special purposes such as education and research. It must also be noted that there are, of late, individual landowners or companies involved in agricultural plantations who have converted their land to forestry purposes. These lands usually started off as a forested area which was alienated for conversion to agricultural crops such as cocoa or rubber, and have now reverted to forests with fast-growing hardwoods

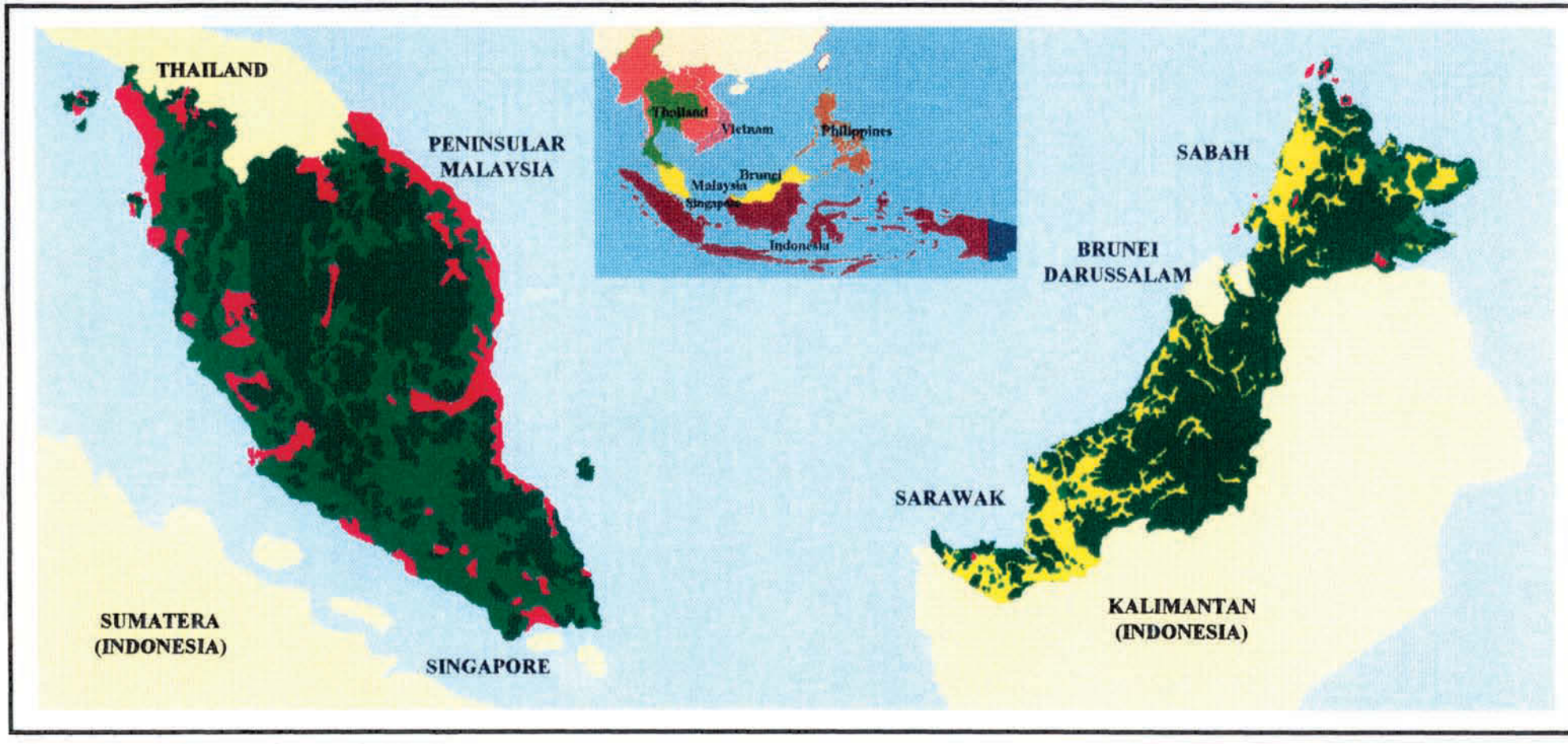


FIGURE 1: Forest Cover in Malaysia

such as *Acacia mangium* (Akasia), *Azadirichta excelsa* (Sentang), and *Tectona grandis* (Teak), and non-wood produce such as *Calamus spp.* (Rattan). Reforestation such as this, and afforestation of degraded land or that which has been left fallow, are good signs towards increasing the country's reserved and productive forests.

3.3 Forest Types

The tropical rainforests of Malaysia are generally synonymous with the species-rich lowland and hill dipterocarp forests which make up 92% of the total forested area in Peninsular Malaysia, and 87% of the total forest in the country. Other forest types include the mangroves, peat swamp forests, heath forests and montane forests. The dipterocarp forests are of vital economic as well as ecological importance to the country while the mangrove forests have long been managed for the sustainable production of charcoal, poles and firewood. The mangroves are also important for protection and conservation of the coastal ecosystem, and especially vital for sustaining fish and sea-food production (Haron, 1981). In this context, the tropical rainforests may be classified into the following ten major forest types (Wyatt-Smith, 1963 and Fox, 1978):

(i) Lowland Dipterocarp Forests

These forests are found in the plains, undulating lands and foothills to an elevation of about 300 m above sea level and are primary climatic climax forests comprising thousands of trees species, as well as shrubs, herbs and woody climbers (see Figure 2). The upper or emergent storey is usually about 30 m to 45 m high, though trees nearly 60 m in height may also be present in certain localities. It is usually characterised by a high occurrence of the family Dipterocarpaceae with many of the species from the genera *Anisoptera, Dipterocarpus, Dryobalanops, Hopea, Shorea* and *Parashorea.* Other common large trees of this storey are *Dyera costulata, Gluta spp.; Intsia palembanica.; Koompassia malaccensis.; Melanorrhoea spp.; Palaquium spp.; Sindora spp.;* and *Tarrietia spp.*

The main storey, or second-tree layer, which occupies a region of about 20 m to 30 m from the ground, forms a continuous canopy except immediately below the large emergent storey trees. This storey consists of young trees of the upper storey species together, with predominant families of *Burseraceae, Guttiferae, Myristicaceae, Myrtaceae* and *Sapotaceae.* The under-storey, or third-tree layer, consists of saplings of the upper two stories together with mainly members of families such as *Annonaceae, Euphorbiaceae, Flacourtiaceae* and *Rubiaceae.*

The density of the shrub layer varies and comprise of species of *Annonaceae, Euphorbiaceae* and *Rubiaceae.* The herb layer consists mainly of young seedlings of the other layers and lianas, with ferns near streams and in moist valleys.

(ii) Hill Dipterocarp Forests

These forests occur on the inland ranges approximately between the latitudinal limits of 300 metres and 800 metres. Aspects and site, however, are important factors, and the forests have a tendency to flourish at the lower limits, even down to 150 m above sea level, on

exposed ridges. At the higher limits they are found in the more sheltered valleys. The main difference between the lowland Dipterocarp and hill Dipterocarp forest is a shift in the floristic composition of the dominants in the upper and main tree storeys. The large trees in hill forest are usually slightly smaller and shorter than the tallest in the lowland forest, except for the big trees on ridge tops which are generally taller. The density of trees on ridge tops is greater than that in the lowland forest and there are correspondingly fewer trees in the under-storey and in the lower part of the main storey. The vegetation on hill slopes, particularly steep slopes, is often ground ferns and poorly stocked in woody species.

The under-storey is usually very rich in stemmed palms such as *Arenga westerhoutii, Oncosperma horrida* and *Orania macrocladus;* stemless palms such as *Licuala spp;* and rattans such as *Calamus castaneus.* In valley bottoms, large woody species are poorly represented and the forest is more characterised by the richness of *Alocasia spp, Colocasia spp, Donax grandis,* and many other ground ferns in the ground flora and shrub layer.

(iii) Upper Hill Dipterocarp Forests

These forests are found on the higher hills, approximately between the latitudinal limits of 750 metres to 1,200 metres but, as in the case of the hill Dipterocarp forests, they may also be found in narrower and much lower belt on coastal rangers or on isolated mountains. The species are very different from those in the hill Dipterocarp forests. Although the forest structure is much the same, namely three-layered, the upper layer is lower and varies between 25 metres and 30 metres in height and with a more even upper canopy level. The second and upper tree layers are frequently less distinct as separate entities. The family *Dipterocarpaceae* is represented by only a few species and this forest is often characterised by the presence of *Shorea platyclados.*

The shrub layer in this forest is often characterised by the presence of rattans and dwarf palms, while the ground flora by species of *Argostemma* (Rubiaceae), *Sonerila* (Melastomaceae), *Selaginella atroviridis* and the fern *Thelypteris chalamydophora.*

(iv) Lower Montane Forests

These forests are found above the upper Dipterocarp forests in the latitudinal range of 1,000 metres to 1,500 metres but these limits vary considerably according to the locality. They are generally three-layered forests with tree heights varying from 20 metres to 25 metres. The upper canopy is fairly even with emergent absent, and trees are relatively short-boled, and are not strongly buttressed. Normally, Dipterocarps are not found in these forests though *Dipterocarpus retusus* and some *Vatica* spp. are occasionally found. The common and characteristic species are representatives of the families *Fagaceae* with many of the genera *Quercus, Lithocarpus, Castanopsis* and *Lauraceae.*

The climbers *Aeschynanthus spp.* and *Poikilospermum* and the fern *Asplenium nidus* are common epiphytes while rattans, stemmed palms and tree ferns dominate the shrub layer with liverworts and mosses being the ground flora.

(v) Upper Montane Forests

These forests occur in the cloud belt above the lower montane forests. They may, however, be found on exposed ridges and summits at lower altitudes of less than 1,500 metres. They differ from the lower montane forests in specific composition, typically a reduction to a single tree layer in structure and a general dwarfing of the forests to about 10 metres tall. Besides, there is normally a greater increase in development of liverworts, mosses and filmy ferns, both on the trunks of the trees and on the ground. *Sphagmum spp.* are also common.

The forest is characterised by the prevalence of ericaceous species, such as *Pieris ovalifolia, Rhododendron spp.* and *Vaccinium spp.* Undergrowth species include *Argostemma* and *Burmannia spp.*. Epiphytic orchids are common and rhododendrons also occur frequently.

(vi) Heath Forests

Heath forests are generally included as part of "hill forests" and are found mainly in the states of Sabah and Sarawak. They contain trees of poor form and small size and are generally found on white sandy soils, or on beach terraces at all elevations, or on weathered steep ridges at higher elevations. The main species are *Casuarina, Agathis alba, Dacrydium, Tristania* and *Shorea albida.*

(vii) Freshwater Alluvial Swamp Forests

The freshwater alluvial swamp forests usually occur under varying degrees of inundation and under varying conditions. Accordingly, their floristic composition and general structure varies enormously from open scrub with a few large 25 to 30 metres-tall, scattered trees, a dense 10 to 20 metres-tall pole forest, to a 30 metres-tall peat, swamp-like forest where the predominance of single species is common.

Common tree species that are found in some of these swamp forest are *Koompassia malaccensis, Calophyllum, Eugenia, Madhuca, Melanorrhoea* and *Palaquium spp.*

(viii) Peat Swamp Forests

These forests are of a very special type found on peat with depth ranging from 0.5 metre to about 6 metres. They occur just behind the coastline and have a three-layered tree structure. This comprises a broken, upper emergent layer, often reaching to a height of 30 to 35 metres and is frequently represented by scattered, truly emergent trees and a fairly continuous under-storey of considerable depth, usually ranging from about 10 to 20 metres above ground level. Frequently, a dense thicket of stemless palms is found in waterlogged areas, otherwise the shrub layer is generally rather sparse.

