Sustaining Malaysia's Future

The Mega Science Agenda

AKADEMI SAINS MALAYSIA

Biodiversity

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EPILOGUE

1. Introduction

Science has been universally touted as the main engine of economic growth and national development. Science from its Latin name 'scienta' means knowledge. A knowledge-based economy is essentially a science-based economy. New knowledge i.e. "science" is generated by undertaking research, experiments and strategic studies or R&D. R & D and strategic studies provide the means to fulfill market needs and find solutions to various problems. The results and findings are delivered in the form of new or enhanced knowledge, technology and products or services. This results in productive economic activities which contribute to wealth creation and economic growth.

Malaysia, as a country, should adopt the concept of a Mega-Science Framework as a comprehensive vehicle to drive the use of science, technology and innovation (STI) to contribute towards economic growth. Mega essentially means big, therefore the discipline of Mega-Science implies a pervasive (broad-based), intensive (in-depth), and extensive (long period of engagement) use of science or knowledge to produce technologies, products and services for all sectors of the economy to derive economic growth and development. It also calls for extensive investment in research activities to enhance the knowledge base for the targeted sectors. Since knowledge in marketing and finance is equally important in promoting the success of a commercial venture as compared to technical needs, it is envisaged that the Mega-Science approach will require research to be conducted both in non-technical sectors as well as in traditional scientific sectors.

2. A need for national knowledge generating mechanism

As we are aware, national economies are classified into 5 sectors namely: agriculture, mining, manufacturing, construction and services (Table 1). Efforts to generate knowledge by establishing research institutions and universities and centers of excellence to support agricultural, mining and manufacturing sectors are well established. The construction and services sectors are also dependent on new knowledge and technology in order to progress and remain competitive. R & D and strategic studies are also necessary to drive the development of these two sectors.

Table 1 NATIONAL ECONOMIC SECTORS (% OF GDP)

SECTOR	2010*	2015**
SERVICES	58.5	61.1
AGRICULTURE	7.6	6.6
MINING	7.9	5.9
MANUFACTURING	26.2	26.3
CONSTRUCTION	3.2	2.9

*Source:*Economic Report 2009/2010 (MoF)*
***RMK10 Report (EPU)*

The Mega-Science approach would emphasize the need to strengthen R & D and strategic studies to be undertaken in these non- traditional sectors. For example, to enhance the development of the tourism industry (service sector), dedicated R&D and strategic studies should be undertaken to generate new knowledge that will lead to the delivery of new tourism products, services and innovative strategies which will improve competitiveness of the industry. Similarly, research studies, market surveys and financial models are proposed especially for the services sector as the knowledge created will fulfill a need or solve a problem which eventually will generate revenue and contribute to economic growth. The Mega Science approach therefore identifies R&D and strategic studies as the key enablers to economic growth in all targeted sectors of the economy.

3. A need to invest sufficiently in knowledge creation: R & D and knowledge acquisition

To become a high income developed economy, Malaysia as a country has to intensify knowledge generating capacity by investing in R&D and strategic studies. The expenditure in R & D must reflect the norm usually associated with countries having a developed economy. While past expenditure in R & D for Malaysia as a developing country has hovered at 0.5% of the national GDP, the present and future rate of spending should be increased to above 2.0% as benchmarked against the rate of spending for countries with developed economies (Figure 1). Towards achieving this goal, it is proposed that the Government formalize the rate of spending of 2% and above through the promulgation of a Science and Technology Act ("S&T Act"), which is long overdue.

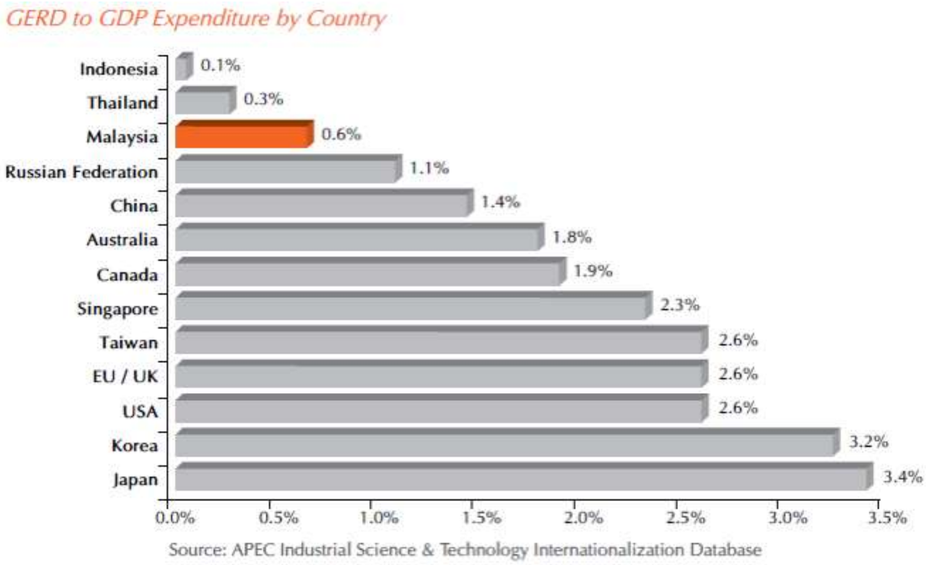

Figure 1 Malaysia's Low R&D Investment

R&D needs a long lead time before beneficial results can be harnessed to contribute to the economy through commercialization of research results and development of expertise (Figure 2). To fulfill the need to have pervasive, intensive and extensive R&D activities and satisfy the long lead time needed for R&D to mature, bold up front investments in R&D spending will be necessary. While this is financially difficult to reconcile, extensive and expensive upfront investment in R & D is necessary and forms a critical dimension of the Mega-Science Framework approach. These long lead times from R&D to Commercialization are amply demonstrated in Malaysia in the rubber and palm oil sectors of agriculture. In rubber, we took some 50 years to see Malaysia "topping the world" in rubber technology since initiating R&D in rubber. Similarly, in palm oil, Malaysia took about 40 years to "top the world".

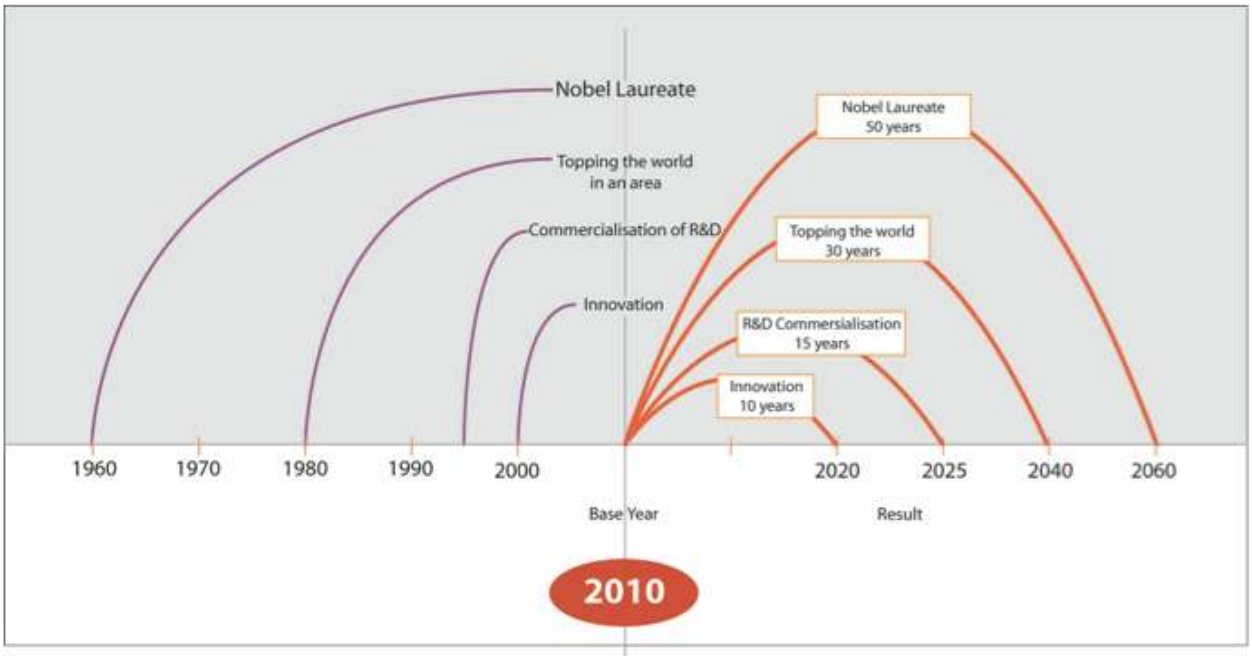

Figure 2 Time Lag on Increase in HR and R&D Investments and the Resultant Key Indicators Stimulating Economic Growth

Although a certain amount of knowledge, technology and research inputs may be imported especially through FDI activities, these are often out-dated or out-of-sync with business and economic needs. Therefore, the process of knowledge renewal and enhancement must continue to be undertaken for the country to remain competitive.

4. A need to manage knowledge generation and acquisition nationally through private and public sector participation

The Mega-Science Framework looks at national efforts in generating new knowledge and STI deliverables. The country's science infrastructure must exist to help deliver the desired results. The science infrastructure should also ensure the evolution of more R&D to be undertaken by the private sector vis-à-vis the public sector as is typically found in a developed country economy.

The present proposal to establish the National Research Council (NRC) and the National Innovation Unit (UNIK) should be encouraged as these provide the management function of ensuring that funding and management for R & D and strategic studies will be maximized. A significant role of ensuring the timely development and availability of STI deliverables for economic growth must be emphasized. In this respect, the role of MIGHT and other Technology Development Corporations in technology foresight scoping, development and acquisition are highly crucial especially bearing in mind that some technologies can be obtained through offset programmes of government international tenders.

5. Knowledge gaps in various economic sectors

In the past, economic growth was a function of knowledge (technology) and capital accumulation. Past investments in R&D in the relevant sectors would have generated knowledge to stimulate economic growth. Continuous knowledge enhancement (training) or accumulation of human capital development (expertise) adds to facilitate and accelerate economic growth. The serious lack of researchers in basic and applied sciences has to be urgently addressed such that it does not hamper the generation of knowledge and hamper sustained economic growth of the nation (Figure 3).

Future economic growth may be limited by natural limits to growth effected by population growth and excessive demand for non-sustainable and non-renewable resources. There is the possibility of reaching limits of environmental carrying capacity. Therefore, future economic development may not only depend on accumulation of capital and technology, but also on natural resources including energy and land, and the carrying capacity of the environment. These additional factors of economic growth must be factored in to the future development of the country’s economy.

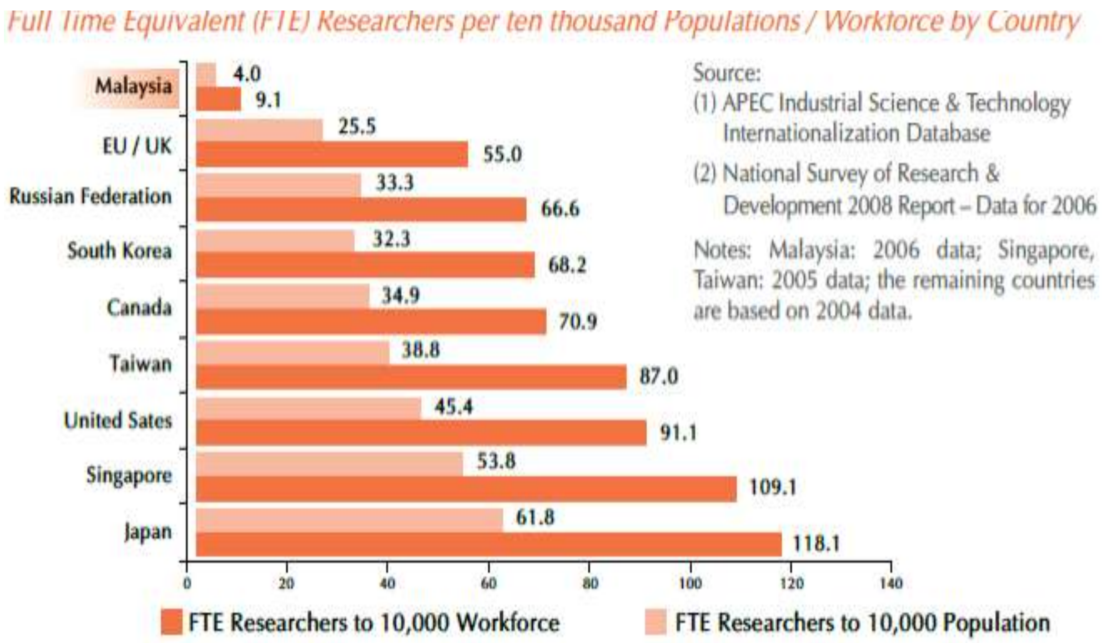

Figure 3 Low FTE Researchers – A Barrier to Sustained Economic Growth

To sustain future economic growth in Malaysia, investment in knowledge creation must be continued or enlarged. The knowledge creation (R&D) function of the Mega-Science Framework will rightly identify and address these needs.

6. Malaysia needs to intensify knowledge generation in niche sectors

Part of the Mega-Science Framework calls for pervasive, intensive and extensive use of science to identify and develop competitive knowledge and STI opportunities for commercialization in various sectors of the economy. Subsequently, another part of the Mega-Science Framework will require prioritizing of sub-sectors so that returns to strategic R&D investments are maximized. This will naturally lead to more efforts being devoted to developing of niche key sectors where Malaysia has certain competitive advantages.

Identification of the niche sub-sectors may employ the process of consultation and short term evaluation of opportunities such as the “laboratory retreats” studies undertaken by the Malaysian government recently. In addition, long term development of niche areas at the national level and the private sector will be necessary. The process is iterative. The more the investment in knowledge (R&D and STI development) the more will be the discovery of niche areas for commercial exploitation where Malaysia has the competitive advantage. But in-depth knowledge developed through the Mega-Science Framework is firstly needed to identify the niche areas.

7. Sectoral knowledge gaps and STI requirements

Studies of various economic sectors have identified the need to invest in knowledge gaps to sustain current and future needs, maintain competitiveness and contribute to the country's economic development. Firstly, cost must be kept optimally low and secondly revenue must be maximized. Ideally, the sector will generate enough commercial revenue to cross-subsidise the need to maintain the sector at minimal cost. For example, in the health and medical sector, knowledge enhancement is continuously needed to maintain the capacity of the sector to provide a high standard of health service. Efforts include promotion of preventive activities which will reduce health treatment in the long run. But there are also opportunities to generate revenue by supplying and exporting competitive health services and products such as health tourism which can contribute directly to economic growth. Similarly, in the Water Sector, ASM's Mega Science Study has identified opportunities in S&T in various niche areas.

In the biodiversity, energy and agricultural sectors which have been subjected to the Mega-Science Framework Studies undertaken by the Academy of Sciences Malaysia (ASM), it was found that the knowledge creation and STI application opportunities and gaps exist in both the home consumption and exportable components of each sector. The defense sector could similarly fall into the two categories of development, and as more economic sub-sectors are evaluated in the future under the Mega-Science Framework Studies, the pattern will probably be the same: the need to develop both the home consumption and exportable components of the sector in order to improve the country's standard of living directly and to generate revenue for increased income.

Examples of gaps in STI adequacy and niche opportunities have been identified during the Mega- Science Framework Studies undertaken by the ASM recently. The examples clearly show that Malaysia has many niche areas for STI development for commercial exploitation especially for the export component. It is also noted that a sector with well developed export component will also provide for adequate home consumption needs. It implies that developing the export component of a sector should be given greater focus and priority as this will serve to also develop the home consumption sector to bring about improved standard of living while increasing revenue and income.

8. Lubricating the Engine of Growth

The Mega-Science Framework advocates the pervasive use of knowledge and proposes the use of STI as the main engine of economic growth and national development. An engine does not function without lubrication. To facilitate the smooth or lubricated functioning of STI, human resource expertise must be adequately available. Fortunately, the enhancement of expertise of human resource is achieved through the same engagement in knowledge creation process (R&D) and other forms of knowledge enhancement process (training) at universities, research institutes and training centers. The more people are involved in R&D and STI development; the better will be the available expertise of the country. R&D investments therefore contribute to expertise and knowledge enhancement of human resource.

Another dimension of the lubrication process to the engine of growth is the level of income itself. There exists an iterative cycle in the relationship between intensity in investment in R&D and the level of income of the country. The higher the R&D expenditure the higher will be the income level. The higher the income level, the higher will be the R&D expenditure. To break this vicious cycle, it is necessary to adopt a strategy of a high income economy, similar to what the country is currently attempting to do. In the past, Malaysia has adopted a low income and low cost economy with a reasonably high purchasing power parity index compared to other countries. It was found that the low income and low cost economy has severe limitations to promote further growth and consequently, Malaysia was led into the middle income trap. Low income strategies do not attract talents and retention of expertise in the country. Low income strategies also under-exploit the services sector which now becomes a major sector of the economy. Services provided in Malaysia earn much lower revenue compared to similar services provided by the developed economy countries.

High income economy means high salary which means high costs. Malaysia must be prepared to adopt a high income and high cost economy as this is the norm seen in other developed countries. High cost is inevitable because when looked from the income side, high income means high salary, but the same high salary will mean high cost when looked at from the cost perspective. The big advantage of high income and high cost (salary) economy is that expertise is easier to obtain and retain, and in addition, the services sector such as hotels, tourism, banking, airlines, etc will be charging internationally competitive prices to maximize revenue and income for the country. Furthermore, efficiency will automatically be enhanced when an economy operates on a high income and high cost strategy. Such an economy will also be able to pay international prices and avoid most subsidies. The billions of Ringgit of subsidy money currently provided in the government budget can instead be distributed to increase salary. Leaving it to the high income individuals to buy the unsubsidized goods and services will further improve efficiency and reduce wastages which are often encountered in a subsidized economy.

9. S&T Governance

In Malaysia, Science, Technology and Innovation are being given very high priority. However, Academics and Researchers need to play a very strong role in evidence- and data-based decision-making, while bureaucrats should continue to play a supporting role.
In the Korean example, a high-level National S&T Council, chaired by the President with the Minister of Environment, Science and Technology as the Vice-Chair and the Ministry of Environment, Science and Technology as the Secretariat, has 5 Committees (Figure 4) on Key Industrial Technologies, Large-Scale Technologies, State-led Technologies, Cutting Edge and Convergence Interdisciplinary Technologies and Infrastructure Technologies.

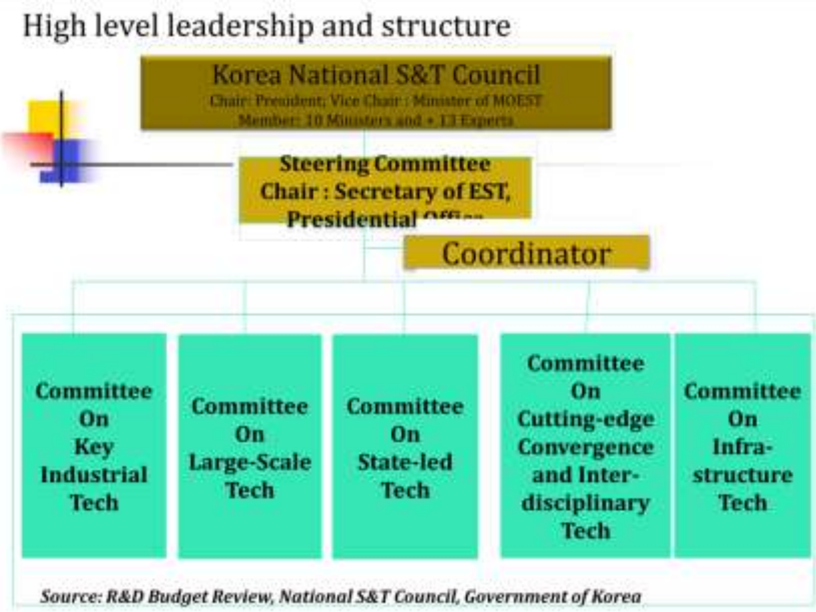

Figure 4 Korean National S&T Council

10. Funding

Malaysia is in the process of improving its science infrastructure to help improve the capacity of the country to use science (STI) as the main engine of growth for its future development. Funding and investment in R&D and strategic studies in all sectors of the economy remain underdeveloped. Such funding is both important and urgent because of the long lead time needed to provide future STI deliverables.

It is proposed that Malaysia makes a 'jump start' and allocates RM 20 billion for an accelerated development of its science industry between now and the year 2020. This fund should be managed by the responsible agencies to ensure both priorities in R&D and strategic studies and the intensification of R&D especially in the private sector can be implemented. Such funding should be increased if necessary during the period of implementation. Commitment to fund the science industry with a RM 20 billion grant would greatly contribute to the achievement of the high income economy strategy as proposed by the government. In comparison, many other countries, both developed and developing, are already providing such mega science grants to invest for their sustained growth in the future. As an example, the Korean Government gave an allocation amounting to US$16 billion to facilitate the R&D programme in the country. UNIK can be authorized to manage, coordinate, distribute and monitor the RM20 billion grant.

As a second option, part of the RM20 billion grant can be created from taxing corporate profits, amounting from ½% to 2%. The corporations will however be exempted from this taxation if they can show that they are undertaking R&D. UNIK can be authorized to verify and certify that the R&D is being carried out. The exemption will be given to corporations able to show that they are undertaking R&D, Strategic Studies and/or undertaking technological acquisitions to further their R&D capacity and capability. In this way, more R&D, of at least 75%, will be carried out by the private sector.

