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WORKING PAPER No. 41

The National Agricultural Research System in Malaysia

by
Mohd. Yusof Hashim

International Service for National Agricultural Research

The mandate of the International Service for National Agricultural Research (ISNAR) is to assist developing countries in bringing about lasting improvements in the performance of their national agricultural research systems and organizations. It does this by promoting appropriate agricultural research policies, sustainable research institutions, and improved research management. ISNAR's services to national research are ultimately intended to benefit producers and consumers in developing countries and to safeguard the natural environment for future generations.

ISNAR offers developing countries three types of service, supported by research and training:

- For a limited number of countries, ISNAR establishes long-term, comprehensive partnerships to support the development of sustainable national agricultural research systems and institutions.

- For a wider range of countries, ISNAR gives support for strengthening specific policy and management components within the research system or constituent entities.

- For all developing countries, as well as the international development community and other interested parties, ISNAR disseminates knowledge and information about national agricultural research.

ISNAR was established in 1979 by the Consultative Group on International Agricultural Research (CGIAR), on the basis of recommendations from an international task force. It began operating at its headquarters in The Hague, the Netherlands, on September 1, 1980.

ISNAR is a nonprofit autonomous institute, international in character, and apolitical in its management, staffing, and operations. It is financially supported by a number of the members of the CGIAR, an informal group of donors that includes countries, development banks, international organizations, and foundations. Of the 18 centers in the CGIAR system of international centers, ISNAR is the only one that focuses specifically on institutional development within national agricultural research systems.

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AGROVOC Descriptors

government research; management; organization of research; public research; research; research institutions; Malaysia.

CABI Descriptors

agricultural research; government management; management; organization of research; planning; research; research institutes; Malaysia.

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List of Acronyms

AAECP	Australian Economic Cooperation Program
ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AFHB	ASEAN Food Handling Bureau
ASEAN-Planti	ASEAN Training and Plant Quarantine Institute
AVRDC	Asian Vegetable Research and Development Center, Taiwan
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	International Maize and Wheat Improvement Center
CPB	cocoa pod borer
CPO	crude palm oil
CPKO	crude palm kernel oil
CSIRO	Commonwealth Scientific Industrial Research Organization
DOA	Department of Agriculture, Malaysia
DOF	Department of Fisheies, Malaysia
DVS	Department of Veterinary Services, Malaysia
EEC	European Economic Community
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization of the United Nations
FAO-UNDP	Food and Agriculture Organization of the United Nations - United Nations Development Programme
FRI	Forest Research Institute
FRIM	Forest Research Institute of Malaysia
GDP	gross domestic product
GNP	gross national product
HRD	human resource development
IAEA	International Atomic Energy Agency
IBSRAM	International Board for Soil Research and Management
IBPGR	International Board for Plant Genetic Resources
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Centre, Canada
IFDC	International Fertilizer Development Center
IMP	industrial master plan
IMR	Institute of Medical Research
INRA	Institut National de la Recherche Agronomique, France
IPI	International Potash Institute
IPM	integrated pest management
IRPA	Intensification of Research in Priority Areas
IRRI	International Rice Research Institute
JETRO	Japan External Trade Organization
JICA	Japan International Cooperation Agency
KEJORA	Southeast Johore Development Authority
KETENGAH	Central Terengganu Development Authority
KESEDAR	South Kelantan Regional Development Authority

KU	Kasetsart University, Thailand
MAB	Man and Biosphere, Thailand
MARDI	Malaysian Agricultural Research and Development Institute
MCB	Malaysian Cocoa Board
MFRDB	Malaysian Forestry Research and Development Board
MOA	Ministry of Agriculture, Malaysia
MPI	Ministry of Primary Industries, Malaysia
MPIB	Malaysian Pineapple Industrial Board
MRRDB	Malaysian Rubber Research and Development Board
MTDC	Malaysian Technology Development Corporation
MOSTE	Ministry of Science, Technology and Environment, Malaysia
NARS	national agricultural research system(s)
NAP	national agricultural policy
NCSRD	National Council for Scientific Research and Development
NIEs	new industrial economies
NUS	National University of Singapore
PCARRD	Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development, Philippines
PERDA	Penang Regional Development Authority
PORIM	Palm Oil Research Institute of Malaysia
PORDB	Palm Oil Research and Development Board
PPI	Potash and Phosphate Institute
QDPI	Queensland Department of Primary Industries, Australia
R&D	research and development
RRI	Rubber Research Institute
RRIM	Rubber Research Institute of Malaysia
S&T	science and technology
SMR	Standard Malaysian Rubber
SOPP	Second Outline Perspective Plan
TARC	Tropical Agricultural Research Centre, Japan
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPM	University Pertanian Malaysia (University of Agriculture, Malaysia)
VOCRS	Vegetable and Ornamental Crops Research Station
VRI	Veterinary Research Institute

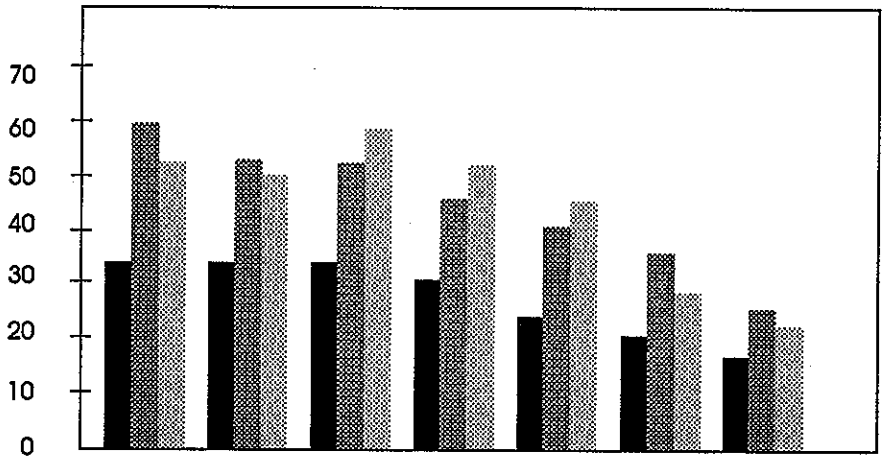
1. Executive Summary

This report provides insight into the Malaysian national agricultural research system (NARS). A general overview of Malaysia is featured with emphasis on the economic scenario especially pertaining to contributions made by the agricultural sector. The resources available and the role of major agricultural products are discussed. Various policy guidelines for the development of the sector as well as issues and challenges are presented.

Specifically, this report documents the evolution and organization of the science and technology (S&T) structure in Malaysia. The NARS as a component of S&T is highlighted. Issues relating to the NARS management and the planning mechanism are discussed. Brief descriptions of major research and development (R&D) institutions are provided, followed by national procedures for R&D priority setting, implementation, funding, and linkages. Emphasis is on the Intensification of Research in Priority Areas (IRPA) mechanism as an R&D implementation procedure.

Finally, an example is provided of public agency involvement in the overall NARS. This information should be of interest to other NARS in their effort to further improve R&D mechanisms.

Figure 1
Contribution of the agricultural sector to the Malaysian economy (1960-1990)



	1960	1965	1970	1975	1980	1985	1990
GDP	32	31.5	30.8	27.7	22.8	20.8	18.7
Employment	59	52.1	50.5	45.3	39.7	35.7	27.8
Export Earnings	52	49	56.8	49.8	43	28.9	23.3

GDP Employment Export Earnings

2. General Overview of Malaysia

2.1 Geographical facts

Located in the tropics, Malaysia straddles the South China Sea. It is made up of two major land bodies. The first, Peninsula Malaysia, comprises 11 states and is located at the tip of mainland Southeast Asia. The second, the states of Sabah and Sarawak, are on the island of Borneo. These two regions are separated by about 530 km of the South China Sea.

Malaysia covers a total area of about 327,910 sq km (32.9 million ha) with 131,480 sq km in Peninsula Malaysia, 71,890 sq km and 124,540 sq km in Sabah and Sarawak, respectively. Peninsula Malaysia shares its northern frontier with Thailand and its southern frontier with Singapore (13). The west coast of the Peninsula Malaysia is bordered by the Straits of Malacca. The east coast is bordered by the South China Sea. Sabah and Sarawak have a common boundary with the Indonesian territory of Kalimantan.

Total population is 18 million, 80% of which is in Peninsula Malaysia. The annual population growth rate is 2.5%.

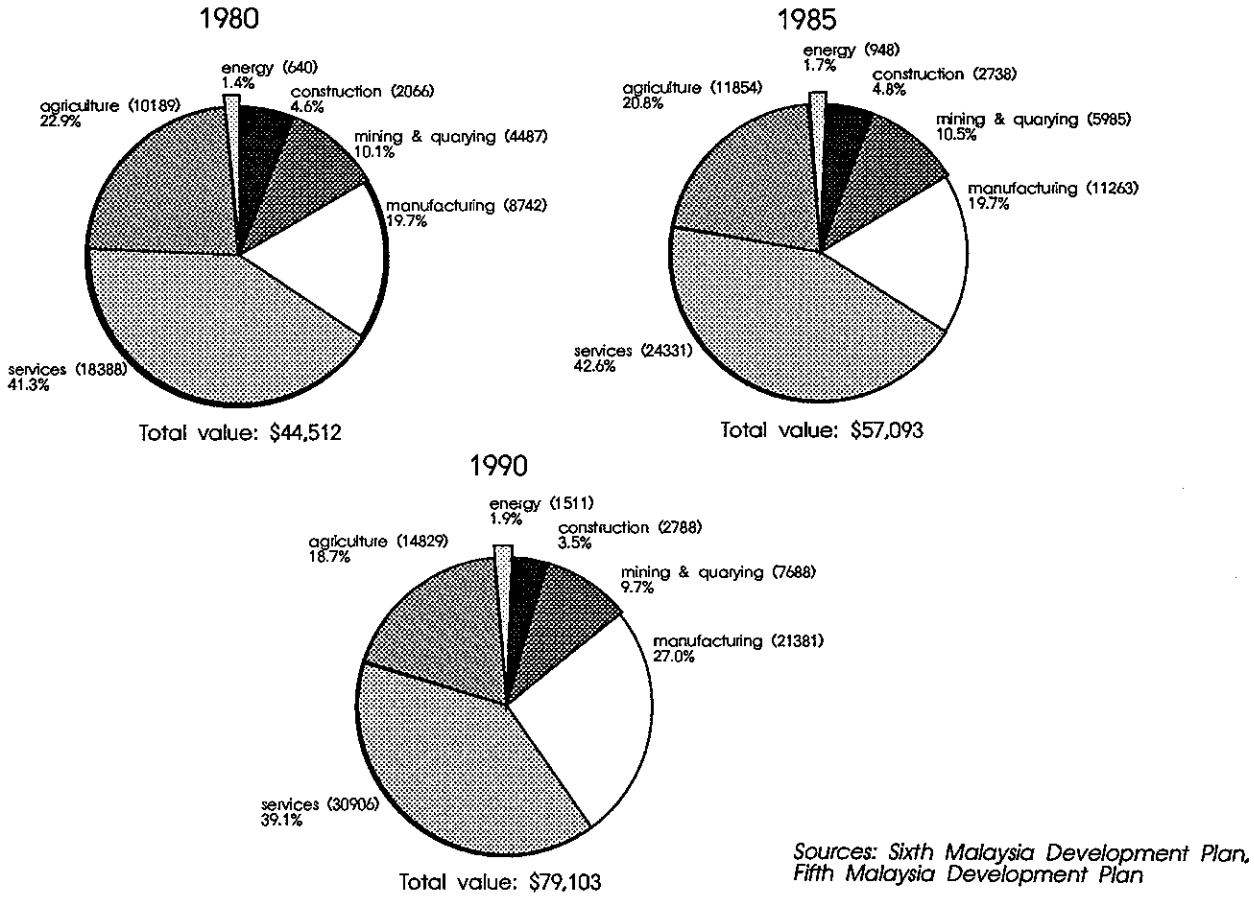
2.2 The economy

Malaysia is gaining ground as a land of opportunities. Natural resources abound, labor is cost effective, industrial land ample, infrastructure adequate, and the currency strong. All these are encased in a framework of official policies and incentives which together provide for a dynamic and efficacious economic climate.

The main thrust of the country's economic development is to stimulate greater and wider private sector growth. In the manufacturing sector, investments to develop resource-based industries and selective heavy industries and to upgrade and diversify other industries are encouraged. Incentives are provided to encourage large scale commercial agricultural ventures.

Efficient economic management has contributed to make Malaysia, a developing country,

Figure 2
Composition of GDP by economic activity, 1980-1990 ($ million)



Sources: Sixth Malaysia Development Plan, Fifth Malaysia Development Plan

the economy with the fastest growth rate in the South East Asian region. Its gross national product (GNP) is about 7.6% per annum, amounting to about M$110 billion in 1990 and resulting in a per capita income of M$6180 (1). Until 1987, the agricultural sector had been the mainstay of the Malaysian economy. Since that time, however, the manufacturing sector has taken the lead, followed by the agricultural and mining sectors.

Total exports for 1990 totaled M$79.5 billion. During the same period, imports amounted to M$79.1 billion (1). The major export and import components and their values were as follows:

Exports (billion $M)		**Imports (billion $M)**	
Agriculture (rubber, palm oil, paper, and cocoa	8.0	Consumption goods	17.3
Forestry (sawlogs and sawn timber)	7.1	Investment goods	28.1
Mining (tin, LPG, crude petroleum)	13.8	Intermediate goods	32.8
Manufactures	48.0	Imports for reexports	0.9
Others	2.6		
	79.5		79.1

Source: Sixth Malaysia Development Plan (1991-1995)

3. The Agricultural Sector and the Economy

The Malaysian agricultural sector is made up of the plantation and the smallholder sectors. The smallholder sector is further subdivided into organized land schemes and the traditional small, scattered, individual smallholders. The land schemes are centrally managed by land development authorities.

Size of individual holdings is the criteria normally used to determine land-holding classification. The plantation sector commands holdings of 100 acres (40 ha) or more. However, plantation holdings of a few thousand acres are the norm.

The duality between the two sectors is also very distinct in terms of crop type, management, and efficiency of production. The plantation and the organized smallholdings concentrate largely on the production of industrial crops, such as rubber, oil palm, cocoa, and pineapple. The unorganized smallholders are concerned with the production of food crops, in particular: rice, fruits, and vegetables, in addition to rubber and cocoa (12). Tobacco and pepper, industrial crops by nature, remain a smallholders' domain. Currently about 60% of the total agricultural land is under the smallholder sector.

3.1 Economic contribution

During the 1960s, the agricultural sector grew by about 7%. This growth began to decline to about 5% during the 1970s, and 4.1% in the 1980s. This decline is expected to continue to a low of 3.5% during the 1990s (1) and is partly the consequence of the government's effort to diversify and industrialize the economy. This effort led to the expansion of the non-agricultural sector — particularly the manufacturing and service sectors. Subsequently, the relative importance of agriculture in the economy has changed somewhat, particularly with regard to output and employment.