The ground flora is comparatively poor, both in species and in cover as shown in Figure 3. Species represented in these forests include *Amoora rubiginosa, Anisoptera marginata, Blumeodendron tokbrai, Calophyllum retusum, Cratoxylon aborescens, Gonystylus bancanus, Shorea albida Dactylocladus stenostachys* and *Eugenia spp.*

(ix) Riparian Fringes

Numerous types occur as narrow strips along the banks of estuaries, rivers and streams. Their composition, and hence their structure, vary enormously and depend on tidal influence, the rate of water flow, the elevation, the width of the river or stream, the nature and aspect of the terrain, and the enrichment of the side by water or silt. Common tree species found in these riparian fringes or on the low-lying land beyond the banks are *Artocarpus peduncularis, Ficus retusa, Intsia palembanica, Dipterocarpus coriaceus, Calophyllum spp., Cratoxylon spp., Dialium spp.* and *Hopea spp.*

(x) Mangrove Forests

Mangrove forests are confined to muddy shores, lagoons, and the estuaries of tidal rivers. The vegetation is simple in structure, 6 m to 25 m in height depending on the community, with a comparatively even and unbroken canopy and a very poor understorey layer. The principal tree species are restricted to this habitat, and are frequently characterised by special root formations such as still roots and pneumatophores. Some species such as *Brugueira spp., Ceriops spp., Kandelia spp., Rhizophora spp., Avicennia spp., Sonneratia spp.* and *Xylocarpus spp.* are also characterised by the habit of their seeds which start to germinate long before the fruits are ripe (Figure 4).

Two types of swamp palm are also present in the mangroves. These are *Nypa fructicans* (nipah) and *Oncosperma horrida* (nibong). *N. fructicans* is a general utility species providing local products such as housing thatch, cigarette paper, sugar, alcohol, vinegar and salt. It is frequently inundated and occurs in pure stands while *O. horrida* prefers the drier zones.

While this forest type classification may still be good for Malaysia, an attempt has been made towards a standard classification for the ASEAN region (Haron, et al, 1997, unpublished) whereby the forest has been categorised into four major classes, viz: Montane Forest, Hill Forest, Swamp Forest, and Mangrove Forest. In this classification all the Dipterocarps are included in the Hill Forest.

3.4 Forest Functional Classification

The Forest Functional Classes (FFCs) have been developed and applied in Malaysia over the past decade. The FFCs are described in a report (Anon, 1986) entitled *Pengelasan Kawasan Hutan Simpanan Kekal* in accordance to *Seksyen 10 (1),* of the National Forestry Act, 1984 along with guidelines for the interpretation of the eleven classes which are legislated in the Act.

The FFCs are delineated on maps and used for forest planning, management, and development purposes. The classes zone the forest reserves for different functions and therefore give the forest manager a broad overview for forest planning and management. In addition, there is a land classification which demarcates all land in Peninsular Malaysia for forestry (proposed classification of land for forestry in Peninsular Malaysia). The FFCs are classified as follows:

Class a: Timber production forest under sustained yield

These are forest lands which are inherently productive or with a high timber production potential and are capable of supplying timber which can be economically produced under sustained yield, both for the domestic and export markets. Generally, these are forest lands with average slope of less than 40° and with easy to moderately difficult access. They include Class 1(Superior), Class 2 (Good), Class 3 (Marginal) and part of Class 4 (Restrictive) as defined in the paper "Proposed classification of land for forestry in Peninsular Malaysia" by Mok and Thang (1983).

Class b: Soil protection forest

These are forest lands which are located in environmentally sensitive areas and particularly on steep terrain. Exploitation and the absence of vegetation cover could result in soil erosion, flash floods, landslips, siltation, loss of nutrients and other forms of environmental degradation which would be detrimental to the well-being of the populace. Such forests, when destroyed, would require expensive alleviation and rehabilitation works. They include part of Class 3 (Marginal), Class 5 (Conservation) and Class 6 (Poor) land. Classification of such forest may vary according to soil, geology and rainfall characteristics of the area.

Class c: Soil reclamation forest

These are generally low-lying forest lands usually formed through a gradual process of soil accretion and forest formation, and include forests established on reclaimed lands. They may be seasonally or permanently subjected to inundation; mainly mangrove and inland swamps. They are equivalent to Class 4 (Restrictive) land.

Class d: Flood control forest

These are forest lands that act as reservoirs for water storage during the monsoon season. The exploitation of such forests could result in massive downstream flooding which is not only undesirable but also detrimental to both agricultural crops and human life. Such forest lands can be identified through historical records and meteorological data on flood-prone areas in the country. Generally, they include fresh-water swamp (seasonal) and the peat swamp forests.

Class e: Water catchment forest

These are forest lands which function as a regulating system against excessive run-off and have water retention capacities. They are vital for ensuring the supply of water to meet the increasing demand for domestic, industrial and agricultural uses. Proper management of such forests is essential for the maintenance of desirable water quality, stable stream flow regime, and the avoidance of damaging floods. Generally, it is made up of hilly, forested land from which rainfall flows into a river system. Such forest is of particular importance where dams are constructed.

Class f: Forest sanctuary for wildlife

These are forest lands where indigenous wildlife exists and which should be reserved for the protection of biodiversity. Sanctuaries may be established for the protection of one or a few species, but generally they are intended for the protection of all species. Such forests are established to prevent the extinction of the already dwindling endangered species of flora and fauna in the country, and access are restricted only to authorised persons undertaking activities compatible with the purpose of the sanctuaries.

Class g: Virgin jungle reserved forest

These are forests which are established to serve as permanent nature reserves and natural arboreta, as controls for comparing with the exploited and silviculturally-treated forests, and as undisturbed natural areas for general ecological and botanical studies.

Class h: Amenity forest

Under the National Forestry Policy, these forests are defined as forest land which are conserved for various purposes such as recreation, education, research and protection of the country's unique flora and fauna.

Class i: Education forest

These are forest lands which are earmarked or reserved for the purposes of furthering education and creating better public awareness with regard to the vital role of forest in the preservation of a balanced physical, social and economic environment.

Class j: Research forest

These are forest lands earmarked or reserved for research purposes. Among the research plots which have been set up throughout the country are Silvicultural Plots, Phenological Plots, Forest Plantation Plots, Ecological Plots, Big Tree Plots, Hydrological Plots, and Growth and Yield Study Plots.

Class k: Forest for federal purposes

These are forest lands earmarked or reserved for federal purposes such as the setting up of Continuous Forest Inventory (CFI) Plots and Research Stations.

4.0 IMPORTANCE OF THE FORESTS

Forests play a very significant role in furthering resource-based industrialisation and the socio-economic development of Malaysia. Besides, they have long been recognised as an important contributor to environmental stability and better quality of life for the country. They protect, maintain and safeguard fresh-water supply and help keep the climate stable and reduce the level of the carbon dioxide content. The forests also enrich the soil and prevent soil erosion. Forest products are wide-ranging, from timber to furniture, medicines, food, paper and many

other daily necessities. The major contribution of forests in Malaysia is described below.

4.1 Environmental Protection and Conservation

Protection of the environment is important to Malaysia. The creation of Permanent Forest Estates (PFE) is to ensure that there will be substantial natural forest cover to maintain the quality of the environment. To further conserve various forest and ecological types in their original condition, Malaysia has set aside pockets of virgin forest. These pockets, known as Virgin Jungle Reserves (VJRs), were established to serve as permanent nature reserves and natural arboreta; as controls for comparing harvested and silviculturally-treated forests; and as undisturbed natural forests for general ecological and botanical studies.

The protection forests within the PFE are further classified into soil protection forests, flood control forests and water catchments. Currently, the extent of water catchment forests (forested watersheds) for major dams are 270,000 ha which are located in Kedah (Pedu and Muda dams), Terengganu (Kenyir dam), and Perak (Temenggor dam). Additionally, two watershed management research programmes have been initiated to provide hydrological data in different types of land use. These are the National Programme for Experimental and Representative Basins and the Forest Hydrological and Conservation Programme which are wide-ranging and multi-disciplinary in concept and approach.

Harvesting is carefully controlled to minimise damage. For instance, the effect of harvesting operations on soil erosion and sedimentation on river systems are being controlled by the enforcement of regulation and guidelines for logging operations. Thus, the documentation and implementation of the "Forest Harvesting Guidelines", the "Forest Engineering Plan" and the "Standard Road Specification". Steps are currently being taken to formulate Environmental Impact Assessment (EIA) guidelines specifically for the various forestry activities as required under the Environmental Quality Act, 1974 (Amended 1995).

Malaysia has also recognised the urgent need to conserve genetic resources of endangered forest tree species and is currently undertaking a project on *in situ* conservation of forest genetic resources. This project will inventorise the current VJRs in order to assess the stocking and distribution of species for effective resource conservation.

4.2 Forest Industries

In recent years, the forest industries of Malaysia have rapidly moved away from the manufacture of low-value primary products. The main forest industries today consist of sawmilling, panel product industry (veneer, plywood, particle board, blockboard, and fibreboard) moulding/joinery industry and furniture industry. Others include secondary and tertiary processing industries such as timber treatment, laminated board, boxes and crates, pencil factories, match factories and parquet flooring plants. Realising the role of forest industries in improving the socio-economic level of the rural population, steps have been taken to encourage the setting up of small-scale, rural-based industries using non-timber forest produce such as rattan and bamboo as raw materials (Figures 5 and 6). A list of important forest-based industries is in Table 3.

Table 3: Forest Industries in Peninsular Malaysia

Type Of Industry	Number (units)
Sawmill	710
Plywood/Veneer Mill	49
Moulding plant	111
Furniture/woodworking/joinery factory	>2300
Blockboard plant	12
Chipboard plant	4
Moulded particleboard plant	4
Medium Density Fibreboard plant	4
Woodwool/wood cement board plant	2
Rubberwood mill	106
Kiln Drying plant	120
Timber treatment plant	117
Pallets/boxes/crates factory	200
Laminated board plant	16
Pencil factory	3
Parquet flooring factory	25
Wooden House prefabrication plant	10
Match factory	4
Rattan/bamboo factory	73
Woodchip plant	1

Malaysian timbers are graded in accordance to the Malayan Timber Grading Rules (MTGR) prior to use both domestically and for export. It should also be noted that the MTGR have gained global acceptance as internationally-recognised tropical timber-grading rules.

Except for a small number of integrated timber complexes that have been established by State Economic Development Corporations, most of the timber industry in Malaysia is owned by the private sector. The forest industry have been identified as one of the resource-based industries to be further developed as an important export-oriented sector. It is the Government's objective to make Malaysia a major producer of high value-added, wood-based products in the world market. Specifically, it is envisaged that Malaysia should become an important furniture and joinery/mouldings centre. Various policy measures have been implemented to create an environment conducive to the accelerated growth of the sector. However, the forest industries sector still has to brace itself for an environment of stiff competition, growing protectionism and mounting pressures of environmentalism and conservation, if it is to successfully carve a niche for itself in the international market.

4.3 Socio-Economic Contribution

As a natural renewable resource, the forest has contributed significantly towards the socio-economic development of Malaysia. The importance of forestry in Malaysia can also be seen from its contribution to Malaysia's foreign exchange and earnings. Income from forestry and related industries has consistently been among the top five income-earners for the country and for a few years in the 1970s it was even among the top two. The forestry sector also provides

income and employment for a large section of the population. It has been estimated that at least 0.5 million people are associated in one way or another with the forestry sector. This can be further elaborated as follows:

(i) The total export value of timber products (excluding rattan and wooden furniture) amounted to nearly FOB RM 3 billion, constituting about 2% of the total gross export receipts of Peninsular Malaysia at FOB RM 144 billion. At the national level, the total export value of timber and timber products (including rattan and wooden furniture) recorded almost FOB RM 14 billion or 9% of the total export receipts of the country at FOB RM 154 billion.