In essence, the following actions are proposed as part of the functions of UNIK which will be authorized to manage, coordinate, distribute and monitor the grant:

(i) Raise R&D funding, amounting to 2% and above of GDP, through the Government initially giving a "launching grant" amounting to RM 20 billion. The grant can be sustained through taxing corporate profits, amounting from ½% to 2% with the necessary tax exemptions given as described above;

(ii) Prioritise R&D areas with advice from the National Science Research Council; and

(iii) Migrate to improving the R&D activities to be mainly private-sector driven with the ratio being private sector: public sector at 75%:25%.

11. Conclusion

A Mega-Science Framework can be the national vehicle to promote the application of knowledge (science) through STI commercialization to generate better standard of living and new sources of revenue and income to achieve economic growth and national development. The advocacy of science (STI) as an engine of growth can be reinforced through the strong recognition given via the Mega-Science Approach on the need to have extensive investment in R&D and other strategic studies in both traditional 'scientific' sectors and the newly-emphasized services sector.

The scientific STI system as an engine of growth can be further 'lubricated' to deliver the end objectives by the adoption of knowledge enhancement strategies through R&D and training, as well as the adoption of a high income and high cost economic system as practiced by other developed economy countries. By systematically evaluating the knowledge and technology gaps in various sectors and sub-sectors of the economy, it is possible to provide the country with a road map of future opportunities in STI implementation for economic growth and national development. Present studies show many fertile areas of future opportunities exist for the sectors evaluated.

Malaysia's rate of knowledge generation is falling far behind the desired target. It can be concluded that science has not be given the needed funding and urgency to enable it to be truly the engine for sustained national growth for the future. It is hoped that the adoption of a Mega-Science Framework approach will help resolve these limitations and assist in the development of the science industry in the country.

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President
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22nd December 2010

PREFACE

The Mega Science Agenda aims at establishing the framework (roadmap) and identify the types and quantity of SET and the areas of development on which these SET will be applied to generate maximum sustainable economic growth and prosperity for the country. For each growth sector, we need to identify the technology frontiers and related requirements to develop the sector into our engine of growth. ASM has initially identified five major sectors such as Water, Energy, Health, Agriculture and Biodiversity to focus on and later on other sectors such as ICT, Transportation, Advanced Materials, Tourism and Housing. The studies and report of the first 4 sectors been completed.

The over arching objectives of the Study is to be achieved by: 1) assessing and analyzing the global drivers of sustainable long-term development and the critical role of technology and innovation in national development programs; 2) to undertake a review and analysis of the various government policies and 5-year plans; 3) to assess and determine the social, economic and environmental targets to reflect the dimensions of sustainability, inclusiveness and wealth creation (high income); 4) to seek stakeholders views on the sectors. The Study will establish the roadmap and identify the STI to be adopted to generate maximum sustainable economic growth and prosperity and wellness for the country.

It is pertinent to be reminded that the competition for S&T innovations and development is not coming just from the developed nations but from all nations of the world today – the difference is only a matter of degrees. Thus it become imperative that we need to be focused and to capitalize on the comparative advantages we have or potentially can be developed. This will not be an easy task as technology has erased national boundaries and cultures – what were national problems are today global issues – climate change, infectious diseases, pollution, liberalized trade and biodiversity loss. Conversely solutions to these also provide global scale opportunities.

In terms of competitiveness for example, Eco-Tourism, we are surrounded by countries that offer Eco-Tourism, so what is our pull factor from the S&T perspective. It will not be hardcore biological science alone but perhaps by demonstrating the highest standard of ethics in hospitality practice, fair cost and immigration facilities. The point to be stressed is how we use our limited resources to the best advantage and planned to better our S&T capabilities in the biodiversity sector so that they will play significant roles in the sustainable development of the country and the wellness of its people and also the health of the planet.

The question in readers mind will probably be what is different in this study or report? Firstly it looks at a longer period that is still 2050. We are aware that projection beyond 5 years is difficult but some of the basics aspects like R&D and training should be looked at over a longer term. Secondly it is focus on opportunities of emerging S&T as the drivers for the transition to a better sustainable world. Where do we fit remote sensing, genomics, nanotechnology, biomimetics, and ICT into the biodiversity conservation and sustainable utilization process. Thirdly it adopts an interdisciplinary approach cutting across sectors and disciplines (one science concept) and fourthly which I am trying to influence all sectors is to look at nature for solutions (Biomimicry) – like close-loop systems (animal waste), superior nitrogen-fixing organisms, biological pest control (owl/rodent), more efficient breakdown of lignin/cellulose by bacteria for better feed conversion.

As stakeholders you have your priorities and special knowledge in the various sub-sectors of biodiversity that you can share to supplement and value-add to this study. Because some of the data and information are held by individuals, agencies and institutions, a workshop like this could unlock important information on the sub-sectors. ASM welcomes all views and constructive proposals to help us give a more complete picture seen from different angles.

Malaysia's economic growth had its foundation on industrial agriculture crops that engaged STE which made her competitive in the global market.

Till today the investments by the government and corporate sectors on Oil Palm R&D continues to pay dividends. Though oil palm has been blamed for the loss of biodiversity it is the least damaging compared to other industrial temperate crops grown on millions of acres. (In the USA the principal crops grown in 2009 occupied 320.9 million acres of which corn and soybean took up 87.9 and 77.5 million acres respectively). The modern practices in the oil palm plantations to recycle biomass as fuel, fiber, fertilizer, animal feed and furniture and at the same time provide the world with the most affordable calories are positive contributions to sustainable development. ***The future development of palm oil is not in planting more acreage but in bioengineering, further processing of the oil and innovating new value added products.***

The warm wet climate of the country provides many niche opportunities that require tropical STE inputs to help develop new food crops, spices, flowers, nutriceuticals, pharmaceuticals, wood and fiber within sustainable systems. The STE opportunities presented in both conventional and sophisticated biotechnology are enormous. Biotechnology will play the major role in increasing yields, improvement of selected qualities, decreasing crop inputs such as water and fertilizer and engagement of biological pest and disease control or by methods more compatible with the environment. Wild species of livestock like the Gaur/Benteng (*Bos gaurus/Bos javanicus*) and deer (*Cervus unicolor*) and selected species of wild fish like Sebarau/Kelah (*Hampala macrolepidota/Tor sp*.) have potential to be domesticated and bred to provide high quality protein. These moves if done strategically will also help conserve the wild species in situ. The improvements and adoption of artificial insemination, artificial spawning, embryo transfer, embryo sexing, improved vaccines (terrestrial & aquatic animals) and innovative formulated feeds would accelerate developments in animal and fish production in sustainable ways.

Malaysia's vast marine areas and resources present even greater opportunities for STE in fisheries management and scheduled harvesting. The challenge of replenishing wild commercial fishes for inshore fishing can be achieved by improving artificial reefs, satellite monitoring, rotational harvesting and social engineering of small fisherman. Collaborative data collection on marine biota, currents, terrain, pollutants, and other necessary data through ASEAN would allow for sustainable and consistent annual catches of deep sea fishes benefiting all the countries. In the future food production would come primarily from the sea if we allow it.

Currently, the world is utilizing only 1% of living organisms for our own benefit. Among plants only 7,000 species out of 75,000 known edible plants are utilized. Malaysia with its rich plant diversity should not be allowed to be lacking in knowledge of their potentials. As an example of Malaysia's genetic diversity of edible fruits – 49 species of mangosteen; 25 species of durians; 22 species of mangoes. This is example of biodiversity potential contribution the food sector.

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2. Professor Dr. Asma Ismail F.A.Sc. (Vice-President ASM)
3. Dato' Dr. Samsudin Tugiman F.A.Sc (Secretary-General ASM)
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Dr. Ahmad Ibrahim (Principal Team Member from 1st September 2008 until 31st December 2010)

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ABBREVIATIONS

ABI - Malaysia Agro-Biotechnology Institute
ABS – Access and Benefit Sharing
AIA – Advanced Informed Agreement
ARI - Agricultural Research Institute
ASM - Academy of Science Malaysia
ASM – Academy of Sciences Malaysia
CDM – Clean Development Mechanisms
CEBLAW - Centre for Biodiversity Law
CIBG – Center for Genetic Engineering and Biotechnology
CITES - The Convention on the International Trade in Endangered Species
COP – Conference of the Parties
CPB - The Cartagena Protocol on Biosafety
CPF - Collaborative Partnership on Forests
DAGS - Demonstrator Application Grant Scheme
DEIA - Detailed Environmental Impact Assessment
DWNP – Department of Wildlife and National Parks
EIA – Environmental Impact Assessment
FAO - Food and Agriculture Organization
FFRS - Freshwater Fisheries Research Centre
FRC Sabah - Fisheries Research Centre Sabah
FRI - Fisheries Research Institute
FRI Sarawak - Fisheries Research Institute Sarawak
FRIM – Forest Research Institute Malaysia
FRIM - Forest Research Institute Malaysia
GBO – Global Biodiversity Outlook
GDP – Gross Domestic Product
GENOMalaysia - Malaysia Genome Institute
GLSI – Global Services Location Index
GRAs - Genetic Resources Areas
GRASP - General Apes Partnership
GRIs – Government Research Institutes
HRD - Human Resource Development
ICGEB - International Center for Genetic Engineering and Biotechnology
ICT – Information and Communication Technology
IFAD - International Fund for Agriculture Development

IGS - Industry Research and Development Grant Scheme
IHLs – Institutes of Higher Learning
IMF - International Monetary Fund
IMR - Institute of Medical Research
IPBES - The International Platform on Biodiversity and Ecosystem Services
IPCC - Intergovernmental Panel on Climate Change
IPharm - Malaysia Institute of Pharmaceuticals & Nutraceuticals
IPO - International Procurement Operations
IPR – Intellectual Property Rights
IRPA – Intensification of Research Priority Areas
ISIS - Institute for Strategic and International Studies
ITTO - The International Tropical Timber Organization
JPSB – Jabatan Perhutanan Sabah
LMEs - Large Marine Ecosystems
LMO – Living Modified Organisms
MAPOL - Marine Related Global/Regional Seas Agreement and Protocols
MARDI – Malaysian Agricultural Research and Development Institute
MARDI - Malaysian Agricultural Research and Development Institution
MCB - Malaysian Cocoa Board
MEA - Millennium Ecosystem Assessment
MEAs - Multilateral Environmental Agreements
MFRDMD - Marine Fishery Resources Development and Management Department
MGS - Multimedia Super Corridor Research and Development Grant Scheme
MIMA - Malaysian Institute of Maritime Affairs
MINT - Malaysian Institute for Nuclear Technology Research
MIT – Massachusetts Institute of Technology
MOA - Ministry of Agriculture and Agrobased Industry
MOSTE - Ministry of Science Technology and Environment
MOSTI – Ministry of Science, Technology and Innovation
MPKSN - National Council for Scientific Research and Development
MPOB - Malaysian Palm Oil Board
MSF – Mega Science Framework
MTCGS - Malaysian Technology Credit Guarantee Scheme
NaFish - National Fish Health Centre
NIB – National Institute of Biodiversity
NCSA – National Capacity Action Plan

NGOs – Non Governmental Organisations
NPABS - The Nagoya Protocol on Access and Benefit Sharing
NPBD - National Policy on Biological Diversity
NRE – Ministry of Natural Resources and Environment
NTBFs - New Technology Based Firms
OPP – Operative Perspective Plan
PCT – Patent Corporation Treaty
PEIA - Preliminary Environmental Impact Assessment
PES - Payments for Ecosystem Services
POPs - The Stockholm Convention on Persistent Organic Pollutants
PRI - Public Research Institutes
R&D - Research and Development
R,D&I – Research, Development & Innovation
REDD & REDD+ – Reducing Emission from Deforestation and Degradation of Forest
RFLP - Restriction Fragment Length Polymorph
RMK 10 – 10th Malaysia Plan
RRIM - Rubber Research Institute Malaysia
S&T – Science & Technology
SaBC - Sabah Biodiversity Centre
SBC – Sarawak Biodiversity Centre
SEA – Strategic Environmental Assessment
SG - Strategic Goals
SIRIM – Standards and Industrial research Institute Malaysia
SMEs - Small and Medium Enterprises
STI - Science Technology and Innovation
ST&I – Science Technology & Innovation
STP - Second Science and Technology Policy
TK – Traditional Knowledge
TRIPS – Trade Related Intellectual Property Rights
TUMEC - Turtle and Marine Ecosystem Centre
UNCBD – United Nations Convention on Biological Diversity
UNCCD - The UN Convention on Combating Desertification
UNCED - United Nations Conference Environment and Development
UNCLOS – United Nations Law of the Sea
UNDP - United Nations Development Programme
UNFCC - The UN Framework Convention on Climate Change
UNGA – United Nations General Assembly

UNIDO - United Nations Industrial Development Organization
VJRs - Virgin Jungle Reserves
VRI - Veterinary Research Institute
WB - World Bank
WCC – Wildlife Conservation Centres
WHO - World Health Organization
WIPO – World Intellectual Property Organization
WPs – Work Packages
WSSD - World Summit on Sustainable Development
WTO - World Tourism Organization
WTO – World Trade Organization

1. EXECUTIVE SUMMARY

Biological diversity, or biodiversity be it the genetic, species and/or ecosystem level has often been aptly referred to as the “fabric or life” or the “web of life”. And to put it another way, “without biodiversity, man will perish, but without man, biodiversity with flourish. The ASM MSF Study on the Biodiversity Sector, is all the more significant for Malaysia, since Malaysia belongs to the twelve “mega(bio)diverse countries in the world. The aforesaid Study is all the more pivotal, as it not only addresses the conventional and traditional dimensions of the conservation and the sustainable use of biodiversity, but also novel and innovative dynamics of the wealth creation of/from biodiversity, including the meaningful contribution of biodiversity towards the country’s GNP/GDP, but without compromising on the richness of Malaysia’s biodiversity in keeping with Malaysia being a party to the UN Convention on Biological Diversity, the Cartagena Protocol on Biosafety and the Nagoya Protocol on Access and Benefit Sharing, as well as Malaysia’s own pro-biodiversity-related and pro-economic priorities, policies, plans, perspectives and practices.

In implementing the Study, ten Work Packages (WP1-10) being central and pivotal for the biodiversity sector were identified and elaborated. Data and information for the WPs was obtained from reviews and analysis of earlier national, regional and international reports and studies, internet searches and from relevant reference texts. Extensive references were also made from reports made available by the Ministry of Natural Resources and Environment (NRE), the Interim Report of the Mega Science for Sustained Development on the Biodiversity Sector, and the United Nations Institutions. The study methodology also included feedback from participants of a Multi Stakeholder Workshop on the Draft Final Report of the Mega Science Framework Study for Sustained Development on the Biodiversity Sector. In addition, data was also obtained through internet search and questionnaire based interviews with CEOs of selected companies.

The *modus operandi* for Malaysia to achieve the conservation, sustainable use and commercialization (wealth creation) of biodiversity in Malaysia include the following findings and recommendations:

Priority of Biodiversity

- Identifying, mitigating and addressing anthropogenic threats (conventional and non-conventional) to biodiversity including its goods and services from the marine, coastal, freshwater and terrestrial resources (genetic, species and ecosystems)
- Exploring and exploiting scientifically, technologically and innovatively through novel research and development on hitherto as yet unutilized biodiversity and their products for the production of notable and value added bioactive compounds
- Augmenting on-going efforts on the R&D and ST&I for the propagation and commercialization of ornamental and medicinal plants and animals including aquaculture (freshwater, brackish and marine) and livestock
- Ensuring adequate, appropriate and continued funding for biodiversity related R&D (fundamental and applied research) and ST&I
- Undertaking a Millennium Ecosystem Assessment on the biological wealth of the country along with its environmental/economic evaluation for its goods and services for decision making

Policy

- Notwithstanding the existence of over 40 environment related rules and regulations in the country, there is still a need for new rules and regulations to be promulgated to address new and emerging issues and initiatives (eg. the need for SEA, using Environmental Economics for decision making, short term versus long term impacts of biodiversity utilization)
- Adapting national policies and plans that corroborate their corresponding international obligations on biodiversity (eg., CBD, CPBS, NPABS, REDD, CITES, UNFCCC, UNCLOS, UNCCD, etc.)

- Reconciling the overlaps of the national constitution and its different sectors of jurisdiction and governance at the federal, state, and concurrent levels particularly with regards to forests, water, minerals and land
- Ensuring proper coordination, consolidation and communication of rules and regulations on biodiversity and its resources between and within different ministries and departments at the federal level and also their corresponding state counterparts
- Undertaking a review and analysis of the Government's various development policies, such as the 5-Year Development Plans, Industrial Master Plans 2 & 3, Outline Perspective Plans, S&T Policy II, K-Economy Master Plan, National Education Policy, National Higher Education Policy, National Agriculture Policy, etc *vis-à-vis* sustained national development

Issues Affecting ST&I

- Balancing the focus in research institutions from R&D (basic research) *per se* to ST&I (commercialization and wealth creation)
- Providing sufficient and continued funding for pursuing ST&I, *viz*. towards the commercialization and wealth creation from biodiversity
- Enhancing the cooperation and collaboration between research institutions and between research institutions and the private sector, both within the country and elsewhere, to maximize the commercial outputs and outcomes of both R&D and ST&I
- Fostering R&D and ST&I into innovative sectors to produce value added products and services (eg. extraction of industrial enzymes, medicinal drugs, gene translocation, biomimicry, nanotechnology, proteomics, genomics)
- Encouraging the adoption of ST&I as one of the driving forces of the education system at all levels

Human Resources

- Building on human resource needs that are appropriate to the required quantity and/or quality (eg. taxonomists, molecular biologists, biotechnologists, biochemists, bioinformatics)

- Making available scholarships/internships/attachments for the disciplines that are in demand for research and commercialization in the biodiversity sector
- Creating avenues for employment opportunities for those with the necessary qualifications in the marketable sectors of biodiversity
- Under the circumstances of the lack of expertise in specific sectors of biodiversity within the country, all efforts should be made to source such expertise from other countries
- Since Malaysia is one of the 12 mega(bio)diverse countries of the world it would seem appropriate to recognize biodiversity "hero's, heroines, icons, champions and ambassadors" of biodiversity
- Using of indigenous communities to assist scientists, bioprospectors and guides.

<u>Scope and Thrusts</u>

The scope and thrust of the report reflect the following sectoral and cross-sectoral outputs and outcomes with regards to conservation, sustainable use and commercialization of biodiversity which would in turn, promote the sustained and sustainable development of Malaysia. The main pillars of the proposed biodiversity framework include the following:

- Integrating environmental, social and economical dimensions into development planning, modeling and implementing, particularly with regard to the conservation, sustainable use and the commercialization or wealth creation of/from biodiversity.
- Adopting proactive, source-oriented and preventive, rather than reactive, end-of-the-pipeline and curative, measures and mechanisms.
- Utilizing improved market-based economic instruments and initiatives, including command and control economic incentives and disincentives.
- Enforcing appropriate legislation, including its effective implementation, monitoring and compliance.
- Facilitating awareness, capacity building and commitment empowerment for the ratification of the obligations of national regional and international conventions and protocols.
- The establishment of a National Biodiversity Centre (and/or National Institute of Biodiversity), along with its National Natural History Institute, to consolidate and to

coordinate the several systematic, scientific and strategic avenues and pathways to be adopted in the conservation, the sustainable use and the wealth creation from the biological resources of mega(bio)diverse Malaysia

The overall strategy of the Study is aimed at formulating, justifying and implementing an action-oriented road map designed to achieve the trifold “Win”, “Win” and “Win” scenario - i) a “Win” for the conservation of biodiversity, ii) a “Win” for the sustainable utilization of biodiversity, and iii) a “Win” for the commercialization and the wealth creation from biodiversity, including its contribution to the GNP/GDP of Malaysia, for present and future generations of all sectors of society in Malaysia.

2. INTRODUCTION

The term biodiversity was coined, as an abbreviation for “biological diversity”, in the late 1980s, and includes the following:

- Genetic diversity, which refers to the variations within or in between populations of species, measured in terms of the variations of the genes within and in between the populations of species
- Species diversity, which refers to the variations within or in between the numbers or the richness of species of living organisms on planet earth
- Ecosystem diversity, which refers to the variations within or in between different habitats, biotic communities and ecological processes in terrestrial, marine and other aquatic environments in a particular system, together with the processes and interactions that take place within and in between such systems

The menu of biodiversity, which forms the basis of the web or fabric of life, and upon which we are all an integral part of, and upon which we are all interdependent for our existence and survival, that evident in today’s planet Earth, is in fact the outcome of billions of years of evolution, shaped both by the natural processes, and more recently by the ever increasing influence of human beings. Further, as articulated in the quotable quote maxim, “Without people, biodiversity can still flourish, but without biodiversity, people will surely perish”.

Biodiversity is most often understood in terms of the wide variety of plants, animals and microorganisms. So far, about 1.75 million species have been identified and documented, primarily small creatures, like insects. Scientists do reckon that there must actually be about 13 million species, although cited estimates range from three to 100 million species.

The sustainability of biodiversity, be it at the genetic, species and ecosystem level, and be it at the global, regional and national level, is therefore pivotal for the very existence and subsistence of all forms and all dimensions of life itself. And more so, in a country like Malaysia, which considering to be one of the 12 mega(bio)diverse countries in the world. And notably, besides its conservation and sustainable use, the prospects are also promising for the commercialization and the wealth creation from biodiversity in a country like Malaysia.

For instance, an analysis of the global biodiversity markets annually reveal anticancer agents from marine organisms valued at U$1 billion; herbal medicines valued at U$43 billion; and coral-reef tourism valued at U$30 billion. It is therefore apparent countries such as Malaysia should be investing much more resources into biodiversity-related S&T and R,D&I, whereby biodiversity-based products and processes can be sustainably contributing towards Malaysia's GDP.