The agricultural sector's contribution to the GDP declined from 32% in 1960 to 22.8% in 1980 and further to 18.7% in 1990. The sector's share of 59.0% of employment in 1960, likewise declined to 39.7% in 1980 and 27.8% in 1990. Similarly, agriculture's share of total export earnings declined from 52% in 1960 to 43% in 1980, and subsequently to 23.3% in 1990 (19). These trends clearly reflect the declining role of agriculture in the economy (Figure 2).

Notwithstanding its declining importance, the total value added for the sector is commendable. In absolute terms, it has increased from M$10.2 billion in 1980 to M$14.8 billion in 1990. It is envisaged that the agricultural sector will continue to contribute

Table 1
Contribution of the agricultural sector to the national economy (constant 1978 prices)

	1990	1995	2000	2010
GDP (M$* billion)	10.2	4.8	20.8	29.4
	(23%)	(19%)	(13%)	(10%)
Export earning (M$ billion)	15.1	17.4	19.6	26.6
Employment (million)	1.8	1.8	1.8	1.7
	(37%)	(28%)	(20%)	(15%)

Sources: 1. Economic Planning Unit (Calculation was based on average annual growth rate of 3.5% envisaged for the 1990-2010 period).2. Ministry of Agriculture (1991).
**M$ 2.5 = US$ 1*

significantly in terms of gross domestic product (GDP), employment, and export earnings in the near future. Its contribution in 1990 and its forecast for the next 20 years is illustrated in Table 1.

3.2 Agricultural resources

3.2.1 Agricultural land

The total land area found to be suitable for agriculture is about 11.63 million ha, representing about 35% of the total land area. Of the total area cultivated (about 5 million ha), 80% is under the main export commodities of rubber, oil palm and cocoa, 10% is under rice, and the remainder is under other crops. About half of the arable land is in Peninsula Malaysia (14).

There are also vast areas of marginal lands which can be improved for agricultural purposes. These are the steeplands (17.9 million ha), deep peat (2 million ha), sandy bris soils (420,000 ha), tin tailings (120,000 ha), and acid sulphate soils (840,000 ha). In spite of their limitations, some of these marginal lands have been put to lucrative use.

About 8,000 ha of the highlands (steepland features) in the Cameron Highlands and Frasers Hill areas are utilized for the production of temperate crops. Another 20,000 ha within the same region have been identified as potential areas for agricultural development. About 20% and 80% of the Peninsular peat and acid sulphate soils have been utilized for agricultural purposes respectively. Pineapple, vegetables, and oil palm are the main crops on peat while the acid sulphate soils are utilized mainly for vegetables and fruits. Tobacco is the major crop on the sandy bris soils along with other minor crops. These crops take up about 80% of the sandy bris area in Peninsula Malaysia. Of the available tin tailing areas, about 20% has been utilized for the cultivation of vegetables and fruits.

3.2.2 Water

The declaration of the Exclusive Economic Zone (EEZ) of Malaysia resulted in the expansion of available sea resources from 47,000 to 160,000 sq nautical miles. There exists a vast potential of marine resources for commercial exploitation, especially through deep sea fishing. The country is also blessed with vast areas of fresh water. In addition to the man-made fishing ponds, the relative abundance of natural resources such as mangroves, sheltered water bodies, rivers, lakes, and ex-mining pools could be utilized for aquaculture development.

3.2.3 Forest

The total area under natural forest is about 18.4 million ha, representing about 56% of the country total land area. Out of this, 30% is located in Peninsula Malaysia, 24% in Sabah, and 46% in Sarawak. However, taking forest plantations and other agricultural crops like rubber and oil palm into consideration, the mean percentage of tree cover to total land area is about 70%.

Forest resources have been one main revenue earner for the country, especially through logging. However, for environmental conservation, the standing policy on forest management is to scale down logging. As a result, land area opened for logging has dropped substantially during the last decade. Greater emphasis is now on environmentally sustainable timber exploitation, through excellent forest management.

3.3 Major agricultural commodities

3.3.1 Agricultural crops

Malaysia remains the world's largest exporter of palm oil, natural rubber, and tropical timber. The country is also a leading exporter of cocoa beans and pepper. A few other products, particularly fruits have recently gained entry into the international market. Malaysia's share of the canned pineapple market, for which the country was once renowned, is now being revived. And rice, in spite of its high cost and heavily subsidized production, continues to be produced.

The nation's staple food, rice remains a strategic crop. Other commercial crops produced are vegetables, flowers, and tobacco.

3.3.1.1 Rubber

Malaysia is the leading producer of natural rubber, contributing towards 31% of the total world production. Rubber cultivation covers 1.9 million ha of the arable land, 64% of which is smallholdings. Ninety three percent of the 1.3 million t production is from the Peninsula.

The total export value of the crop is M$3 billion. Export is mainly in the form of Standard Malaysian Rubber (SMR). The primary processing of the coagulated rubber to the SMR contributed 13.5% of the total agricultural value added.

Domestic consumption is about 14% of total production. Rubber is used mainly in the tire, pharmaceutical equipment, and rubber shoe industries, engaging over half a million full- and part-time workers.

3.3.1.2 Oil palm

Malaysia is also the world leader in palm oil and palm kernel oil with production contributing 57% of the world production. About 2 million ha are under the crop yielding 6.6 and 1.8 million t of crude oil and palm kernel oil, respectively. The plantation sector contributed 47% to the total area cultivated, while organized and unorganized smallholders accounted for the remaining 45% and 8%, respectively.

Primary processing of the commodity contributed about 35% to the total agricultural value added, while the total export value of the commodity amounted to $4.4 billion.

About 163,000 workers are employed by the oil palm industry, of which 60,000 are smallholders in public-sector land schemes.

3.3.1.3 Cocoa

Malaysia is one of the world's largest producer of cocoa. The total production of 262,000 t contributes about 10% of total global cocoa output. Eighty percent of the production is contributed by the plantation sector. Almost 420,000 ha of the crop are cultivated, 55% of which is in the plantation sector, mainly in Sabah. The rest is in smallholdings on the Peninsula. Processing of the commodity contributed about 18% to Malaysia's total agricultural value added. About 80% of cocoa produced, valued at about M$729 million, is exported.

3.3.1.4 Rice

About 664,000 ha of rice is cultivated in Malaysia. This area is declining every year, with many rice fields being left idle. This is mainly due to a shortage of labor and rising costs of production. About 80-90% of the area is fully or partially irrigated.

The rice self-sufficiency level is currently 65-70%, leading to an annual import of about 390,000 t valued at M$340 million. Rice imports come mainly from Thailand and China.

As rice is considered a strategic crop, the industry is subsidized with guaranteed pricing and fertilizers.

3.3.1.5 Fruits

Traditionally, tropical fruit production has been the domain of the smallholders. From the late 1980s, however, a few plantation concerns have ventured into commercial fruit production. Currently, about 1.2 million t of local Malaysian fruit are produced on a total area of 162,000 ha (Peninsular Malaysia). Part of the production, valued at about M$200 million, is exported. The traditional market for the Malaysian fruits is Singapore. More recently, however, the market has expanded into East Asia and Europe.

Fruit crops cultivated on a commercial basis by the plantation sector include papaya, carambola, guava, and, to a lesser extent, durians. The choice is mostly due to the expansion of domestic and overseas markets for these fruit types.

3.3.1.6 Tobacco

Tobacco falls wholly in the domain of the smallholders. The total area under the crop is 10,000 ha, producing 10,000 t of cured tobacco. All production is consumed in local cigarette manufacturing. The industry supports about 37,000 farm households, 28,000 curing station workers, and 2,700 cigarette factory workers.Malaysia is a net tobacco importer, both in the form of cigarettes and not refined leaves. The total import is valued at around M$75 million and comes mainly from the USA.

3.3.1.7 Pepper

Malaysia is one of the world's largest producers of pepper, with pepper output 20% of total world export. The total area cultivated with the crop is about 9,400 ha, almost all of which (98%) is in Sarawak. The total pepper production in 1989 was 23,000 t, and increased to about 29,000 t in 1990 as new Sarawak plantings come into production.

3.3.1.8 Pineapple

The total area under pineapple is about 9,000 ha with a production capacity of 173,000 t. The plantation sector contributes 89% to total production, the bulk of which comes mainly from the state of Johor. Total pineapple export amounted to about M$60 million, mainly in canned form (slice and juice).

3.3.1.9 Vegetables

The total area cultivated with vegetable in Peninsular Malaysia is about 14,700 ha, with a total production of 224,000 t. Production is for both domestic consumption and export. The main export market is Singapore. Malaysia is a net vegetable importer, with about M$258 million imported compared to M$70 million exported.

3.3.1.10 Other minor crops

This group includes the floricultural crops (orchids and temperate flowers), cassava, grains (maize), and legume (groundnut) crops. Their contribution to the total economy, although now of little significance, is emerging in importance.

3.3.2 Livestock

Until recently, livestock has been largely a smallholders' concern. Production of poultry meat (300,000 t), poultry egg (4 billion), and pork (271,000 t) is now in excess of domestic demands. However, the country is still deficient in mutton and beef. The self-sufficiency level for both commodities are at 10% (700 t) and 30% (13,000 t), respectively.

The present production of dairy milk (34 million L) is sufficient to meet the fresh milk market demand. However, local dairy production accounted for only 5% of the total domestic demand for milk and milk products. About 688 million L of liquid milk valued at M$280 is imported annually.

3.3.3 Forestry products

Past emphasis in the forestry sector has generally been in the extraction of selected stock. Of late, however, concern for the environment has become a primary consideration, yet not at the expense of development. Indiscriminate and excessive exploitation without regard to forest protection, such as destructive logging, is curtailed. With prudent management, being a renewable resource, the forest will continue to provide viable economic returns to the economy.

The forest product industry produces 41 million cubic meters of sawlog. Twenty million cubic meters, valued at M$4 billion, is exported. Almost 9 million cubic meters of sawn timber are also produced, out of which 5.2 million cubic meters, valued at M$3.1 billion, are exported.

Almost the entire log production on the Peninsula Malaysia is domestically processed, compared to 32% each in Sabah and Sarawak.

3.3.4 Fisheries

Malaysia has ventured both into marine and fresh-water fisheries, producing 830,000 and 68,000 t catch respectively. Malaysia started significant enterprise in deep fishing in 1985. Deep-sea landings rose from 18,300 t in 1985 to 100,000 t in 1990. Aquaculture activities produce about 52,400 t catch, from about 12,000 ha of water bodies.

To sustain the level of fishery output, fishery management, and conservation measures is the main thrust of the sector's development. With regard to inshore fishing, the exploitation rate is carefully monitored and harvested in a coherent program of and fisheries resource development. Use of modern fishing technology is the main source of productivity growth for the industry.

3.3.5 Agriculture-based industries

The major industries based on agriculture, as identified by the country's Industrial Master Plan are rubber-based, palm-oil based, wood-based, and food processing. These industries have tremendous potential for further growth and expansion.

3.3.5.1 Rubber-based industry

Some 191,000 t natural rubber (14% of total production) are utilized for domestic consumption and downstream processing. The industry specializes in latex-based products (57%), tires and tubes (17%), footwear (20%), and other products (6%). Since 1986, the industry has grown at the rate of 21% per annum. Current production level is valued at M$2.1 billion. Also since 1986, export growth is almost 58% per annum, with a total export value of M$1.7 billion.

3.3.5.2 Oil palm-based industry

The major products produced are processed palm oil, processed palm kernel, oleochemicals, and manufactured fats. About 6.8 million t of these products are produced, out of which 5.9 million t are exported. About 13% of the product is processed domestically.

3.3.5.3 Food processing industry

There are currently about 5,100 food processing factories in the country, 92% of which represents small-scale processing, each with investment capital not exceeding M$500,000. About 50% of these are involved in processing cereals; 9% coffee, cocoa, tea, and spices; and 8% fish-based products. Others include those processing animal feed, meat products, coconut products, confectioneries, and beverages. Total employment in the subsector is about 36,000 and the total export value generated is M$1.46 million (mainly from fish products and processed cocoa).

3.3.5.4 Wood-based industry

Major products from this industry are in the form of sawn timber, panel woods, veneer, and furniture. The phased extension of the current ban on the export of sawlogs from Peninsula Malaysia to cover the states of Sabah and Sarawak is to ensure the availability of required raw materials for further downstream industries. An export value of M$4.8 billion had been reaped from these industries.

3.4 Policies governing the agricultural sector's development

The future agricultural development in Malaysia is dictated by the following policies:

- Vision 2020 (1991-2020), the national vision to make Malaysia a developed country by the year 2020;
- Second Outline Perspective Plan (SOPP) (1991-2010), outlines the national development plan towards achieving economic growth and equitable distribution for all sectors (20);

- National Agricultural Policy (NAP) (1984-2000), orients the country's agricultural development to maximize income by optimal utilization of resources in the sector and revitalizing the contribution of the sector to overall economic development (2);
- Industrial Master Plan (IMP) (1986-1995), outlines the development plan for resource-based industries (3).

In essence, the agricultural development agenda calls for food sufficiency and balanced growth with other economic sectors. The agricultural sector is expected to contribute to doubling the GNP every ten years. The sector is also expected to supply the necessary raw materials for resource-based industries and provide the necessary linkages with other sectors of the economy in the industrialization process.

Specific policy guidance for future agricultural development, as provided by the Second Output Perspective Plan (SOPP), are as follows:

- increase rationalization and conservation efforts;
- enhance linkages with the manufacturing sector;
- reach the growth target of 3.5% per annum;
- follow commercial orientation in the choice of commodities and management styles;
- emphasize in-situ rather than new land development;
- specialize in high-value added, market-oriented commodities;
- promote horizontal integration of crops with viable livestock and forestry enterprises;
- intensify the use of biotechnology and R&D efforts to ensure cost-efficient productivity improvement;
- develop sustainable agriculture and environment-friendly technologies.

3.5 Issues and challenges facing the agricultural sector

The major issues and challenges (22) currently facing agricultural development are:

i. As the country moves towards industrialization, competition for resources between agriculture, manufacturing, and industries within the agricultural sector itself will be more acute. Labor, production inputs, and capital will shift to more competitive industries.

ii. Exports of Malaysian agricultural produce are narrowly-based, mainly confined to palm oil, rubber, cocoa, and timber. Aggravating the situation is the sluggish demand of these primary commodities in the international market. To increase export earnings, Malaysia must diversify and expand its agricultural production and export base. The value of Malaysian agricultural exports will increase significantly with increasing output of value-added products from these primary commodities.

iii. Current activities of the agricultural sector still have weak backward and forward linkages to other economic sectors. Strong linkages to input and final output sectors should be established via intensification of upstream and downstream activities. Backward linkages to the input sector can be enhanced through promotion of local capital goods industry. This would intensify the development of industries manufacturing agricultural machinery and equipment. On the output front, forward linkages can be further strengthened through intensification of activities relating to food processing and food products manufacturing.

Links to the other sectors of the economy in the industrialization process can also be established through the supply of the required raw materials for resource-based industries.

iv. Efficient agricultural management practices must be developed, able to sustain and conserve resources and the environment.

v. The primary production of crops must realize economies of scale in production systems. Crop production should increasingly become organized under large-scale operations and more commercially oriented. The duality in agriculture is expected to diminish as smaller farms and plantations consolidate. Small, unorganized, scattered, and inefficient smallholders will gradually be phased out.