(ii) Revenue derived from the forest in the form of royalties, premium, forest development fund, and others represent a considerable and important proportion of the State Government's total income, while at the federal level, export cess and income tax are collected. The total forest revenue collected by the various State Governments in Peninsular Malaysia amounted to RM 391 million. Of this total, RM 270 million or 69% of the total revenue was used to finance State forest administrations and development.

(iii) The forestry sector provided direct employment for more than 92,000 persons and about 80% are in the downstream industries including sawmilling, plywood/veneer, moulding, furniture and other wood and non-wood factories. More than RM 500 million were paid out in terms of annual salaries and wages for workers involved in the forestry sector.

(iv) Total investment estimated in the major wood-based industries in Peninsular Malaysia was RM 1,834 million. Of this total, RM 933 million or 51% were in the sawmilling industry, RM 672 million or 37% in the plywood/veneer industry and RM 229 million or 12% in the wood-moulding industry.

Apart from their monetary value, forests have many intangible functions and an aesthetic value. They also play important protective functions such as the maintenance of environmental stability, minimisation of damage to rivers and agriculture land by floods and erosion and the safeguarding of water supplies. It must be stressed that the success and development of the agricultural sector depends very much on the protective role of the forest.

The non-wood forest produce is now becoming as important, comparable to timber, with the increase in demand. Harvesting it is also less destructive than logging. These non-wood products include rattan, bamboo, fruits, resin and others of ornamental and medicinal value. The food security provided by the forest is very important in the rural areas, and to the large populace who live within its vicinity, particularly in Sabah and Sarawak.

4.4 Educational and Social Benefits

The rainforest of Malaysia provides us with many opportunities for education and recreational enjoyment such as bird-watching, hiking, swimming, mountain-climbing and camping. A waterfall in the forest, for instance, is a source of beauty and enjoyment, and inspires picnickers, tourists and holiday-makers to relax and unwind.

The need for recreational areas in the forest was recognised, and in 1967, following the advent of high economic growth and rapid urbanisation in the country, such areas were developed to cater for outdoor recreation, including picnicking, camping, hiking and swimming. Now there are at least 98 of these areas, popularly known as *Hutan Lipur*, in every shape and sizes, each with its own uniqueness all over the country.

The forest provides excellent 'natural laboratories and classrooms' for students, researchers, scientists and artists. They can increase their knowledge in the fields of botany, zoology, chemistry, geography, geology, medicine and others by studying the forest. The forest enriches our lives in many ways. Such recognition has made Malaysia strongly committed to ensuring the sustainable management of its natural resource.

A variety of fruits are found in the natural forests which are of economic value to local communities. These include *Parkia speciosa* (Petai), *Durio zibethinus* (Durian), *Mangifera spp.* (Macang), *Pithecellobium jirinya* (Jering), *P. bubalinum* (Kerdas) and *Baucaria spp.* (Tampoi). The demand for these fruits has been on the increase and they fetch high prices in the cities and towns. Malaysia has embarked on traditional fruit tree planting to meet this demand. More than 2600 ha of *P. speciosa, D. zibethinus* and other fruit trees have been planted along fringes of forest reserves near existing villages to supplement the needs of the rural population and improve their subsistence requirements. This obligation is a social gesture to incorporate community forestry into the hearts of the people who live in its vicinity, and help to reduce the encroachment or unnecessary felling of trees.

For centuries Malaysians have been using rattan and bamboo for numerous applications. Passed on from generation to generation, the use of these materials has expanded into a productive industry, although the sustainably of supply is being threatened due to over-exploitation and necessitates complementary cultivation. Thus, in addition to planting in the natural forest, rattan, for instance, is also being planted in rubber plantations and in between rows of some fast-growing forest plantation.

Out of the 50 bamboo species found in the forests, 11 are currently commercially viable. About 250,000 tonnes are harvested annually, both from cultivated and natural stands. Among the items fashioned from bamboo are handicrafts, utensils, chopsticks, traditional brushes, furniture and scaffolding material for the construction industry.

Remedies for ailments and wounds are also found in the forest. In Malaysia, effective cures has long been derived from roots, leaves, stems, fruits, fungi, flowers and even the bark of certain trees and plants for traditional herbal medication to treat wounds, snakebites, diabetes, fever, kidney ailments, high blood pressure, migraine, poisoning, digestive problems and a variety of other ills.

These diverse resources and benefits have resulted in the forest being looked upon as a valuable asset which merits continued management and reinvestment. Malaysia is spending much time, money and effort towards forest regeneration and rehabilitation to ensure its perpetuity and sustainability of these natural resources.

4.5 Forest Conservation and Biodiversity

Malaysia is fully aware of the immense diversity of biological species in its rainforest. These rich species of flora and fauna are an important natural heritage. Hence, in line with the concept of sustainable forest management, development and conservation, Malaysia has, over the years, established a network of protected areas for the conservation of biological diversity. Some of these national parks, wildlife reserves and sanctuaries, nature parks, bird sanctuaries and marine parks have been gazetted as conservation forests since the 1930s. The largest national park is the Taman Negara covering 434,351 ha. It was gazetted in 1939 and consists of virgin forest of various forest types. Currently, Malaysia has 1.39 million ha of conservation areas protected by legislation (Table 4), of which 1.06 million ha are located outside the Permanent Forest Estate (PFE) whilst another 0.33 million ha are within.

Table 4: Areas Under National Parks, Wildlife and Bird Sanctuaries in Malaysia, (million ha)

Region	National Park	Wildlife and Bird Sanctuary	Total
Peninsular Malaysia	0.43	0.31	0.74
Sabah	0.26	0.14	0.40
Sarawak	0.08	0.17	0.25
Malaysia	0.77	0.62	1.39

An additional area of 1.42 million ha is under consideration for future reservation: about 0.67 million ha are in Peninsular Malaysia, located in the Permanent Forest Estate and 0.75 million ha are in Sarawak comprising ten national parks and four wildlife sanctuaries. Priority for conservation is given to special habitats such as wetland areas, open lakes ecosystem, quartz-ridge forests and limestone formations.

In this context, Malaysia has drawn up a comprehensive list of plants and animals to be protected. Currently, many of these, such as the *tiger, rhinoceros, slow loris* and even the *birdwing butterfly* are fully protected by law. The Department of Wildlife and National Parks in Peninsular Malaysia runs active programmes to conserve the larger mammals. In Sabah and Sarawak, the Forest Departments manage wildlife rehabilitation centres for wild animals with special emphasis on the *orang utan.* Complementing these efforts are many other programmes, co-ordinated by a National Steering Group, to conserve the plant genetic resources of the country. One such programme is the conservation of wild fruit trees. The Forestry Departments in Peninsular Malaysia have also recognised the urgent need to conserve genetic resource of endangered forest tree species and are currently undertaking the project on *in situ* conservation of forest genetic resource. This project will inventorise existing Virgin Jungle Reserves (VJRs) in order to assess the stocking and distribution of species for effective resource conservation. Malaysia is also included in a current project on Planning Practical

and Cost-Effective Strategies for Genetic-Resource Conservation of Commercial Tree Species in Tropical Asia and the Pacific being undertaken by the ASEAN Institute of Forest Management (AIFM) for the International Tropical Timber Organisation (ITTO).

These VJRs are pockets of virgin forest representing various forest and ecological types in their original condition and were established to serve as permanent nature reserves and natural arboreta which can act as controls for comparing harvested and silviculturally treated forests and for general ecological and botanical studies. Since its inception in 1950, a total of 72 VJRs covering 21,271 ha have been established throughout Peninsular Malaysia while Sabah has a total of 48 VJRs covering an area of 88,299 ha. These VJRs represent samples of the many types of virgin forest found in the country and are located in the PFEs. Sarawak has virgin areas known as Totally Protected Areas (TPA) covering a total of 110,000 ha.

To ensure that the detrimental effects on the environment arising from forest harvesting are minimised, Malaysia has embarked on comprehensive studies to monitor and evaluate the impact of forest harvesting on yield of water in hill forest and sediment yield downstream resulting from logging activities. These study areas are located in the Sungai Tekam Experimental Basin for the lowland forest established in 1973, and the Jengka and Bukit Berembun Experimental Basins for the hill forest established in 1978. Initial results from these studies indicated that hydrological parameters, such as water yield, water quality and sediment yield, reverted back to their original conditions, i.e. prior to logging, within a period of three to four years. These studies have since been continued to be monitored by the Forest Research Institute of Malaysia.

4.6 Forestry and Ecotourism

Malaysia has a wide range of forest habitats, stretching from the mangrove and riparian fringes to the montane forests. Peninsular Malaysia alone has an area of 745,997 ha established as national park and wildlife reserves not including the 72 VJRs and 79 recreational forest areas. In Sabah, 265,794 ha are managed as national parks while another 141,200 ha are wildlife reserves. The total area of Sarawak under national parks and wildlife reserves is more than 252,870 ha (MPI, 1988).

Forest makes up an important resource for recreation. The literature of forestry abounds with references to the intangible benefits provided by forest recreation. In Malaysia, the increasing demand for forest recreation has longed been anticipated (Sheikh Ali , 1983). The number of recreational forests that were set aside in The First Malaysia Plan (1966 – 1970) was only two and this increased to 25 in the Third Malaysia Plan (1976 – 1980) and to 37 in the Fourth Malaysia Plan (1980 –1985) because of the continued demand (Jalil and Chee, 1983).

The population of Malaysia was growing at a rate of 2.7% annually in the 1970s (Drysdale, 1981) and the current rate has remained fairly consistent at 2.3% (FAO,1995). A larger percentage of this population (now close to 20 million) will be youthful and well-educated (Wan Sabri Mansor, 1983). Coupled with increased income, leisure time and better mobility, the rapid rate of industrialisation and urbanisation experienced by the country has increased awareness and need for more recreational spaces which are clean and peaceful, away from the urban concrete jungle.

Forestry has an important role to play in nature tourism (Laarman & Durst, 1987) which requires efficient management of the natural resources and an understanding of the role of trees in the ecosystem. Many forested areas are suitable for ecotourism. Facilities available within the national parks are generally adequate for this purpose. If managed on a commercial basis, they are able to cater for both domestic and international tourists (Yap, 1992). The potential of ecotourism in Malaysia is enormous. It can serve a dual purpose of enhancing public awareness and appreciation of aesthetic conservation efforts as well as the ability to tap an economic return from the forested areas without excessive damage to the natural beauty and resources.

5.0 DEVELOPMENT OF FOREST MANAGEMENT

The forests in Peninsular Malaysia have been systematically managed since the beginning of this century when the first Forest Officer was appointed in 1901. Over the years, ecologically and environmentally sound forest conservation and management practices have been developed to ensure forest renewal and sustainable yield of timber and other products. The earlier silvicultural management systems were primarily concerned with improving the existing timber crop for future exploitation. Very few timber species were harvested, then, and trees were felled selectively according to the requirements of good forest management, such as the removal of the overmature trees, and those which might compete with favoured species (Thang, 1986).

Market demands, however, increased tremendously after 1960s and coupled with aggressive land development projects and nation-building after independence, over-exploitation was rampant. This led to a crisis situation whereby it was forecasted in 1980 that by year 2000, Malaysia would become a net importer of timber as opposed to enjoying the status of a top exporter, then. If this happens, the balance of trade would certainly be affected and, subsequently, the wood-based and related industries would either be forced to scale-down or close down altogether. This could lead to retrenchment of workers and higher prices of timber products. The social, economic and political implications of the consequences should never be underestimated. In fact, rumour was rife that the timber trade was destined to be a sunset industry and timber merchants were busy diversifying into other trades. Positive measures, however, including intense research activities and reduction of the allowable annual coupe, were undertaken to face and prevent the impending timber crisis from happening in the country.