Based on the premise and the proven track record that the strategic and the proactive intervention of Research and Development (R&D) and Science, Technology and Innovation (ST&I) can contribute immensely towards the future sustainable development of Malaysia, the Academy of Sciences Malaysia (ASM) decided to undertake a "Mega Science Framework Study for Sustained National Development of Malaysia over the period 2011-2050, in selected sectors, including in the "Biodiversity Sector".

ASM contends and advocates that mainstreaming R&D and ST&I can be the fundamentals in providing the significant stimulants for the steering of the sustainable development, the commercialization and the wealth generation/creation for Malaysia, particularly when it involves the biodiversity sector.

Further, due to the ever increasing scope and thrust of the competitiveness of globalization, FTAs and the demise of the non-tariff trade barriers, the feasibility of countries to rely on and to leverage on R&D and STI would become more and more tactically and strategically reinforced for the manifestation of paradigms of national sustainable development. More so, as novel and innovative methodology and technology could well be formulated, developed and/or adapted through successful R&D and STI for boosting commercialization, exploiting economic competitiveness, and the generation/creation of wealth and influence.

Interestingly, the pursuit of R&D and STI, while leading to remarkable advances and accomplishments that have benefitted the well-being and welfare of peoples immensely, it could also, concurrently, precipitate the degradation and decay of the environment and its biodiversity, besides triggering and spurring much more dramatic socio-economic imbalances, political instabilities and haves-have nots divides, especially if the right and correct governance structures and if the effective control commands are not in place as yet.

Development planners and decision makers, at all levels, do need access to timely and reliable knowledge, originating from R&D and STI, to be capable of introducing rational and relevant policies which do reflect a far better understanding of the complex and integrated range of technical, economical, social, cultural and ethical issues and initiatives associated with the dynamics of the people, the earth and the environment.

National sustainable development ought to be conceptualized holistically, in order to also include its interdependent political, institutional and managerial dimensions, as well as its intangible dynamics like that of the unity, peace, fulfillment, harmony and happiness of its citizens.

Additionally, the adoption of the National Innovation Model, at the Second National Innovation Council, held in November 2007, had also laid a firm foundation for wealth-creation and the societal well-being of the country. However, in order to ensure that its 5-pronged National Mission thrust is duly reflected and reiterated, a framework of sustained national development, as its overarching principle, and which is underpinned by R&D and STI, must be further considered and incorporated to deliver its consolidated and comprehensive sustained national development. Such a R&D and STI-led economic model would invariably be a springboard not only for the take-off of Malaysia, but also for the leap-frog of Malaysia into the group of R&D and STI-based and technologically-advanced nations.

The present Study would also need to examine all the resource sectors, including the Biodiversity Sector, which could contribute positively towards the economy, besides analyzing the extent of their STI application, and of their appropriateness and optimality, for the benefit of the Malaysia. Likewise, the type and quantity of STI to be applied to selected sectors in the future would also have to be identified, to ensure the maximum sustainable growth of the country.

However, since the issues, interventions, initiatives, impacts and implications that are inter-linked and inter-twined with the pursuit of national and international sustained development are invariably complex and interdependent in their nature, scope and thrust, it would be prudent and judicious to appropriately reoriented multi-sectoral and multi-dynamical approaches and strategies (of both the natural and social sciences) for their subsequent adaptation and/or adoption while undertaking the present Study.

Ideally, the present Study should also be designed to address, inter alia, the spectrum of inter-related and multi-faceted sectors, not only from the perspective of the Development of Science ("accelerating STI through knowledge generation, new discoveries and creating new value-added opportunities for future development"), but also from the perspective of the Science for Development ("application of R&D and science and technology for sustained (sustainable) development, wealth creation and societal well-being"), which are crucial and pivotal for the national economy and the well-being and welfare of the country and its citizens.

As such, from the aforesaid perspective, the present Study would be formulated and implemented to attain and sustain the following goals and objectives:

1. To identify the sources of future growth opportunities in the various areas of the biodiversity sector (terrestrial and marine subsectors).

2. To identify the current gaps in the R&D and STI of the biodiversity sector, and on how (and the areas in which) science and technology can assist in the economic growth of the biodiversity sector.

3. To undertake comparative studies with other developed countries that would allow the local biodiversity sector to grow, including of the identification and/or the development of policies that are necessary to sustain such growth.

4. To identify and to propose appropriate measures in the R&D needs of the biodiversity sector that can contribute towards sustained economic growth.

5. To conduct a review of the international best practices of STI policies and plans for ensuring sustained national development in the Biodiversity Sector.

6. To review and to analyze the Government's various policies, strategies and plans for identifying the educational, capacity building, technological, scientific, governance and institutional framework gaps in the Biodiversity Sector.

7. To propose appropriate measures for R&D needs in the Biodiversity Sector as potential areas for future growth.

8. To propose an Action Plan for implementation.

9. To propose a roll-out Action Plan for a Biodiversity Sector road-map, and also for the implementation of the Action Plan.

As such, to facilitate and to enhance the earlier realization of the stated goals and objectives, the following ten work packages (WP) have been identified as being central and or pivotal for the Biodiversity Sector:

1. WP1 – Global perspectives: Biodiversity-related industries, market volumes and economic impacts.
2. WP2 – Global perspectives: STI in biodiversity utilization and commercialization.
3. WP3 – Global perspectives: R&D in biodiversity utilization and commercialization.
4. WP4 – Global Perspectives: International policies, strategies and plans in biodiversity-related STI.
5. WP5 – National perspectives: Biodiversity resources, utilization and commercialization.
6. WP6 – National perspectives: STI in the utilization of biodiversity.
7. WP7 – National perspectives: R&D in the utilization of biodiversity.
8. WP8 – National perspectives: Domestic policies, strategies and plans in the biodiversity sector and STI.
9. WP9 – Identification and economic analyses of future economic growth opportunities within various areas of the biodiversity sector.
10. WP10 – Wealth creation opportunities (in plants, animals, microbes, aquatic organisms, ecotourism, combinations and others).

The expected deliverables of the Study would include:

i. An overview, to document the type and the quantity of STI, and also the areas of R&D where the STIs are to be applied for generating maximum sustainable economic growth and prosperity for the country.

ii. A framework, to serve as an over-arching conduit for the Government to mainstream innovative R&D and STI inputs into national development policies and plans for the period 2011 to 2050 (10th to 18th Malaysia Plans).

<u>Expected Sectoral And Cross-Sectoral Outputs And Outcomes</u>

It is hoped that the scope and thrust of the draft final report would reflect the following sectoral and cross-sectoral outputs and outcomes with regards to conservation, sustainable use and commercialization of biodiversity which would in turn, promote the sustained and sustainable development of Malaysia. The main pillars of the proposed biodiversity framework are herewith attached.

1. *Integrating environmental, social and economical dimensions into development planning, modeling and implementing, particularly with regard to the conservation, sustainable use and the commercialization or wealth creation of/from biodiversity.*
2. *Adopting proactive, source-oriented and preventive, rather than reactive, end-of-the-pipeline and curative, measures and mechanisms.*
3. *Utilizing improved market-based economic instruments and initiatives, including command and control economic incentives and disincentives.*
4. *Enforcing appropriate legislation, including its effective implementation, monitoring and compliance.*
5. *Facilitating awareness raising, capacity building and commitment empowerment for the ratification of the obligations of national regional and international conventions and protocols*.

3. STUDY METHODOLOGY

Notably, Malaysia is recognized globally to be one of the 12 “mega(bio)diverse countries throughout the world. The Government of Malaysia’s 2008 Common Vision on Biodiversity in the Government’s and the Development Process for Planners and Decision Makers, defines “Biodiversity – or the web or fabric of life - as the variability among living organisms from all sources, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes the diversity within species, between genes and of ecosystems. Ecosystem properties depend greatly on biodiversity in terms of the functional characteristics of organisms present in the ecosystem, and the distribution and abundance of those organisms over space and time. Species effects act in concert with the impacts of climate change, natural resource availability, and disturbance regimes in influencing ecosystem dynamics. And human activities can, or course, modify all of the above mentioned factors.”

Information for the report was also obtained from reviews and analysis of earlier national, regional and international reports and studies. Extensive references were also made from reports made available by the Ministry of Natural Resources and Environment (NRE), the Interim Report of the Mega Science for Sustained Development on the Biodiversity Sector, and United Nations Institutions. The study methodology also included feedback from participants of a Multi Stakeholder Workshop on the Draft Final Report of the Mega Science Framework Study for Sustained Development on the Biodiversity Sector (see Section 16 on page 268). A graphic overview of the overall study methodology, including its expected sectoral and cross sectoral outputs and outcomes, are presented in Chart 1.

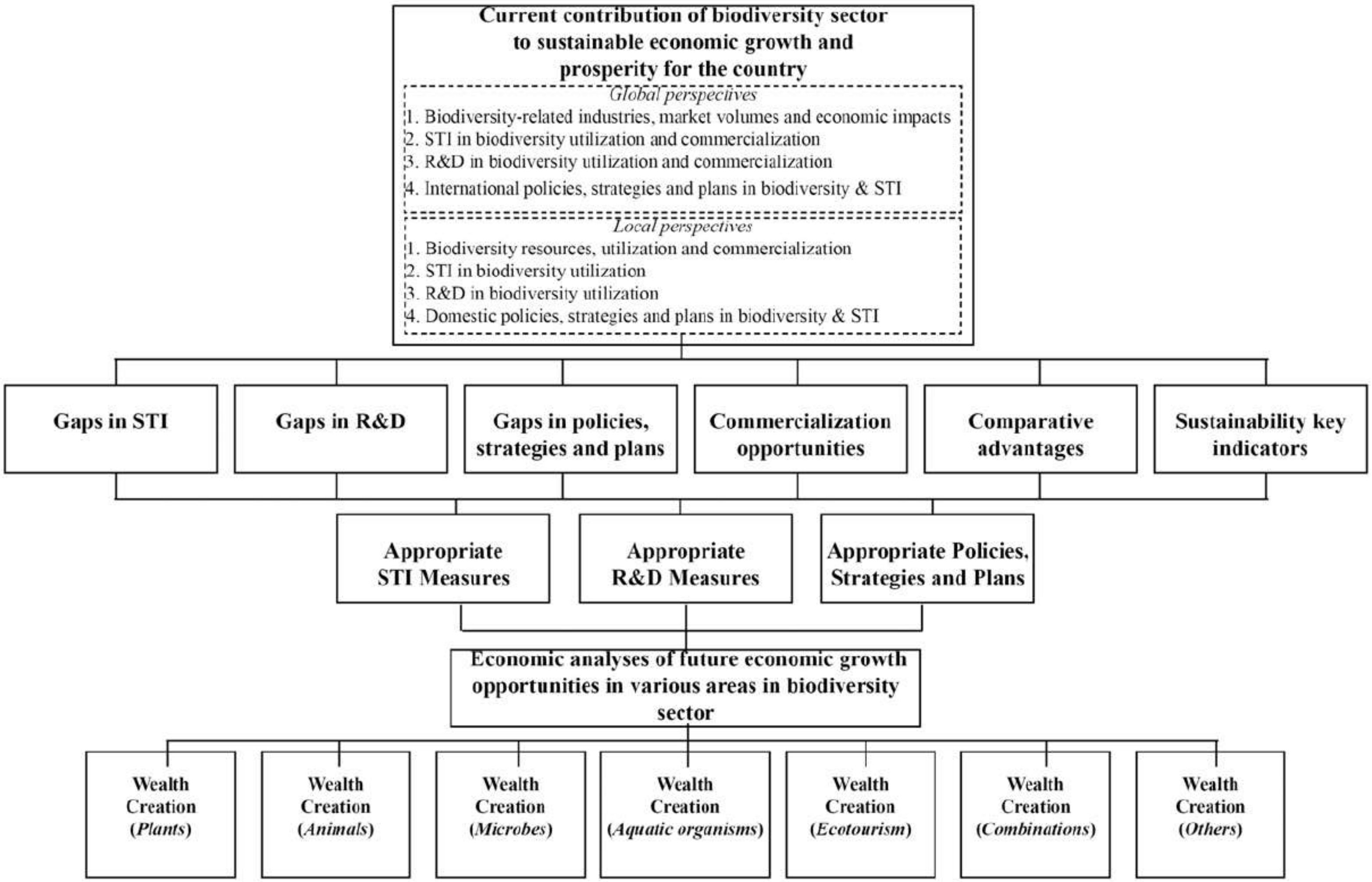


Chart 1 The Framework for a coordinated and integrated approach for mainstreaming inputs into national development strategies and plans, including its outputs and outcomes

In implementing the Study, the ten WPs of the Biodiversity Sector were categorized into five groups of two WPs each, with a set of two WPs assigned to each of the five project study leaders. Additionally, five graduates from three different universities in Malaysia were also employed, over the period February 2010 to July 2010, as "project study officers" (PSOs), with each of the five PSOs assigned to each of the five project study leaders, along with a set of two WPs. Besides the five PSOs, another "data base developer" was also employed for purposes of creating an appropriate data base and a data entry module that would best suit the needs of the Study.

In all cases, each of the PSOs, under the supervision of their respective project study leader's, were tasked to undertake the following assignments for their own set of the two WPs:

i. Collect and compile all available references on the WPs;
ii. Search for internet websites on the WPs (eventually a total of some such 1,400 websites were sourced); and
iii. Document graphically the trends emerging from a detailed analysis of the data and information contained in the various internet websites on the WPs.

Further, the PSOs, in consultation with their project study leaders, developed a tailor-made questionnaire that coincided with the requirements of the Study and its WPs, particularly from a Malaysian perspective. The questionnaire was also pilot-tested and fine-tuned based on face to face question and answer field testing with some 20 selected respondents in Malaysia. However, due to time constraints, and on account of the commercial sensitivities of some of the questions asked, the said questionnaire was not disseminated widely to relevant institutions, agencies, corporations, universities, ministries, etc, in Malaysia and elsewhere.

4.STATUS OF THE SECTOR/SITUATIONAL ANALYSIS[1]

It is critical and pivotal to realize and recognize that "biodiversity" per se exists at three distinct, but yet mutually and symbiotically integrated and interdependent, levels, viz. the genetic level, the species level, and the ecosystem level, which inherently influence and are influenced by interventions aimed at the conservation, the sustainably utilization and/or the commercialization for wealth generation of biodiversity-based natural resources and life-support functions.

The wealth of biodiversity has immense significance and potential for the benefit of Malaysia and Malaysians, including, inter alia, the following:

i) Economic Prospects:

The economic prospects of biodiversity includes from timber and non-timber products, food crops in the agricultural sector, food sources in the aquatic sector, and floriculture of ornamental plants and flowers. Further, biologically active compounds, derived from indigenous plants and animals, can also serve as potential starters for the production of drugs, pharmaceuticals, antibiotics and vaccines, through processing and biotechnology.

ii) Food Security:

Malaysia is known to harbour about 185,000 species of fauna and 12,500 species of flowering plants and 1,100 species of ferns, many of which could be transformed into food sources in the future, or utilized for the biological control of pests that against our food crops, besides the wetlands, rives and seas serving as a continuous source of aquatic foods.

iii) Environmental Stability:

Reduction in biodiversity would threaten the balance of the environmental stability within the various types of ecosystems, thereby leading to a loss of ecological resilience, which would in turn adversely affect human lives.

[1] *Besides the information provided in the Draft Final Report, Appendices IV to XVIII provide an overview of the status and situational analysis of the biodiversity sector at the global and/or regional level*

iv) National Biological Heritage:

Several of the Malaysian species of flora and fauna are endemic to Malaysia. For instance, some 26% of tree species in Peninsular Malaysia are considered to be endemic, to be found only in a few localized valleys or mountain-tops. Additionally, the coral reefs of Malaysia are also deemed to be among the most diverse coral reefs in the world, albeit its fauna and flora still remain relatively poor in terms of their proper documentation. Although the biodiversity of the terrestrial fauna and flora in Malaysia is enviably vast and varied, the repeated destruction of habitats has resulted in a steady decline of the biodiversity in Malaysia, sadly often even before it can be identified and recorded.

v) Scientific, Educational and Recreational Values:

Much of the terrestrial and marine biodiversity in Malaysia requires systematic taxonomical identification and documentation, which would in turn pave the way for opportunities and avenues in the exploration, conservation and sustainable utilization of biodiversity, especially for genetics, species, ecosystems, biotechnologies, pharmaceuticals, agriculture, fisheries, eco-tourism, wealth generation, etc.

4.1 The Wealth of Biodiversity in Malaysia

As reiterated earlier, Malaysia is categorized among the select and handful of the 12 countries globally, regarded as being the "12 mega (bio) diverse countries" in the world (Table 1).

Table 1. The Twelve Mega-Diverse Countries in the World (in thousand km^{2}) (sourced from: Interim Report, 2011)

China	9.57	Indonesia	1.90
Brazil	8.55	Peru	1.28
Australia	7.68	Colombia	1.14
India	3.16	Madagascar	0.59
Democratic Republic of Congo	2.35	Malaysia	0.33
Mexico	1.96	Ecuador	0.27

(The 12 mega (bio) diverse countries by themselves alone, are said to collectively comprise at least 60% of the world's known species of biodiversity, with Malaysia containing about 7% of the world's biodiversity species.)

As expected, over 90% of terrestrial biological species in Malaysia occur within natural forests (Table 2). However, only much less of lowland dipterocarp forests now do remain in Malaysia, with much it having been converted for agricultural farming and/or logged for timber, but yet the largest reservoir of genetic biodiversity variation of the terrestrial flora and fauna in Malaysia are still found within the remaining forests. And in the aquatic (including marine) ecosystems, coastal mangroves and coral reefs are known to be very rich in species biodiversity. Reportedly, there exist an estimated 4,000 species of marine fishes and 300 species of freshwater fishes in Malaysia.

However, and rather unfortunately, Malaysia has also been identified as being one of the 25 "biodiversity hotspots" in the world, with a "biodiversity hotspot" being defined is a habitat that

Table 2. Malaysia: Total Forested Area (Various Years) (NRE, 2010b)

Category	1990	2000	2005	2007
	Area ('000 ha)			
Permanent Reserved Forest (PRF)				
- Peninsular Malaysia	4,750	4,800	4,800	4,696
- Sabah	3,350	3,600	3,600	3,605
- Sarawak	4,500	6,000	6,000	6,000
(a) Total PRF	**12,600**	**14,400**	**14,400**	**14,301**
(b) Stateland Forest	6,820	4,640	4,141	3,416
(c) National Parks and Wildlife & Bird Sanctuary	1,120	1,120	1,120	1,946
Total Forested Area (a+b+c)	**20,540**	**20,160**	**19,661**	**19,663**
(d) Rubber plantation	1,836	1,431	1,229	1,207
(e) Other land (Oil palm, agricultural crops, urban and other uses)	10,480	11,265	11,966	11,986
(f) Inland water bodies	119	119	119	119
Total area for country (a+b+c+d+e+f)	**32,975**	**32,975**	**32,975**	**32,975**

Source: Forestry Department Peninsular Malaysia.

is rich in biodiversity, but which is also facing grave threats to its continued existence. In most developing countries, such threats to biodiversity are often associated with the ever increasing populations, the constantly higher demands for natural resources, the lack of efforts for the proper conservation and management of natural resources, etc.

4.2 Ecosystem Diversity

The terrestrial biodiversity of Malaysia is concentrated in tropical rainforest that extends from the coastal plains to the mountain areas, including inland waters such as lakes and rivers, while its marine biodiversity is found among islands, marine and coastal ecosystems such as coral reefs, sea grasses and mangroves (Tables 3, 4, 5, 6 and 7).

Table 3. Diversity of Ecosystem Types in Malaysia (sourced from NRE, 2010b)

Thematic Area	Ecosystem
Forests Biodiversity	- Lowland evergreen forest - Lowland dipterocarp forest - Heath forest - Limestone forest - Mixed dipterocarp forest - Hill dipterocarp forest - Hill mixed dipterocarp forest
Mountain Biodiversity Inland Waters Biodiversity	- Montane forest - Subalpine forest - Peat swamp forest - Freshwater swamp forest - Riparian forest - Rivers, ponds, lakes, etc. - Mangrove forest
Marine and Coastal Biodiversity Islands Biodiversity (please refer to Forest Biodiversity for non-marine and non-coastal related ecosystems)	- Coastal hill dipterocarp forest - Mangrove forests - Mudflats - Coral reef - Seagrass
Agricultural Biodiversity	- Plantations - Rice fields - Fruit orchards & vegetable farms - Livestock rearing and aquaculture farms

Malaysia has a total land area of 32.86 million ha , 56 % of which is still forested or is under tree cover. 1.39 million ha (7.6%) of the forests (all types, included) in Malaysia have been set aside for the conservation of biodiversity. As such, the National Forest Policy of 1978 and the National Forest Act of 1984 have designated 12.73 million ha as Permanent Forest Estates.