4. Science and Technology Development

Early scientific research activities in Malaysia can be traced back to the early 1900s, when a few R&D institutions, such as the Institute of Medical Research (IMR), the Rubber Research Institute (RRI), and the Forestry Research Institute (FRI), were established. This development was to support the country's interest in tropical medicine, rubber, and timber, respectively (4). Over the years, the development of S&T became more prominent and more R&D institutions and universities were established. This occurred in tandem with national development needs. A few research institutions were also established by the private sector, particularly by the plantation sector for agricultural R&D activities.

4.1 Science and technology policy

The need for S&T to spearhead socioeconomic development in Malaysia has been accepted nationally and is enshrined in the '*Rukun Negara*' (National Guiding Principles). The twin prongs of the National S&T Policy are:

1. The national S&T policy, as an integral part of the country's socioeconomic development policy, is to promote the utilization of S&T as a tool for economic development; improvement of human, physical, and spiritual well-being; and the protection of national sovereignty.

2. The national S&T policy is to promote scientific and technological self-reliance in support of economic activities, by upgrading R&D capabilities through the creation of an environment conducive to scientific creativity and the improvement of scientific, educational, and other relevant infrastructures.

The national S&T policy is fully incorporated into the national five-year development plans and is pursued in consonance with other national policies such as the national agricultural policy (NAP), the national education policy, the industrial master plan (IMP), and the SOPP. The national vision, Vision 2020, also identifies S&T as one of the nine central strategic challenges that the country must fact to become a fully developed nation by year 2020. At that time, the country should not be only a consumer of technology but also a contributor to the scientific and technological civilization of the future. The challenge is to establish a scientific and progressive society that is innovative and forward looking.

In order to develop competitive S&T, and an intensive and globally based economy in the 1990s and beyond, the government has identified the following policy framework for the S&T development (15):

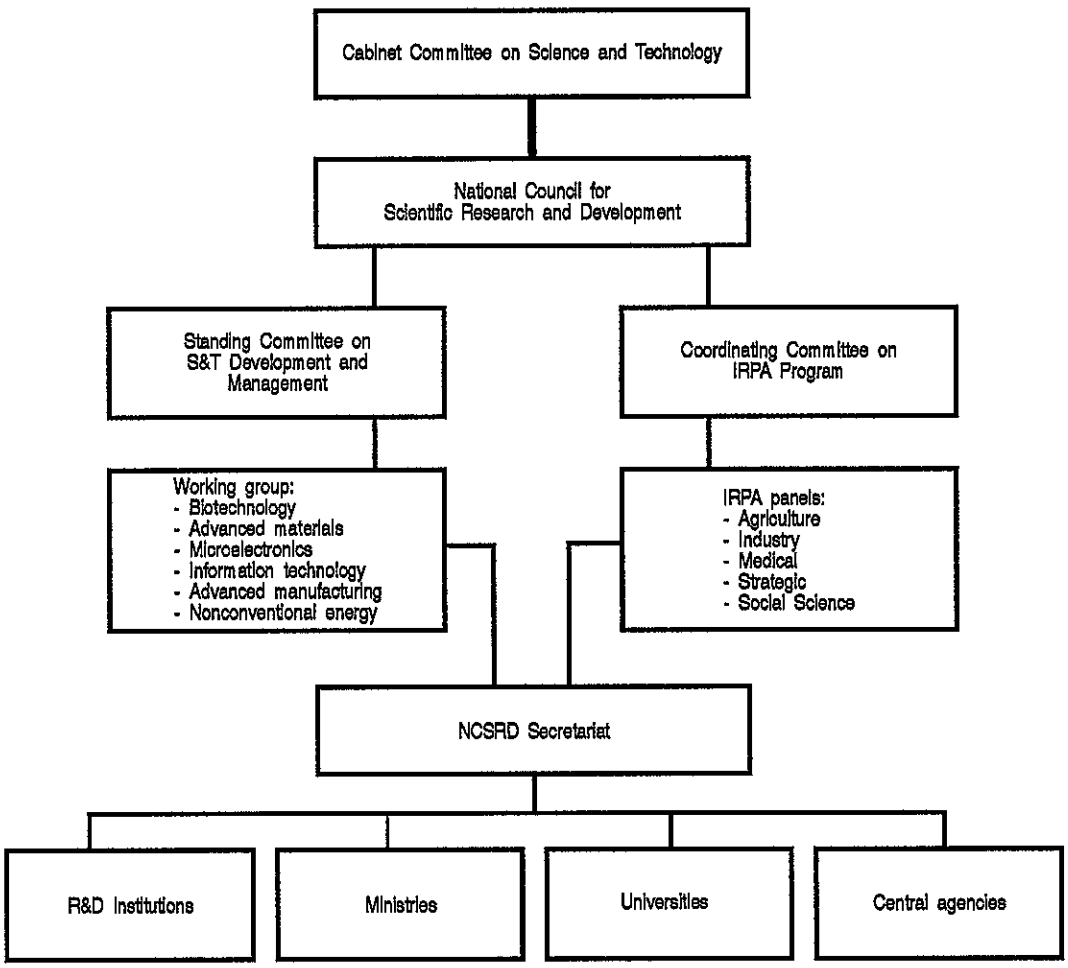
- establish a coherent framework of S&T goals, strategies and policies, taking global developments into account;

- Ensure adequate and well directed national investments in S&T activities;
- Develop a strong S&T research base;
- Encourage greater private sector investments in R&D;
- Provide a supporting regulatory regime which fosters innovations;
- Create operating conditions in which research organizations can flourish;
- Ensure an effective system of education and training in S&T;
- Inculcate positive public attitudes towards S&T;
- Develop effective mechanisms to commercialize R&D results and to identify and exploit emerging and generic technologies;
- Institute an effective mechanism to select key areas for R&D support.

4.2 Science and technology management

Various aspects of scientific activities are embodied in the various ministries of the government

Figure 3
Operational structure of the National Council for Scientific Research and Development (NCSRD)



of Malaysia. Realizing the importance of S&T as a tool for the national growth, the Ministry of Science, Technology, and Environment (MOSTE) was established in 1973. This ministry is the lead body executing all S&T policies and plans. The National Council for Scientific Research and Development (NCSRD) was established in 1975, aiming to provide a more consolidated, comprehensive, and long-term planning body for S&T development (4).

The development of S&T in Malaysia is further supported by the establishment of a cabinet committee on S&T in 1990. This committee examines and endorses S&T policies and activities proposed by the NCSRD. The committee is chaired by the prime minister, with the minister of science, technology, and environment; the minister of international trade and industry; the minister of education; the minister of finance; and the minister of human resources, as members.

4.2.1 National Council for Scientific Research and Development (NCSRD)

The NCSRD is chaired by the chief secretary to the government and is represented by members from various fields of science. There are also appointees from the public and private sectors as well as from professional organizations, and individuals who can significantly contribute to scientific and technological activities in the country. Besides advising the government on S&T matters, the council also has a role in:

- Formulating S&T policies;
- Identifying S&T priority areas;
- Coordinating, implementing, and evaluating S&T activities;
- Utilizing S&T in the public and private sectors;
- Monitoring the implementation of the action plans approved by the government.

The NCSRD has a simple but effective operational structure (Figure 3). It operates through two main committees: the Standing Committee on S&T Development and Management and the Coordinating Committee on the Intensification of Research in Priority Areas (IRPA) Program.

The following are among the main functions of the Standing Committee on S&T Development and Management:

- evaluate issues related to the organization and management of S&T;
- evaluate and prioritize activities in S&T and related skills development in support of national objectives;
- evaluate opportunities, advantages, and disadvantages of international linkages and cooperation, as well as determine the political implications of such cooperation; and
- evaluate new technologies and their implications on Malaysia's trade and economic development.

The Coordinating Committee on IRPA Program has the following responsibilities:

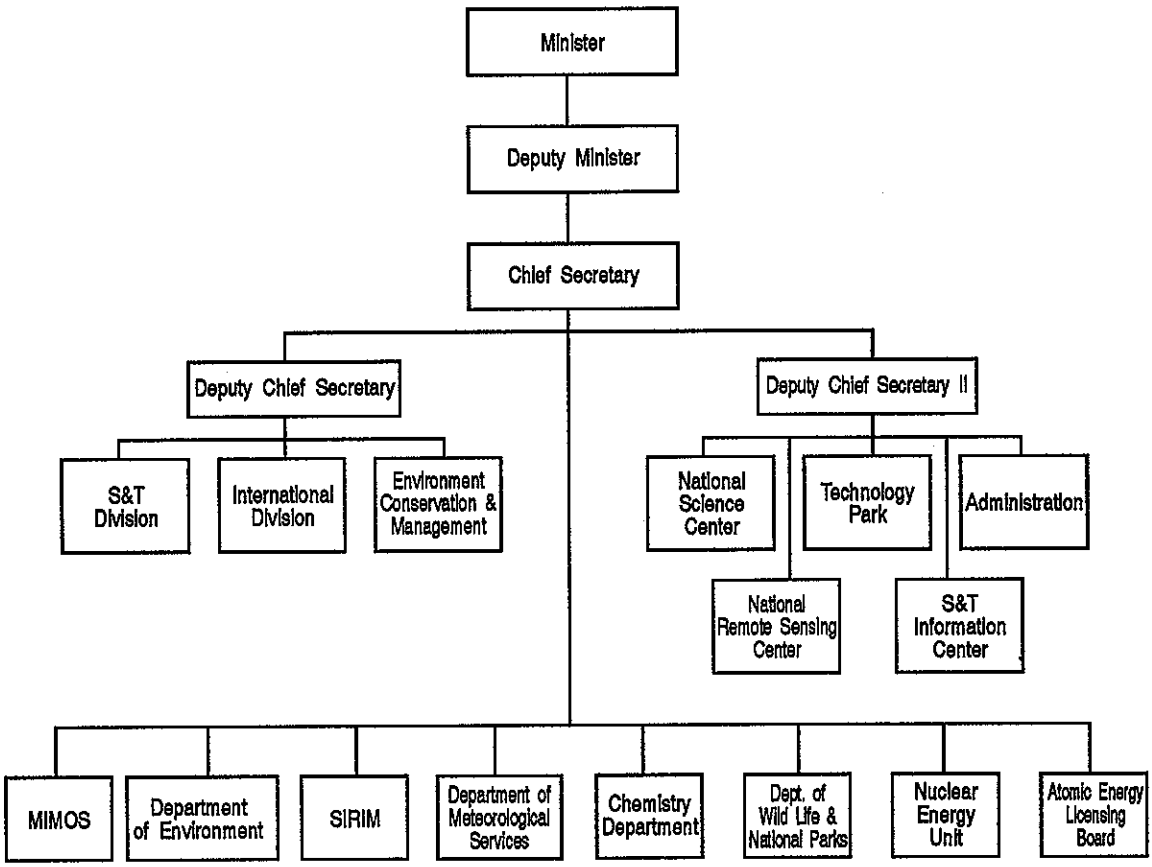
- implement the IRPA program;
- monitor and evaluate the IRPA program;
- coordinate and monitor the functions of the various IRPA panels; and
- collect findings and recommendations of the various IRPA panels and communicate them to the NCSRD.

Five IRPA panels now assist the Coordinating Committee in research in agriculture, industry, medicine, and the strategic and social sciences.

4.2.2 Ministry of Science, Technology and Environment (MOSTE)

The current organizational structure of MOSTE enables the ministry to execute approved S&T policies and strategies, and to carry out several S&T developmental and regulatory functions

Figure 4
Organizational structure of the Ministry of Science, Technology, and Environment



(Figure 4). MOSTE also serves as the secretariat to the cabinet committee on S&T and to the NCSRD (11).

4.3 R&D management - IRPA mechanism

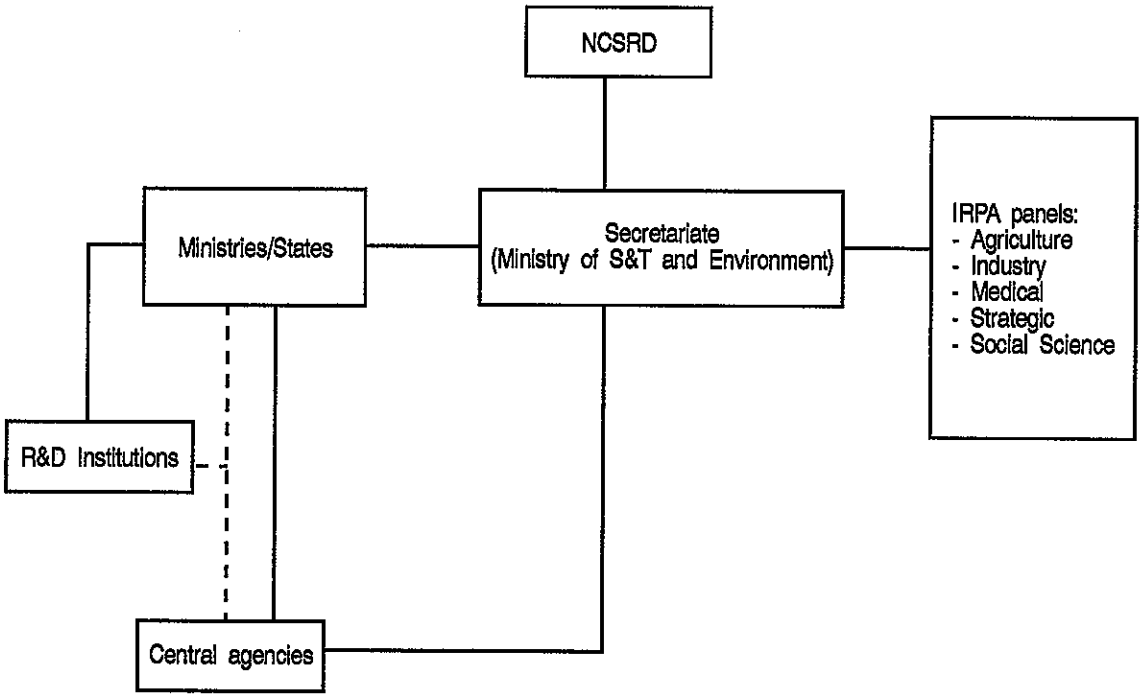
The management of R&D activities became more coordinated and systematic with the establishment of the IRPA mechanism in 1987. This mechanism provides greater accountability and sensitivity to national development needs. Its implementation involves the determination of R&D priorities at national and institutional levels and the formulation of research proposals based on these priorities. There is also strict peer reviewal and continuing monitoring and evaluation, at times by external experts. IRPA is therefore not just a procedure but a strategy for S&T development (7).

4.3.1 Criteria for R&D priority setting

In determining R&D priorities at the national level, the following factors are taken into consideration:

- Government policy statements and objectives;
- Need enunciation from the users (e.g. industry); and
- Current status of resources and constraints.

Figure 5
IRPA mechanism for R&D management in Malaysia



Note: ——— R&D budget
- - - - - Development & operating budgets

Source: Ministry of Science, Technology, and Environment, Malaysia

Under the IRPA mechanism, the R&D priorities are identified separately for agricultural, industrial, medical, strategic and social science research.

At the institutional level, priority determination is based on national priority listings, taking institutional mandate and capabilities into account. These are then translated into institutional R&D thrust areas and finally program and project proposals.