The great concern regarding forest management in Malaysia, can best be understood by tracing the past developments of previous silvicultural and management practices. The history of forestry practices can be conveniently divided into three major eras, namely: the Pre-World War Era (Before 1940); the Pre-Independence Era (1940 – 1957) and the Post-Independence Era (After 1957). These periods were marked with very distinct and interesting political, technological as well as economic developments which, to a large extent, have affected the management of the Dipterocarp forests in the country.

5.1 The Pre-World War (Before 1940)

The first Forest Department in the then 'Malaya' (now Peninsular Malaysia) was formed in 1883 under the Control of the Singapore Botanic Gardens to cover the Straits Settlements which included Malacca, Penang and the Dindings (now part of Perak). From 1895, this duty was transferred to the Land Office together with those of the forests in the then 'Federated Malay States' until 1901 when the Malayan Forest Service was established to serve all the 11 states in the Peninsular.

The early forest operations in the country placed special emphasis on the natural reproduction and stand improvement of lowland forests rich in *Palaquium gutta* trees and other valuable hardwood timbers such as Merbau *(Intsia palembanica)* and Chengal *(Neobalanocarpus heimii)*. The *P. gutta* tree was felled for its latex (getah taban) which fetched high prices during those days and became a major export-earner of the Federated Malay States until the early 1920s. Other species of the same *Palaquium* genus were also utilised for their latex such as *P. maingayi* for its 'getah sundex' and *P. obovatum* for its 'getah putih'. The exploitation of naturally durable heavy hardwood in the State land forests was, however, essentially on a small-scale basis due to lack of mechanisation and the very restricted demand. Plantations of *P. gutta* and rubber *(Hevea brasiliensis)* were also tried besides enrichment planting of Chengal.

During the years 1910 to 1915, a series of stand improvement felling and silvicultural treatments were designed and carried out on a trial-and-error basis with the objective of favouring the growth of *P.gutta* poles and other more valuable timber tree species. Some of these treatments were found to be successful leading to the recommendation that natural regeneration should be preferred to planting. After 1915, few departmental works were done owing to shortage of staff during the First World War and the economic slump of the 1920s. By 1926, the various tending and felling operations were conveniently divided into three distinct classes for different objectives:

(i) ***Departmental Improvement Felling***
The operation here is to assist the most preferred trees of certain ages by removing inferior species.

(ii) ***Departmental Regeneration Felling***
The intention here is to assist new natural regeneration of the most preferred tree species by removing the inferior species before the felling.

(iii) ***Normal (Commercial) Regeneration Felling***
The operation is for similar purposes as (i) and (ii) but contracted out to other agencies at a profit.

The Departmental Improvement Felling went out of favour by 1932 (Hodgson, 1932). While the second and third methods had a great deal of similarity with the classical shelterwood systems where the original forest canopy was gradually removed over a period of eight to ten years. The 'Seedlings Felling' system was formulated in 1927 and required a five-year regeneration period with several clearings. This operation involved the gradual removal, in several stages, of the inferior species before the felling of the useful species was permitted.

These commercial operations supplied a market for firewood and for added revenue to the Forestry Department. The sequence of operations is outlined in Table 5.

Table 5: Sequence of Operations for Commercial Regeneration Felling

Year	Operation	
n–1	P	Felling of unmarked class 2 poles under 20 cm dbh
n	S1	First seedling felling of marked class 2 trees
n+2 or +3	C1	First cleaning, if necessary
n+4	S2	Second seedling felling of marked class 2 trees
n+5	C2	Second cleaning
n+6	F	Final felling of marked class 1 trees provided successful regeneration is verified in C2
n+7	C	Clearing after final felling, if necessary

Regeneration Felling involved girdling rather than felling. Girdling helps to reduce damage to the residual stand, deprives climbers of the convenient ladder of a fallen but still strong crown, and slows down the increase of light, thereby giving trees more chance of competing with the more rapidly responding light demanding climbers. This operation was profitable as long as there was a high demand for fuelwood, but with the ever-increasing competition from coal, oil and electricity greater numbers of unwanted trees had to be removed by deep girdling. The loss in revenue, coupled with costly girdling operations, resulted in the evolution of a cheaper and more efficient in tree-killing operations by the use of an aqueous solution of sodium arsenate poured into a shallow frill-girdle round the tree. The Departmental Regeneration Felling, then, became known as Regeneration Improvement Felling (RIF), and correctly this should only be applied to the departmental operations (Table 6). However, it appeared to be a standard practice to refer to either type of regeneration inducement as RIF, in view of the considerable similarity between them. Moreover, from about 1935 onwards, as the demand for firewood decreased in the face of competition from alternative sources of fuel, and as the market for mining poles became more limited, departmental operations became increasingly widely applied.

During the period 1935–1941, there was a severe decline in the demand for firewood due to the introduction of other fuels. However, the development of medium-powered sawmills and the shortage of supplies from accessible State Land forests had led to an increasing demand for timber from the Forest Reserves and less selective timber exploitation and to the evolution of 'sawmill silviculture' (Barnard, 1954). As research results began to become available during this period, it was also realised that successful regeneration could be established with fewer cleanings. There were suggestions that cleaning of the regeneration carried out after exploitation was completed, in contrast to the pre-treatment involved, combined with poison-

Table 6: Sequence of Operations for Departmental Regeneration Improvement Felling (RIF)

Year	Operation	
n	GC1	First girdling of inferior species and cleaning
n + 3 or + 4	GC2	Second girdling and cleaning
about n + 5	C3	Cleaning, if necessary
about n + 7	F	Final felling of marked trees

girdling of the remaining large trees would ordinarily suffice. There was also a general introduction of cheap poison-girdling by the application of sodium arsenate at 0.25 – 0.5 kg per litre of water to the frill (Mead, 1940).

In 1938, a scheme was devised on an all-Malayan basis, of setting aside a total of about 404,860 ha. of reserved forests for the purpose of intensive management for the future timber requirements of the country with the assumption that each hectare, if areas rich in primary hardwoods were chosen, would produce an average of 0.70m^3/ha of primary hardwoods and 2.8m^3/ha of other timbers annually. One third of this area was supposed to be managed for Heavy Hardwoods and the other two-thirds for Medium and Light Hardwoods. The ambitious plan, however, did not materialise for various reasons, particularly in relation to the Japanese occupation during the Second World War in the early 1940s.

5.2 The Pre-Independence Era (1940 – 1957)

During the period of the Japanese occupation of Malaya from 1942 to 1945, there was considerable destruction of accessible forested lands due to the conversion into agricultural land for food growing. About 14,200 ha. under regeneration felling and 5,300 ha. or nearly half of the fully regenerated forest, then, were destroyed. Uncontrolled timber exploitation on State Land forests and in Forest Reserves occurred and no silvicultural operations were carried out.

After the Second World War, the RIF was discontinued because of the increased demand for raw materials with increasing number of sawmills and the use of heavy machinery in harvesting. Moreover, it was observed that many of the untended clear-felling made during the Japanese Occupation, and that of the suspected 'storm forests', contained adequate advanced seedlings regeneration which were present on the ground at the time of felling. These seedlings had survived undamaged and had grown rapidly to form the dominant crop without any assistance while the slower growing 'economic species' had formed the sub-dominant crop. Seedlings already on the ground were also observed to respond immediately to a sudden drastic canopy opening. This led to the formulation of the Malayan Uniform System (MUS) in 1948. It is basically a system for converting the complex lowland

dipterocarp forest to more or less even-aged stands containing more commercial species (Wyatt-Smith, 1963).

The mature crop is harvested in one single felling of all trees above 45 cm. dbh for all species. This allows the natural regeneration of varying ages which are mainly the light-demanding medium and hardwood species. The felling operation is followed by a poison-girdling operation of defective relics and non-commercial species down to a minimum of 5 cm dbh. A linear strip sampling is carried out at least five years later to verify the presence of sufficient regeneration and to determine suitable silvicultural treatments.

The success of the MUS system depends on the presence of adequately well-distributed stocking of seedlings of economic species at the time of felling; complete removal of the original canopy through poison-girdling of all remaining large trees and other species considered as non-commercial down to 5 cm dbh.; no tending of re-growth is necessary; maintenance of good new canopy to prevent the redevelopment of climbers; and linear samplings carried out at regular intervals to assess the regeneration status of the seedlings. The normal sequence of operations under the MUS is shown in Table 7.

The end of the 1940s and early 1950s saw a great increase in world demand for timber. The introduction of preservatives and timber treatment technology coupled with research intensification of the mixed unclassified timber resulted in a large surplus of unacceptable timber in the market. The demand for inland firewood during the period was, on the other

Table 7: Sequence of Operation under the Malayan Uniform System

Year	Operation
n - 1½	Linear sampling (2 m x 2 m) of regeneration, and enumeration of merchantable trees.
n to n + 1	Exploitation, followed by poison-girdling down to 5 cm dbh.
n + 3 to n + 5	Linear sampling (5 m x 5 m) of new crop, followed by cleaning, climber cutting and poison-girdling as required.
n + 10	Linear sampling (10 m x 10 m) of new crop, followed by treatment as required or passed as regenerated.
n + 20, n + 40 etc.	Sampling and thinning as required.

hand, reduced virtually to nil. Towards the end of the 1950s, plans were drawn up which showed the future requirement in Peninsular Malaysia of an overall productive forest estate of 3.24 million ha.

5.3 The Post-Independence era (After 1957)

With the achievement of independence in 1957, there was a great revival in silvicultural interest and activity. The "Manual of Malayan Silviculture for Inland Forests" (Malayan Forest Record No. 23), which subsequently became the most important source book of Malaysian silviculture and management until today, was published in 1963.

The early 1960s also saw a tremendous drive in rural development resulting in a great pressure on the accessible Lowland Forest Reserves, most of which were then under regeneration. Concerns were expressed as some State Governments began exploiting State Land forests for conversion to other non-forestry activities. The operation of the National Land-Use Policy based on the Land Capability Classification (LCC) which was adopted in 1964, had pushed forestry to the hill forests and those on the non-agricultural soils in the lowlands. Unfortunately attempts to apply the MUS to the hill forests met with failures due to the inherently different character of these forests as compared to the lowland dipterocarps. The terrain was more difficult, the stocking was uneven, and the natural regeneration on the forest floor was insufficient before logging. Seedling regeneration after logging is also uncertain because of irregular seeding from potential mother trees, sometimes at intervals of several years (Whitmore, 1975) and heavy seedling mortality due to felling damage on steep slopes and the poor viability of *Shorea curtisii*, the main commercial species in the hills (Burgress, 1968, 1971). Other factors, including the danger of erosion on steep slopes and the incidence of *Eugeissona triste* (Bertam) and other secondary growth, do not favour a drastic opening of the canopy. Moreover, the poison-girdling of species down to a minimum of 5 cm dbh was considered to be too drastic in the hill forests and it is not always possible in practice to delay harvesting until there is adequate regeneration present on the ground. Under the MUS pre-Felling (Pre-F) sampling is mandatory but this is often not practicable in the hills until after the harvesting operation. Thus, in the hill forests the MUS has to be modified in various ways, in the light of experience over the first decade of implementation (Baur, 1964). The general pattern of the sequence of operations of the modified MUS is shown in Table 8. This modified version is still being used today in some States.

Realising the urgent need for further research into the silvicultural and management of the mixed Dipterocarp forests, particularly at high altitudes, a project was initiated to study the ecology of the hill forest and to devise a silvicultural system for their natural regeneration after timber exploitation. The study concluded that forests of 45 degree slope and steeper are impossible to regenerate and should not be exploited. However, the lower hill-slope and valley-bottom forests where the timber stand is low can be harvested and regenerated by artificial means through enrichment planting (Burgess, 1970).

In 1972, the Bi-cyclic Felling System (BFS) was introduced in anticipation of replacing the Modified MUS. The BFS was based on a rotation of 50 years with a felling cycle of 25 years. However, due to several reasons particularly with regard to its lack of universal applicability in the highly variable forest conditions encountered in Malaysia, the BFS failed to gain sufficient footing. On the other hand, towards the middle of the seventies there was a shift towards a more 'conservational approach' to forest management and a stronger emphasis on multiple-use forestry, and everyone knew that a new development was about to happen again.