Table 4. Tropical Rainforest Types in Malaysia (sourced from: Interim Report, 2011)

Climatic Climax Forest	Edaphic Forest
Lowland dipterocarp forest	Heath forest
Hill dipterocarp forest	Limestone hill forest
Upper dipterocarp forest	Forest over ultramafic outcrops
Montane oak forest	Beach stand forest
Lower ericaceous forest (Rhododendrons)	Mangrove forest
Montane subalpine forest	Brackish water forest
Semi-evergreen seasonal forest	Peat swamp forest
Freshwater swamp forest	
Seasonal swamp forest	

("Biodiversity conservation in ASEAN", A. Latiff and A.H. Zakri, Institute of Biodiversity and Environmental Conservation, UNIMAS)

Table 5. Permanent Forest Estates in Malaysia (sourced from; Interim Report, 2011)

Permanent Forest Estate (12.73 million ha)		
Productive Forest (9.99 m ha or 78.5%)	Protective Forest (2.74 m ha or 21.5%)	
For timber production	For protection of watersheds and environment (1.35 m ha or 49.5%)	For biodiversity conservation (1.39 m ha or 50.5%)

Table 6. National Parks and Wildlife sanctuaries in Malaysia in 1989 (million ha) (sourced from: Interim Report, 2011)

Region	National Parks	Wildlife Sanctuaries	Total
Peninsular Malaysia	0.43	0.31	0.74
Sabah	0.25	0.14	0.39
Sarawak	0.08	0.18	0.26
Total	0.76	0.63	1.39

Table 7. Classification of Malaysian Forest by the Different Sectors (sourced from Interim Report, 2011)

Classification of Malaysian Forests by the Different Sectors.

Classification	Forest type	Examples
Ecology	Coastal swamp	Kuala Selangor
	Peat swamp	Paya Indah Wetlands, Selangor
	Lowland dipterocarp	FRIM, Kepong
	Hill forest	Fraser's Hill
	Montane forest	Gunung Tahan
Administrative	Permanent / Protection Forest reserve	Danum Valley, Sabah Maliau Basin, Sabah
	Federal forest reserve	Taman Negara
	State parks	Endau-Rompin State Park
	Aborigine forest reserve	Taman Negara
	National wildlife parks	Taman Negara
	Other reserves	
Silviculture	Virgin forest	Belum Forest Reserve / State Park, Perak
	Protected forest	Taman Negara
	Forest plantation	Chikus Forest Reserve, Perak
	Recreational forest (Hutan lipur)	Templer's Park
	Urban forest	Bukit Gasing
	Forest research plots	FRIM Kepong

4.3 Species Richness of the Biodiversity in Malaysia

Tables 8, 9, 10 and 11 depict a sampling of the species richness of biodiversity in Malaysia.

Table 8. Estimated Numbers of Flora Species in Malaysia (sourced from NRE 2010b)

Group	Number of Species		
	Peninsular Malaysia	Sabah	Sarawak
Algae	377		
Bryophytes	475	582	330
Fern and associates	637	963	
Gymnosperm	27	34	
Monocots	2,010	2,170	
Dicots	5,529	4,497	

Table 9. Summary of Terrestrial Fauna in Malaysia (sourced from NRE 2010b)

Class	No of Species		
	Peninsular Malaysia	Sabah	Sarawak
Vertebrate			
1. Mammals	229	221	
2. Birds	742		
3. Amphibians	242		
4. Reptiles	567		
5. Freshwater fish	290	100	200
6. Marine fish	1,500		
Invertebrate			
1. Butterfly	1031	936	
2. Leaf insect	1,073		
3. Freshwater crabs	102		
4. Hard coral	500-600		
5. Soft coral	200		
6. Mollusc	3,000		

Table 10. Inventory of Marine Organisms in Malaysia (sourced from NRE 2010b)

Organisms	Species
Corals	435
Worms	9
Phytoplankton	61
Fish	700
Seashells	50
Crabs, Barnacles, Prawns, Crayfish, Lobsters and Shrimps	48
Marine Fungi	56
Marine Mammal	21
Jellyfish	7
Turtles	4
Seaweed	289
Seagrass	15
Sponges	21
Squid, Cuttlefish, Octopus	18
Starfish and Sea urchins	12
Sea cucumber	19
Sea Snakes	9

The diversity of floral and faunal species in Malaysia is also being threatened by the destruction and reduction of habitats, poaching and human encroachment. Table 12 shows the number of animal species being threatened by such interventions.

Table 11. Species Richness and Endemism in Malaysia (sourced from Interim Report, 2011)

Flora & Fauna	Estimated No. of Species	Number of Endemic Species
Flowering plants	15,000 species	
Trees	4,2000 species	
Orchids	3,850 species	
Palms	500 species	
Conifers	< 24 species	
Bamboo	80 species	
Ferns and fern allies	1,100 species	
Wild mammals	286 species	14 species
Birds	736 species (about two-thirds are resident birds and one-third are migratory birds)	4 species
Reptiles	350 species	- no data -
Amphibians	165 spp	39 species
Freshwater fish	300 species	
Butterflies	1,200 species	
Moths	12,000 species	
Invertebrates	100,000 species	

4.4 Number of Threatened and Protected Species in Malaysia.

The numbers of threatened and protected biodiversity species in Malaysia include those listed in Tables 12, 13, 14, 15, 16, 17, 18 while Table 19 lists threats to the thematic areas in biodiversity in Malaysia.

Table 12. Threatened Animal Species in Malaysia (sourced from Interim Report, 2011)

Mammals	42
Birds	34
Reptiles and Fishes	14

Table 13. Peninsular Malaysia: Number of Species Protected under the Protection of Wildlife Act 1972 (sourced from NRE, 2010b)

Status of Protection	Mammal	Bird	Reptile	Insects	Total
Totally Protected	55	571	5	0	631
Protected	17	71	5	29	122
Total	**72**	**642**	**10**	**29**	**753**

Source: Department of Wildlife and National Parks.

Table 14. Sabah: Number of Species Protected under the Wildlife Conservation Enactment 1997 (sourced from NRE, 2010b)

Status of Protection	Mammal	Bird	Reptile	Insects	Plants sp	Total
Totally Protected	7		3		4	14
Protected	73	132	7	2	13	227
Total	**80**	**132**	**10**	**2**	**17**	**241**

Source: Sabah Wildlife Department.

Table 15. Sarawak: Number of Species Protected under the Wildlife Protection Ordinance 1998 (sourced from NRE, 2010b)

Status of Protection	Mammal	Bird	Reptile	Insects	Others, eg. Fish
Totally Protected	21 (1*)	26(2*)	5(1*)	-	-
Protected	12(7*)	17(10*)	8(3*)	1	**2***

Table 16. Examples of Threatened Animals and Birds in Protected Areas of Malaysia (sourced from NRE, 2010b)

Common Name	Scientific Name
Mammals	
Sumatran Rhino	*Dicerorhinus sumatrensis*
Elephant	*Elephas maximus*
Tiger	*Panthera tigris*
Gaur	*Bos gaurus hubbacki*
Tapir	*Tapirus indicus*
Malay Bear / Sun Bear	*Helarctos malayanus*
Serow	*Capricornis sumatraensis*
Red Dog or Dhole	*Cuon alpinus*
Siamang	*Hylobates syndactylus*
Orangutan	*Pongo pygmaeus*
Proboscis Monkey	*Nasalis larvatus*
Red-banded Langur	*Presbytis chrysomelas*
Silvered Langur	*Presbytis cristata*
Hose's langur	*Presbytis hosei*
White-fronted langur	*Presbytis frontata*
Maroon langur	*Presbytis rubicunda*
Bornean Gibbon	*Hylobates muelleri*
Clouded leopard	*Neofelis diardi*
Birds	
Great Argus	*Argusianus argus*
Malaysian Peacock Pheasant	*Polyplectron malacense*

Common Name	Scientific Name
Crested Argus	*Rheinardia ocellata*
Mountain Peacock Pheasant	*Polyplectron inopinatum*
Rhinoceros Hornbill	*Buceros rhinoceros*
Indian/Oriental Pied Hornbill	*Anthracoceros albirostris*
Black Hornbill	*Anthracoceros malayanus*
Wrinkled Hornbill	*Aceros corrugatus*
Blyth's/Plain-pouched Hornbill	*Aceros subruficollis*
Helmeted Hornbill	*Buceros vigil*
Wreathed Hornbill	*Aceros undulates*
White-crowned Hornbill	*Aceros comatus*
Great Hornbill	*Buceros bicornis*
Bornean peacock	*Polyplectron schleiermacheri*
Bulwer's pheasant	*Lophura bulweri*
Bushy-crested hornbill	*Anorrhinus galeritus*

Table 17. Protected Marine Animals in Malaysia (sourced from NRE, 2010b)

Group	Species
Dugong	*Dugong dugon*
Whale	*Balaenoptera edeni*
	Balaenoptera borealis
	Balaenoptera musculus
	Balaenoptera physalus
	Balaenoptera acutorostrata
	Megaptera novaeangliae
Dolphin	*Orcaella brevirostris*
	Sousa chinensis
	Orcinus orca
	Tursiops truncates
	Lagenodelphis hosei
	Stenella longirostris
	Globicephala macrorhynchus
	Grampus griseus
	Kogia breviceps
	Neophocaena phocaenoides
	Delphinus delphis
	Pseudorca crassidens
	Physeter catadon
Whale Shark	*Rhincodon typus*
Clams	*Tridacna gigas*
	Tridacna squamosa
	Tridacna maxima
	Tridacna crocea
Sawfish	*Anoxypristis cuspidate*
	Pristis clavata
	Pristis microdon
	Pristis pectinata
	Pristis perotteti
	Pristis pristis
	Pristis zijsron

Table 18. Protected Tree/Plant Species in Malaysia (sourced from NRE, 2010b)

1. Peninsular Malaysia

Currently, in Peninsular Malaysia, there are 32 timber species that are not allowed to be harvested within the PRF. They are conserved because of their importance to fauna species, medicinal values, and usage by *Orang Asli* (Indigenous Peoples). In practice, these trees are not tagged by Forestry Department staff during the tree marking operations and thus, cannot be removed by the loggers. These species are:

Under-storey species

Scientific Name (Local Name)

1. *Archidendron bubalirum* Kerdas (fruit)
2. *Archidendron jiringa* Jering (fruit)
3. *Durio zibethinus* Durian (fruit)
4. *Mangifera indica* Mangga (fruit)
5. *Baccaurea maingayi* Tampoi (fruit)
6. *Baccaurea sumatrana* Tampoi (fruit)
7. *Artocarpus rigidus* Temponek (fruit)
8. *Dysoxylum sp.* Mersindok (jungle langsat)
9. *Nephelium lappaceum* Rambutan Hutan (fruit)
10. *Garcinia artoviridis* Asam Gelugor (fruit)
11. *Boucea macrophyla* Kundang Hutan (fruit)
12. *Barringtonia sp.* Putat (fruit)
13. *Sandoricum koetjape* Sentul (fruit)
14. *Ardisia sp*. Mata Pelanduk (fruit)
15. *Artocarpus heterophyllus* Nangka (fruit)
16. *Aglaia sp.* Bekak (fruit)
17. *Eugenia (Syzygium) sp.* Kelat Jambu Laut (fruit)
18. *Artocarpus integer* Cempedak (fruit)

Over-storey species

Scientific Name (Local Name)

19. *Koompassia excels* Tualang (depository of wild honey)
20. *Ficus spp*. Ara (fruit)
21. *Manifera longipetiolata* Machang (fruit)
22. *Parkia sp.* Petai (bean)
23. *Podocarpus sp.* Podo (hill/beach conservation)
24. *Dialium sp.* Keranji (fruit)
25. *Sterculia foetida* Kelumpang Jari (seeds)
26. *Lithocarpus cyclophorus* Mempening Gajah (fruit)
27. *Knema sp.* Basong (fruit)
28. *Myristica sp.* Basong (fruit)

29. *Sterculia parvifolia* Kelumpang (fruit)
30. *Santiria laevigata* Kedondong Gergaji Daun Licin (fruit)
31. *Castanopsis spp.* Berangan (fruit)
32. *Irvingia malayana* Pauh (fruit)

2. Sabah

Under Sabah enactments, the term used for protected tree species is "prohibited species". Prohibited species means:

- Any tree marked for retention by the Director of Forestry.
- The following trees*:

Scientific name (Local Name)
All *Mangifera spp*. (Assam family – Mangga or Machang Hutan)
All *Durio spp*. (Durian)
Triomma, Dacryode and *Canarium spp.* (All Kedondong species)
Shorea pinanga, Shorea amplexicaulis, Shorea pilosa, Shorea mecistopteryx, Shorea cristata, Shorea macrophylla (All Tengkawanag / kawang)
All *Dracontomelon spp*. (Sengkuang)
All *Lansium spp*. (Langsat)
All *Baccaurea spp*. (Terap)
Artocarpus dadah (Buruni)
Artocarpus integer (Pulutan)
All *Nephelium spp*. (Meritam and Rambutan)
Paranephelium nitidum (Membuakat)
Aquileria malaccensis (Gaharu)
Euphoria malaiensis (Mata Kuching)
*Forest Reserve only

3. Sarawak

Under section 31 of Sarawak's Wildlife Protection Ordinance, 48 protected plant species are listed as follows:

Part I – Totally Protected Plants

Scientific Name (Local Name)

1. All *Rafflesia* species (Bunga pakma)
2. *Dipterocarpus obloglofolius* (Ensurai)

Part II – Protected Plants

Scientific Name (Local Name)

1. *Shorea macrophylla* (Engkabang jantong)
2. *Shorea splendida* (Engkabang bintang)
3. *Shorea hemsleyana* (Engkabang gading)
4. *Shorea seminis* (Engkabang terendak)
5. *Shorea palembanica* (Engkabang asu)
6. *Shorea stenoptera* (Engkabang rusa)
7. *Shorea pinanga* (Meranti langgai bukit)
8. *Shorea ochracea* (Raruk)
9. All *Ficus* species (Ara, Entimau, tempan)
10. *Sonneratia alba* (Perepat)
11. *Sonneratia caseolaris* (Pedada)
12. *Avicennia alba* (Api-api hitam)
13. *Avicennia lanata* (Api-api bulu)
14. *Avicennia marina* (Api-api merah)
15. *Avicennia officinalis* (Api-api sudu)
16. *Lumnitzera littorea* (Teruntum merah)
17. *Koompassia excels* (Tapang)
18. *Koompassia malaccensis* (Menggris)
19. *Aetoxylon sympetalum* (Kayu gaharu)
20. *Aquilaria beccariana* (Kayu gaharu, engkaras)
21. *Aquilaria malaccensis* (Kayu gaharu)
22. *Aquilaria microcarpa* (Kayu gaharu)
23. *Didesmandra aspera* (Simpor pelagus)
24. *Casuarina equisetifolia* (Rhu Laut)
25. All *Rhododendron species* (Bunga gegansai)
26. All *Napenthes species* (periok kera, Entuyut)
27. All *Orchidaceae* species (Orkid)
28. *Salacca magnifica* (Salak)
29. *Johannesteysmannia altifrons* (Ekor buaya)
30. *Areca triandra* (Pinang borneo)
31. *Areca jugahpunya* (Pinang jugah)
32. *Pinang mirabilis* (Pinang tudong pelandok)
33. *Areca subcaulis* (Pinang pici)
34. *Licuala orbicularis* (Biris)
35. *Eurycoma longifolia* (Tongkat ali, Sengkayap)
36. *Goniothalamus velutinus* (Kayu hujan panas, Lim panas)
37. All *Monophyllaea* species
38. *Antiaris toxicaria* (Ipoh)
39. All peat swamp species of *Madhuca* (Ketiau)

40. *Calophyllum lanigerum* (Bintangor)
41. *Calophyllum teysmanii* (Bintangor gading)
42. *Cycas rumphii* (Paku gajah, Paku laut)
43. All epiphytic *Lycopodium* species (Ekor tupai)
44. All *Begonia* species (Riang, Telinga gajah)
45. All *Aeschynanthus* species (Lip-stick plant)
46. All *Cyrtandra*, *Didymorcarpus*, and *Didissandra* species (Melebab)
47. All species of plants listed in Appendices I and II of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), excluding those already listed in Part I.

Table 19. Main Threats to Thematic areas of Biodiversity (sourced from NRE, 2010b)

Thematic Area	Threats	Impacts/Implications on Biodiversity
Forest Biodiversity Mountain Biodiversity	Land development Encroachment Poaching and collection Climate change*	- Habitat loss - Fragmentation of ecosystems - Loss of species, especially endemic species, and threatened species - Pollution of inland waters - Loss of ecosystem benefits
Marine and coastal Biodiversity Island Biodiversity	Land development Encroachment Over-fishing Pollution Climate change*	- Loss and degradation of habitats such as coral reefs and mangrove areas - Loss of ecosystem benefits including degradation of the attractiveness of tourism destinations where relevant
Inland waters Biodiversity	Pollution Land development Invasive alien species Poaching and collection Climate change*	- Habitat loss including degradation in lakes and freshwater swamp forests - Loss of species, especially endemic species, and threatened species in lakes and swamps Loss of ecosystem benefits
Agricultural Biodiversity	Land development Invasive alien species Pollution Climate change*	- Loss of species, especially endemic species, and threatened species in lakes and swamps - Loss of diversity in local species in agricultural sector - Pollution of inland waters Loss of ecosystem benefits

Notes: * Considered as an indirect non-specific threat

4.4.1 Genetic Diversity.

Genetic diversity is the diversity that exists within species, as expressed and as measured by the variation between/within/among genes of individual species of plants, animals and microorganisms. Tables 20, 21 and 22 provides an insight into the genetic diversity found between/within/among some species of local fruits and seeds in Malaysia.

Table 20. Examples of Germplasm Collection Conserved in Seed Genebanks (sourced from NRE, 2010b)

Location	Rice (No of accessions)	Traditional Vegetables (No of accessions)	Ulam[17] (No of accessions)
Malaysian Agricultural Research and Development Institute (MARDI) Genebank, Bertam, Seberang Perai, Penang	11,470 (67% are of local origin)	130	100
Specific MARDI Stations		50 (chilli and tomato)	
Agricultural Research Centre / Department of Agriculture, Tuaran, Sabah	941 including 18 varieties of rice are also conserved	38 (number of species)	
Agriculture Research Centre*, Semengguh, Sarawak and various centres	1,690	646 (encompassing 29 species)	

Table 21. Examples of *Ex Situ* Conservation of Indigenous Fruit Species: Maintained at Various Institutional Field Genebanks/Arboratia in Malaysia (sourced from NRE, 2010b)

Institutions	Location of Field Genebank/Arboretum	No of species	No of accessions
MARDI	Various stations	165	3757*
Department of Agriculture, Peninsular Malaysia	Serdang	17	1,000
	Hulu Paka	110	235
Department of Agriculture, Sabah	Various agriculture Research Stations	204	n.a.
Department of Agriculture, Sarawak	Bintulu Agriculture Park	48	60
	Agriculture Research Centre, Semengguh**	88	197
Department of Agriculture, Sarawak	Betong Layar Station	54	n.a.
FRIM	Kepong	100	816
Universiti Putra Malaysia	Serdang	36	238
Universiti Kebangsaan Malaysia	Bangi	38	n.a
Universiti Malaysia	Rimba Ilmu, Petaling Jaya	71	207

* inclusive of over 1,000 accessions of traditional cultivar and land races involving 14 major fruit species.

Table 22. Examples of Germplasm Collection Conserved at MARDI Field Genebanks and other Centres (sourced from NRE, 2010b)

Crops	Location of Field Genebank/ Arboretum	No of accessions
Coconut	MARDI, Hilir Perak	45
Coffee	MARDI, Kluang	425
Roots and tubers	MARDI, Serdang	800*
Medicinal Plants (encompassing 275 species)	MARDI, Cameron Highlands	62
	MARDI, Jerangau	3,377
Spices and beverages	MARDI, Kluang	300
Ulam	MARDI, Jerangau	78
	MARDI, Seberang Perai	60
Herbal plants	Department of Agriculture, Sarawak, various centres	over 200
Useful Plants	Sarawak Biodiversity Centre	1155**

*estimates, ** updated during preparation of this report.

In response to the various threats posed to some specific flora and fauna in Malaysia, the government of Malaysia has initiated a number of breeding programmes among threatened animals, some examples of which are given Table 23 and Table 24.

Table 23. Examples of Threatened Animals with Breeding Programmes (sourced from NRE, 2010b)

Common Name	*Scientific Name*
Mammals	
Tiger	*Panthera tigris*
Orangutan	*Pongo pygmeus*
Lesser Mouse-deer	*Tragulus kancil*
Barking Deer / Indian Muntjac	*Muntiacus muntjac*
Large Mouse-deer	*Tragulus napu*
Sambar Deer	*Cervus unicolor*
Gaur	*Bos gaurus hubbacki*
Tapir	*Tapirus indicus*
Porcupine	*Hystrix brachyura*
Slow Loris	*Nycticebus coucang*
Reptiles	
River Terrapin	*Batagur baska*
Painted Terrapin	*Callagur borneoensis*
Birds	
Green Peafowl	*Pavo muticus*
Malaysian Peacock Pheasant	*Polyplectron malacense*
Crested Fireback	*Lophura ignita*
Great Argus	*Argusianus argus*
Crestless Fireback	*Lophura erythrophthalma*
Mountain Peacock Pheasant	*Polyplectron inopinatum*

Table 24. Summary of *Ex Situ* Conservation Programmes in Malaysia (sourced from NRE, 2010b) (sourced from NRE, 2010b)

Seladang (*Bos gaurus hubbacki*)
There are three centres for breeding of this species in captivity located in Wildlife Conservation Centres (WCC) at Jenderak Selatan in Pahang, Sungkai in Perak and Gua Musang in Kelantan. The number of Seladang in captivity is 48. To increase the population of Seladang, coordinated breeding and the application of the advanced reproductive biotechnology are being carried out. Four tamed Seladang are selected for this programme which is a collaborative research between DWNP, MARDI and the National Agro Biotechnology Institute (ABI).

Sambar Deer (*Cervus unicolor*)
There are two centers for breeding this species in captivity located in WCC at Songhai, and Guam Musing. DNA fingerprinting is being carried out to identify pure breed to be used for the breeding and release programs.