4.3.2 Research appraisal

IRPA calls for two levels of appraisal for research proposals. The first is institutional, where scientific and technical merits as well as economic viability are considered. This in-house, ex-ante evaluation is carried out according to the system adopted by each respective institution.

Favored program and project proposals are then submitted to the NCSRD, where second level appraisal is carried out by the respective IRPA panel.

The IRPA panels appraise programs and projects, considering their potential contributions to national priorities, technical and socioeconomic benefits, cost effectiveness, interdisciplinarity, intra- and inter-institutional collaboration, and involvement of industry. The panels' recommendations are then presented through the Coordinating Committee of IRPA Program to the main committee of NCSRD for approval.

Approved proposals are finally forwarded to the central agencies (Economic Planning Unit of the Prime Minister's Department and the Federal Treasury) for budget application. Approved funds are disbursed by the Treasury to the R&D institutions through the appropriate ministries.

Table 2
R&D budget allocation by sector

Sector	Fifth Malaysia Plan (1986-1990)		Sixth Malaysia Plan (1991-1995)	
	Amount (M$ million)	%	Amount (M$ million)	%
Direct R&D	**413.8**	**76.6**	**600.0**	**51.7**
- Agriculture	203.2	49.1	273.8	45.6
- Industry	138.1	33.4	177.7	29.6
- Medical	33.1	8.0	59.8	10.0
- Strategic	39.4	9.5	78.6	13.1
- Social	0	0	10.1	1.7
S&T Infrastructure	**126.7**	**23.4**	**560.3**	**48.3**
(Total)	540.5		1,160.3	

Source : National Council for Scientific Research and Development.

A schematic illustration on the IRPA mechanism is presented in Figure 5.

4.3.3 Research monitoring and evaluation

Approval for research programs and budgets under the IRPA mechanism is on a five-year basis, in line with the national development plans and budget system. Similar to the appraisal process, the implementation of the programs and projects is monitored and evaluated both at the institutional and national levels.

At the national level, the monitoring process is carried out by the respective IRPA panels two times a year. The first monitoring is based solely on the mid-year progress report submitted by the respective R&D institutions. The second monitoring is carried out annually in conjunction with that of the budget system as adopted by the government.

The following are the specific purposes of the monitoring exercise:

- examination of the progress in the implementation and achievements of the various programs and projects;
- decision on the termination of on-going programs or projects due either to implementation problems or to loss of relevancy and decision on the inclusion of new programs;
- examination of the annual budget request by various R&D institutions, both for on-going programs and new submissions, if any.

4.4 Science and technology fund

The budgetary allocation for S&T within public-sector agencies during the Fifth Malaysia Development Plan period (1986-1990) was M$540.5 million, of which M$413.8 was allocated for R&D specifically. In the Sixth Development Plan (1991-1995), the allocation was increased to M$1,160.3 million; M$600 million is for R&D and M$560.3 million for S&T infrastructure development. The distribution of the R&D allocation among various sectors is presented in Table 2.

Current expenditure on S&T in Malaysia is estimated at 0.8% of the GDP. More than 80% of this expenditure is made by the public sector. The percentage (0.8%) is quite low compared to the relatively higher percentage of 1.0% to 2.9% committed by the industrialized countries

Table 3
Number of research scientists by discipline and qualification

Field	Highest qualification PhD	MSc	BSc	Total
Research Scientists				
Engineering	149	504	700	1353
Computer	33	139	70	242
Medical	87	134	112	333
Agriculture	366	543	253	1162
Basic	500	516	616	1632
Others	154	411	250	815
Total	1289	2247	2001	5537
Public Sector	1254	2181	1679	5114
Private Sector	35	66	322	423
Supporting Staff				
Public Sector				6656
Private Sector				1412
Total				8068

Source: Sixth Malaysian Development Plan (1991-1995)

and the newly industrialized economies (NIEs). However, in line with the policy to intensify the development of S&T in Malaysia, the government is now embarking on a deliberate effort to increase private- and public-sector investment with the minimum objective of doubling its share as a percentage of GDP by year 2000 (20).

4.5 Science and technology manpower

Full- or part-time personnel involved in S&T activities number 13,605. Of this figure, 5,537 are research scientists. The remaining 8,068 are support staff members (Table 3). The ratio of research scientists to population is about 300 to a million. This is rather low compared to the ratios of 3,500 to 6,500 per million normally found in the industrialized countries. By the year 2000, however, Malaysia aims to have at least 1,000 research scientists to every million of the population. This will be in line with the target of doubling the current percentage share of S&T to the GDP (20).

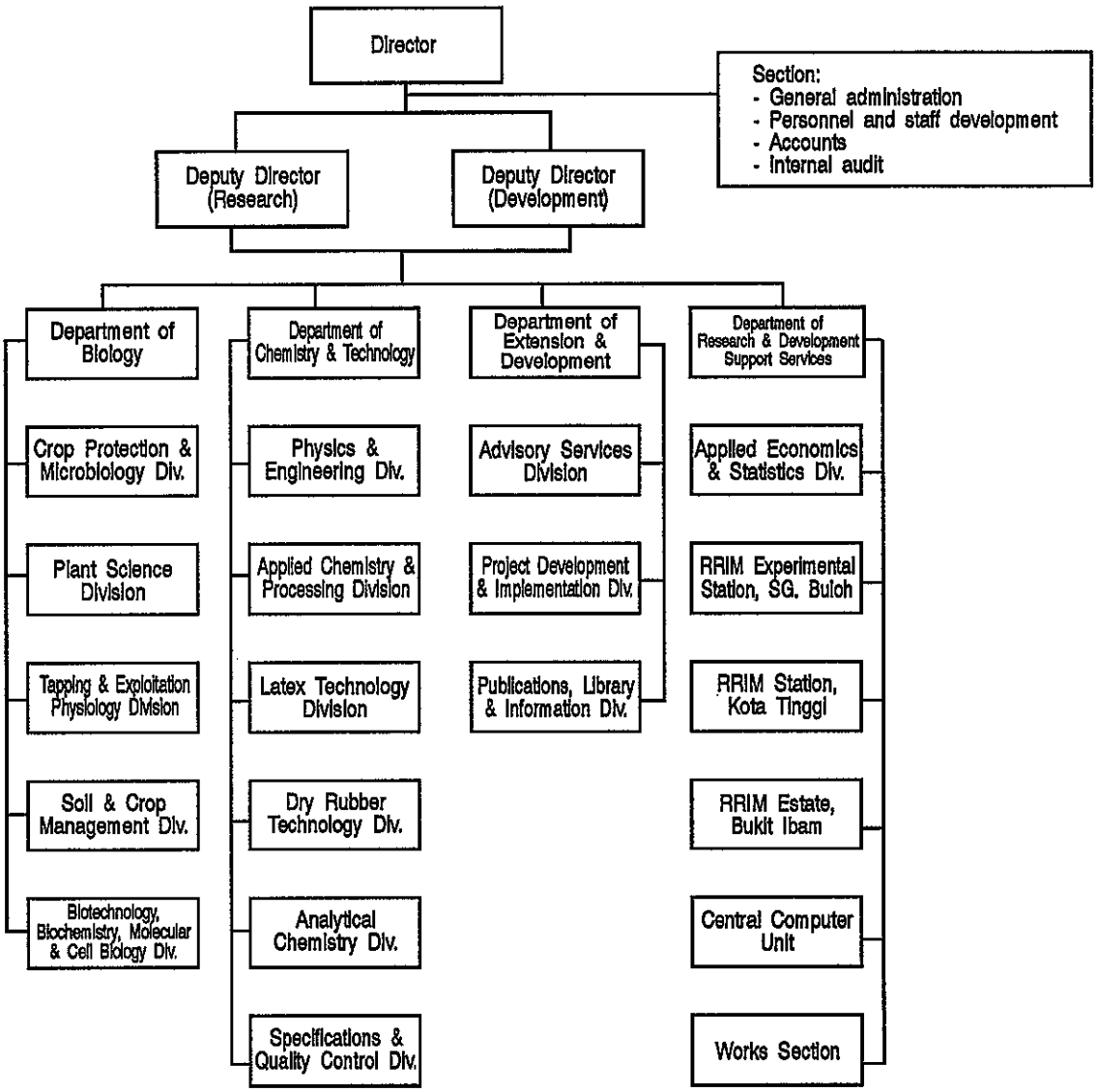
4.6 Commercialization of research results

Because R&D is regarded as an investment towards national development, special attention is given on the issue of technology transfer, particularly towards ensuring the commercialization of research results. Three major programs are currently being pursued (15).

i. Establish a technology park to promote better interaction between R&D institutions and industry.

ii. Establish a policy calling for the R&D institutions to be self-financing (the targets are 30% and 60% of the operating budget by the year 1995 and 2000, respectively). This policy is to

Figure 6
Organizational structure of the Rubber Research Institute of Malaysia (RRIM)



ensure that research activities carried out by public R&D institutions become more market oriented.

iii. Establish the Malaysian Technology Development Corporation (MTDC) to facilitate commercialization of technologies generated by the R&D institutions. MTDC is currently operating on a paid-up capital of M$50 million, 30% of which is contributed by the government.

Table 4
Major Malaysian agricultural research institutions by ministries with program and budgetary allocation

Ministry/State	Institution	No. of Program	Budget (M$)
1. Ministry of Agriculture	Malaysian Agricultural Research and Development Institute (MARDI)*	137	127,217,200
	Fisheries Research Institute (FRI), DOF**	7	27,000,000
	Veterinary Research Institute (VRI), DVS**	6	3,100,000
2. Ministry of Primary Industry	Forest Research Institute of Malaysia (FRIM)*	6	7,500,000
	Palm Oil Research Institute of Malaysia (PORIM)*	11	7,000,000
	Rubber Research Institute of Malaysia (RRIM)*	15	17,755,500
	Malaysian Cocoa Board*	8	2,965,545
3. Ministry of Education	University of Agriculture, Malaysia (UPM)***	71	44,869,011
	University of Malaysia***	15	4,450,000
	University of Science, Malaysia (USM)***	5	9,000,000
	National University of Malaysia (UKM)***	11	9,462,000
	University of Technology, Malaysia (UTM)***	1	300,000
4. Ministry of Science Technology and Environment	Nuclear Energy Unit**	3	2,000,000
5. State of Sabah	Department of Agriculture**	6	1,000,000
	Department of Fisheries**	1	1,000,000
	Department of Veterinary**	1	500,000
	Department of Forestry	1	2,000,000
6. State of Sarawak	Department of Fisheries**	2	1,500,000
	Deparment of Forestry**	1	5,000,000

* *Statutory research organization*
** *Government research departments*
*** *University*

5. Agricultural R&D

During the colonial period and much of the period following independence in 1957, agricultural research in Malaysia was heavily concentrated on a single commodity — rubber. It was only in the 1960s that the country began to develop its research capabilities in other export commodities and domestic food crops. Presently, there are 19 public institutions involved in agricultural research and development. Table 4 indicates the institutions involved in agricultural R&D, with programs and budget allocated. These R&D institutions comprise five statutory (quasi government) organizations, nine research sections of government departments, and five universities. The involvement of the private sector is limited to developmental research on specific areas or commodities and are carried out by a few large and established companies (21).

5.1 R&D Institutions

With the exception of the universities, all Malaysian public R&D institutions are commodity industry based. That is, they integrate agricultural research with research on the processing of agricultural products. R&D activities are thereby tailored to support the developmental programs of the ministries responsible for the various industries. The universities are less restricted in their R&D activities, and thus focus more on basic and academic research embracing all aspects of the agricultural industry.

Prior to the establishment of the IRPA mechanism, the institutional and interministry coordination in agricultural R&D was rather loose. The current procedures, under the IRPA mechanism, are very effective in consolidating the R&D activities conducted in the country, particularly those of the public institutions.

Table 4 presents a brief description of the establishment history, roles, and organizational structure of the major agricultural R&D institutions.

5.1.1 Rubber Research Institute of Malaysia (RRIM)

RRIM was established in 1925 to provide technological support in the production of rubber to the plantation and smallholder sectors. RRIM operates under the umbrella of the Malaysian Rubber Research and Development Board (MRRDB), a statutory body under the Ministry of Primary Industries (MPI). MRRDB is responsible for the overall research, technical development, and promotion activities of natural rubber.

RRIM is responsible specifically for R&D on all aspects of cultivation, production, and processing, as well as producing new forms and innovative applications for natural rubber (18). RRIM also provides advisory and information services to extend the benefits of R&D to all sectors of the rubber industry, especially for the modernization of the smallholder sector.

RRIM's organizational structure consists of four major departments with 17 divisions and three out-reach research stations (Figure 6). The institute is administered by a director, assisted by two deputy directors. There are 196 senior staff and 1,857 supporting staff.

5.1.2 Malaysian Agricultural Research and Development Institute (MARDI)

MARDI is a statutory body established in 1969 under the Ministry of Agriculture (MOA) to take over the R&D functions on all crops (except rubber) from the Department of Agriculture (DOA) and the Malaysian Pineapple Industry Board (MPIB); livestock (except in the area of animal health) from the Department of Veterinary Services (DVS); and freshwater fisheries from the Department of Fisheries (DOF).

In 1974, MARDI took over R&D functions of the Food Technology Department of the MOA (17). MARDI's responsibility for oil palm research was, however, transferred to the Palm Oil Research Institute of Malaysia (PORIM) in 1979; and in 1984 MARDI's research functions on freshwater fisheries was transferred to the DOF.