Table 8: Modified Malayan Uniform System

Year	Operation
n - ½ to n - 1	Enumeration data of trees greater than 35 cm dbh as required for premium determination only (10% sampling intensity). Tree-marking may be carried out for checking completeness of felling only. No marking of residual trees for retention.
n	Felling of all commercial and utilisable species of 45 cm dbh and above.
n + 1/4 to n + 1/2	Post-felling sampling to determine fines on trees unfelled, royalty on short logs and tops, damage to residuals.
n + 5 to n + 5	Linear Regeneration Sampling (5 m x 5 m) to determine appropriate silviculture treatments. Generally, poison-girdling of all dbh and climber cutting. Retention of advanced-growth of potentially commercial stems.
n + 20	Linear sampling of regenerated forest to determine status of the forest.

Forest land clearance and conversion to agriculture gained momentum and peaked in 1976 during which year the rate of forest removal hit a figure in excess of 404,860 ha a year. Thus the need to conserve and 'defend' the forests and to arrest the speed of forest alienation was felt even more. The concern and interest in the predicament of the Dipterocarp forest swept through a cross-section of Malaysian society as well as the international community and this did, to some extent, influence the policy-makers' decisions. Appropriate measures were taken to reduce the rate of forest removal as well as environmental conservation.

Since 1952, forest administration and management were guided by the Interim Forestry Policy which was adopted as the National Forestry Policy only in 1978. However, due to the recent emphasis on environmental issues, particularly that relating to global warming, the National Forestry Policy was revised in 1992. Meanwhile, other policies and strategies have also been formulated specifically for forest management, development, silviculture, research and industries.

Technological innovations and sophistication in wood-processing, coupled with the changing pattern of wood utilisation, have resulted in the current management policies favouring timber harvesting regimes that are more flexible, consistent with steps to safeguard the environment, and at the same time take advantage to the demands of the timber market (Darus, 1983). The Selective Management System (SMS) was, therefore, formulated as a more cautious approach to managing the hill forests and to accommodate these changes. The concept and philosophy underlying this system are in accordance with the 'conservational approach' to hill Dipterocarp forest management.

Basically the SMS is 'the application of cutting regimes (minimum cutting limits) over a specified area of forest that will yield an economically viable amount of timber while retaining adequate advanced regeneration for future economic cutting cycle in the shortest possible time' (Griffin and Caprata, 1977). It was developed to meet the following requirements:

(i) to allow flexibility in managing the highly variable forest conditions and the changes in the socio-economic environment;

(ii) to enable decisions be made more rationally, based on the inherent characteristics of the forest and the prevailing socio-economic conditions;

(iii) to allow for the optimisation of forest management goals, namely, on economic cut, sustainability and minimum cost.

Thus, SMS is designed to optimise the management objectives of economic and efficient harvesting, sustainability of the forest and minimum forest development cost, under prevailing conditions. It requires the selection of management (felling) regimes based on inventory data, instead of an arbitrary prescription, which will be equitable to both logger and forest-owner as well as to ensure ecological balance and maintain environmental quality.

In order to determine the appropriate minimum cutting limits (ideally of at least 45 cm dbh for the non-Dipterocarp and 50 cm dbh for the Dipterocarp species) under this system of management, a Pre-Felling Inventory is carried out to provide reliable estimates of the population parameters that are being measured as follows:

(i) inventorise all tree species 5 cm dbh and above and tree species having a dbh of less than 5 cm dbh but having a minimum height of 15 cm and above, by dbh class, species, and volume/stems per ha;

(ii) note incidence of weed species and climbers;

(iii) note physiography by slope, elevation, soil types and river systems;

Based on the above information and other relevant information about the markets and other socio-economic considerations, a felling regime will be formulated that will optimise the stated goals. Colour-coded stock maps which enable the sub-division of compartments in areas of different types of tree stock by predominant species groups and/or size (dbh) classes, are also prepared.

Under this system of forest management, growth rates and the required stand determine the length of the cutting cycle. Disappointing growth rates would mean that the cutting cycle will have to be prolonged and allowable annual coupe reduced, while higher growth rates would lead to a shorter cutting cycle and higher allowable annual coupe.

A series of one hundred continuous inventory plots, each of 0.4 ha were established in logged-over hill forest. The following growth data was observed (Wan Razali *et al*, 1988; UNDP/FAO, 1978).

(i)	Diameter growth in cm/year:		
	(a)	all marketable species	0.80
	(b)	dark/light red Meranti	1.05
	(c)	medium-heavy marketable species	0.75
	(d)	light non-Meranti marketable species	0.80
	(e)	non-marketable species	0.75
(ii)	Gross volume growth in m^3/ha/year:		
	(a)	all marketable species	2.20
	(b)	all species	2.75
(iii)	Gross volume growth per cent:		
	(a)	all marketable species	2.1%
	(b)	all species	1.9%
(iv)	Annual mortality per cent: (of marketable species)		0.9%
(v)	Annual ingrowth per cent: (of marketable species growing for trees over 30 cm dbh limit)		0.6%

The economics of logging in Peninsular Malaysia is still not well understood because of the lack of definite economic studies under the various logging systems. However, based on current log prices, the estimated cost of logging and government charges, the minimum economic cut should be in the range of 35 m^3 to 40 m^3 per ha of currently commercial and utilisable species. Net volume is derived from its gross volume minus 40% for trees having dbh less than 60 cm, and minus 30% for trees having dbh greater than 60 cm.

Forest planning and operational studies carried out so far in Malaysia have clearly indicated the feasibility of continuous and economically-viable hill forest production in terms of economic log-out-turn volumes. Periodic cuts are every 25 – 40 years using locally-appropriated cutting limits and leaving adequate number of medium-sized trees of marketable species for natural ingrowth into commercial sizes. It has been shown that, with an average growth rates of trees of over 30 cm dbh of 0.8 – 1.0 cm per year in diameter and 2.0 – 2.5 m^3/ha. per year in commercial gross volume, about three-quarters of the hill forest is capable of producing every 30 years about 40 – 45 net m^3/ha which is about the current average out-turn level of virgin forest (Thang, 1987). However, it is imperative to curtail exploitation damage of the residual stands to not more than 30% of intermediate-sized trees.

There are two opportunities presently favouring the implementation of the Selective Management System (SMS) in Malaysia. First, this type of management requires concentration of operations on a large-scale using mechanised equipment, and provides higher employment and job diversification. These operations will become increasingly sophisticated and would enhance the prospect of transferring technical and organisational skills to local communities. Secondly, the large land development schemes which is expected to continue in the 1990s release large amounts of utilisable wood material readily available to the

Table 9: Selective Management System (SMS)

Year	Operation
n - 2 to n - 1	Pre-felling forest inventory using systematic-line-plots and determination of cutting regimes (limits)
n - 1 to n	Climber cutting to reduce damage during logging. Tree marking incorporating directional felling. No marking of residual trees for retention.
n	Felling of all trees as prescribed
n + 2 to n + 5	Post-felling inventory using systematic-line-plots to determine residual stocking and appropriate silvicultural treatments.

industry. The extensive tree-crop plantations of rubber and oil palm annual replanting schemes also provide excellent source of wood (fibre) materials with the potential for industrial processing to compensate for the expected decline of wood materials from the PFE under the SMS. The sequence of operations under the SMS is shown in Table 9 (Thang, 1987).

6.0 REVIEW ON APPROACHES TO SUSTAINABLE FOREST MANAGEMENT

The management of tropical rainforests, including those in Malaysia has of late been the focus of world attention, especially in the developed countries. The major concern is the alarming rate of tropical forest deforestation worldwide, which was reported to be as high as 16.8 million ha annually for the period 1981 – 1990. It is now realised that forests are important, amongst others, for carbon dioxide fixation preservation of biological diversity and the maintenance of an equable climate. Concern has also been raised that the tropical forests will be completely depleted in the near future and hence, there has been an unfortunate tendency to discourage the use of tropical timber in Europe and North America.

6.1 Policy and Strategies

In the endeavour to ensure sustained development of the forestry sector in Malaysia and as a supplement to the National Forestry Policy, the following explicit management and conservation policy and objectives have been formulated and adopted for implementation, especially in Peninsular Malaysia:

(i) to manage and utilise the forest resource for maximum benefits based on the inherent capability of the forest and its optimal use;

(ii) to manage the utilisation of the forest resource, based on comprehensive forest land-use management plans;

(iii) to determine potential yield on the basis of systematic and in-depth appraisals of the forest resource base, its growth potential and other relevant factors;

(iv) to regulate log-flow, based on a careful balance of supply and demand, maximum utilisation prospects and constraints;

(v) to harvest the forest resource conservationally by selective felling and retention of adequate natural regeneration, consistent with economical harvesting, so as to ensure the sustainability of the forest resources base;

(vi) to apply optimal forest management regimes formulated on the basis of information generated by systematic integrated forest management and operational research;

(vii) to establish forest plantations of quick-growing industrial wood species;

(viii) to promote multiple-use forestry and environmental conservation;

(ix) to ensure that sufficient forested areas are protected for the conservation of genetic resources, soil and water;

(x) to promote efficient harvesting and utilisation of all forms of forest produce;

(xi) to attain a national balance between national industrial processing capacity and resource availability;

(xii) to stimulate planned development and product diversification of the existing forest-based industrial sector;

(xiii) to promote the exportation of more value-added forest products;

(xiv) to ensure that domestic requirements for all forms of forest products will be adequately met; and

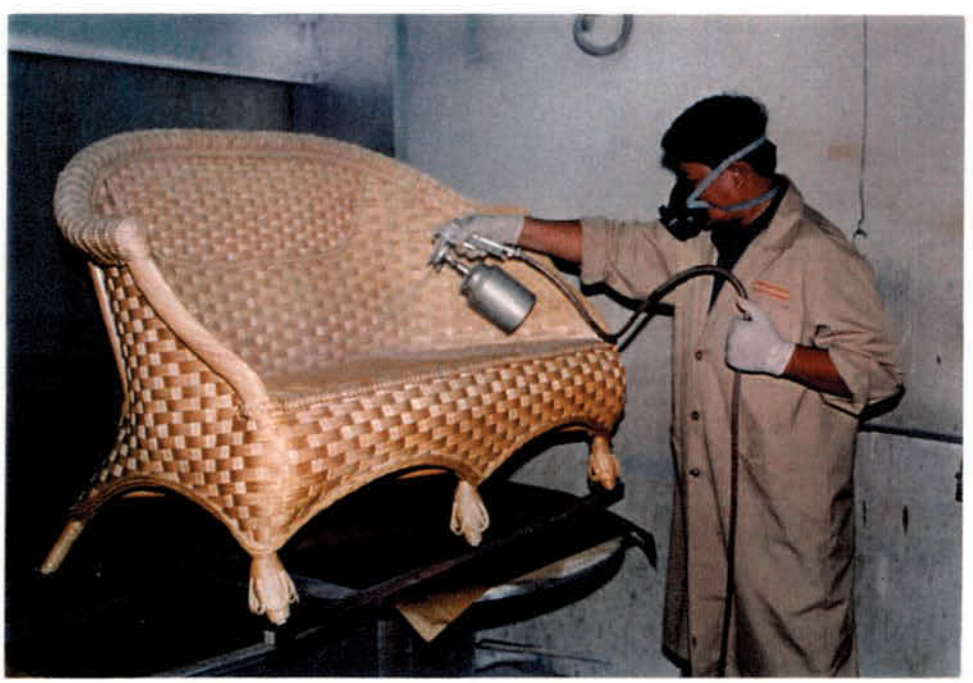
(xv) to encourage wider use of the under-utilised timber species, small dimension logs and the development of new forms of wood processing industries.