Barking Deer (*Maniacs manta*, *Maniacs at erodes*)
There are three centers for breeding of this species in captivity. Barking deer's are "highly-strung" and tense species. Breeding them in captivity has been a challenge.

Lesser Mousedeer (*Tragus's javanicus*)
There are two centres for breeding of this species in captivity located in WCC at Sungai Batu Pahat in Perlis and Bangas in Johor. DWNP also has a commercial breeding programme for the species above.

Greater Mousedeer (*Tragulus napu*)
There is a captive breeding programme for this species at the Sungai Batu Pahat WCC.

Malayan Tapir (*Tapirus indicus*)
There is a captive breeding programme for this species at the Sungai Dusun WCC in Selangor. The birth of the twin tapirs on 2 May 2007 at Sungai Dusun is the first ever recorded twin birth in the world.

Malayan Porcupine (*Hystrix brachyura*)
There is a captive breeding programmes for porcupines at the Sungai Dusun WCC. As part of a collaborative research programme, 20 Malayan Porcupines are also placed in Universiti Kebangsaan Malaysia and their breeding behavior studied. DWNP also has a collaborative programme for commercial breeding of this species aimed at sustainable use of resources, and prevention of reduction of population in the wild.

River Terrapin and Painted Terrapin (*Batagur baska and Callagur borneoensis*)
There are three WCCs working with these two species. These are located at Bota Kanan WCC in Perak, Bukit Pinang WCC in Kedah, and Kuala Berang WCC in Terengganu. A total of 230 river terrapins were released at Sungai Bukit Paloh and Sungai Terengganu in March, May and December 2007 in conjunction with the release programs for terrapins.

Julung-julung Crocodile (*Tomistoma schlegelii*)
The programme for the species above is located at the Sungai Dusun WCC in Selangor.

Pheasants (*Polyplectron inopinatum*, *Polyplectron malacense*, *Lophura ignata*, *Lophura erythropthalma*, *Argusianus argus*, *Rheinardia ocellata*, *Pavo muticus*)
The pheasants breeding programs are carried out at the Sungkai WCC in Perak and Jemaluang WCC in Johor.

Hornbills *(Buceros rhinoceros*, *Buceros bicornis*, *Anthracoceros malayanus*, *Anthracoceros albirostris*, *Aceros comatus)*
The Sungkai WCC in Perak is the conservation centre for hornbills.

4.4.2 Threats of biodiversity degradation in Malaysia.

Factors and forces which threaten biodiversity extinction in Malaysia include:

i. Logging and deforestation (including shifting cultivation);
ii. Pollution of rivers and beaches;
iii. Unsustainable exploitation of mangroves;
iv. Poaching and illegal wildlife hunting;
v. Bombing and cyanide poisoning of fish;
vi. Excessive use of agrochemicals; and
vii. Clearing of habitats for development, etc.

4.4.3 Implications of the extinction of ecosystem, species and genetic biodiversity for human beings and the environment.

Ecosystems provide, for free, a wide range of critical and pivotal national, regional and global “goods and services”, including the following:

a. “Goods” furnished by species within ecosystems, like:

i. Foods
ii. Fuels
iii. Fibres
iv. Pharmaceuticals
v. Molecular biologicals, etc

b. “Services” furnished by ecosystems themselves, like:

i. Clean water sources
ii. Pest and disease controls
iii. Protection of coastal zones
iv. Regulation of climate regimes
v. Absorption and deflection of radiation rays

vi. Formation and holding of soils
vii. Absorption and breakdown of wastes
viii. Recycling of nutrients
ix. Maintenance and nurturing of a genetic vault
x. Promoting tourism, aesthetic and cultural values
xi. Enabling life-support systems and exchanges, etc
xii. Sequestration of carbon

4.4.4 Wealth of Marine and Coastal Biodiversity.

Oceans cover 70% of planet Earth, and represent over 95% of its biosphere. Marine and coastal habitats include coral reefs, mangrove forests, seagrass beds, estuaries, intertidal zones, hydrothermal vents, seamounts and soft sediments on the ocean floor deep below the surface of seas and oceans. Besides being much more than merely a valuable source of foods, oceans and seas are also one of the largest natural reservoirs of carbon, which store over 15 times the amount of CO_2 when compared to the terrestrial biospheres and soils, thereby playing a critical role in the moderation of climate.

Deep-seabed habitats host between 500,000 and 10 million species of flora and fauna. Deep-sea life forms are also essential to life on planet Earth, particularly due to its central role in the operation of global biogeochemical cycles, including in the regeneration of nutrients and oxygen. However, the tremendous wealth of marine biodiversity and ecosystem services are not infinite. More so, as human activities are ever increasingly threatening the oceans, seas and coasts through various means, including overfishing, destructive fishing practices, pollution and disposal of wastes, agricultural run-offs, intrusion of invasive alien species, destruction of habitats, etc. Further, the effects of global climate changes will only further aggravate the dilemma, by causing sea levels to rise, water temperatures to elevate, oceans and seas to acidify, worsening of storms and natural disasters.

Oceans are by and large severely under-protected, with about only 0.8% of the oceans and 6% of the territorial seas falling under protected areas. Countries that have ratified and adopted the UN Convention on Biological Diversity are therefore addressing the various challenges posed to the conservation and sustainable use of marine and coastal biodiversity. Through the systemic marine and coastal ecosystem approach, the focus is on the strategic management of the seas and coasts, coral reefs, marine, coastal and deep sea biodiversity, protected areas, mariculture and invasive alien species.

Notably, about 80% of the world fish stocks, for which assessment data is available, are considered to be fully- or over- exploited, thereby requiring effective and precautionary management tools and mechanisms. Oceans contain a vast diversity of habitats and spectacular seascapes, which host 32 of the 34 phyla on planet Earth, of which some 13 phyla are deemed to be exclusively or primarily marine. Further, the genetic resources of the oceans, seas and coasts have valuable potentials and prospects for commercial uses. However, pressures on the sustainability of the coastal and marine biodiversity worldwide are bound to continue increasing, especially since 50% of the world's population would be living along coastal areas by 2015, putting added and unsustainable pressures on coastal and marine biodiversity and resources.

4.4.5 Mangroves and Mudflats

The significant mangrove areas on the west coast of Peninsular Malaysia are mainly coastal and are located at Merbok, Matang, Rungkup, Bernam, Klang, Kuala Selangor, Sepang, Lukut, and Sg. Pulai. These habitat losses are substantial especially when mangroves sustain coastal and artisanal fisheries (Singh *et al.*, 1994). The mangroves of the east coast of Peninsular Malaysia are primarily riverine (Sg. Semarak, Sg. Setiu, Sg. Kemaman, Sg. Kuantan, Sg. Pahang, Sg. Miang, Sg. Bebar, Sg. Merchong, Sg. Rompin, Sg. Pontian, Sg, Endau, Sg. Sedili Besar and Sg. Sedili Kecil) (Jaharah & Santha, 2004) and in sheltered bays and coves on the islands especially in P. Redang, P. Tulai, P. Semilang, P. Seri Buat, P. Tioman, P. Sibu and P. Tinggi. Most of the more than 300,000 ha of mangroves in Sabah are found on the east coast with its associated extensive mudflats, especially in and around estuarine areas. In Sarawak, there is approximately 172,792 hectares of mangrove forest, of which 30,928 hectares constitutes nipahswamps. In

Sarawak, the primary locations of mangroves are in the deltas of Sungai Sarawak, Sungai Rejang and Sungai Trusan-Lawas while some mangrove areas are protected in the Bako and Similajau National Parks and the Samunsam Wildlife Sanctuary. There generally has been a decline in the mangrove cover for both the total mangrove area (36% decline, 1973-2005) (Table 25) and the mangrove forest reserves (22% decline, 1980-2005) (Table 26) in Malaysia (Tan, 2008).

There are approximately 41 true mangrove flora taxa in Malaysia (Tan, 2005 & 2007; Tan & Primavera, 2008) (Table 27). Two are hybrids (*Rhizophora X lamarckii* and *R. X annamalayana*), one is common on the east of Peninsular Malaysia and Sabah (*Avicennia rumphiana*) while others are restricted either to Sabah or Sarawak (*Aegiceras floridum*, *Aglaia cucullata*, *Heritiera globosa* and *Osbornia octodonta*). The non-market and net market values (products and services) of the west-coast Peninsular Malaysia mangroves amounted to approximately USD$1.38 billion (MPP-EAS, 1999) (Table 28). The mangrove associated mudflats are also important habitats for invertebrates and feeding sites for migratory and resident birds.

The mudflats of the west coast of Peninsular Malaysia produced 72,000 mt of marketable cockles and 11,000 mt of cockle seeds (Mohd Mazlan, 2001). Important cockle culture areas are located at Kuala Sungai Merbok (Kedah); Juru (Penang); Kuala Gula, Kuala Sangga-Matang, Kuala Trong and Sungai Jarom (Perak); Kuala Selangor (Selangor); and Muar (Johor). The cockle landings for Malacca Strait are given in Table 29 and while Table 30 gives the production and economic value for the cockles.

Besides the blood cockle (*Anadara granosa*) the mudflats and mangroves also support other organsisms like the venus clams (*Paphia textile*), mudsnail (*Nassarius* spp), polychaete worms (eg. C*eratonereis*, *Diopatra*, *Mellina* and Nereis, *Marphysa*, *Lumbriconereis)*, pistol shrimp (*Alpheus,Synalpheus)*, brachyuran crabs (eg. *Metaplax*, *Metopograpsus*, *Grapsus*, *Sesarma*, *Uca*, *Cleistosoma*), gastropods (mainly *Cerithedia cingulata*), anomuran crabs (*Diogene*,*Clibanarius*), sipunculid worms (*Phascolosoma arcuatum*), benthic micro-algae (*diatoms* and *euglenoids*)meiofauna communities (Nematoda, Foraminifera, Copepoda and Ostracoda),mudskippers (eg.*Balaeopthalmus boddaerti*, *Periophthalmus chrysospilos*),prawns (eg. *Metapenaeus brevicornis*, *Metapenaeus affinis*). The mangrove gastropods of Selangor are listed in Table 31. In general, mudflats and mangroves of Malaysia bear unique flora and fauna but knowledge on their biodiversity, especially benthos (meio- and macrobenthos), bacteria and fungi remains somewhat fragmented.

Table 25. Compariosn of total mangrove forest areas in Malaysia in 1973 and 2005 (sourced from: Tan, 2007)

State	Mangrove areas (ha)		Mangrove loss	
	1973	**2005**	**ha**	**%**
Johor	39,700	23,000	-16,700	-42.07
Kedah	10,250	8,200	-2,050	-20.00
Kelantan	300	150	-150	-50.00
Melaka	300	100	-200	-66.66
Negri Sembilan	3,500	800	-2,700	-77.14
Pahang	3,500	3,000	-500	-14.29
Perak	56,500	43,000	-13,500	-23.89
Perlis	250	30	-220	-88.00
Penang	3,900	1,400	-2,500	-64.10
Selangor	32,000	17,000	-15,000	-46.88
Terengganu	3,500	2,500	-1,000	-28.57
Sarawak	175,000	130,000	-45,000	-25.71
Sabah	366,000	346,000	-20,000	-5.46
Total	**694,700**	**575,180**	**-119,520**	**-17.20**

Table 26. Compariosn of total mangrove forest reserve areas in Malaysia in 1980 and 2005 (sourced from: Tan, 2007)

State	**Mangrove areas (ha)**		**Mangrove loss/gain**	
	1980	**2005**	**ha**	**%**
Johor	25,619	17,029	-8,590	-33.53
Kedah	9,037	7,949	-1,088	-12.04
Kelantan	Nil	Nil	0	0
Melaka	77	77	0	0
Negeri Sembilan	1,352	204	-1,148	-84.91
Pahang	2,469	2,675	+206	+8.34
Perak	40,869	41,302	+433	+1.06
Perlis	Nil	Nil	0	0
Penang	406	451	+45	+11.08
Selangor	28,243	15,090	-13,153	-46.57
Terengganu	2,982	1,130	-1,852	-62.11
Sarawak	44,491	73,000	+28,509	+64.08
Sabah	349,773	325,000	-24,773	-7.08
Total	**505,318**	**483,907**	**-21,411**	**-4.24**

Table 27. Checklist of true mangrove species of Malaysia (sourced from Tan, 2005, 2007)

Mangrove Taxa	**Family**	**Status**
Acanthus ebracteatus	*Acanthaceae*	Widely distributed
Acanthus ilicifolius	Acanthaceae	Widely distributed
Acanthus volubilis	Acanthaceae	Rare in several areas
Acrostichum aureum	*Pteridaceae*	Widely distributed
Acrostichum speciosum	Pteridaceae	Widely distributed
Aegiceras corniculatum	Myrsinaceae	Widely distributed
Aegiceras floridum	Myrsinaceae	Confined to northern Sabah
Aglaia cucullata	Meliaceae	Mostly found in Sabah and Sarawak

Table 27.continued

Avicennia alba	*Avicenniaceae*	Widely distributed
Avicennia marina	Avicenniaceae	Widely distributed
*Avicennia rumphiana**	Avicenniaceae	Common in the east coast to south western coast of Peninsular Malaysia and northern Sabah
Avicennia officinalis	Avicenniaceae	Common and widely distributed
Bruguiera cylindrica	Rhizophoraceae	Common and widely distributed
Bruguiera gymnorhiza	Rhizophoraceae	Widely distributed
Bruguiera hainesii	Rhizophoraceae	Very rare and restricted to Klang Islands and Kuala Trong
Bruguiera parviflora	Rhizophoraceae	Common and widely distributed
Bruguiera sexangula	Rhizophoraceae	Widely distributed
Ceriops tagal	Rhizophoraceae	Common and widely distributed
Ceriops zippeliana[¶]	Rhizophoraceae	Widely distributed except north western coast of Peninsular Malaysia
Excoecaria agallocha	Euphorbiaceae	Common and widely distributed
Heritiera fomes	Sterculiaceae	Very rare and restricted to Merbok mangroves
Heritiera globosa	Sterculiaceae	Endemic to Borneo Island
Heritiera littoralis	Sterculiaceae	Common and widely distributed
Kandelia candel	Rhizophoraceae	Common in east coast of Peninsular Malaysia and Sarawak, rare in Sabah
Lumnitzera littorea	Combretaceae	Common and widely distributed
Lumnitzera racemosa	Combretaceae	Common and widely distributed
Nypa fruticans	Palmae	Common and widely distributed
Osbornia octodonta	Myrtaceae	Rare and restricted to Sarawak and Sabah
Phoenix paludosa	Palmae	Confined to several areas in Peninsular Malaysia
Rhizophora apiculata	Rhizophoraceae	Common and widely distributed
Rhizophora mucronata	Rhizophoraceae	Common and widely distributed
Rhizophora stylosa	Rhizophoraceae	Common in Sabah
Rhizophora X lamarckii	Rhizophoraceae	Rare and confined to several areas
Rhizophora X annamalayana	Rhizophoraceae	Rare and confined to several areas
Scyphiphora hydrophyllacea	Rubiaceae	Common and widely distributed
Sonneratia alba	Sonneratiaceae	Common and widely distributed
Sonneratia caseolaris	Sonneratiaceae	Common and widely distributed
Sonneratia griffithii	Sonneratiaceae	Very rare and restricted to Merbok mangroves
Sonneratia ovata	Sonneratiaceae	Widely distributed but not common
Xylocarpus granatum	Meliaceae	Common and widely distributed
Xylocarpus moluccensis	Meliaceae	Widely distributed but not common

Table 28.Total economic value of mangrove ecosystems (83,259 ha) in the west coast of Peninsular Malaysia

Use Value	Gross Benefits	Net Benefits	Assumptions
Direct Value			
Charcoal and Poles	28,641,130	8,592,339	$344/ha; 30% net return
Fish and Prawns	5,099,344	1,496,148	29.3% net return
Mud Crabs	4,224,720	1,239,533	29.3% net return
Tourism	35,301,858	21,181,115	$424/ha; 60% net return
Indirect Use			
Nursery Role	343,220,013	67,717,309	19.7% net returns
Carbon Sequestration	150,698,971	150,698,971	$1,810/ha
Erosion Protection	207,659,742	207,659,742	$221,333/km; 938.2km
Option Value			
Biodiversity Value	1,248,887	1,248,887	$15/ha
Non-use Value			
Existence Value	919,180,464	919,180464	$11,040/ha
Total	**$1,695,275,129**	**$1,379,014,508**	

Adapted from Chong, V.C (2006). Sustainable utilization and management of mangrove ecosystems in Malaysia. Aquatic Ecosystem Health & Management, 9(2); 249-260.

Table 29. Total Cockle culture area (hectare) and production on mudflats on the west coast of Peninsular Malaysia (Annual Fisheries Statistics, Fisheries Department Malaysia)

Year	Cockle Culture (hectare)	Cockle Culture (tonnes)
2000	7,129	64,396
2001	6,741	70,815
2002	6,891	78,706
2003	7,447	71,067
2004	6,662	64,564
2005	6,797	59,520
2006	6,250	45,674
2007	6,236	49,620

Table 30. Bivalve Aquaculture Production Malaysia, 2003 (Annual Fisheries Statistics, Fisheries Department Malaysia)

Type	**Area**	**Production (metric tonnes)**	**Wholesale Value (RM 000)**	**Retail Value (RM 000)**
Cockle	7447 ha	71,067	56,769	92,251
Mussel	109,816 m^2	7701	2854	5970
Oyster	103,212 m^2	256	1263	1955

Table 31. Mangrove Gastropods of Selangor

Cassidula mustelina	*Morula musiva*
Cerithidea cingulata	*Nassarius jacksonianus*
Cerithidea obtusa	*Nassarius livescens*
Cerithidea quadrata	*Nassarius olivaceus*
Cerithidium coralium	*Nassarius pullus*
Chicoreus capucinus	*Natica tigrina*
Clithon oualeniensis	*Naticidae*
Clypeomorus batillariaeformis	*Nerita albicilla*
Clypeomorus pellucidus	*Nerita chameleon*
Columbella duclosiana	*Nerita lineata*
Drupa margariticola	*Nerita planospira*
Ellobium aurisjudae	*Nerita polita*
Ellobium aurismidae	*Nerita squamulata*
Gyrineum natator	*Nerita undata*
Haminoea sp.	*Neritina violacea*
Laemodonta siamensis	*Onchidium*
Littoraria albicans?	*Planaxis sulcatus*
Littoraria carinifera	*Phythia scabareus*
Littoraria conica	*Pyrene fulgurans*
Littoraria melanostoma	*Sphaerassiminea miniata*
Littoraria scabra	*Telescopium mauritsi*
Littoraria sp.	*Telescopium telescopium*
Littoraria vespacea	*Thais carinifera*
Melongena pugilina	*Thais echinulata*
Monodonta labio	*Thais gradata*
	Thais tissoti

4.4.6 Sea-grasses

The important areas of sea grasses on the west coast of Peninsular Malaysia are located in Langkawi, Beting Tengah, Seberang Prai, Teluk Nipah, Port Dickson, Pulau Serimbun Sungai Pulai Estuary and the Marambong shoals (Fig. 1). The Teluk Kemang (N. Sembilan) (coral reef flats) and the Tanjung Adang-Marambong shoal (interitidal and sub-tidal) (Sg. Pulai estuary, Johor) are the major areas for the sea-grasses in the Straits of Malacca. The sea-grasses on the east coast of Peninsular Malaysia are located in Kelantan (Pangkalan Nangka Lagoon, 40 ha; Kampung Baru Nelayan to Kampung Sungai (Sg.) Tanjung, 27 ha; and Pantai Baru Lagoon, 20 ha), Terengganu (Sg. Kemaman, 17 ha; Telaga Simpul, 28 ha; and the Sg. Paka Shoal, 43 ha) and Johor (Tan & Basiron, 2004; Japar Sidek & Muta Harah, 2003). Other areas on the east coast important for the sea-grasses are located at Pulau Tioman (Pahang), Gong Batu, Kemasik (Terengganu) and the Mersing Islands (Tan & Basiron, 2004). The important areas for sea-grasses in Sabah are located along the west coast at Bak-Bak, Tanjung Mengayau, Sepangar Bay and Pulau Gaya, Pulau Maganting, Pulau Tabawan, Pulau Bohay Dulang and Pulau Sipadan (Fig.2) (Norhadi, 1993). In Sarawak, sea-grass locations include Sungai Bintulu, Pulau Talang-talang and Semantan (Fig.3) (Den Hartog, 1970). A total of 14 taxa of segrasses are known from the Malaysian marine waters (Table 32). Among the sea-grass taxa, *Halodule pinifolia* and *Halophila ovalis* have the widest distribution in Malaysia while *Ruppia maritima* and *Thalassodendron ciliatum* are rare.