Figure 7
Organizational structure of the Malaysian Agricultural Research and Development Institute (MARDI)

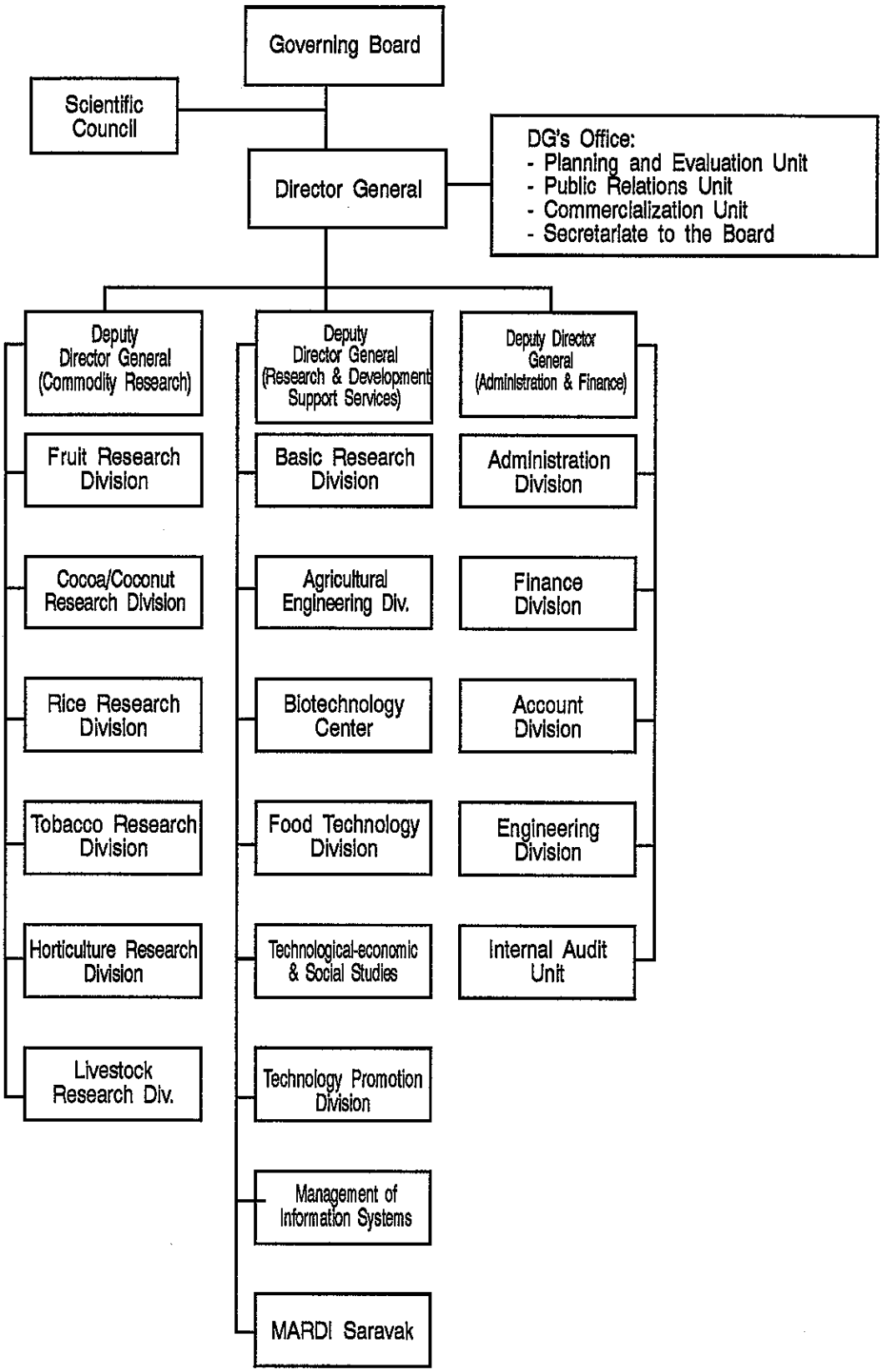
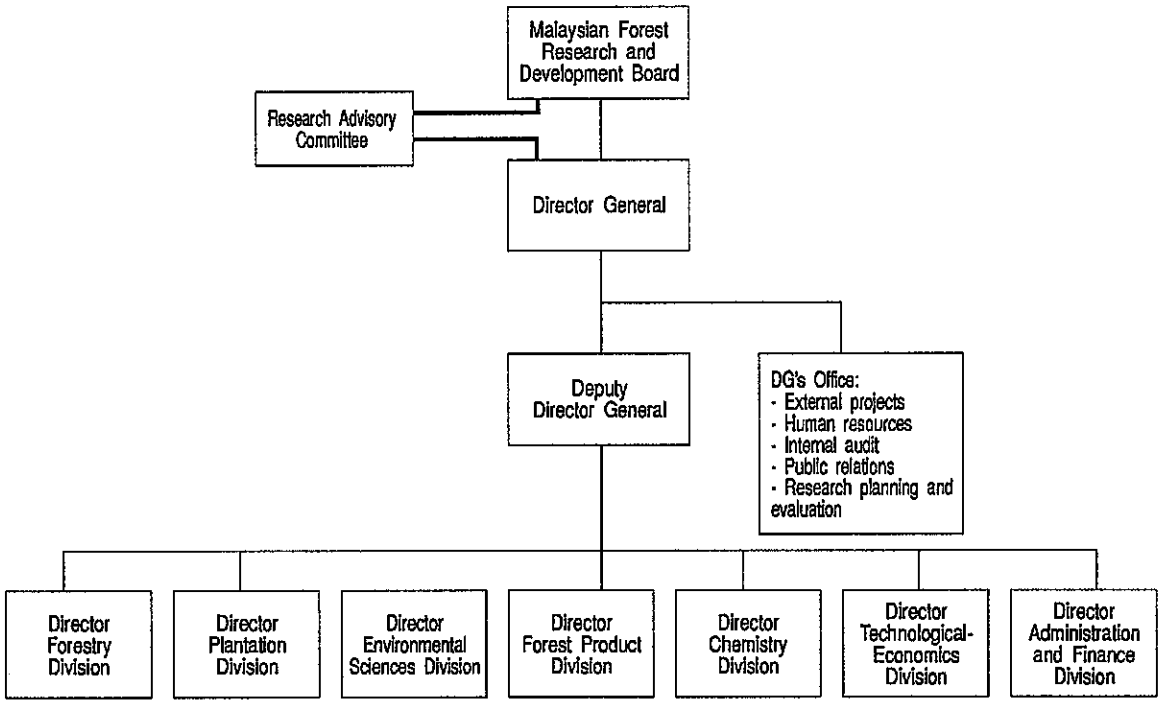


Figure 8
Organizational structure of the Forest Research Institute of Malaysia (FRIM)



In addition to conducting research, MARDI also serves as a centre for specialist extension services and training of workers in the agricultural industry.

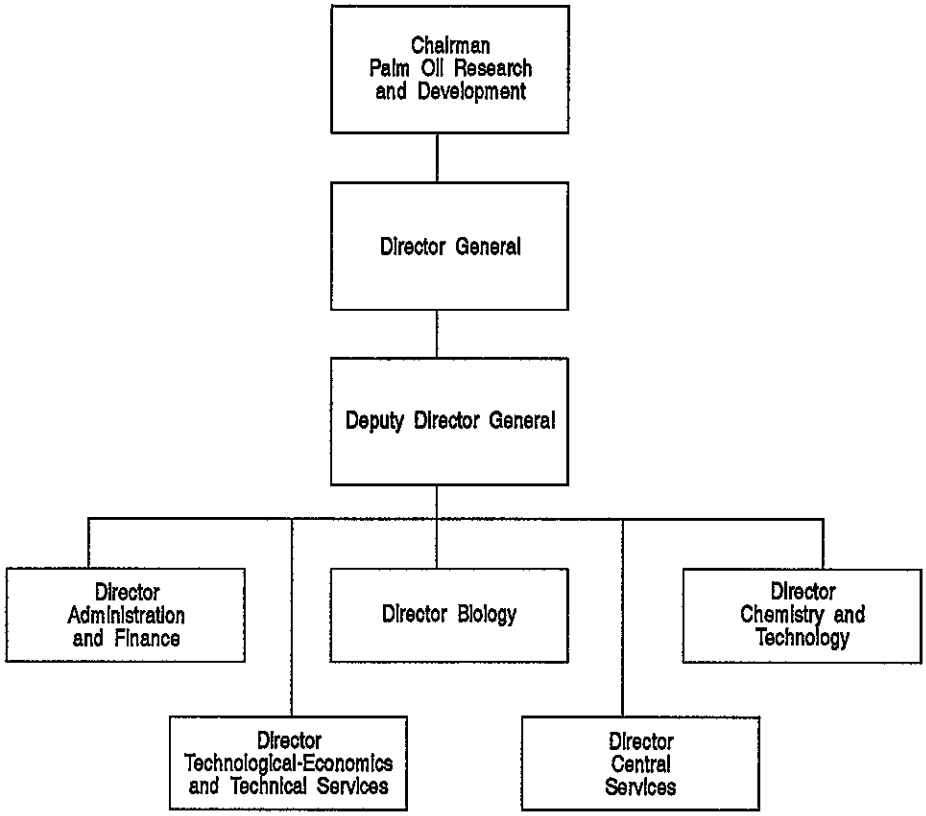
In contrast to RRIM, MARDI is governed by its own Board that reports direct to the Minister of Agriculture. The institute is headed by a Director General and assisted by three Deputy Director Generals. The implementation of MARDI activities is carried out through six commodity research divisions, seven research support divisions and four central administrative divisions (Figure 7). Currently MARDI has a total manpower of 3,595 personnel, comprising of 474 research scientists, 849 technicians and 2,272 administrative and general support staff. They are deployed to 29 commodity research centers and outreach stations located throughout the country.

5.1.3 Forest Research Institute of Malaysia (FRIM)

Prior to 1985, FRIM operated as a research unit under the Department of Forestry and was known as the Forest Research Institute (FRI), Kepong. A parliament act in 1985 sanctioned the establishment of the Malaysian Forest Research and Development Board (MFRDB). FRI was reorganized and renamed Forest Research Institute of Malaysia (FRIM). It is a statutory body under the MPI. The main function of FRIM is to conduct research in the production, extraction, processing, storage, transportation and utilization of forest products (16).

The institute is headed by a Director General who is assisted by a Deputy Director General. Currently, FRIM has a total manpower of 445 personnel, of which 91 are research scientists. The institute is organized into six research divisions and one administrative division (Figure 8).

Figure 9
Organizational structure of the Palm Oil Research Institute of Malaysia (PORIM)



5.1.4 Palm Oil Research Institute of Malaysia (PORIM)

The expansion in oil palm cultivation and the consequent rapid development of the refining industry triggered the establishment of the Palm Oil Research and Development Board (PORDB) under the MPI in 1979. The Board was entrusted with the task of organizing and managing research pertaining to oil palm and palm oil. It was for the implementation of this task that PORIM was created (23).

Having taken over research on palm oil from MARDI, PORIM conducts and promote research on the production, extraction, processing, storage, transportation, marketing, consumption, and end-use of palm oil and palm oil products.

Administratively, the institute comprises three research divisions and two central administrative and services divisions (Figure 9). The current manpower comprises 108 research scientists and 449 supporting staff.

5.1.5 Malaysian Cocoa Board (MCB)

The rapid expansion of the cocoa industry in 1970s and 1980s has brought about a realization of the importance of having all activities related to the development of cocoa coordinated under an umbrella organization to ensure effective expansion of the commodity. On this rationale, the MCB was established in 1989 under the MPI (10).

In contrast to other statutory R&D institutions, MCB is entrusted with functions and responsibilities including market development, grading, registration, licensing, and certification for the cocoa industry.

Specific to its research function, MCB conducts and promotes research on the production, extraction, processing, storage, transportation, marketing, consumption, and end-use of cocoa

and cocoa products. These activities are carried out through two divisions each under the responsibility of a Deputy Director General (Research) (Figure 10).

5.1.6 Veterinary Research Institute (VRI)

VRI was established in 1948 as a division under the Department of Veterinary Services (DVS) to conduct animal health research with emphasis on diseases of national economic importance. The institute also provides diagnostic services, produces vaccines, and conducts training on related techniques. Currently VRI has 30 research scientists and 170 support staff (27).

5.1.7 Fisheries Research Institute

Significant development of research capability to support the fisheries industry in Malaysia began in 1957 when the DOF established the Fisheries Research Institute. The institute conducts research on resource management and capture technology of marine fisheries. The research scope was later expanded to cover brackish and freshwater fisheries (26).

Presently research activities carried out by the institute are organized under three main areas: resource research, aquaculture research, and aquatic ecology research. These activities are implemented by 75 research scientists at seven research stations. Administratively, FRI is headed by a branch head under the Division of Planning and Research of the DOF (Figure 11).

Figure 10
Organizational structure of the Malaysian Cocoa Board (MCB)

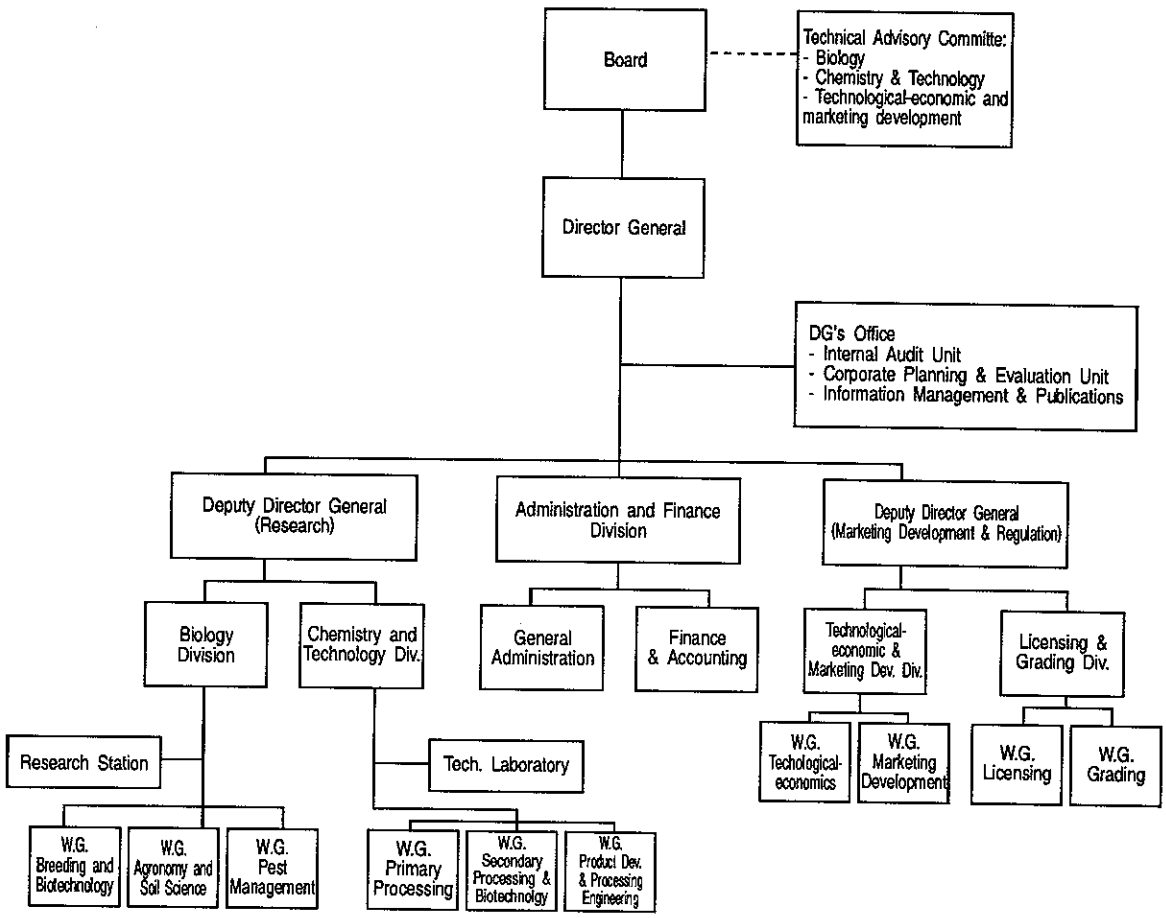
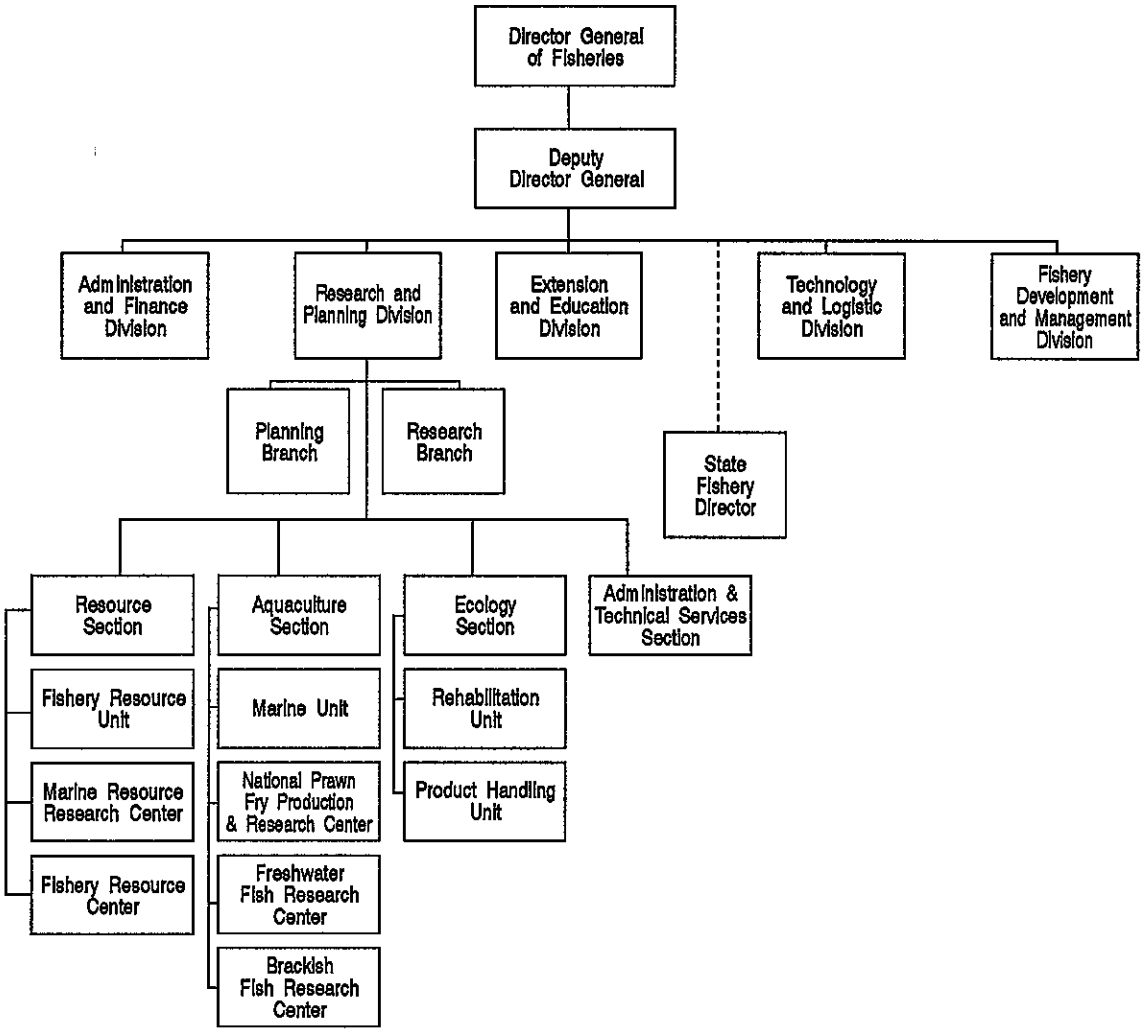