Sabah and Sarawak have their own priorities in their management policy and strategies but, in general, they are quite similar to those of Peninsular Malaysia.

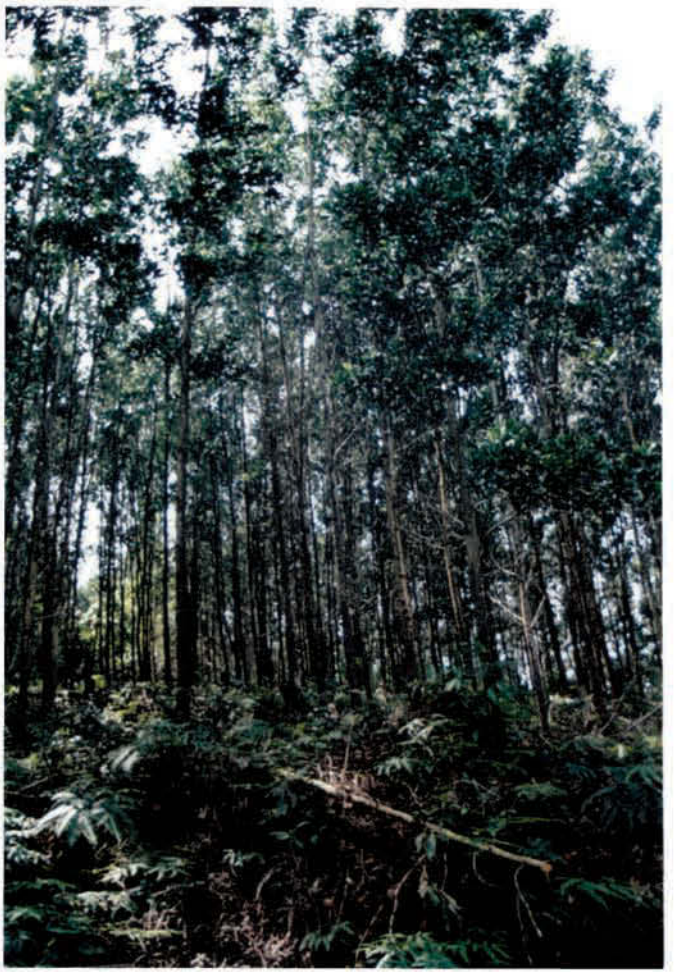
6.2 Natural Forest

In the pre-World War II era, forest and forest resources were abundant. Land development during that time was at a low ebb. There was little demand for timber and, subsequently, low pressure on timber exploitation. Thus, it was to be expected that the forest management system during that period was simple and straightforward as depicted in the early stand

Above: Mangrove forest at low tide. Note the painted trees soon to be felled. *Above right:* Peat swamp in Kuala Langet Selatan Forest Reserve, Selangor. The ground is often soggy but can be deep with litter. *Right:* Rural-based industry—a rattan chair being given fine finishing in a furniture factory in Negeri Sembilan.



Above: A nursery of *Rhizophora spp.* ready for planting in the mangrove forest. *Left:* Enrichment planting with marketable indigenous species of *Shorea leprosula* in Cikus Forest Reserves in Perak. Planted in 1968, measurements are made regularly to monitor growth. *Below:* Lowland Dipterocarp forest rich with *Dryobalanops aromatica* in Bukit Lagong Forest Reserves in Selangor.



Above: Research on forest fire management—to determine litter content in relation to biomass and availability of fuel on the forest floor. *Above right: Acacia mangium* plantations just after first thinning at age six years. With more space and sunlight the released crown will close again very soon. *Right:* A waterfall in Sungai Gabai forest recreation area in Hulu Selangor.

improvement felling, viz. Regeneration Improvement Felling, Departmental Regeneration Felling and Commercial Regeneration Felling, which were primarily concerned with improving the existing timber crop for future exploitation. There simply was no need for elaborate forest management systems.

Immediately after the war, the MUS evolved when in 1948 it was discovered that the rampant and untended forest exploitation carried out in the war years had resulted in abundant advanced seedling regeneration on the ground which is adequate for natural regeneration.

Between the formulation of the MUS and the current Selective Management System (SMS) in 1980s, the demand for timber increased substantially due to land development and conversion being on the rise. The 1960s also saw the start of a series of five-year Malaysian Plans. The effects of these plans were greatly felt in the forestry sector when more and more lowland forest reserves were converted or cleared for development. This occurred especially between 1960-1970. The Forestry Department was virtually 'powerless' to stop the rapid loss of forested land. Forestry work, then, was mainly towards revenue collection where the already limited manpower had to concentrate more on administering logging activities rather than on silviculture and other forest development.

It was about this time too that forest exploitation was moving towards higher ground or the hill forests. The MUS, which was especially adaptable for lowland forests, failed when applied in the hills. In the mid '70s, there was a strong shift in forest management towards the 'conservational approach'. There was growing emphasis on multiple-use forestry and the emergence of topical issues by the NGOs. Around 1976, forest land clearance and conversion hit its peak which finally resulted in the need to conserve and 'defend' the forest and curb its rate of removal. All these factors eventually led to the current Selective Management System being adopted in the 1980s.

It should also be noted that, between 1965 and 1978, there was no proper Forest Planning Policy. The National Forestry Policy was approved only in 1978. Prior to its approval, the Forestry Department had to refer to the Interim Policy. Thus, there were no clear-cut policies, planning tools or legal support to uphold the industry.

The MUS was, undoubtedly, a good system but only applicable in lowland forests. Unfortunately, there is no MUS Forest Model because there are insufficiently suitable areas left in Peninsular Malaysia to warrant the existence of a defined sustainable lowland Dipterocarp forest management system. Obviously, the management systems that came into being in Malaysia were not products of development or refinement of the systems prior to it. In reality, the change from MUS to SMS, for instance, happened due to differing forest types, viz., lowland forests versus hill forests, and the SMS was not actually an improved version of the MUS. The MUS and SMS were two discrete systems. Nevertheless, the historical development of the management systems in Malaysia has been unique and the result of years of experience gained in managing the forests. In fact, the management system developed in what was then Malaya was adapted in many countries around the world.

In order to implement silvicultural operations more effectively, a Silvicultural Cess Fund was created in 1973 in all states except Sabah and Sarawak. The fund is disbursed for the implementation of the various reforestation activities in each state. With the adoption of the

National Forestry Act 1984, the Silvicultural Cess Fund is now known as the Forest Development Fund. While the modified MUS is still being practised, the tendency now is more towards SMS with less worries about insufficient natural regenerations. In pursuance of sound management objectives, forest-harvesting in Sabah is undertaken in accordance with the prescribed silvicultural practices of promoting the development of natural regeneration. Forest areas in Sabah are harvested on an 80-year rotation and only trees of 60cm dbh above are removed.

In Sarawak, the cutting cycle for the Peat Swamp forest is 45 years with the prescribed cutting limits for *Gonystylus bancanus* (Ramin) and that of other species being 40cm dbh and 45cm dbh and above, respectively. The cutting cycle adopted for the Hill Mixed Dipterocarp Forest is 25 years where the prescribed cutting limits for the Dipterocarp and Non-Dipterocarp species are for trees over 60cm dbh and 45cm dbh respectively.

Besides managing the inland forests systematically under sustained yield management and for the protection and conservation of soil and water, the mangrove forests in Malaysia are also being managed to achieve maximum sustained yield of wood for charcoal, poles and fuelwood. In practice, these mangrove forest are managed under rotation cycles varying from 20 to 30 years. In Peninsular Malaysia, mature trees are clear-felled with the retention of seven mother trees per hectare and a river and coastal strip, while in the states of Sabah and Sarawak a minimum girth system of 21cm and 23cm respectively are adopted. Harvesting of these forests is carried out in batches of several hectares in area and the timber is removed for firewood or for conversion to charcoal. The tree stumps and slash material are left to decay. If, after about two years, no natural regeneration occurs, these areas are planted up with *Rhizophora spp*. Commercial thinning for poles is carried out once or twice before clear-felling, on 15-year and 20-year old stands using 1.2m and 1.8m stick lengths respectively, such as being carried out in the Matang Mangroves of Perak (Haron, 1981). Working plans for these mangrove forests are revised every 10 years based on the principles of sustained yield management.

6.3 Forest Plantation

As stated in the National Forestry Policy 1978 (Revised 1992), sufficient forest plantations of fast-growing tropical timber species and forest plantations of high quality timber species would be established throughout the country to supplement supply of timber from the natural forests. In this regard, private sector investment would be encouraged to enhance its development.

Forest plantations which are capable of yielding a high volume of wood per unit area and in a shorter period of time are becoming increasingly important in meeting the future timber requirements of the country. In the 1950s a number of forest plantations trials were established mainly with fast-growing exotic species. It has been envisaged that by the year 2000 forest plantations in Malaysia will be about 500,000 ha.

Commercial establishment of forest plantations was started in 1957 with the planting of teak in the northern states of Perlis and Kedah. Although the area planted now is still small (455 ha), 150 ha have been planted annually since 1986. Teak is a prime quality timber species and its choice for plantation is mainly due to the favourable climatic conditions in these states

and the high quality of wood it produces, although it is limited by the unavailability of suitable areas.

In the late 1960s and 1970s, plantation efforts in Malaysia were directed at establishing fast-growing tropical pines to produce long-fibred pulp, with a view to setting up a local pulp and paper mill. Although almost 7,000 ha have been planted mainly with *Pinus caribea, Pinus merkusii* and *Araucaria spp.*, the planting of these conifers was terminated in 1980 due to a change in management objectives and strategy.

With the increase in domestic demand for timber and timber products as population grow, there is an urgent need to develop and expand the forest resources of the country. One of the strategies adopted was to implement a programme of fast-growing forest plantation species that could supplement the timber from the natural forest or compensate for the forested areas that have been converted to other land-use. Thus, the launching of the Compensatory Forest Plantation Project in 1982 in the states of Pahang, Johore, Selangor and Negeri Sembilan. The project was to establish about 188,000 ha of forest plantation in Peninsular Malaysia within 15 years with specific targets for the Fourth, Fifth and Sixth Malaysia Plan of 8,000 ha, 74,000 ha and 106,000 ha respectively. The estimated cost of establishment was $517 million but the three chosen fast-growing species of *Acacia mangium* (Akasia), *Gmelina arborea* (Yemane) and *Paraserianthes falcataria* (Batai) were deemed economically viable hardwood species for this project. These species were expected to yield 210 m^3 per hectare of sawlogs after 15 years. The average annual log production was estimated at 2.63 million m^3 from 1998 onwards. At first *Eucalyptus camaldulensis* was also included in the original planting, but ran out of favour after the first few years.

However, after a few years of implementation, many shortfalls were detected including a lack of suitable land, high maintenance costs (for weeding, pruning and thinning), poor tree (bole) form, and a high incidence of suspected heart-rot disease (particularly in *Acacia mangium).* Regarding the latter, Appanah and Weinland (1993) observed that generally the common defects of the fast-growing species in Malaysia were brittle heart, heart rot and fungal infection. The targeted area to be planted under this project was then reduced to 100,000 ha, but still by 1995 only about 55,000 ha was planted. This shortfall could have been due to the moratorium period between 1992 and 1994 when consolidation was necessary in view of the heart-rot problem. Lack of funding has also contributed to the slowing down. For these reasons the project target area was further reduced to 80,000 ha with the year 2000 as the new date of completion. The total area of compensatory plantation till 1995 is shown in Figure Eight.

Nevertheless, the other States of Perak, Kelantan and Terengganu have also embarked on fast-growing forest plantation. Selangor has also recently completed establishment of 150 ha of *Hevea brasiliensis* (rubber) as forest plantation species using specially selected clones for timber production.