The sea-grasss habitats of Malaysia are also associated with other important biota like seaweeds, fishes, prawns, corals, crabs, gastropods, sea cucumbers, eels, echinoderms, sea horses (*Hippocampus kuda*) and bivalves. Approximately 100 fish species and 20 prawn species are known from sea-grass beds on the west coast of the Peninsular (Tan, 2008). The sea-grass habitats are also important as traditional fishing grounds supporting local coastal populations, nursery grounds for invertebrates and vertebrates (eg. dugong, birds, turtles) (Japar *et al.*, 2006). Besides artisanal fisheries (utilizing gill nets, drift nets, cast nets, pull nets, hook and line) comprising landings of commercially important fishes (eg., *Caranx sexfasciatus, Leiohnathus equulus, Lutjanus russelli, Mugil cephalus, Periopthalmus sp., Scatophagus argus, Tylosurus* *crocodilosus* and *Scomberoides lysan*) (Japar Sidek et al., 2001), sea-grass habitats are also important for aquaculture (*Saccostrea culcullata*; *Lates calcarifer* – siakap, *Epinephelus sexfasciatus* - kerapu); as gleaning sites for bivalves (*Modiolus senhausii, Gelonia coaxans, Meretrix meretrix, Hiatula solida*); as gastropod collection sites (*Lambis lambis, Strombus canarium*); as migrant bird sites (eg. *Egretta garzetta*) and as polychaete collection sites. Approximately 76 species of fish from 41 families have been recorded from the Tanjung Adang sea-grass-mangrove habitats (Sasekumar *et al.*, 1989) while 35 fish species are commercially important (Arshad *et al*., 2001). The sea-grasses are important diets of the dugong (*Dugong dugon*, status: vulnerable; protected species) and the green turtle (*Chelonia mydas*, status: endangered). The economic contribution of the sea-grass associated resources in Malaysia has not been documented well (Japar Sidek *et al.*, 2006) but global estimates are between US$19,000 to US$22,400 ha^{-1} yr^{-1} (Costanza *et al*. 1997).

Figure 1. Important Sea-grass Areas in Peninsular Malaysia and the Sea-grass Taxa (sourced from Tan & Basiron, 2004)

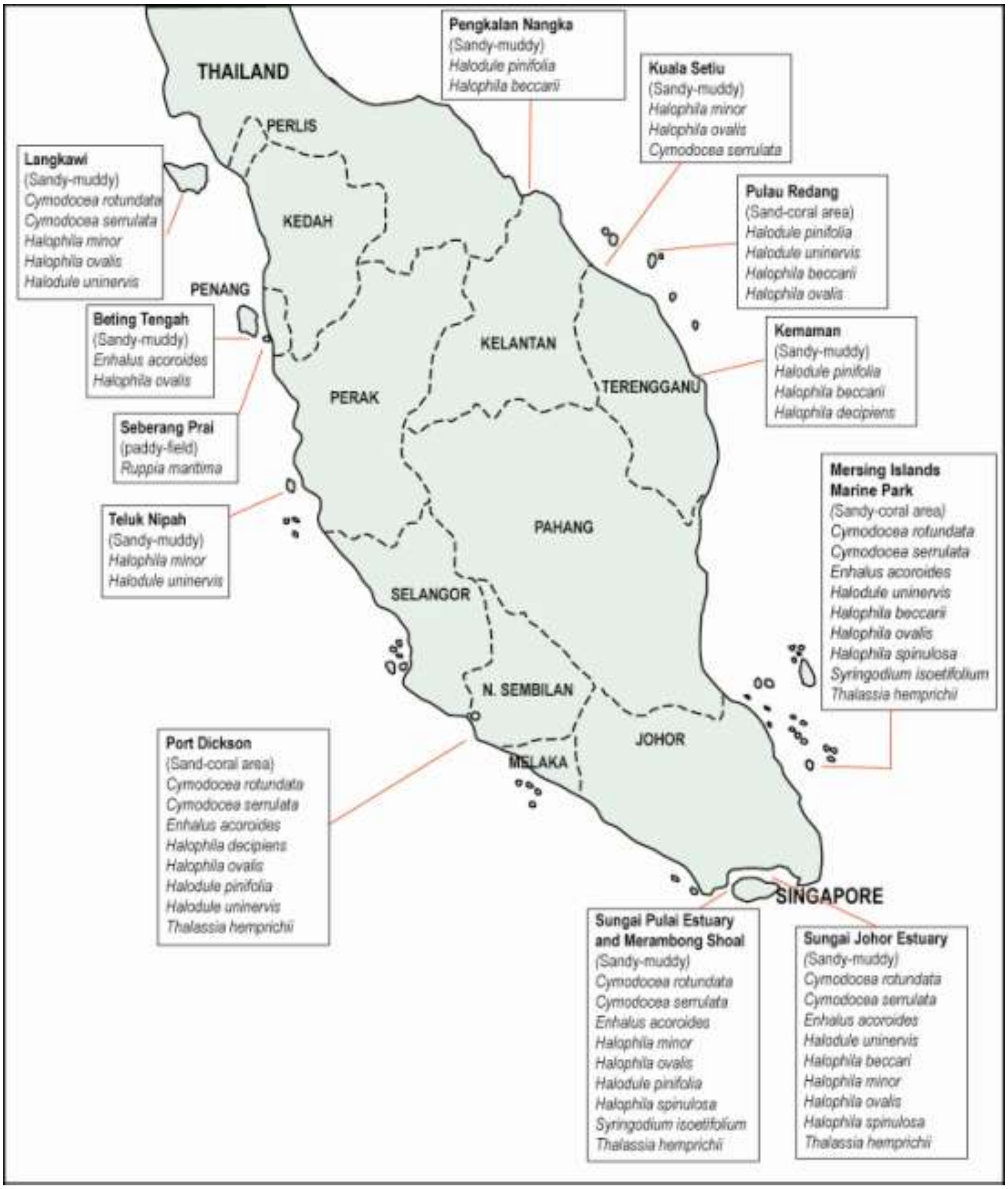


Figure 2. Important Sea-grass Areas in Sarawak and and the Sea-grass Taxa (sourced from Tan & Basiron, 2004)

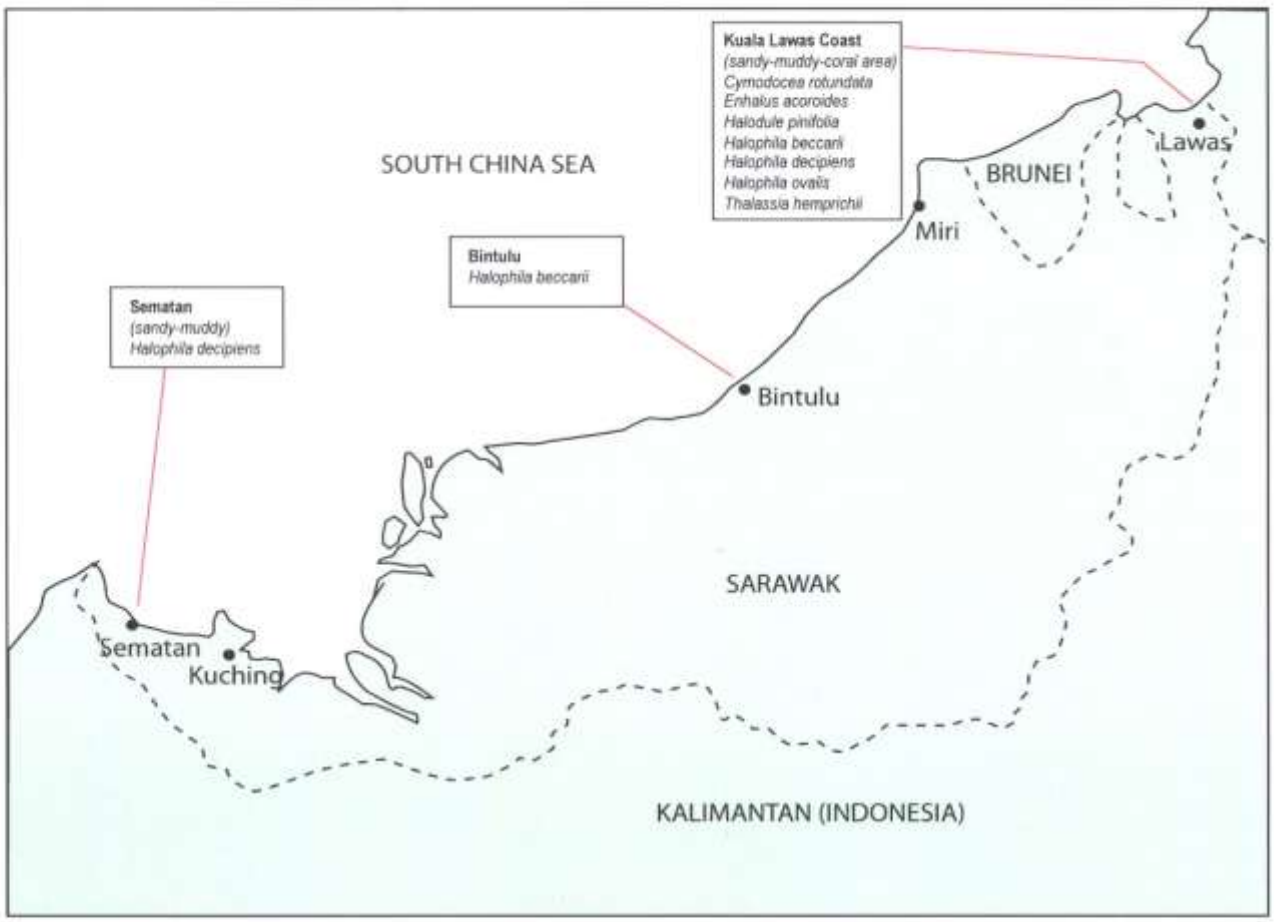


Figure 3. Important Sea-grass Areas in Sabah and and the Sea-grass Taxa (sourced from Tan & Basiron, 2004)

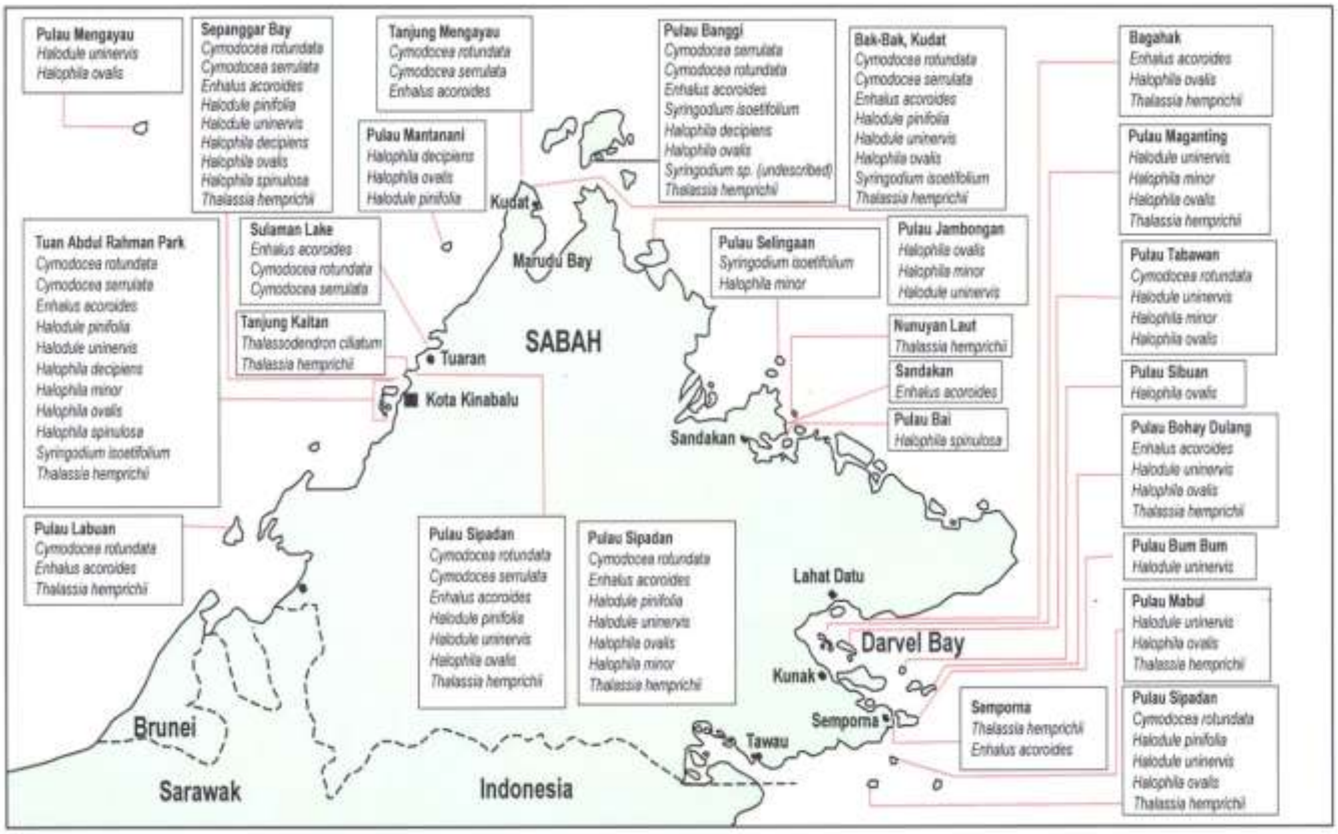


Table 32. Sea-grass Species of Malaysia (sourced from: Tan & Basiron, 2004)

Family	Species	Status / Remarks
Cymodoceae	*Cymodocea rotundata*	Common and widespread throughout Sabah, rare in Peninsular Malaysia.
	Cymodocea serrulata	Common and widespread throughout Sabah, rare in Peninsular Malaysia.
	Halodule pinifolia	Common and widespread throughout Malaysia, especially in the east coast of Peninsular Malaysia.
	Halodule uninervis	Common and widespread throughout Malaysia.
	Syringodium isoetifolium	Not common, restricted to a few sites in Malaysia.
	Thalassodendron ciliatum	Only recorded in Tanjung Kaitan, Sabah
Hydrocharitaceae	*Enhalus acoroides*	Common and widespread throughout Malaysia.
	Halophila beccarii	Common and widespread throughout the east coast of Peninsular Malaysia. Presently not found in west coast of Peninsular Malaysia, Sarawak and Sabah.
	Halophila decipiens	Not common.
	Halophila minor	Some records previously recognised this species as *Halophila ovata*. Rare and restricted to a few sites in east coast of Peninsular Malaysia and Sabah.
	Halophila ovalis	Common and widespread throughout Malaysia.
	Halophila spinulosa	Rather rare and restricted to a few sites in southern and east coast of Peninsular Malaysia and Sabah.
	Thalassia hemprichii	Common in Sabah.
Potamogetonaceae	*Ruppia maritime*	Very rare and only recorded in Seberang Prai, Penang.

4.4.7 Seaweeds

The tally of the Malaysian marine algae currently stands at 373 specific and intraspecific taxa (17 taxa of Cyanophyta, 102 Cholophyta, 182 Rhodophyta and 72 Phaeophyta) (Phang, 2006). Traditionally, seaweeds have been used as a food source (*Caulerpa*, *Ulva*, *Gracilaria*, *Sargasum*, *Gelidinium*, *Eucheuma*) animal feed, fertilizer and traditional medicine (*Carollina, Sargassum, Turbinaria*). Even though seaweeds have been utilised by fishing and coastal communities as a food source but there has been decline of it as a food source (Phang, 1984). *Halimeda opuntia*, *Acanthophora spcifera*, *Eucheuma spinosum*, *Graciliaria* sp., *Hypnea musciformis*, *Dictyopteris* sp., and *Sargassum* spp. have demonstrated antibiotic properties (Phang, 2006). Amomg the seaweed taxa only *Eucheuma* and *Gracilaria changi* is cultivated. The genera of seaweeds recorded from the east coast of Peninsular Malaysia is listed in Table 33.

Table 33. The family and genera of seaweeds sampled from the east coast of Peninsular Malaysia (sourced from: Phang, 2006)

Family	**Genera**	
Nostocaceae	*Calothrix*	*Foisliella*
Ulvaceae	*Enteromorpha*	*Jania*
Anadyomenaceae	*Ulva*	*Hypnea*
Siphonocladaceae	*Anadyomene*	*Champia*
Valoniaceae	*Boergesenia*	*Gastroclonium*
Cladophoraceae	*Boodlea*	*Lomentaria*
Bryopsidaceae	*Cladophoropsis*	*Chamaebotrys*
Caulerpaceae	*Dictyosphaeria*	*Gelidiopsis*
Codiaceae	*Struvea*	*Anotrichium*
Halimedaceae	*Valonia*	*Callithamnion*
Udoteaceae	*Chaetomorpha*	*Centroceras*
Dasycladaceae	*Cladophora*	*Ceramium*
Polyphysaceae	*Rhizoclonium*	*Pthilothamnion*
Acrochaetiaceae	*Ventricaria*	*Spyridia*
Liagoraceae	*Bryopsis*	*Wrangelia*
Gelidaceae	*Derbesia*	*Dasya*
Gelidiellaceae	*Caulerpa*	*Heterosiphonia*
Gracilariaceae	*Codium*	*Hypoglossum*
Pterocladiophilaceae	*Halimeda*	*Martensia*
Halymenaiceae	*Arainvillea*	*Acanthophora*
Kallymeniaceae	*Tydemannia*	*Chondria*
Peyssonneliaceae	*Udotea*	*Herposiphonia*

Rhizophyllidaceae Corralinaceae Hypneaceae Champiaceae Lomentaraiaceae Rhodymeniaceae Ceramiaceae Dasyaceae Delesseriaceae Rhodomelaceae Ectocarpaceae Dictyoceae Cystocieraceae Sargassaceae	*Rhipidosiphon* *Neomeris* *Acetabularia* *Acrochaetium* *Liagora* *Pterocladida* *Gelidiella* *Glacillaria* *Asparagopsis* *Halymenia* *Callophyllis* *Peyssonnelia* *Portieria* *Amphiroa*	*Laurencia* *Murrayellopsis* *Neosiphonia* *Polysiphonia* *Tolypiocladia* *Feldmannia* *Dictyota* *Lobophora* *Padina* *Cystoceira* *Hormophyssa* *Sargassum* *Turbinaria*
Total = 26	**Total = 71**	

4.4.8 Corals

The coral reefs of Malaysia are mainly situated on the east coast islands of Peninsular Malaysia and Sabah. The significant coral reefs on the west coast of Peninsular Malaysia are situated in Kedah at the Pulau Payar Marine Park (Pulau Payar, Pulau Kaca, Pulau Segantang, Pulau Lembu) and at Tanjung Tuan in Negeri Sembilan. Other coral areas of less significance are found at Pulau Langkawi (Geopark status), Pulau Sembilan and Pulau Pangkor in Perak, and Pulau Besar in Melaka. Much of these smaller reefs have low diversity due to high water turbidity and muddy substrates (Chua & Charles, 1980). Goh and Sasekuamr (1980) recorded 41 coral species at Cape Rachado, Port Dickson but the reefs have been degraded through siltation and unrestricted collection activities (Gopinath *et al.*, 2001). The main coral areas in Sabah are located at Semporna, Pulau Sipadan and Pulau Layang-Layang and the 40 or so islands off the west coast. The main coral areas in Sarawak are located at Pulau Talang Talang Kecil, Talang Talang Besar, Luconia reef and the Miri-Sibuti reef.

The coral species richness for Malaysia amounts to 519 taxa from 70 genera (Veron, 1995) (expected >550 species, Veron & Stafford-Smith, 2000) of which 346 species (Spalding *et al.*, 2001) are scleratinian corals. Coral reefs in the Straits of Malacca are less diverse consisting of only 35.9% - 39.6% of the total number of species in Malaysian waters, probably due to higher stress conditions in the Straits compared to the South China Sea (Ridzwan, 1995). Live coral cover from tourism sites at Pulau Langkawi ranged from 20-50% while in the less developed north and northeast areas showed live coral cover ranging from 50%-58% (Tun *et al*., 2005). The live coral cover at the Pulau Payar Marine Park showed decrease from 43.2% (1982) to 33%. Among the east coast island groups the Pulau Tioman group has the highest coral species richness with 183 taxa (35.2% of total) followed by the Pulau Tinggi group with 155 taxa (29.8% of total) and the P. Redang group with 149 taxa (28.7% of total). In a recent survey of Pulau Perak (2004 & 2006), after a lapse of 46 years, Affendi *et al*. (2008) reported58% coral cover for the island. Tun *et al.* (2008) stated that between 2004 and 2008 the coral reefs in Malaysia indicated an overall decline in condition (very healthy reefs less than 10%; healthy reefs less than 30%; fair reefs about 42%; and poor/very poor averaging 34%).

Besides corals the reefs in Malaysia support fishes like groupers, snappers, grunts, parrotfishs, angelfishes, wrasses and butterflyfish and these are important assets to the coastal tourism industry. Two hundred and thirty four (234) species of fish comprising 105 genera from 50 families are known from Pulau Payar Marine Parks (Yusri, 2006). Pulau Payar (species=217, genera=101, families=48) recorded the largest species richness, followed by P. Segantang (114, 61, 30), P. Kaca (90, 51 24) and P. Lembu (90, 50, 28). The dominant families of the fish species recorded were Pomacentridae (32 spesies) followed by Labridae (25), Chaetodontidae (19), Lutjanidae (17), Serranidae (17), Gobiidae (14), Apogonidae (11), Scaridae (8), Nemipteridae (7), Carangidae (7) and Siganidae (7). These 11 families comprised 164 species or 70% of the total species richness that was observed.

<u>4.4.9 Plankton</u>

The genera of marine phytoplankton of Malaysia from both the Straits of Malacca and the South China Sea is listed in Table 34. One hundred and seventy three species from 41 genera are known (Lokman, 1990). One hundred and seventeen species of copepods (zooplankton) have been recorded from the Straits of Malacca (Rezai *et al*., 2004; Chew & Chong, 2010) (Table 35).