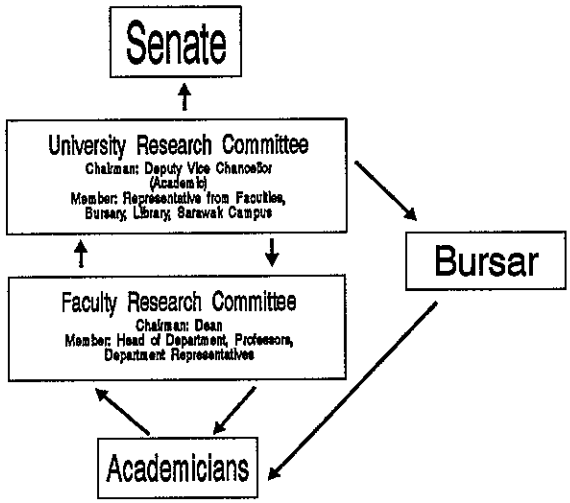
Figure 11
Organizational structure of the Fisheries Research Institute, Department of Fisheries (DOF)



5.1.8 University Pertanian Malaysia (UPM)

UPM was established in 1971 from the merger of the College of Agriculture Malaya and the Faculty of Agriculture, University of Malaya. UPM is a service-oriented university with three main functions: teaching, research, and extension. It is also given the role of providing an overall support to the country's agricultural development, particularly in the generation of qualified manpower and basic scientific knowledge. Currently, agriculture-related research activities at UPM are carried out by about 250 academic staff from various faculties. The activities as shown in Figure 12 are managed through a formal mechanism, which is operated through research committees established at the University and Faculty levels (8).

Figure 12
Organization of research at the University Pertanian Malaysia (UPM)



5.2 Research priority and program

During the Fifth Malaysia Development Plan (1986-1990), agricultural R&D was conducted based on the following national priority listing (6):

i. Production Research
   - Maximizing land/water use in:
     - farming systems,
     - agriculture (crops, livestock & fisheries),
     - forestry;
   - Increasing quality, productivity and efficiency in production of crops, livestock and fisheries;
   - Maintaining sustainable development of forest and aquatic resources;
   - Quality improvement in pre-harvest, in-field handling/drying and in-field transportation.

ii. Post-harvest Research
   - Improving harvesting technology including harvesting, handling, drying, packaging storage, and transportation;
   - Processing and product development;
   - Quality control and standards for consumer production and market acceptability

iii. Basic and Supportive Research
   - Exploitation of new or untapped resources (e.g., biological and genetic resources, soils, and agriculture by-products);
   - Biotechnology (plants, animals, and food);
   - Agricultural engineering;
   - Water management;
   - Technological-economic and marketing research:
     - market intelligence,

- production economics and sociology,
- technology assessment,
- technology transfer.

iv. Agricultural Development & Environmental Research

- Input studies (land development, agriculture practices, afforestation, drainage, and irrigation);
- Management of agriculture waste and residues;
- Environment changes (ozone layer and acid rains).

In view of the challenges facing the agricultural sector and the likely future development scenario in the country, the role of National Agricultural Research System (NARS) is becoming more fundamental.

Determination of appropriate R&D activities is vital for the sector to achieve its desired position in the context of an industrialized, developed nation. The current effort to review the national priority listing for agricultural R&D suggests a more comprehensive research thrust as follows:

i. Productivity and Efficiency Improvements

In the light of competitive labor use and rising production costs, productivity and efficiency improvements through efforts in R&D need intensification. This is to minimize unit cost, reduce losses, and increase net yield. The following areas of research are promoted and encouraged:

- R&D to generate high-yield and high-performance crops, livestock, and aquatic varieties;
- R&D to effect greater substitution of labor for capital through the development of mechanized and automated systems, especially in labor intensive production operations; and
- R&D to increase efficiency through reduction of post-harvest losses.

ii. Competitive Advantage Improvement of Agricultural Products

Agricultural development needs to be intensified by specializing in the production of high-value crops and value-added products. This is targeted at specialized markets to achieve competitive advantage. In this respect, the following research areas are given emphasis:

- R&D in high-value crops such as selected fruits, vegetables, and floriculture crops and livestock and aquaculture species;
- R&D to enhance downstream activities and development of agriculture-based industries in food, animal feed, and non-food products; and
- R&D for the utilization of agricultural by-products and wastes for other economic use.

iii. Sustainability in Agricultural Production

In order to sustain the environment in light of depleting natural resources, revitalization and conservation measures and efforts to maintain and improve the environment will have to be emphasized. The R&D areas to be focused on in addressing these issues are:

- R&D to increase efficiency in the use of natural resources such as improvement in soil, water, forest, and aquatic resource management technologies;
- R&D to generate technologies for better utilization of marginal soils such as the sandy bris soils, peat, tin tailings, and acid sulphate soils and the exploitation of natural and man-made water bodies for aquaculture.

Table 5
Malaysian agricultural extension agencies

Ministry	Agency responsible	Commodity
Ministry of Agriculture	Department of Agriculture	All crops except rubber, oil palm, tobacco, and pineapple
	Veterinary Department	Livestock
	Fisheries Department	Aquaculture and marine fish
Ministry of Primary Industries	Malaysian Pineapple Industry Board (MPIB)	Pineapple
	National Tobacco Board	Tobacco
	Malaysian Cocoa Board	Cocoa
Ministry of Rural Development	Rubber Industry Small Holders Development Authority (RISDA)	Rubber
	Federal Land Consolidation and Rehabilitation Authority (FELCRA)	Rubber, oil palm, and other crops
Ministry of Land and Regional Development	Federal Land Development Authority (FELDA)	Rubber, oil palm, and other crops
	Regional Development Authorities: e.g., PERDA, KESEDAR, KEJORA, KETENGAH	Rubber, oil palm, and other crops and food processing industries

- R&D to generate environmentally sound technologies for the conservation of natural resources and maintenance of ecological balance and environmental quality; and
- R&D in the management and conservation of genetic resources.

iv. Production of High Quality Food Products

As both the domestic and export markets become more sophisticated, there will be increasing demand for high-quality and nutritious foods, health foods, and convenience foods. Consequently, R&D emphasis will be given in the areas of:

- R&D to upgrade nutritive value of processed food and food safety;
- R&D on the development of special food for specialized health needs; and
- R&D on the diversification of food products and the development of convenience foods.

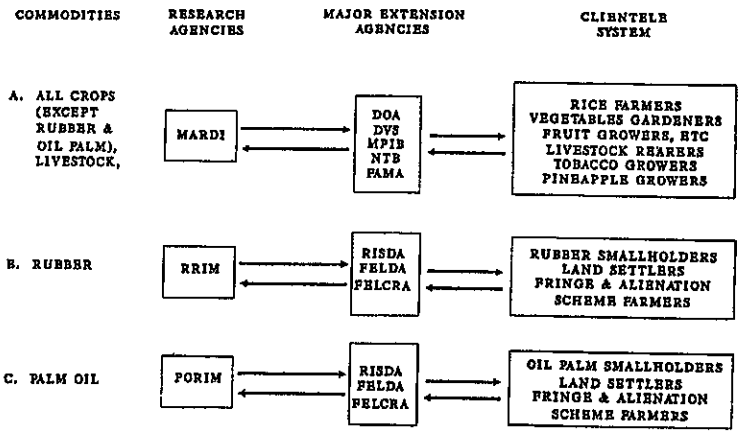
v. Exploitation of Emerging Sciences in Agricultural Production

Conventional R&D may be limited in its role in breaking production frontiers. Efforts are thereby needed to intensify R&D in the areas of new and emerging sciences such as biotechnology and other non-conventional research.

vi. Economic and Social Forces that Influence Agricultural Production

There is a need to understand the economic and social forces that influence production behavior, resource use, competitiveness, and markets. Specific R&D focus in these areas are

Figure 13
Research and extension linkages in Malaysia



R&D in marketing, including studies in changing trends and preferences of food consumption patterns and habits; R&D to understand factors affecting the social organization of production as a result of technological change; R&D on policy issues and implications in relation to agricultural development; and R&D on the optimization of resource use in agriculture.

5.3 Implementation of research programs

The implementation of agricultural R&D activities includes the whole procedure (project appraisal, monitoring, and evaluation) practiced under the IRPA mechanism, as described in Section 4.3. Under the Fifth Malaysia Development Plan (1986-1990), a total of 290 agricultural R&D programs were implemented. A national seminar to evaluate the progress, achievement, and impact of the programs was held at the end of the implementation period. The seminar also helped to provide research directions for the Sixth Malaysia Development Plan (1991-1995).

In the Sixth Malaysia Development Plan (1991-1995), the IRPA panel approved the implementation of 306 programs (Table 4). MARDI implements the largest number of these, 137, 45% of the total approved.

5.4 Agriculture R&D fund

The total government fund allocated for agricultural R&D in the Fifth Malaysia Development Plan was M$202 million. Under the Sixth Malaysia Development Plan, the total R&D budget approved for the sector is M$ 273.8 million. The distribution of the budget among R&D institutions is presented in Table 4. The distribution by major agricultural subsectors is as follows:

Sub-sector	Amount (M$ million)	%
Crops	171.0	62.5
Livestock	43.0	15.7
Fisheries	42.8	15.6
Forestry	17.0	6.2
(Total)	273.8	

In addition to the funds allocated through the IRPA mechanism, institutions like RRIM and PORIM are also respectively funded by the cess levied on rubber and oil palm produced. In the case of rubber, the cess-rate allocated for research is M$0.0385 per kg rubber exported. RRIM is usually provided with about 70% of the total research cess collected; the rest is used for other MRRDB research activities. The industrial funding to PORIM is in the form of a M$5.00 per t cess on all crude palm oil (CPO) and crude palm kernel oil (CPKO) produced in the country, regardless whether they are exported or consumed domestically.

5.5 Linkages

In general, there are two major types of linkages established by most agricultural R&D institutions in Malaysia. The linkages are on research and technology transfer activities.

5.5.1 Inter-institution R&D linkages

With the purpose of maximizing the utilization of expertise and research facilities, bilateral cooperation on common research areas exists between local R&D institutions (e.g., MARDI/UPM on all crops and livestock; UPM/FRIM on forestry). Local linkages occur through national committees, such as the National Committee on Biotechnology Research and the National Committee on Integrated Pest Management. Most R&D institutions have established linkages and research collaborations with international research organizations. The following are some of the major linkages established between local R&D institutions and international bodies:

MARDI:	ACIAR, TARC, IRRI, AVRDC, IBPGR, ICRISAT, AFHB, CIP, IDRC, CIAT, CSIRO, IAEA, USAID, FAO/UNDP, INRA, CABI, JICA, JETRO, CIMMYT, Rockefeller Foundation.
PORIM:	ENAA, JAIF, BIDEC, GIRIS (all Japan), KAIST (Korea), CSIRO
RRIM:	EEC, IFS, UNIDO, ACIAR, IBSRAM
FRIM:	ACIAR, IDRC, GTZ, JICA, TARS, FAO/UNDP, Wageningen University
UPM:	IDRC, JICA, USAID, FAO, UNESCO, PEPAS, ACIAR, IAEA

Such sharing of knowledge and technology transfer has enhanced domestic scientific and technological capabilities. Several international linkages involve more than one research institution. This has promoted further research collaborations amongst local R&D institutions.

5.5.2 Linkages in technology-transfer mechanisms

Currently, there are at least nine government agencies from three different ministries that are directly involved in agricultural extension activities (Table 5). The transfer of technology from major commodity-based R&D institutions to the clientele systems of extension and development agencies (5) is best illustrated by Figure 13.

Linkages between R&D and extension agencies take place at two levels: the ministry and the institution. Linkages at the ministry level are limited to the agencies under the same ministry. Institutional level linkages are implemented through the various bilateral committees established between R&D institutions and extension agencies. Various training programs, seminars, study tours, and pilot projects are conducted through these bilateral arrangements. Besides the extension agencies, agricultural development in Malaysia is also conducted by several regional development authorities (RDA). The representation of relevant R&D institutions in the governing or advisory boards of these RDAs greatly facilitates technology transfer. The governing or advisory board of most R&D institutions are also represented by members from relevant industries of the agricultural sector. This allows the private sector to follow the development of agricultural research activities implemented by public R&D institutions.