Sabah has also recognised the need for the establishment of forest plantations to supplement the natural forests. Plantation forestry started in Sabah in 1973 with the formation of the Sabah Softwood Company. The development of forest plantations was further enhanced when the Sabah Forestry Development Authority (SAFODA) was established to re-afforest the

grasslands and areas denuded trough shifting cultivation by the natives. At the end of 1995, SAFODA succeeded in establishing 46,043 ha with *Acacia mangium* (Figure 9).

Forest plantation was also established by Sabah Forest Industries. The species planted were *Eucalyptus deglupta, Paraserianthes falcataria, Gmelina arborea, Pinus caribaea,* and *Acacia mangium.* The total area planted at the end of 1995 was 92,075 ha. The Sabah state government has envisaged the eventual establishment of 600,000 ha of forest plantations throughout the state.

Forest plantation programmes in of Sarawak mainly involved the rehabilitation of degraded areas in the Permanent Forest Estate that have undergone shifting cultivation. At the end of 1995, the total area planted were about 10,000 hectares, mainly with *A. mangium, G. arborea, Shorea macrophylla, Swietenia macrophylla* and *Araucaria cunninghamii.* It has plans to establish 14,060 ha annually in areas of the Permanent Forest Estate that have been deforested by shifting cultivation.

It must also be noted that a Rattan Information Centre has been established at the Forest Research Institute of Malaysia with the support of the International Development Research Centre of Canada with the objective of conserving and managing the rattan resource of the country in perpetuity. Rattan, especially *Calamus manan (Rotan manau)* and *Calamus caesius (Rotan sega)* has been removed in large quantities from the natural forest due to their great demand both locally and for the export market. Adequate measures have been taken to sustain the resource supply by planting rattan in the natural forest as well as in rubber plantations. Currently about 12,000 ha of rattan have been planted in the natural forest areas of the PFE in Peninsular Malaysia, and many rubber smallholders have planted rattan in between their rubber trees for a short rotation of 9 – 12 years. The embarkation into rattan planting on a commercial scale is viable to meet the future supply of this resource. Sabah had planted 20,600 ha of rattan by the end of 1995 through the SAFODA Kinabatangan Rattan project.

6.4 Forest Development and Rehabilitation

The forest planning and integrated operational studies carried out so far in Malaysia, especially in Peninsular Malaysia, have clearly indicated the feasibility of continuous economically viable hill forest production in terms of economic log-out-turn volume with periodic cuts every 25 – 40 years using locally-appropriate cutting limits and leaving an adequate number of medium-sized trees of marketable species for natural growth into commercial sizes. It has been shown that, with average growth rates of trees over 30cm dbh of 0.8 – 1.0cm per year in diameter and 2.0 – 2.5 cubic metres per hectare per year in commercial gross volume, about three-quarters of the hill forests in Peninsular Malaysia are capable of producing every 30 years at least 40 – 45 nett cubic metres per hectare which is about the average current log outturn of the virgin hill forest. However, it is imperative to curtail harvesting damage of the residual stand to not more than 30% of the intermediate-sized trees.

In fact, the current practice of selective harvesting in Malaysia would ensure that the larger trees that remain would reach maturity in 20 – 30 years to allow for a second round of harvesting. And the process goes on. This in itself is a form of silvicultural treatment

because natural regeneration is increased by the gaps created during forest harvesting. Several studies have also indicated that regeneration of desirable species occur naturally in and around the gaps left by logging, and the logged-over forests are silviculturally treated to aid their rehabilitation, only when necessary.

The annual coupe of the Permanent Forest Estate under the Sixth Malaysian Plan (1991–1995) in Peninsular Malaysia was 52,250 ha of which 31,805 ha and 20,445 ha were managed under a 30-year (SMS) and a 55-year (MUS) cutting cycle, respectively. In addition, a total of 101,429 ha of stateland forest was also being harvested annually but no special attention was necessary here because they did not come under the PFE, and may sooner or later be converted to agricultural tree crop plantation or other land development. The annual coupes for the Permanent Forest Estate for the same period in both Sabah and Sarawak were about 60,000 ha each. Besides, the total area annually harvested in stateland forests of both states was about 300,000 ha. These states have also taken appropriate steps to control the rate of forest-harvesting, particularly in the PFE, in accordance with sustained yield principles.

Malaysia is committed to ensure that all harvested production forests of the Permanent Forest Estate are silviculturally treated. In early 1996, a total of 1,461,370 ha of the logged-over forests in Peninsular Malaysia have been silviculturally treated by poison-girdling and climber cutting while 21,286 ha have been enriched with commercial indigenous species (Figure 10). The main species that have been planted include *Shorea leprosula* (Meranti tembaga), *S. parvifolia* (M. sarang punai), *S. platyclados* (M. bukit), *Anisoptera spp.* (Mersawa), *Dryobalanops aromatica* (Kapur), *Scaphium spp* (Kembang semangkuk), and *Dyera costulata* (Jelutong). Annually, it is targeted that 80,000 ha of logged-over forests will be silviculturally treated while an area of 850 ha will be enriched with indigenous species. This progress, when compared to the annual rate of forest harvesting in the Permanent Forest Estate of 52,250 ha is very encouraging and certainly is a positive step towards more effective conservation and rehabilitation of the forest resources.

In Sabah, the total area which has been silviculturally treated is 298,000 ha with another 1,645 ha of poor forest being enriched with indigenous species. Annually, an area of about 12,000 ha of logged-over forest is planned for silvicultural treatment.

In Sarawak, a total area of 289,000 ha of logged-over forests was silviculturally treated by early 1996, in the Peat and Mixed Swamp Forests and the Hill Mixed Dipterocarp forests. Annually, an area of 6,000 ha of logged-over forests will be similarly treated.

Apart from rehabilitating the harvested natural forests, the planting of rattan in natural forests, as well as, in rubber smallholdings is also being implemented. As mentioned earlier, about 12,000 ha of rattan has been planted in Peninsular Malaysia, mainly with *Calamus manan* and *Calamus caesius,* 20,600 ha in Sabah, and 2,000 ha in Sarawak. The annual target for rehabilitation with rattan is about 2,000 ha, mainly in the natural forest and rubber smallholdings.

Moreover, *Parkia speciosa* (Petai), *Durio zibethinus* (Durian) and other fruits come from the forest during the main fruiting season annually. The Malaysian community enjoy these fruits despite the current high prices. As the Forestry Departments feel obligated to meet this demand by the community at reasonable cost, they have embarked on traditional fruit tree-

planting to supplement and complement the dwindling supply. The various Forestry Departments in Peninsular Malaysia have planted 2,606 ha of *Parkia speciosa, Durio zibethinus* and other fruit trees along fringes of forested areas which are located in the vicinity of existing villages. In Sarawak, about 400 ha of these species have also been planted. It will help the rural population a long way towards improving their quality of life.

In the mangrove forest reserves 1,500 ha are harvested annually. These areas will either be naturally regenerated or planted mainly with *Rhizophora spp.* (Figure 11).

6.5 Helicopter Logging

Helicopter logging was first introduced in the state of Sarawak in April, 1993. It is used mainly for logging in hilly and the less accessible forest areas. The ability of the helicopter to uplift logs vertically greatly helped logging operations in these areas.

The helicopters used in Sarawak are the Sikorsky S-64E which is also known as the Erikson Air Crane, and the Bell helicopter. The Sikorsky S-64E, with a lifting capacity of 20,000 lbs (9,000 kg), is used to vertically uplift logs from felling areas in the forest onto the roadside drop zone. The flying range of the helicopter is kept within 3 km from the drop zone. The Bell helicopter is used for transporting felling crews to the felling areas and for aerial supervision of the logging operations.

Each felling crew consists of a chainsaw operator and an assistant. On average, each crew can only cut eight to nine trees a day. This is because of the difficult terrain conditions and the need to select only good merchantable trees. The lifting operation by the helicopter is carried out continuously, and because of the short runs, it is necessary to ensure that there is a sufficient quantity of logs for the helicopter to lift (Figure 12). As such, the felling operation is planned so that it has a headstart of at least 14 days from the helicopter lifting operation. All logs are numbered with paint and located on a map to assist the pilots in identifying the location. The logs are lifted to the drop zone, after which they are transported to the stacking area by a front-end loader.

A study made by the Forestry Department, Sarawak had indicated some positive attributes of helicopter logging. These include the following advantages:

(i) Suitability for logging in hilly and the less accessible forest areas.

(ii) High machine productivity of 70 per cent.

(iii) Average production rate is 671 m^3 per effective working day which is 15 times more than that of the tractor.

(iv) Harvesting damage to surrounding trees in helicopter logging areas is almost four times less than that using a tractor.

(v) Land erosion resulting from building of roads is minimised because the flying range of the helicopter is three km, whereas the optimum skidding distance of tractors is only one km.

(vi) Negligible increase in stream turbidity.

The study also indicated some disadvantages in that the operational cost of helicopter logging is very high. The maximum lifting capacity of the helicopter of 9,000 kg also meant that only good, merchantable logs were selected to be lifted which resulted in low utilisation of felled trees. The study showed that about 1.76m^3 of each felled tree were not utilised. As harvesting of the forest was very selective, the growth rate of the residual trees will also be slow.

From the above observations, it is clear that helicopter logging is a low environmental impact harvesting system. It also reduces pollution caused by land erosion as it minimises the building of logging roads. However, its implementation would depend largely on the ability to absorb the high operating costs.

6.6 Multi-Storied Forest Management

The Multi-Storied Forest Management Project was established in 1991 and funded with expert assistance by the Japan International Cooperation Agency (JICA). The purpose of the project is to collect useful data through the establishment of a Multi-Storied Forest Management System in the tropics, which will contribute to the promotion of reforestation/afforestation by the private sector and the sustainable development of the forest. The system has been tried in both plantation and logged-over forest.

The Multi-Storied Forest Management System is a management system for diversified timber production developed to create a mixed forest of complex structure taking into account environmental considerations and resistant to pests and diseases. Two sites were chosen for the project, viz. Chikus Forest Reserve and Bukit Kinta Forest Reserve with an area of 500 hectares each respectively. The Chikus Forest Reserve site comprises three to four year-old *Acacia mangium* plantations while the Bukit Kinta Forest Reserve site comprises logged-over natural forest. The species suitable for the planting of multi-storied forests are *Shorea leprosula, Shorea parvifolia, Neobalannocarpus heimii* and Hopea odorata.

Two models have been tried under this project, as follows:

a. Model I (three-storied type)
Planting with *Acacia mangium* (short-rotation species) as upper trees and *Shorea parvifolia* and *Shorea leprosula* (long-rotation species) as lower trees.

b. Model II (four-storied type)
Same as Model I, but medium-rotation species such as *Tectona grandis, Khaya ivorensis* and *Swietenia macrophylla* were planted to provide income before long-rotation species could be harvested.

6.7 Bentong Model Forest

The Bentong Model Forest, initiated in 1995, comprises the whole district of Bentong in Pahang State. The State Forestry Department of Pahang, Peninsular Malaysia and Canada are the co-implementors of this Model Forest. It provides for the establishment of Permanent

Forest Estate (PFE) and for the proper and effective management, utilisation and development of the forest resources. This 'Malaysian' Model Forest is the third international example to be initiated by Canada, after Mexico and Russia, and may also be the third of its kind in the world. The goals and objectives of the Models Forest are as follows:

(i) maintenance of a healthy forest ecosystem;

(ii) to ensure renewable and sustainable source of economic, social and ecological benefits;

(iii) generation and assurance of stable revenue and employment;

(iv) implementation of integrated resource management principles incorporating environmentally sound technology;

(v) raise awareness and total commitment in the sustainable development of forest among forest users;

(vi) resolving conflicting land use;

(vii) promotion of better understanding on the multiple role of forest.