Table 34. The genera and species richness of the marine phytoplankton of Malaysia (Lokman, 1990)

Genus	No	Genus	No
Paralia	1	*Bellerochea*	1
Stephanopyxis	3	*Didylum*	2
Skeletonema	1	*Biddulphia*	9
Coscinosira	1	*Cerataulina*	2
Concinodiscus	18	*Hemiaulus*	4
Planktoniella	1	*Hemidiscus*	1
Actinoptychus	1	*Licmophora*	3
Asterolampra	1	*Raphoneis*	2
Asteromphalus	3	*Thalassiothrix*	5
Corethron	2	*Asterionella*	2
Lauderia	2	*Achnanthes*	2
Schroderella	2	*Campyloneis*	1
Leptocylindrus	1	*Navicula*	6
Guinardia	2	*Pleurosigma*	13
Rhizosolenia	17	*Amphiprora*	2
Bacteriastrum	5	*Mastogloia*	1
Chaetoceros	25	*Amphora*	5
Eucampia	2	*Bacillaria*	1
Climacodium	2	*Nitzschia*	13
Streptotheca	2	*Surirella*	4
		Compylodiscus	2

Table 35. Copepods sampled from the Straits of Malacca (Rezai *et al*., 2004)

CALANOIDA
ACARTIIDAE
1. *Acartia* sp. 1
2. *Acartia* sp. 2
3. *Acartia amboinensis* Carl
4. *Acartia erythraea* Giesbrecht
5. *Acartia pacifica* Steuer
6. *Acartia spinicauda* Mori

PARACALANIDAE
7. **Paracalanus aculeatus* Giesbrecht
8. **Paracalanus denudatus* Sewell
9. **Paracalanus parvus* s.l. (Claus)
10. *Paracalanus* sp.
11. **Parvocalanus crassirostris* Dahl
12. **Parvocalanus elegans* Andronov
13. **Acrocalanus gibber* Giesbrecht
14. *Acrocalanus gracilis* Giesbrecht
15. *Acrocalanus longicornis* Giesbrecht
16. *Acrocalanus monachus* Giesbrecht
17. **Bestiolina similis* (Sewell)
18. *Delius nudus* (Sewell)

CENTROPAGIDAE
19. *Centropages dorsispinatus* Thompson and Scott
20. *Centropages furcatus* (Dana)
21. *Centropages orsinii* Giesbrecht
22. *Centropages* sp.
23. *Centropages tenuiremis* Thompson and Scott

CLAUSOCALANIDAE
24. *Clausocalanus arcuicornis* (Dana)
25. *Clausocalanus furcatus* (Brady)
26. *Clausocalanus jobei* Frost and Fleminger√
27. *Clausocalanus pergens* Farran√

PONTELLIDAE
28. *Labidocera minuta* Giesbrecht
29. *Labidocera acuta* (Dana)
30. *Labidocera bengalensis* Krishnaswamy
31. *Labidocera rotunda* Mori√
32. *Labidocera euchaeta* Giesbrecht√
33. *Labidocera pectinata* Thompson and Scott
34. *Labidocera kroyeri* (Brady)
35. *Labidocera* sp. 1
36. *Labidocera* sp. 2
37. *Pontella* sp. 1
38. *Pontella* sp. 2
39. *Pontella* sp. 3
40. *Pontellina plumata* Dana
41. Unidentified Pontellidae
42. *Calanopia elliptica* Dana
43. *Calanopia* sp.
44. *Calanopia minor* Scott
45. *Calanopia thompsoni* A.Scott

EUCALANIDAE
46. *Eucalanus pileatus* (Giesbrecht)
47. *Eucalanus attenuatus* (Dana)
48. *Eucalanus subtenuis* Giesbrecht
49. *Eucalanus crassus* Giesbrecht
50. *Eucalanus* sp.

Table 35. continued

51. *Eucalanus subcrassus* Giesbrecht

EUCHAETIDAE
52. *Euchaeta concinna* (Dana)
53. *Euchaeta marinella* Bradford

LUCICUTIIDAE
54. *Lucicutia gaussae* Grice
55. *Lucicutia flavicornis* (Claus)

ARIETELLIDAE
56. *Metacalanus* sp.√

PSEUDODIAPTOMIDAE
57. *Pseudodiaptomus aurivilli* Cleve
58. *Pseudodiaptomus* sp.

SCOLECITHRICIDAE
59. *Scolecithricella* sp.
60. Unidentified Scolecithricidae

TEMORIDAE
61. *Temora discaudata* Giesbrecht
62. *Temora stylifera* (Dana)
63. *Temora turbinata* (Dana)

CALOCALANIDAE
64. *Calocalanus styliformis* Giesbrecht
65. *Calocalanus pavo* (Dana)
66. *Calocalanus* sp.

CANDACIIDAE
67. *Candacia bradyi* Scott
68. *Candacia curta* (Dana)
69. *Candacia discaudata* Scott
70. *Candacia ethiopica* (Dana)
71. *Candacia pachydactyla* (Dana)

CALANIDAE
72. **Canthocalanus pauper* Giesbrecht
73. *Nannocalanus minor* (Claus)
74. *Undinula vulgaris* (Dana)

TORTANIADAE
75. *Tortanus forcipatus* (Giesbrecht)
76. *Tortanus gracilis* Brady

CYCLOPOIDA
OITHONIDAE
77. **Oithona attenuata* Farran
78. *Oithona brevicornis* Giesbrecht
79. **Oithona nana* "Plumosa form" Giesbrecht
80. **Oithona oculata* Farran
81. **Oithona plumifera* Baird
82. *Oithona rigida* Giesbrecht
83. **Oithona similis* Claus
84. **Oithona simplex* Farran
85. *Oithona* sp.

POECILOSTOMATOIDA
CORYCAEIDAE
86. *Corycaeus affinis* McMurrich
87. *Corycaeus agilis* Dana
88. **Corycaeus andrewsi* Farran
89. *Corycaeus asiaticus* F. Dahl
90. *Corycaeus catus* F. Dahl
91. *Corycaeus dahli* Tanaka
92. *Corycaeus dubius* Farran
93. *Corycaeus erythraeus* Cleve
94. *Corycaeus lautus* Dana
95. *Corycaeus limbatus* Brady
96. *Corycaeus pacificus* F. Dahl
97. *Corycaeus speciosus* Dana
98. *Corycaeus subtilis* M. Dahl
99. *Farranula* (*Corycaeus*) *rostratus* (Claus)
100. *Farranula gibbula* (Giesbrecht)

ONCAEIDAE
101. **Oncaea clevei* Früchtl
102. **Oncaea media* Giesbrecht
103. *Oncaea paraclevei* sp. nov.√
104. *Oncaea scottodicarloi* Heron & Bradford-Grieve√
105. *Oncaea venusta* f. *typica* Philippi

SAPPHIRINIDAE
106. *Copilia mirabilis* Dana
107. *Copilia quadrata* Dana
108. *Sapphirina metallina* Dana
109. *Sapphirina angusta* Dana
110. *Sapphirina gastrica* Giesbrecht

MACROCHIRONIDAE
111. *Pseudomacrochiron* sp.√

HARPACTICOIDA
CLYTEMNESTRIDAE
112. *Clytemnestra scutellata* Dana

EUTERPINIDAE
113. **Euterpina acutifrons* (Dana)

ECTINOSOMATIDAE
114. **Microsetella norvegica* Dana
115. *Microsetella rosea* (Dana)

MIRACIIDAE
116. *Distioculus minor* (Scott)√
117. **Macrosetella gracilis* Dana

√ New records for the study area.
* One of the 20 most abundant species in the entire collection.

4.4.10 Sea cucumber

The marine sea cucumber species from the various islands of Peninsular Malaysia are listed in Table 36.

Table 36. Sea cucumber Species of Penisnsular Malaysia (Baine & Forbes, unpublished. Cited in MOSTI, 2009)

Taxa	Islands				
	Pangkor	**Sembilan**	**Tioman**	**Payar**	**Langkawi**
Stichopus variegatus	x	x	x	x	x
Stichopus chloronotus			x	x	
Stichopus horrens				x	
Stichopus sp. 1			x	x	
Stichopus sp. 2			x		
Stichopus sp. 3				x	
Thelenota ananas			x		
Actinopyga echinites			x		
Actinopyga lecanora			x		
Actinopyga miliaris			x		
Bohadschia argus			x		
Bohadschia graeffei			x		
Bohadschia marmorata			x	x	
Holothuria atra	x	x	x	x	x
Holothuria coluber			x		
Holothuria edulis			x		
Holothuria impatiens			x		x
Holothuria hilla			x		
Holothuria leucospilota			x	x	x
Holothuria sp. 1		x			
Holothuria sp. 2			x		
Synapta recta			x	x	
Synapta sp. 1				x	
Total	**2**	**3**	**19**	**10**	**4**

4.4.11 Marine Mammals and Turtles

The marine mammals that have been sighted or stranded in the Malaysian marine waters are listed in Table 37.There are 27 species from 8 families of marine mammals but there is generally lack of scientific studies on these mammals in Malaysia.

Table 37. Marine mammals of Malaysia (source from: National Oceans Policy Malaysia, unpublished)

Family Dugongidae	Family Delphinidae
Dugong (*Dugong dugon*)	Spinner dolphin (*Stenella longirostris*)
	Pantropical spotted dolphin (*Stenella attenuata*)
Family Balenopteridae	Striped dolphin (*Stenella coeruleoalba*)
Omura's whale (*Balaenopteridae omurai*)	Fraser's dolphins (*Lagenodelphis hosei*)
Bryde's whale (*Balaenopteridae edeni*)	False killer whale (*Pseudorca crassidens*)
Blue whale (*Balaenoptera musculus*)	Pygmy killer whale (*Feresa attenuata*)
Fin whale (*Balaenoptera physalus*)	Melon-headed whale (*Peponocephala electra*)
Non-*edeni* Bryde's whale (*Balaenoptera* sp.)	Rough-toothed dolphin (*Steno bredanensis*)
	Killer whale (*Orcinus orca*)
Family Ziphiidae	Risso's dolphin (*Grampus griseus*)
Cuvier's beaked whale (*Ziphius cavirostris*)	Short-finned pilot whale (*Globicephala macrorhynchus*)
Ginkgo-toothed whale (*Mesoplodon ginkgyodens*)	Indo-Pacific humpback dolphin (*Sousa chinensis*)
	Irrawaddy dolphin (*Orcaella brevirostris*)
Family Physeteridae	Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)
Sperm whale (*Physeter macrocephalus*)	Long-beaked common dolphin (*Delphinus capensis*)
Family Kogiidae	Common bottlenose dolphin (*Tursiops truncatus*)
Pygmy sperm whale (*Kogia breviceps*)	
	Family Phocoenidae
	Finless porpoise (*Neophocaena phocaenoides*)

Three species of turtles are found on the west coast of Peninsular Malaysia. These include the more widely distributed green turtle (*Chelonia mydas*), followed by the hawksbill turtle (*Eretmochelys imbricata*) and the olive ridley turtle (*Lepidochelys olivacea*) which is on the verge of extinction (Chan, 2006). The leatherback turtle (*Demochelys coriacea*) is however, not found on the west coast of Peninsular Malaysia. Among the turtles, the green turtle and the hawkbill turtle are important on the west coast of Peninsular Malaysia. The green turtle is known to nest mostly in Perak (Pantai Remis) but it is also found in Melaka, Penang and Kedah. The hawksbill turtle’s main nesting area is in Melaka while the olive ridley’s nesting area is fragmentary and isolated to Penang Island.The turtle populations on the west coast of the peninsular are in the decline (Chan 2007) but the hawksbill nesting population in Melaka has somewhat reached a stable population numbering approximately 200 nests per year (Chan, 2006) (Table G). Sharma & Hiew (2003) noted that Segari Beach, Perak (for the green turtle), Pulau Upeh and Tanjung Tuan at Pengkalan Balak for the hawksbill turtle (Melaka) are important turtle nesting areas.

The leatherback (*Demochelys coriacea*), hawksbill (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea*) and the green (*Chelonia mydas*) are the four turtles that nest along the shores of the east coast of Peninsular and the east coast islands. The distribution of the turtles along the coastal and islands is given in Table 38. The Hawksbill and the Green turtles are associated with islands, coral reefs and the sea grasses. The Green turtle is more widely distributed and its important nesting sites are in Terengganu (P. Redang, P. Perhentian, Kemaman & Kerteh) and Pahang (Chendor and Cherating) (Chan, 2006). The population of the Hawksbill turtle is low and found only in Terengganu and Johor while the nesting status of the olive ridley is not well understood. Turtle nesting trends on the east coast and the islands showed dramatic decline for the leatherback, olive ridley and the hawksbill turtles from Terengganu and the data suggests virtually extinct local populations (Chan, 2006). Past records have indicated that the leatherback population has dropped drastically from 10,000 annual nesting in 1950 to a dozen sightings in recent years and the cause of decline has mainly been centred on egg exploitation (Chan, 2006). The income from turtle collection in Terengganu has been estimated at around RM100,000 $year^{-1}$ (US$27,000).

Table 38. Distribution of turtles on the east coast of Peninsular Malaysia (MIMA, 2006)

State	**Area/Island**	**Species**
Kelantan	Tumpat Pantai cahaya Bulan Pantai Bachok Pantai Semarak	*Chelonia mydas*
Terengganu	P. Perhentian, P. Penarik, P. Redang	*Chelonia mydas* *Eretmochelys imbricata* *Lepidochelys olivacea*
	P. Kapas, Rantau Abang, P. Kerengga	*Chelonia mydas* *Demochelys coriacea*
	Dungun, Paka, Kemaman	*Chelonia mydas* *Eretmochelys imbricata* *Lepidochelys olivacea* *Demochelys coariacea*
Pahang	Pantai Cherating	*Chelonia mydas* *Demochelys coriacea*
	P. Tioman, P. Mertang, P. Seri Buat, P. Sembilang	*Chelonia mydas* *Eretmochelys imbricata*
Johor	P. Mertang, P. Sibu, P. Simbang, P. Lima	*Chelonia mydas* *Eretmochelys imbricata*

4.4.12 Marine Fishes and Fisheries

4.4.12.1 Marine Fishes

The Malaysian freshwater and marine habitats (mangroves, coral reefs, seagrass meadows, estuaries or mixed habitats) are hosts to approximately 1951 species (704 genera and 186 families) with brackish-water and marine species amounting to 81 and 1400 respectively (coral reefs with 925 species including 815 exclusive species) (Chong *et al*., 2010) (Table 39). One hundred and fifty five families are marine species while 74 families are estuarine species with 14 families (Ambassidae, Anguillidae, Ariidae, Batrachoididae, Belonidae, Clupeidae, Dasyatidae, Engraulidae, Gobiidae, Hemiramphidae, Polynemidae, Soleidae, Syngnathidae and Tetraodontidae) represented in freshwater, brackish and marine habitats. Malaysia is identified as one of the world's 12 mega-diversity centres (The Coral Triangle), which boasts the most diverse and richest coral reefs in the world (>3000 species of reef fish).

Table 39. Fish type, their Habitats and Species Richness for Malaysia (adapted from Chong *et al*., 2010)

Fish Type	Habitat	Species Richness
Brackish water (81 species)	Estuaries	326
	Mangroves	296
	Seagrass meadows	182
	Mixed mangrove and seagrass	178
Marine (1400 species)	Coral reefs	925
	Mixed mangrove and coral	110
	Coastal waters	539
	Offshore waters	100

Almost half (48%) of Malaysian fish are presently threatened to some degree, with approximately one third (27%) mostly from the marine and coral habitats requiring further scientific works to determine their status (Chong *et al*., 2010). Sixty six percent (66%) of estuarine fish species are threatened and of the 32 species of highly threatened (HT) species, 16 are largely marine–euryhaline species (Table 40 and Table 41). Among the coastal and marine habitats, the estuarine habitats (66%; 35/53) showed the highest percent and proportion of evaluated fish species that were threatened), followed by marine-euryhaline (53.8%; 112/208), coral (57%; 335/558) and mixed habitats (36%; 27/76) (Chong *et al*., 2010).

IUCN lists the main threats to fish and their habitats as anthropogenic activities such as overexploitation, habitat loss and degradation, pollution, by-catch and human disturbance that reflect development activities from region to region (Darwall *et al*., 2009). Malaysia's estuarine and marine species are threatened by habitat loss/modification (76%), overfishing (27%) and by-catch (23%). Brackish-water, euryhaline and marine fishes are threatened mainly by anthropogenic activities such as overfishing, by-catch and habitat modification (Table 42 and

Table 43) while sedimentation additionally threatens coral-reef fishes (Chong *et al*., 2010). Global data across spatial and temporal scales show that as marine biodiversity declines, the capacity for coastal and marine waters to provide food, maintain water quality and recover from perturbations becomes severely impaired. Biodiversity losses in coastal ecosystems impair ecosystem services related to fisheries such as nursery, breeding and spawning habitat functions and filtering and detoxification services as provided by suspension feeders, submerged vegetation and wetlands.

Table 40. Threatened Marine Water Fish Species of Malaysia (adapted from Chong *et al*., 2010 (HT – Highly threatened; MT – Moderately threatened; TC – Threat category; TL – Threat level)

Species	TC	TL		Species	TC	TL
Aetomylaeus maculatus	HT	5		*Fisturia petimba*	MT	4
Aetomylaeus nichofii	HT	5		*Forcipiger longirostris*	MT	4
Antennarius commerson	HT	5		*Grammatobothus polyopthalmus*	MT	4
Antennarius striatus	HT	5		*Gunnelichthys curiosus*	MT	4
Apogon cavitensis	HT	5		*Gunnelichthys viridescens*	MT	4
Brachirus orientalis	HT	5		*Gymnocranius microdon*	MT	4
Carcharhinus hemiodon	HT	5		*Himantura bleekeri*	MT	4
Cynoglossus macrostomus	HT	5		*Himantura granulata*	MT	4
Kurtus indicus	HT	5		*Hologymnosus annulutas*	MT	4
Lampris guttatus	HT	5		*Hologymnosus doliatus*	MT	4
Lutjanus stellatus	HT	5		*Ilisha kampeni*	MT	4
Paraplagusia bilineata	HT	5		*Inimicus didactylus*	MT	4
Pristis microdon	HT	5		*Johnius amblycephalus*	MT	4
Pristis zijsron	HT	5		*Kumococius rodericensis*	MT	4
Scorpaenodes guamensis	HT	5		*Larimichthys polyactis*	MT	4
Terapon puta	HT	5		*Lethrinus microdon*	MT	4
Acanthurus bariene	MT	4		*Lethrinus miniatus*	MT	4
Acanthopagrus berda	MT	4		*Lethrinus rubrioperculatus*	MT	4
Acanthosphex leurynnis	MT	4		*Letrhinus xanthochilus*	MT	4
Albula vulpes	MT	4		*Liza tade*	MT	4
Alectis ciliaris	MT	4		*Lutjanus boutton*	MT	4
Alepes kleinii	MT	4		*Lutjanus fulvus*	MT	4
Amblyglyphidodon indicus	MT	4		*Lutjanus rivulatus*	MT	4
Anacanthus barbatus	MT	4		*Lutjanus sanguineus*	MT	4
Anampses melanurus	MT	4		*Lutjanus sebae*	MT	4
Anguilla nebulosa	MT	4		*Manta birostris*	MT	4
Anomalops katoptron	MT	4		*Naso brachycentron*	MT	4
Antennaris pictus	MT	4		*Naso lopezi*	MT	4
Antennarius dorehensis	MT	4		*Nemipterus celebicus*	MT	4

Aprion virescens	MT	4		*Nibea chui*	MT	4

Table 40 (continued)

Arius arius	MT	4		*Ophichthus altipennis*	MT	4
Arnoglossus tapeinosoma	MT	4		*Otolithoides biauritus*	MT	4
Arothron immaculatus	MT	4		*Parachaetodon ocellatus*	MT	4
Atherinomorus duodecimalis	MT	4		*Paramonacanthus pusillus*	MT	4
Belonoperca chabanaudi	MT	4		*Pardachirus pavoninus*	MT	4
Bregmaceros mclellandi	MT	4		*Parupeneus ciliatus*	MT	4
Cantherhines fronticinctus	MT	4		*Pennahia argentata*	MT	4
Caranx lugubris	MT	4		*Pictichromis diadema*	MT	4
Caranx papuensis	MT	4		*Platax batavianus*	MT	4
Chaetodon burgessi	MT	4		*Plectorhinchus schotaf*	MT	4
Chaetodon decussatus	MT	4		*Plectorhinchus vittatus*	MT	4
Chaetodon plebeius	MT	4		*Plectroglyphidodon leucozonus*	MT	4
Chaetodon triangulum	MT	4		*Pomacanthus semicirculatus*	MT	4
Cheilinus undulatus	MT	4		*Pomacentrus pavo*	MT	4
Chirocentrus nudus	MT	4		*Pomadasys argyreus*	MT	4
Chlorurus bleekeri	MT	4		*Pristotis obtusirostris*	MT	4
Chromis ovatiformes	MT	4		*Pseudorhombus diplospilus*	MT	4
Chrysiptera bleekeri	MT	4		*Pseudorhombus elevatus*	MT	4
Chrysiptera brownriggii	MT	4		*Pseudorhombus natalensis*	MT	4
Chrysochir aureus	MT	4		*Rastrelliger faughni*	MT	4
Cociella crocodilus	MT	4		*Rhinobatos schlegelii*	MT	4
Congrogadus subducens	MT	4		*Saurida gracilis*	MT	4
Coradion melanopus	MT	4		*Scomber japonicus*	MT	4
Cosmocampus banneri	MT	4		*Scomberoides tala*	MT	4
Cyclichthys orbicularis	MT	4		*Scorpaenopsis venosa*	MT	4
Cyclichthys spilostylus	MT	4		*Sillago chondropus*	MT	4
Cygnoglossus cygnoglossus	MT	4		*Solea elongata*	MT	4
Cymolutes torquatus	MT	4		*Solenostomus cyanopterus*	MT	4
Dascyllus carneus	MT	4		*Sphyrna lewini*	MT	4
Decapterus macarellus	MT	4		*Stegates nigricans*	MT	4
Decapterus macrosoma	MT	4		*Stegostoma fasciatum*	MT	4
Dentex angolensis	MT	4		*Stenatherina panatela*	MT	4
Encrasicholina heteroloba	MT	4		*Symphorus nematophorus*	MT	4
Engyprosopon grandisquama	MT	4		*Synaptura commersonnii*	MT	4
Epinephelus amblycephalus	MT	4		*Syngnathoides biaculeatus*	MT	4
Epinephelus corallicola	MT	4		*Taenianotus triacanthus*	MT	4
Epinephelus multinotatus	MT	4		*Taeniura meyeni*	MT	4
Etelis carbunculus	MT	4		*Temera hardwickii*	MT	4
Euthynnus affinis	MT	4		*Tetrosomus gibbosus*	MT	4
				Torpedo fuscomaculata	MT	4