Table 6
MARDI research planning and monitoring and evaluation process

Level: Divisional Management
Panel: Director & Deputy

Implementation Process

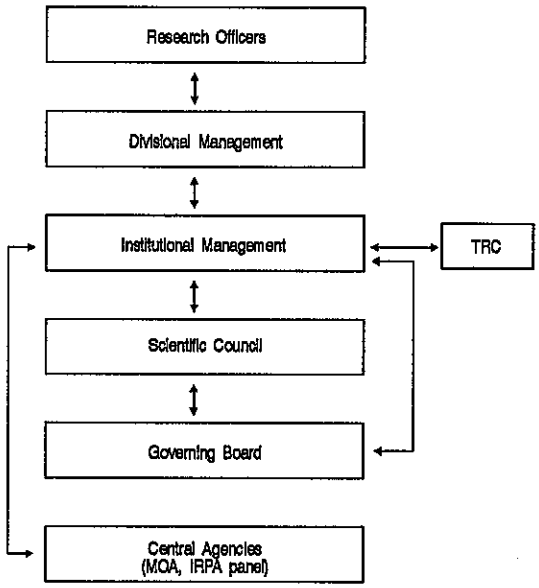
Document	Purpose	Mechanism
Research proposals and progress reports from research scientists.	**New** – to ensure relevancy of new program/project; – to examine and coordinate resource requirements (funds, manpower, research facilities); **On-going** – to monitor implementation status (research activity, resource use); – to identify and solve problems faced by the implementors; **Completed** – to ensure technical validity of the research results; – to examine reports on resource use.	Annual Monitoring Meeting (monitoring exercise) at the divisional level; Research Progress Report (mid-year and annual); Monthly Divisional Management Meeting.

Level: Institutional Management
Panel: Director General & Deputies

Implementation Process

Document	Purpose	Mechanism
Proposals and progress reports on all programs submitted by the divisions.	**New** – to ensure relevancy of new programs based on institutional thrust areas and national listing; – to examine and approve resource requirements; **Ongoing** – to monitor implementation status of all programs and make directives for necessary changes; – to monitor status of resource use and solve problems which could not be solved at the divisional level; – to ensure quality of research (through TRC); **Completed** – to evaluate research results and decide on the follow-up actions for technology transfer; – provide direction on follow-up research activities.	Annual Monitoring Meeting (monitoring exercise) at institutional/corporate level; Research Progress Report (mid-year and annual); Technical Review — carried out by the TRC appointed by the institutional management; MARDI Research Management Committee.

Figure 14
Linkages in the MARDI research monitoring and evaluation process



6. Agricultural R&D Management at the Institutional Level

In consonance with the high emphasis accorded to the role of S&T as a tool to achieve national development goals, various strategies are followed to enhance the country's capabilities in R&D. These include appropriate policy directions, R&D management support, and increase funding for R&D programs and manpower development by the government.

The task of management at MARDI, the largest R&D institution in the country responsible for multiple agricultural commodities, is equally heavy and complex. Nevertheless, based on the significant overall progress made throughout the last 20 years, MARDI is confident with the management philosophy, approach and system that it has practiced.

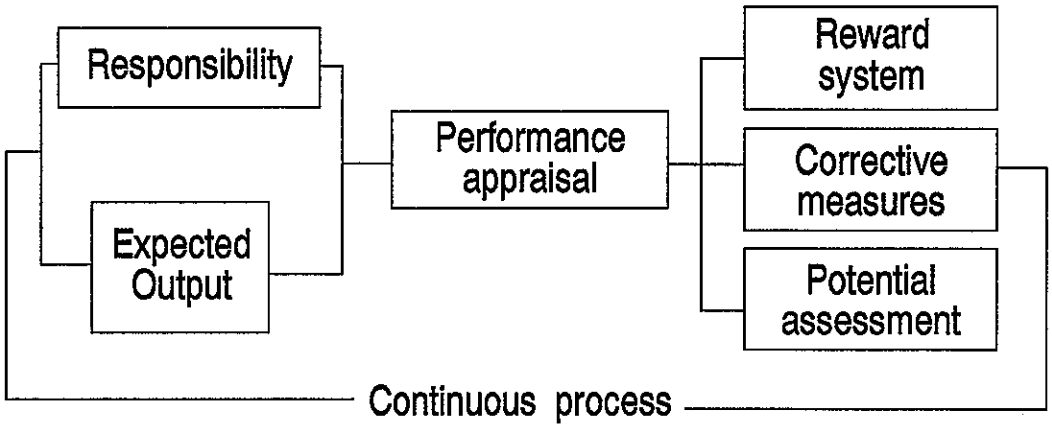
6.1 Management approach

To ensure a continuous, efficient, and effective mechanism for fulfilling its responsibilities, MARDI reorganized several times over the years. These were aimed to help the institute meet new challenges, particularly in response to new or added dimensions in governmental national agricultural policies. The current organizational structure is the outcome of a major review of MARDI's functions and objectives, carried out in 1984, at the time when the national agricultural policy was launched by the government.

Currently, research in MARDI is commodity oriented. A comprehensive, integrated applied-research approach is adopted for the major commodities: rice, fruits, cocoa, coconut, vegetables, field crops, tobacco, floricultural crops, and livestock. The main aim is to produce appropriate technology packages ready for transfer to the client system.

The commodity research program is further supported by basic research, support research, and technical services. Basic research includes crop science, crop protection, and soil science. Support research covers biotechnology, agricultural engineering, food technology, and technological-economic and social studies. Technical support embraces statistical and analytical

Figure 15
Performance appraisal mechanism in MARDI



services, and computer operations. This approach has enabled the institute to be productive, efficient, and expedient in the development of expertise in the various disciplines.

Structured into the system is the promotion of the research findings through technical training programs, advisory and consultation services, pilot projects, and active public-relation programs. A recent amendment to the MARDI Act allows MARDI to commercialize its research findings through joint-venture undertakings with interested commercial entrepreneurs. A special unit was recently established to handle this task.

The whole R&D structure is supported by a management support group covering general administration, finance, accounting, planning and evaluation, and information.

6.2 Research planning, monitoring, and evaluation

Prior to 1984, MARDI did not institutionalize formal in-house planning, monitoring, and evaluation (M&E) mechanisms for the management of its R&D activities. Assessment of quality and effectiveness was carried out through presentation of annual and half yearly reports to a governing board, scientific council, advisory committees, management committees, or project monitoring panels.

This mechanism was rather loose and not effectively organized. Consequently, many technologies developed were in 'bits and pieces' and failed to make substantial impacts on industry. The mechanism was also not capable of providing sound basis for research planning over an expected period of time. Realizing these weaknesses, MARDI formulated and institutionalized a research management mechanism.

As a whole, MARDI practices corporate planning in the formulation and implementation of its research activities. It involves the establishment of corporate strategic and operational plans (CSP and COP), as well as the tactical or annual implementation plans (AP).

6.2.1 Planning process

In general, MARDI practices top-down and bottom-up approaches in the planning of its research activities. The CSP is prepared by the senior management group (Director General and the Deputies) with contributions from all divisional directors. Specifically, the steps involved in the preparation of CSP are as follows:

i. Identification of long-term, overall objectives based on a comprehensive analysis of

Table 7
MARDI budget components (M$ million)

Year	Operating		R&D	Develop-ment	Total	% Salary to total budget
	Salary	Others				
1971	01.8	01.9	00.0	01.1	04.8	37.5
1975	10.5	05.9	00.0	04.6	21.0	50.0
1980	24.7	19.3	00.0	22.5	66.5	37.1
1985	33.7	35.8	00.0	06.3	75.8	44.5
1990	40.5	38.8	00.0	05.7	85.0	47.6
1991	44.3	34.7	19.0	11.0	109.0	40.6
1992	45.5	36.5	28.0	15.0	125.0	36.4

national policies and developmental goals pertaining to agriculture. Current objectives follow the SOPP period;

ii. Identification of long-term strategies to achieve the objective. Strategies cover both the external factors (through the analysis on environmental opportunities and constraints) and the internal factors (through analysis on the institute's strengths and weaknesses);

iii. Identification of research thrusts through a comprehensive analysis on the agricultural industries relevant to MARDI's scope of functions.

All research divisions, using the CSP as a guide, prepare the COP for research or research-support plans for which they are responsible. COP is developed for a five-year period, in line with national development and budgetary systems.

The preparation is headed by the divisional director with contributions by all program leaders and research scientists.

The steps involved are as follows:

i. The formulation of research programs and their expected outputs;

ii. The formulation of research projects under each program, carried out through an information-gap analysis technique;

iii. Preparation of implementation schedule and resource use (manpower, research facilities);

iv. Preparation of financial requirement.

The prepared COPs are tabled to senior management for approval. Both CSP and COP are then presented to the scientific council and governing board for comments and endorsement.

Table 8
MARDI staff structure (1992)

Research Scientist	456
Technical Support Staff	1191
Administrative Staff	263
General Supporting Group	1637
(Total)	3547

Subsequently, the approved research programs and projects are submitted to the IRPA panels via the Ministry of Agriculture before they can be finally implemented.

AP is an annual plan implementation document consisting of the following infomation:

i. Annual activities (experiments) under each research project, and their targets; and

ii. Annual utilization of resources (manpower and funds).

6.2.2 Monitoring and evaluation (M&E)

There are three forms of research M&E practiced in MARDI:

i. Ex-ante evaluation on new research programs and projects;

ii. Monitoring for on-going research programs and projects;

iii. Ex-post evaluation on completed programs and projects.

The ex-ante evaluation is incorporated in the formulation process of the corporate plan. The

Table 9
MARDI budget allocation in Sixth Malaysia Development Plan (1991-1995)

Plan	Program	Project	R&D*	Development	Operating**
Fruits	27.0	128.0	20.0	12.4	13.0
Cocoa and Coconut	7.0	38.0	9.5	1.6	8.1
Rice	7.0	35.0	11.5	2.6	17.2
Tobacco	3.0	24.0	6.5	1.3	3.5
Horticulture	16.0	69.0	15.5	12.6	12.5
Livestock	18.0	74.0	30.5	14.8	14.4
Basic Research	33.0	129.0	10.0	8.8	15.6
Agricultural Engineering	17.0	87.0	14.0	3.4	4.3
Biotechnology	5.0	44.0	11.5	1.0	2.1
Food technology	23.0	104.0	18.0	7.4	16.6
Technological Economic and Social Studies	5.0	25.0	2.5	—	4.1
Research in Sarawak	3.0	13.0	2.0	9.0	1.3
Technology promotion	1.0	3.0	0.5	—	7.0
Management of information system	—	—	—	5.1	6.5
Directorate	—	—	—	—	2.8
Administration	—	—	—	2.1	25.2
Serdang Station	—	—	—	1.2	6.5
	165.0	773.0	152.0	83.3	160.7

* *$127,217,200 for agriculture, the rest for strategic, industrial and social science sector;*
** *refers to operating budget for 1991 and 1992 only.*

Table 10
List of MARDI foreign scientific partners (1987-1991)

AAECP	Australian Economic Cooperation Program
ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AFHB	ASEAN Food Handling Bureau
	ASEAN-Australian Economic Cooperation Program
	ASEAN-European Economic Countries
ASEAN-Planti	ASEAN Training and Plant Quarantine Institute
AVRDC	Asian Vegetable Research and Development Centre, Taiwan
CIAT	International Centre of Tropical Agriculture (cassava)
CIMMYT	International Centre for Improvement of Maize
CSIRO	Commonwealth Scientific Industrial Research Organization, Australia
FAO	Food and Agriculture Organisation of the United Nations
FAO-UNDP	Food and Agriculture Organisation of the United Nations-United Nations Development Project
IAEA	International Atomic Energy Agency, Vienna, Austria
IBSRAM	International Board for Soil Research and Management
IBPGR	International Board for Plant Genetic Resources
ICRISAT	International Research Centre for Research in Semi-Arid Tropics, India
IDRC	International Development Research Centre, Canada
IFDC	International Fertilizer Development Centre
INRA	Institut National De La Recherche Agronomique, France
IPI	International Potash Institute
IRRI	International Rice Research Institute, Philippines
JETRO	Japan External Trade Organization
JICA	Japan International Cooperation Agency
KU	Kasetsart University, Thailand
MAB	Man and Biosphere, Thailand
NUS	National University of Singapore
PCARRD	Council for Agriculture and Resource Research Development, Philippines
PPI	Potash and Phosphate Institute
QDPI	Queensland Department of Primary Industry, Australia
	Rockefeller Foundation, USA
TARC	Tropical Agricultural Research Centre, Japan
UNDP	United Nations Development Project
UNESCO	United Nations Educational, Scientific and Cultural Organization
VOCRS	Vegetable and Ornamental Crops Research Station

ongoing activities are monitored twice a year. The first monitoring is based on the mid-year progress report submitted by the research scientists. The second is carried out at the end of the year through formal meetings (M&E exercise) organized at division and institute levels. Besides monitoring the progress and achievements for the year, the meetings also evaluate (ex-post) completed activities, as well as the annual plan prepared for the coming year.

In addition to the above monitoring process, the ongoing programs and projects are also presented for review every two years by a Technical Review Committee (TRC). TRC is established to help the effort to ensure quality and scientific excellence in research undertakings. The committee is made up of selected experts from local and international R&D institutions and relevant industries. Table 6 provides the complete steps of the in-house research M&E process. The linkages among all components is shown in Figure 14.

The formal research planning and M&E processes adopted by the institute has been successful in identifying and implementing relevant research activities to the development of the desired technology. A sample case on the adoption of these procedures in the development of new papaya hybrid is reflected in Appendix I.

6.3 Human resource development

Realizing the importance of having adequate high-quality manpower to meet organizational goals and objectives, MARDI has embarked on a serious program of human resource development (HRD). The planning and implementation of which is based on the following philosophy:

> *"As an R&D institution, MARDI is not only responsible for the production of technologies. Equally important is to develop a high-quality, innovative, motivated, and productive scientific community and experts in agriculture and nation building. A positive approach in human resource development ensures a much better MARDI and country in the future"*

6.3.1 Staff structure

In general, the staff structure in MARDI comprises three major groups: the research scientist, the technical support staff, and the administrative and general support groups. Starting with a modest staff of 31 research scientists and 391 support staff, the institute has now met the staff quota planned at its inception (Table 7).

An aggressive staff recruitment carried out during the 1970s and early 1980s was country's response to its need for a strong R&D support to agricultural development.

6.3.2 Staff development

The development of scientific manpower with the desired qualification and skill is achieved through continuous long-term and short-term training programs. The long-term training program involved upgrading the researchers' academic qualifications to the highest level possible. Besides fulfilling the need to have scientists more specialized in various disciplines, training also provides added incentives to the scientists for career development.

The short-term training program is designed to upgrade the researchers' knowledge and skill through short courses, job attachments, technical visits, seminars, and conferences. It provides an opportunity for the scientists to establish linkages with peers and to further strengthen joint and collaborative research. A similar approach is adopted to enhance the capability of the technical and administrative staff.