The implementation and execution of the Bentong Model Forest is carried out within the existing administrative and legislative structure and framework of the government. In highlighting the values of the forest resources, a number of forestry functions are taken into account, namely:

(i) Regulatory function, which includes climate, waterflow, protection of water catchment, prevention of erosion, maintenance of biodiversity and fixation of carbon dioxide.

(ii) Carrier function which includes:
- living area for people, especially indigenous populations;
- areas for cultivation of agricultural crops;
- areas for recreation.

(iii) Production function which includes:
- timber production;
- non-timber forest produce; and
- genetic resources.

(iv) Information function, which includes spiritual, religious, cultural, technical, and educational purposes.

The recognition of the District of Bentong as a model forest reflects a holistic and integrated approach to the management of the forest resources. All aspects of forest management are included and there is full participation of all the interested groups in the locality. Undoubtedly, enormous efforts have been taken to ensure sustainability of the forest resources in the overall context of the socio-economic growth of the area.

The establishment of the Bentong Model Forest is seen as a commitment by Malaysia, and in particular the state of Pahang, to be more transparent and accountable in its commitments towards sustainable forest management. Unfortunately, however, the implementation of this project has been deferred by the authorities concerned.

7.0 MANAGEMENT ISSUES AND CHALLENGES IN FORESTRY

It is envisaged that more intensive forest management will be carried out in the coming years, particularly with increasing emphasis now being placed on topical forest with regard to its sustainability, conservation and development. This is in line with Malaysia's stand as a member of producer countries where it is required that all trade in tropical timber follow the decisions agreed in UNCED which was held in Rio de Janeiro, Brazil in June, 1992. There the "Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of all Types of Forests" was agreed and the "Convention on Biological Diversity" by the European Economic Community and 153 countries, including Malaysia, was signed. Malaysia ratified the convention on Biological Diversity on 2 June, 1994.

Efforts will also be taken by Malaysia to facilitate the full implementation of this UNCED statement on forestry and the obligations as required under the convention on Biological Diversity. Malaysia will be examining closely and identifying, in particular, the areas under agenda 21, especially Chapter 11 (Combating Deforestation) and Chapter 15 (Conservation of Biological Diversity), where financial assistance and the transfer of environmentally-sound technologies are required to ensure their successful implementation.

In 1992, Malaysia and United Kingdom conducted a wide-ranging programme for the biodiversity conservation, management and development of Malaysian forest resources. This programme also conducted research into these imaginative concepts ??? as it has a prodigious diversity of plant and animal life, and large areas of the permanent forest estate. The programme was divided into two sub-programmes, A and B, concerning 'upstream' basic research and 'downstream' developments dealing with industrial and commercial aspects, respectively. Sub-programme A for the research activities taken place in readily accessible 'Demonstration and Development Areas', was intended to be show-cases for learning and training in suitable forest management, while sub-programme B focused on the valuation of costs and benefits of non-timber forest products and services.

The Development of Indirect Values for forest recreational areas in Peninsular Malaysia was also carried out between Malaysia and United Kingdom (ODA – Overseas Development Agency) for the purpose of developing a method to determine the indirect values of forest recreational areas. In 1995, analysed data from 20 study areas were computerised and a training workshop was conducted on the methodology of the study methods, concepts, use of the data and its applications.

Malaysia will redouble its effort towards achieving sustainable forest management in the overall context of sustainable development. In this regard, Malaysia will operate the "ITTO Guidelines for the Sustainable Management of Tropical Forest Management" and its "Criteria for the Measurement of Sustainable Tropical Forest Management" in managing its natural

forest. Efforts will be made to ensure that the establishment and development of forest plantations are also consistent with the "ITTO Guidelines on the conservation of Biological Diversity in Tropical Production Forest" and the "ITTO Guidelines for the Establishment and Sustainable Management of Planted Tropical Forests".

Currently, the economic valuation of the forest resource on the basis of the monetary costs of extraction and distribution has often resulted in inadequate incentives for sustainable resource use. In future the introduction of incentives and penalties will be re-examined and re-oriented to fully reflect the full costs of forest products, including environmental costs. The internalisation of environmental costs will dispel the assumption that the environment is a free good.

Moreover, widely-used economic indicators, such as the gross national product, do not reflect the sustainability of the forest resource in the overall development processes. Thus, it is imperative that national policy and development projects should take full account of their effects on their environment and include the costs of natural resource depletion, particularly forest, in the valuation of environmental quality in national accounting systems. This will bring about fundamental changes in the integration and accounting of the environment as well as the development of forest resource in decision-making. This will also facilitate the shift from a 'post factor' approach to an anticipatory approach in addressing forest resources used, and environmental degradation at their roots.

The potential of biodiversity contribution to human health and welfare, through new and improved food crops, the development of pharmaceutical products and the improvement of biotechnological processes cannot be over-emphasised (Thang,1993). Every effort should be made to nurture this potential, as suggested subsequently.

1. An inventory should be made to appraise genetic resources of the forests to enable the formulation of nationally agreed bio-geographic areas for the conservation of biodiversity in Malaysia, ensuring completeness of representations of the various forest ecosystems.

2. The cost of protecting and managing existing biological reserves in implementing *in situ* conservation should be quantified.

3. Economic values to the natural biological resources utilised by rural people should be ascribed.

4. An effective joint management mechanism in the conservation of biodiversity between the conservators and users should be developed to ensure equitable returns to both parties.

The sustainable management of the forest resources in Malaysia may further be enhanced through careful implementation of policy and the recognised forest management system. The following actions should be considered to achieve this.

1. Harvesting and reforestation technologies must be refined through operational studies to achieve higher efficiency and cost-effectiveness.

2. Reforestation and diversification of forest plantation programmes should be expanded to produce higher-value speciality timbers and raw materials for specialised, as well as small-scale, industries.

3. Fiscal and monetary incentives should be provided for the establishment of forest plantations by private sectors to make them both financially and economically attractive and viable. Public investments in agricultural development should be encouraged to include large-scale forest plantation establishment for timber production without affecting environmental quality.

4. Computerised forest information system should be operationalised, based on timely and comprehensive data to improve the effectiveness of forest practices.

5. Integrated operational research of forest management, including genetic tree improvement, fertilisation and other silvicultural practices, should be strengthened.

6. Preparation of forest management plans, harvesting plans and reforestation plans should be in consultation with the state governments and the relevant concessionaires so as to ensure their effective implementation.

7. Forestry with agriculture could also be integrated in rural development to expand employment opportunities and supplement income-earning, and to help solve the practice and problem of shifting cultivation in Sabah and Sarawak.

The rate of forest harvesting could be reduced and forest resources conserved if actions are taken to:

(i) reduce the high level of losses due to felling breakage, high stumps and short logs left in the forest after harvesting. The harvesting losses in Malaysia can be as high as 45% or more of the total utilisable volume;

(ii) increase efficiency and recovery of existing mills with greater emphasis on the processing of small-sized timber and the under-utilised timber species;

(iii) export only value-added forest products to encourage greater conservation and utilisation of raw timber;

(iv) promote optimal use of lesser-known timber species and processing them into value-added products;

(v) encourage establishment and development of secondary and tertiary wood-processing industries with a view to achieving greater value-added products;

(vi) promote small-scale rural based industries using other forest produces such as rattan and bamboo to enhance socio-economic development of rural areas;

(vii) promote fuller utilisation of timber from trees other than those from the natural forests such as rubberwood logs which are readily available.

Furthermore, it is imperative that a practical and workable scheme in certifying timber emanating from sustainable managed forests be developed and that such timber should be provided with greater market accessibility and financial returns. Besides, timber also emanates from planned and controlled conversion of forested land to non-forestry uses, such as in the establishment of agricultural tree crops and in meeting the need for infrastructure development. It is, therefore, critical to provide better conservation and management of these renewable forest resources for long-term benefits, to promote economic growth and development. In this light, future emphasis should focus on:

(i) development of methodologies for the valuation of non-wood forest resources as well as the environmental cost incurred in forest harvesting;

(ii) quantification of cost of forest depletion and its integration into the national accounting system;

(iii) development of techniques for the complete appraisal of all forest genetic resources and ascribing economic values to them;

(iv) improvement of harvesting techniques which are environment-friendly so as to reduce the current high level of harvesting losses, while promoting the utilisation of the under-utilised timber species;

(v) identification of appropriate species for the rehabilitation of areas degraded by shifting cultivation.

(vi) increment of the utilisation of other lignocellulosic materials, especially those from perennial agricultural crops through the development of appropriate industrial processes.

8.0 RESEARCH AND DEVELOPMENT ON FOREST MANAGEMENT PRACTICES

Forestry research in Malaysia dates back to the beginning of the century with the establishment of the Forest Research Institute in Kepong, near Kuala Lumpur as a research unit of the Forestry Department. In October 1985, the Institute became a statutory body, and is now known as the Forest Research Institute of Malaysia (FRIM). FRIM is responsible for research on all aspects of forestry and forest products. Research in ecology (Figure 13) and silviculture is carried out with the objective of developing suitable management and silvicultural techniques for the forest in Malaysia. Studies conducted in these areas are aimed at providing information to enhance the knowledge and understanding of the ecology and dynamics of these forests and their response to logging and other disturbances. Research in forest plantation is geared towards the fuller utilisation of wood properties, growth characteristics and species suitability. Forest products research is directed towards a more efficient and diversified utilisation of the nation's forest resource with the aim of promoting higher operational efficiency in existing production systems by introducing innovative technological systems, thereby reducing wood waste and encouraging fuller utilisation of the currently under-utilised timber species.

Being the national R & D organisation, however, does not mean it is the only agency responsible for forestry research in the country. There are a number of other centres of excellence where complementary R & D activities are being carried out. These include the Forest Research Centre at Sandakan in Sabah; the Timber Research and Technical Training Centre and the Forestry Research Division of the Sarawak Forest Department; and the Faculty of Forestry of University Pertanian Malaysia.

The need to carry out continued research and development on mangrove forests requires no emphasis as the ecology of mangrove forests has been found to be productive not only in terms of timber but also in the protection of the marine environment itself. Coastal erosion has recently been identified as having significant repercussions on agriculture schemes. Research is now under way, in collaboration with the Malaysia Agricultural Development Authority (MARDI), to overcome this problem.

Research has significantly influenced the development of the forestry sector and has resulted in the comprehensive documentation of the tree flora and fauna. Years of monitoring growth and performance of trees in established plots have provided the basis for current practices in silviculture. These lend support for the forest management policies in Malaysia and have influenced similar practices implemented in some other tropical countries.

9.0 CONCLUSION

Malaysia is aware of the need to manage sustainably its forests, not only for socio-economic benefits but also for climatic, ecological and environmental stability. It strongly believes in the principles of sustainable management and is openly committed to maintain its Permanent Forest Estate and the network of conservation areas. Compared to European forestry, forest management in Malaysia is relatively new, but British involvement in the early twentieth century administration of the Straits Settlement, the Malay States and North Borneo had brought Malaysian forestry to the fore in South-east Asia and the tropical world. "Malaysianisation" of the civil service in the post-independence era saw local foresters take over the helm as conservators and guardians of the forest, and with them, a lot of the knowledge and experience of the expatriates as well as what they had learned in British and Australia universities in the 1960s.

Almost three-fifths of the country is still forested, and its rainforest has been recognised as a rich, natural heritage which, in addition to providing valuable timber and other forest products, also provide essential environmental-friendly services such as recreation, aesthetics and other intangible values. The forests are also important for the conservation of biodiversity and as a carbon sink for the continually industrialised world. The anti-tropical timber campaign in the 1980s might also have helped Malaysia to consolidate its forest management practices and encourage diversification in the timber industry while instilling more conservational measures towards sustainability of this important resource. Indeed, for Malaysia, the long-term objective for the sound and sustainable management of its forests must be one that balances the needs and wants of society, both local and global, as well as the economic growth of the country and the environment.

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