MARDI spends about M$2.5 million a year on staff training. The long-term training program has, so far, produced 89 PhD, 284 MSc, and 83 basic degree holders in various disciplines.

MARDI's research activities are organized on a commodity-discipline matrix system. Under this system the researchers are given the opportunity to expand their knowledge and research experience on a wide range of agricultural industries. The system also allows them to follow the development process of a specific technology, that is, from the research to the development stage, during which they are involved in related activities such as teaching and consultancy projects.

As they move up the ladder within the mainstream of research, researchers are given the opportunity to be involved in R&D management. The divisional directors and the program leaders are selected from potential and interested researchers.

6.3.3 In-service incentives

The current scheme of service for research scientist in the public sector is fairly competitive, allowing advancement to the higher salary scales based on performance and merit. The scheme

is also recognized as critical in the public sector and thus is granted a monthly critical-service allowance.

As an added incentive, awards and recognition are given to outstanding achievers. An annual excellent service award is conferred on staff with outstanding research work and overall performance.

6.3.4 Performance appraisal

In line with the objective to develop a well-trained and motivated work force, MARDI practices a developmental approach in its performance appraisal system (Figure 15). The system allows the participation of all staff in a continuous development program that has been mutually conceived and accepted by staff and supervision.

6.4 Management of research funds

Research activities in MARDI are fully supported by the government through three fund components: the operating budget; the development budget; and, from 1991, the R&D budget. The operating budget is for routine administrative and maintenance costs inclusive salary. The development budget is for physical development and the purchase of capital items. The R&D budget is for direct research costs which, prior to 1991, was embedded in the operating budget. The current salary component is about 36.4% of the total budget allocated to MARDI (Table 8). Distribution by division for the Sixth Malaysia Development Plan is shown in Table 9.

Other than these fund sources, and in line with the government policy calling for R&D institutions to have a target for self-financing (30% by 1995 and 60% by 2000), MARDI instituted several income-generating measures:

- Contract Research
  - Through this mechanism, some proportion of the research cost is assumed by interested parties, normally from the private sector. In return, MARDI conducts research in areas specific to the needs of the relevant parties.
- Consultancy Services
  - This service is offered to the private sectors, government and semi-government agencies, and to entrepreneurs wanting to venture into agricultural production and processing. For a fee, a complete consultancy service package, including land-suitability and feasibility studies are conducted. Since 1984, 63 major projects were carried out under this service.
- Other Sources of Revenue
  - Included are income generated by MARDI's own farm products (6,248 ha), finished products (especially processed products), analytical services, sales of publications, and interests on savings. MARDI has set a target of M$6.5 million to be derived from these sources for the year 1992. The amount achieved in 1991 was M$4.4 million.

To facilitate the commercialization of its research findings, through joint-ventures, MARDI Tech Corporation was recently established, provided with an initial launching grant of M$16 million. It is envisaged that the profits earned from this business venture will, in the long run, make MARDI less dependent on government funds.

6.5 Research collaboration

R&D is pursued in step with technological advancements taking place in various disciplines the world over. This has been made possible mainly through active training programs and research collaborations. Embedded in the latter are the inherent functions of knowledge sharing and

Table 11
Exaples of MARDI's successful contract research

Client	Technology generated through contract research
1. S&P Coconut Pt. Ltd	Use of binders in the production of instant coconut powder
2. Oiltech Pt. Ltd.	Evaluation of the tubular pasteurization system in the production of jams and papaya sauce
3. Malaysian Oxygen Ltd.	Evaluation of cryogenic freezer in the preparation of TV dinners
4. Vita Tenggara Pt. Ltd.	Production of tropical fruits
5. Eastern Plantation Agency	Production of tropical fruits and establishment of tissue culture laboratory
6. DCA Management Pt. Ltd.	Vegetable production
7. Pilgrimage Management Brd.	Papaya production
8. Lembaga Kemajuan Pertanian Pahang (Pahang State Ag. Development Board)	Fruit and livestock production and processing of agricultural produce
9. Asiatic Development Co.	Freezing of durian

technology transfer. Research linkages and collaboration is established both domestically and internationally (25).

6.5.1 International collaboration

International collaboration was established much earlier relative to domestic collaboration, as the initial thrust was more for funding assistance and engagement of expatriates. The funds made available were mainly utilized in the development and upgrading of in-house research expertise, and acquiring of research facilities and equipment. Now MARDI's role in collaborative work has changed somewhat, from learner to contributor of expertise and knowledge. MARDI's contribution to the scientific world, especially in the fields of tropical agriculture and food, is well noted.

MARDI collaborations in research with parties having similar functions and interested in the development of R&D capabilities in agriculture and food world wide. To date, the institute has established extensive linkages with institutions and centers in 22 countries (Table 10).

These collaborations involve a number of R&D programs on various commodities and research disciplines. For example, in rice research MARDI enjoys a long-standing cooperation with the Australian Centre for International Agricultural Research (ACIAR), Tropical Agriculture Research Centre (TARC), and with the International Rice Research Institute (IRRI) in the Philippines. Apart from this, MARDI/ACIAR projects also focus on pesticide residues, and post-harvest management of grains and horticultural produce. Concurrently, MARDI/TARC projects focus on the ecology, major pest development and the soil aspects of the major rice growing areas in the country.

6.5.2 Local collaboration

Collaborative effort in national research is well established in such areas as integrated pest management (IPM), counteracting the cocoa pod borer (CPB) menace, bee keeping, bulk drying and storage of rice, biotechnology research, and post-harvest management of horticultural produce, to name a few of the more prominent ones. The IRPA mechanism has opened fresh channels for collaboration with local R&D institutions and universities. Apart from pooling

expertise and optimizing resource use, the mechanism has made the scientific community more responsive to the needs of client groups.

As the research capabilities improve, local recognition is also accorded. At present the institute is not only involved in collaborative research with local R&D institutions but has also dared to venture into contract research with the private sector, mainly aimed at developing technologies specific to the needs of the clients. Depending on the agreement, generally part of the research cost is borne by the interested party. This is normally strengthened by signing memoranda of understanding between the parties concerned. Examples of successful contract research efforts are provided in Table 11.

6.6 Technology transfer

MARDI evolved from an institution that began with learning and acquiring R&D capabilities to one capable of sharing and transferring its knowledge and technology (24). Transfer of research findings to the scientific community is effected through dissemination of technical papers and via seminars and conferences. The mechanics of technology transfer to the small farmer are mainly organized through the extension intermediary of the Department of Agriculture, the Veterinary Department, and the Fishery Department. These have been augmented by technical training to finally mature into MARDI's direct participation in the transfer system. Currently the extension intermediaries are expanded to include the regional development authorities and other agricultural development agencies.

Initial technology-transfer efforts were hampered by inexperience and other technical shortcomings. As most technologies were developed in the confines of laboratories and research stations, their impacts on farms were much to be desired, especially when subjected to farm-level environmental complexities. Programs to disseminate or evaluate technologies for their appropriateness and acceptance were at first not well planned or executed. As a result adoption levels were generally poor.

Recognizing these shortcomings, a project development concept was instituted in 1973. The concept involved testing component and package technologies for their appropriateness and acceptance on selected farms with participation of farmers or through organizations and government agencies involved in agriculture development. These test sites became demonstrations for surrounding areas and resulted in the direct transfer of technologies to selected and surrounding farmers.

With the assimilation of the Food Technology Department of the Ministry of Agriculture in 1974, MARDI took on additional technology transfer responsibilities. Apart from food technology research and development of food technologies, MARDI was made responsible for food technology extension services for the food industries. In contrast to crop and animal production technologies, no extension intermediaries were used to transfer food-technology research findings to users. These were done via entrepreneur training, food-industry 'adopted' entrepreneur schemes, food-industry development programs, advisory and consultancy undertakings, and contract research. Technological information also spread through the normal channels of publication, such as seminars and conferences.

The technical training unit was formally instituted in 1977. It serves as one of the official channels to transfer technologies to the client groups. Over the years impressive training programs have been designed and conducted.

MARDI was only able to embark on an aggressive transfer of technology program after its reorganization and restructuring in early 1984. The Technology Promotion Division was then established with facilities to conduct pilot projects, advisory and consultancy services, dialogues and colloquium sessions, participation in technology exhibitions, and field days. Better state-level representation was also made possible through the MARDI State Offices which were established in the realm of the Technology Promotion Division.

Concurrent to this reorganization, the marketing concept approach was adopted for

Table 12
List of recipients of MARDI's technologies

1. **Ministry of Agriculture**
   - Department of Agriculture
   - Department of Veterinary Services
   - Federal Agricultural Marketing Authority
   - Farmers Organization Authority
   - Muda Agricultural Development Authority
   - Kemubu Agricultural Development Authority
   - Integrated Agricultural Development Projects
2. **Ministry of Land and Regional Development**
   - Federal Land Development Authority
   - Regional Development Authorities: e.g., PERDA, KESEDAR, KEJORA, KETENGAH
3. **Ministry of Primary Industries**
   - Rubber Research Institute of Malaysia
   - Palm Oil Research Institute of Malaysia
   - Forest Research Institute of Malaysia
   - National Tobacco Board
   - Malaysian Pineapple Industry Board
   - Malaysian Cocoa Board
4. **Ministry of Public Enterprise**
   - National Padi Board
   - State Economic Development Corporations
   - State Agricultural Development Corporations
   - Majlis Amanah Raayat
5. **Ministry of Rural Development**
   - Federal Land Consolidation and Rehabilitation Authority
   - Rubber Industry Small Holders Development Authority
   - Community Development Deparment
6. **Ministry of Health**
7. **Ministry of Science, Technology, and Environment**
8. **Ministry of Education**
   - Universities, colleges, and schools
9. **Private Sector**
   - Plantations, farmers' groups, food industries, individual entrepreneurs, etc.

technology development and transfer (9). This involves identifying the problems and needs of the clients, developing and implementing relevant R&D programs, disseminating appropriate technologies, and studying the impact of technologies adopted. This has facilitated and enhanced the transfer process as research is now very much client oriented.

Though the restructuring gave MARDI the opportunity to pursue technology transfer activities with vigor, it was found necessary to further upgrade the manner in which activities were undertaken. The latest change made was in setting up the commercial unit. Apart from being an active partner in joint-venture companies, all of MARDI's latest proven and relevant

technologies support these ventures. While this effort is now in its infancy, active negotiations are underway with a number of interested investors. The current recipients of MARDI's technologies are listed in Table 12.

It is evident that technology transfer mechanisms adopted are increasingly becoming more sophisticated and bold. Passive and noncommittal mechanisms like technical training and publications are gradually being taken over in emphasis by more direct, active, and committed mechanisms. This is apparent in the pilot projects, entrepreneur training, food-industry 'adopted' entrepreneur schemes, food-industry development programs, advisory and consultancy undertakings, and contract research. The climax is in the recent equity participation in joint businesses. These are major turning points, as such maturity entails even amendments to the MARDI Act.

It must also be highlighted that there is a marked shift in the objectives of technology transfer. Most evident is the shift from mere dissemination of information about new products and processes to the building of entrepreneurial skills and technological capabilities, through the active participation of R&D personnel in business-motivated production entities and in R&D collaborations.

7. Conclusion

Agricultural research in Malaysia began in the early 1900s. Significant expansion occurred during the 1970s and 1980s as evident from the establishment of new R&D institutions and the upgrading of existing ones. At this time, a more centrally coordinated system for agricultural research at the national level began to emerge in the mid-1970s, when research was absorbed as a component of the newly established National Committee for Science, Research and Development (NCSRD). When NCSRD introduced the Intensification of Research in Priority Areas (IRPA) mechanism, agricultural research activities became better organized and managed, and more closely linked to the R&D activities of the other sectors.

The overall improvement of agricultural R&D management is reflected at the institution level in the various R&D institutions. The situation is exemplified in MARDI.

Acknowledgement

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Appendix 1
Development of new papaya variety: Eksotika Malaysia

1. Rationale

Local available papaya varieties compare poorly in quality to those already in the export market. This is especially true in terms of sweetness (9-12% total soluble solids, TSS) and flavour. Poor quality disqualifies local papaya from the up-class local and international dessert fruit markets. Although there was persistent effort to improve fruit quality, it appeared unlikely that further progress could be achieved using the locally available gene pool.

2. Research programs

The alternative was to introduce new genetic materials with the desired TSS and flavour characteristics. One such variety was the Sunrise Solo (15-16% TSS) from Hawaii. The Sunrise Solo is, however, small fruited (300-400 g) and is thus not popular in the local market. Vigorous breeding programs of the Sunrise Solo with the local large-fruit variety, Subang 6, were initiated in 1972. The progeny was backcrossed for several generations to the Sunrise Solo to reconstitute the original flavour and sweetness of the Solo. The product of the hybridization program was a high quality fruit which met most desirable specifications. This fruit is characterized by:

- attractive flesh (orange red);
- high sugar content (13-14% TSS) with aromatic flavour;
- uniform fruit size (600-800 g) convenient to handle; and
- attractive to pack for both local and export markets.

The relevant crop husbandry practices for the cultivation of this new cultivar was also examined based on technology gaps identified. Subsequent research activities on land preparation, nursery management, field management, water requirements, pests and diseases, as well as means of overcoming some physiological problems were carried out. Areas found to be suitable for commercial papaya cultivation were also identified, taking into consideration both biological needs and the socioeconomic scenario. Feasibility studies for large scale cultivation were conducted. The variety developed, Eksotika Malaysia, was released in 1987. To fully exploit the export market, fruit handling, storage, and other post-harvest technologies were improved or developed, including transportation trials (by air and sea) to several overseas destinations.

3. Technology promotion

Various mechanisms for promoting the adoption of this variety among smallholders as well as among agricultural development agencies (both public and private sectors) were conducted. Pilot scale testing, training for the extension agents, seminars, expositions, workshops and consultancy activities are some of the mechanisms adopted. A total of 343 ha of the variety was evaluated under pilot scale testing.

4. Impact

The variety received overwhelmingly positive response from the smallholders and the plantation sector. By 1990, about 1,000 ha was cultivated with Papaya Eksotika, representing about 60% of total area under papaya. About 13,500 t of the crop valued at M$15.0 million was exported, mainly to Hong Kong, Singapore, and to some European countries. This represents about a fivefold increase in papaya export since the release of the new variety.

5. Follow-up activities

The overwhelming response to this variety is not without its problems. With large commercial cultivation, some previously unobserved shortcomings of Eksotika became evident and needed rectification. Among these are:

- poor cosmetics because of its susceptibility to freckling;
- rough fruit surface;
- seed infection suseptablility in the ovarian cavity, resulting in forced ripening showing as patchy, irregular yellowing of the skin;
- soft texture, leading to handling problems;
- short storage life, extending it would allow more flexibility in handling and marketing;
- orange red flesh poorly inherited in later generations and color paler for the first few fruits harvested.

To overcome these shortcomings, hybridization between several selected lines in the backcrossed populations was initiated in 1984. By 1990, an improved F_1 hybrid, Eksotika II, as a replacement for the Eksotikam, was developed and released. Eksotika II has desirable characteristics to overcome the above limitations. Its yield exceeded that of Eksotika by 20%. The flesh is sweet and the texture firm. It has little fruit freckles and keeps better. Subsequent promotional activities have since been carried out.

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