Table 41. Marine Fish Families that are Threatened (adapted from Chong *et al*., 2010)

Acanthuridae	Fistulariidae	Pseudochromidae
Albulidae	Haemulidae	Rhinobatidae
Anguillidae	Labridae	Scaridae
Anomalopidae	Lampridae	Sciaenidae
Antennariidae	Lethrinidae	Scombridae
Anthennariidae	Lutjanidae	Scorpaenidae
Aploactinidae	Lutjanidae	Scorpaenidae
Apogonidae	Microdesmidae	Serranidae
Ariidae	Monacanthidae	Sillaginidae
Atherinidae	Mugilidae	Soleidae
Bothidae	Mullidae	Soleidae
Bregmacerotidae	Myliobatidae	Solenostomidae
Carangidae	Myliobatidae	Sparidae
Carcharhinidae	Narcinidae	Sphyrnidae
Chaetodontidae	Nemipteridae	Stegostomatidae
Chirocentridae	Ophichthidae	Synanceiidae
Cynoglossidae	Ostraciidae	Syngnathidae
Cynoglossidae	Paralichthyidae	Synodontidae
Dasyatidae	Platycephalidae	Terapontidae
Diodontidae	Pomacanthidae	Tetraodontidae
Engraulidae	Pristidae	Torpedinidae
Ephippidae	Pristigasteridae	

Table 42. Threat Status or Extinction and Intrinsic Vulnerability to Local Extinction for marine Fishes of Malaysia (adapted from Chong *et al*., 2010) (Values indicated are Species Richness)

Habitat	Threat Status or Extinction Risk					Intrinsic Vulnerability to Local Extinction, I_v			
	1	**2**	**3**	**4**	**5**	**0 to <25**	**25 to <50**	**50 to <75**	**75 to 100**
Marine	184	3	18	17	3	58	102	41	16
Marine-Euryhaline	42	96	73	27	12	13	123	36	14
Coral-Reef	227	253	261	74		386	358	64	3
Mixed-Coral	34	49	22	5		26	61	17	3

The intrinsic vulnerability index (I_V) of each fish species is defined as the risk of localextinction associated with the life-history and ecological characteristics of the fish (Cheung*et al*., 2005) based on maximum length, age at first maturity, Von Bertalanty growth function (VBGF) parameters, natural mortality, maximum age, fecundity, spatial behaviour strength and geographic range. I_V (from Fishbase) are classified as follows: low (IV values from 1 to <25), moderate (25 to <50), high (50 to <75) and very high (75 to 100)

Table 43. Anthropogenic Threats to Malaysian Coastal and Marine Fishes (adapted from Chong *et al*., 2010)

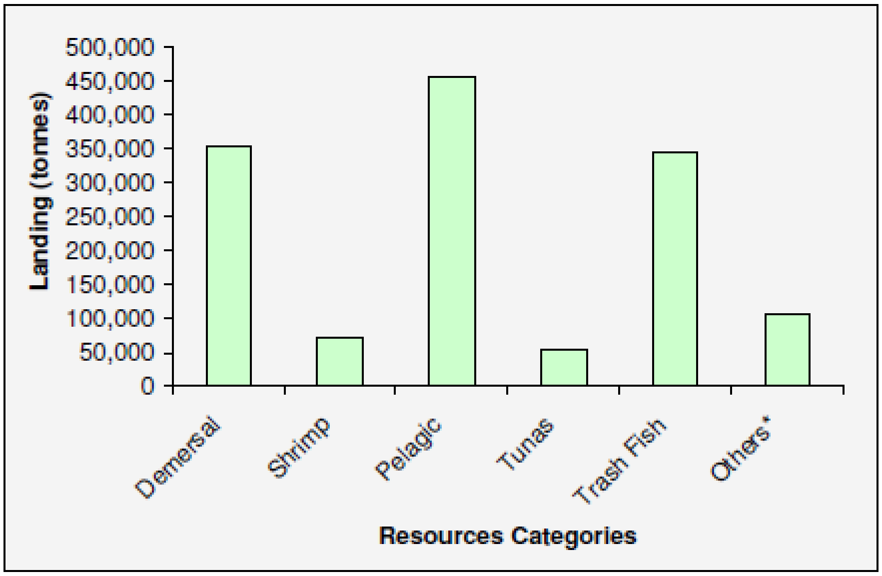
Fish Type	Anthropogenic Threats to Fish Species							
	No of Species	**Threatened**	**Over Harvesting**	**By Catch**	**Habitat Degradation**	**Pollution**	**Human Disturbance**	**Endemicity**
Brackish Water	81	35	6	6	25	1	5	0
Marine-Euryhaline	250	112	62	83	69	8	64	1
Marine	225	38	24	30	17	1	18	1
Mixed-Coral	110	27	11	4	11	1	9	0
Coral	815	335	73	95	213	115	4	0
Percentage (%)			**27.1**	**23.3**	**76.0**	**16.0**	**11.5**	**3.9**

4.4.12.2 Marine Fisheries

The marine fisheries sector plays an important role in Malaysia's culture and economywhere its contribution to the Gross Domestic Product (GDP)in 2007 was about 1.2% (Department of Fisheries, 2009). The fisheries sector is a source of food and employment opportunity (either directly or in associated industries) and it is an earner of foreign exchange (Jamaludin, 2004). In 2007, the fisheries industry provided direct employment to 99,617 fishermen. The majority, (66,732) worked in Peninsular Malaysia, while 21,445 were in Sabah and 11,440 in Sarawak (Department of Fisheries, 2009). The per capita fish consumption of Malaysians in 2010 was 56 kg making fish a strategic food commodity (Abdullahi *et al*., 2010).

The total marine landings in Malaysia for the year 2007 amounted to 1,381,424 tonnes valued at RM5.04 billion. Inshore landings (1,117,056 tonnes or RM4.17 billion) contributed about 81% of the total marine landings, while the deep-sea landings only contributed 19% (264,367 tonnes or RM0.87 billion) (Department of Fisheries, 2009). Landings in Malaysia can be divided into six (6) types of resources categories i.e. demersals, shrimp, pelagics, tunas, trash fish and others (squids, crabs, jellyfish and shellfish). Pelagic fish was the most dominant amounting to 32.9% or 454,076 tonnes in 2007, followed by demersals (25.5% or 352,315 tonnes) and trash fish (24.8% or 342,971 tonnes) (Figure 4).Other categories only constituted around 3.8 – 7.7% of total marine landings. Pelagic and demersal fish had a higher commercial value as compared to other resources categories. Pelagic fish accounted for 37.5% (RM2.12 billion) of total wholesale value, followed by demersals (26.3% or RM1.48 million) and shrimp (16.5% or RM0.93 billion), where retail values were concerned, however, the demersal fish accounted for 35.4% (RM2.89 billion), followed by pelagics (31.7% or RM 3.23 billion) and shrimp (12.2% or RM 1.11 billion). The wholesale and retail values by resource categories from 2003-2007 is given in Table 44.

Figure 4. Fisheries Landings by Resource Category in Malaysia in 2007



Source: Department of Fisheries, 2009

Table 44. Fisheries Retail Value by Resource Category for Malaysia (2003-2007)

Resources Category	Year				
	2003	2004	2005	2006	2007
Demersal	1,643,373	1,792,389	1,764,382	1,928,953	3,231,273
Shrimp	1,211,048	1,320,960	949,538	1,026,720	1,113,290
Pelagic	2,150,378	2,365,326	2,356,701	2,676,247	2,890,720
Tunas	283,641	240,286	260,518	308,995	309,420
Trash Fish	155,676	181,260	141,656	171,399	617,348
Others*	731,993	763,940	550,550	881,704	957,039
Total (RM/tonnes)	6,176,109	6,664,159	6,023,346	6,994,020	9,119,089

* Include Squids, Crabs, Jellyfish and Shellfish

Source: Department of Fisheries, 2005 – 2009

The major fishes (either demersal orpelagic, or by species or species groups) that contribute to Malaysia's fisheries include Pelaling (*Rastrelliger* spp.), Kembong (*Rastrelliger* spp.), Selayang (*Decapterus* spp.), Gelama (*Pennahia* spp./*Johnius* spp.), Menkerong (*Saurida* spp./*Trachinocephalus* spp.), Kerisi (*Nemipterus* spp./*Pentapodus* spp.), Aya Hitam (*Thunnus tonggol*), Aya Kurik (*Euthynnus affinis*), Pari (*Himantura* spp./*Gymnura* spp./*Myliobatis* spp./*Aetobatus* spp.), Tamban (*Sardinella* spp./*Dussumieris*spp.), Demuduk/Rambai (*Carangoides* spp.), Biji Nangka (*Upeneus* sp./*Parapeneus* spp.), Tenggiri (*Scomberomorus* spp.) and Cincaru (*Megalapis cordyla*). The invertebrates include shrimps such as Udang Puteh (*Matapenaeus lysianassa*), Udang Kulit Keras (*Parapenaeopsis* sculptilis) Udang Pasir Kecil (*Metapeneopsis stridulans*), Udang Putih Besar (*Penaeus merguiensis*) Udang Merah (*Panaeus latisucatus*); squids like Sotong Biasa (*Loligo* spp.) and Sotong Katak (*Sepia* spp.); Ubur-Ubur (*Rhopilema* spp.), and Ketam Laut (*Portunus pelagicus*).

A review by Stobutski *et al* (2006) of theresource assessments undertaken by the Department ofFisheries indicated that Malaysia's demersal fisheries stocks had declined by 80 -96% since the 1970s being affected by pollution, decimation of marine habitats and overexploitation of fisheries stocks.

4.4.13 Wealth of Terrestrial and Marine Biodiversity-Reinforced Biotechnology.

The inputs for this particular section on biotechnology are largely extracted from a biodiversity-pegged article on biotechnology, as posted below, authored by the Malaysia Biotechnology Corporation, entitled "Biotechnology Industry Overview", dated 15 August, 2008.

4.4.14 Core Capabilities

Malaysia's competitive edge is its biodiversity of natural resources and strong industrial and manufacturing capabilities. Coupled with strong economic fundamentals, excellent infrastructure, political stability and skilled workforce, Malaysia has the potential and the right environment for the biotechnology industry to flourish. A National Biotechnology Policy (NPB) was formulated in 2005 by the government that outlined Malaysia's niche and competitive advantages in biotechnology.

In line with the NPB, Malaysia is taking the opportunity in this growing market to accelerate the transformation of the country into a highly industrialized nation by year 2020. Likewise, with a third of its economy still dependant on agriculture and natural resources, Malaysia has since recognized that biotechnology will enhance the productivity of these sectors while creating new opportunities for the emergence of new industrial sectors. Leveraging on excellence and adaptable human capital, Malaysia will be able to be a world player in the field of biotechnology by the year 2020 opportunities in Malaysia. Malaysia's rich biodiversity offers vast opportunities for investors venturing into the fields of genomics, proteomics, and structural biology for discovery of new products or improved existing products. Over 1,000 species of flora are reported to have therapeutic value that can be tapped for medicinal potential. Other areas include:

- Food biotechnology/agro-biotechnology.
- Biopharmaceuticals (antibodies/vaccines).
- Nutraceuticals.
- Biodiagnostics.
- Industrial Enzymes.
- Strategic alliances and research partnership/joint discovery of bioactive compounds for healthcare.
- Skilled Human Resource.

Malaysia's current National Education Policy emphasizes on science and technology in the country's 37 institutions of higher learning. There are 13 universities offering biotechnology programmes and 12 universities offering chemical engineering programmes with about 3.000 undergraduate studying biotechnology annually. There are about 23,000 research personnel and more than 5,000 R&D scientists and skilled workforce are expected to be available over the next five years. Malaysia provides key components to biotechnology value chain

4.4.15 Regulatory Framework

Malaysia has a strong intellectual property rights (IPR) regime and ranks high among East Asian countries in IPR protection. Malaysia is a member of the World Intellectual Property Organisation (WIPO) and signatory to the Paris Convention, the Berne Convention and the

Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) under the World Trade Organisation (WTO). Malaysia also has acceded to Patent Cooperation Treaty (PCT) with effect from 16th August, 2006.

4.4.16 Government Programmes and Policies

The objective of biotechnology development will be to harvest the potential as a growing source of wealth creation. The target of the Ninth Malaysian Plan will be to at least double the number of biotechnology and biotechnology-related companies to 400 in 2010. Furthermore, the Ninth Malaysian Plan will focus on implementing the New Biotechnology Policy to develop Malaysia's niches in agriculture biotechnology, healthcare-related biotechnology, industrial biotechnology as well as bioinformatics. In this regard, the promotion of foreign and domestic investments and close collaboration with foreign entities to access new technology, markets and expertise will be intensified.

The government has allocated RM2 billion to implement under the Ninth Malaysian Plan to cover the development of biotechnology in agriculture, healthcare, industry and bio-informatics. Of the RM2 billion 45.9% will be used to develop physical infrastructure and the balance will be for R&D and commercialization as well as business development.

Furthermore, under the 2006 Budget the Malaysian government has announced the setting up of the Malaysian Life Science Capital Fund. The fund will be launched with RM100 million and it is expected that Government-linked companies and private investors both foreign and local top up the fund. The fund will invest 70% of the fund in about 20 local and foreign companies, while the remaining 30% will be invested in Burill Life Science Capital Fund.

Notably, the National Biotechnology Policy of Malaysia was launched by the Prime Minister, on 28 April, 2005, and it refers to nine specific thrusts:

Thrust 1: Agriculture Biotechnology Development.

Thrust 2: Healthcare Biotechnology Development.

Thrust 3: Industrial Biotechnology Development.

Thrust 4: R&D and Technology Acquisition.

Thrust 5: Human Capital Development.

Thrust 6: Financial Infrastructure Development.

Thrust 7: Legislative and Regulatory Framework Development.

Thrust 8: Strategic Positioning.

Thrust 9: Government Commitment.

Initiatives pursued under the National Biotechnology Policy are implemented within timeframe of the Biotechnology Master Plan from 2005-2020.

4.4.17 Economic Contributionsand Market Capitalisation

Globally, there are more than 5,000 biotechnology companies with a market capitalization of US$700 billion (RM2.660 billion) and an annual turnover of US$50 billion (RM190 billion). Together, these companies are expected to create a biotechnology value chain worth estimated US$1,8 trillion (RM6.84 trillion) by 2010.

Malaysia has identified biotechnology to be the new engine of growth for the country and with its rich biodiversity and cost-competitive skilled labour markets combined with good transportation and ICT infrastructure as well as strong support in R&D, the country is an attractive destination for foreign biotechnology companies. Biotechnology as a key driver of growth for Malaysia is expected to generate RM270 billion in revenue for the country by 2020.

With the increasing global competition the Malaysian Government has decided to focus on developing Malaysia's niches in agriculture biotechnology, healthcare-related biotechnology, industrial biotechnology as well as bioinformatics.

The biotechnology sector's contribution is expected to be approximately 2.5 % by 2010, 4.0% by 2015 and 5.0% by 2020. Furthermore, it is estimated that the sector by 2020 has created 280,000 new jobs – both directly and indirectly. In addition, it is expected that 100 biotechnology companies will be established in Malaysia over the next 15 years.

4.4.18 Global Market Capitalization Growth

In 2006, USD 153.7 billion Growth.
In 2005 USD 136.5 billion Growth.
In 2007, RM 2.5 billion Malaysian Market Capitalization Growth.

In 2007, the numbers of Malaysian biotechnology companies listed were:

In the healthcare sector	7
In the other sectors	4
The total number of companies	11

4.4.19 Bionexus Status

BioNexus status is a designation awarded to qualifying biotechnology companies, making them eligible for privileges contained within the BioNexus Bill of Guarantees. (Bionexus companies statistics; as at 31 March, 2008.)

4.4.20 Research and Development

Malaysia provides strong R&D support especially with the government funding for R&D, human resources development and infrastructure. There are established research institutions housing modern facilities and state-of-the art equipment for biotechnology research. Strong R&D expertise in the country's long established agriculture and food industry particularly for industrial crops (oil palm, rubber, rattan, forest trees), food crops (rice, banana, sago, herbs and medicinal plants) and ornamentals (orchids, pitcher plants). Specialized science and technology parks, incubation centres and clinical trial centres are available to cater to the needs of biotechnology and other technology-intensive industries and R&D activities.

Included among the various biotechnology collaborative partners of Malaysia, which are located elsewhere, are the following:

- Massachusetts Institute of Technology (MIT), USA.
- National Cancer Institute, USA.
- Medichem Research of Lemont, Illinois, USA.
- Nimura Genetic Solutions, Japan.
- Functional Food Creation Research Institute Co. Ltd., Japan.
- Cambridge University, UK.
- Centre for Genetic Engineering and Biotechnology, Cuba (CIBG)

Malaysia is currently on an accelerated and sustained economic growth pathway towards achieving its Vision of 2020 by way of a Knowledge-based Economy (9MP, 2007), that is reinforced by strategic Research and Development (R&D) and Science, Technology and Innovation (STI). In this context, the Government would therefore be continuing to shift from a production- and resource-based economic growth to a knowledge-based economic growth. Hence, Malaysia's development paradigm is correspongingly oriented for the generation of knowledge that would in turn create and sustain economic growth and wealth generation for the societal and the environmental, including biodiversity, well-being of Malaysian and its citizens. The R&D and STI investments and interventions of the Government clearly reflects its commitments to be further elevating its future efforts and its performances, and also its capacity and capability to undertake the required R&D and STI. The aforesaid trends are well documented by the various indicators depicted in Table 45 and Table 46 and Figures 5, 6, 7 8, and 9.

Table 45. Total R&D Expenditures as a Percentage of GDP's of Various Countries (sourced from: Interim Report, 2011)

National R&D Highlights - 2005	M'SIA*	SPORE	TAIWAN	JAPAN	USA
Total R&D on Expenditure (US$ million)	1,136	2,753	8,735	146,001	312,535
R&D Expenditure as percentage of GDP	0.64	2.36	2.52	3.17	2.67
Researchers per 10,000 labour force	17.9	118.01	NA	125.03	89.6
Total Expenditure On R&D per capita (US$)	42.6	634.0	383.6	1,143.4	1,064.3

In 2007, a total of 194 biotechnology research projects were approved and funded under the aegis of the Science, which was introduced by the Government in its Ninth Malaysia Plan, for seven priority areas, viz. Plant Biotechnology, Animal Biotechnology, Food Biotechnology, Molecular Biology, Biopharmacy, Medical Biotechnology and Industry/Environment Biotechnology.

Figure 5. Science Fund Allocation According to Biotechnology Priority Areas in Malaysia until October 2007 (RM Million)(sourced from: Interim Report, 2011)

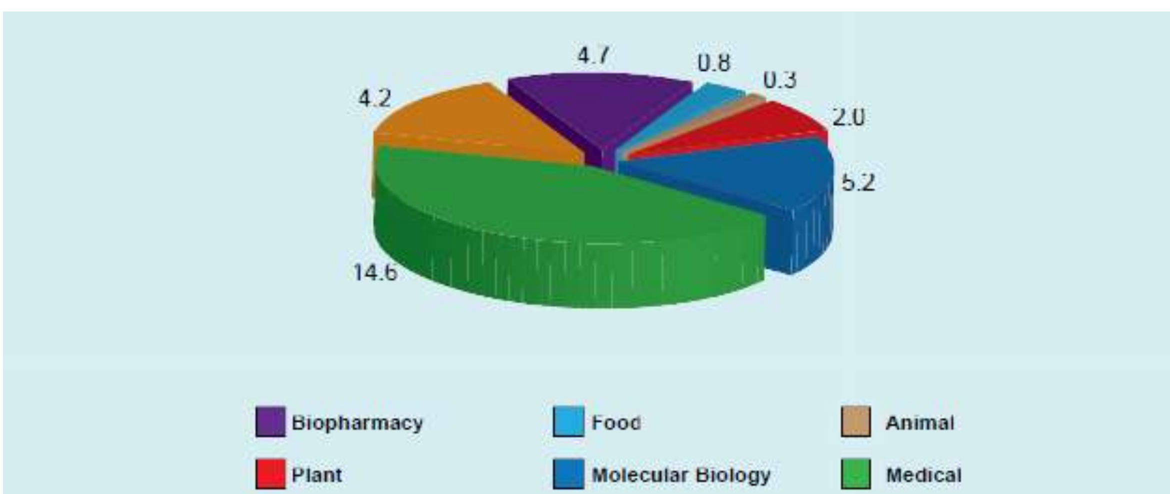


Figure 1: Science Fund allocation according to Biotechnology Priority Areas until October 2007 (RM Million)

Table 46. R&D-related Expenditures Contracted to Government Research Institutes (GRIs), Private Sectors, Instututes of Higher Learning (IHLs), and Other Institutes in Malaysia and Elsewhere (sourced from: Interim Report, 2011)

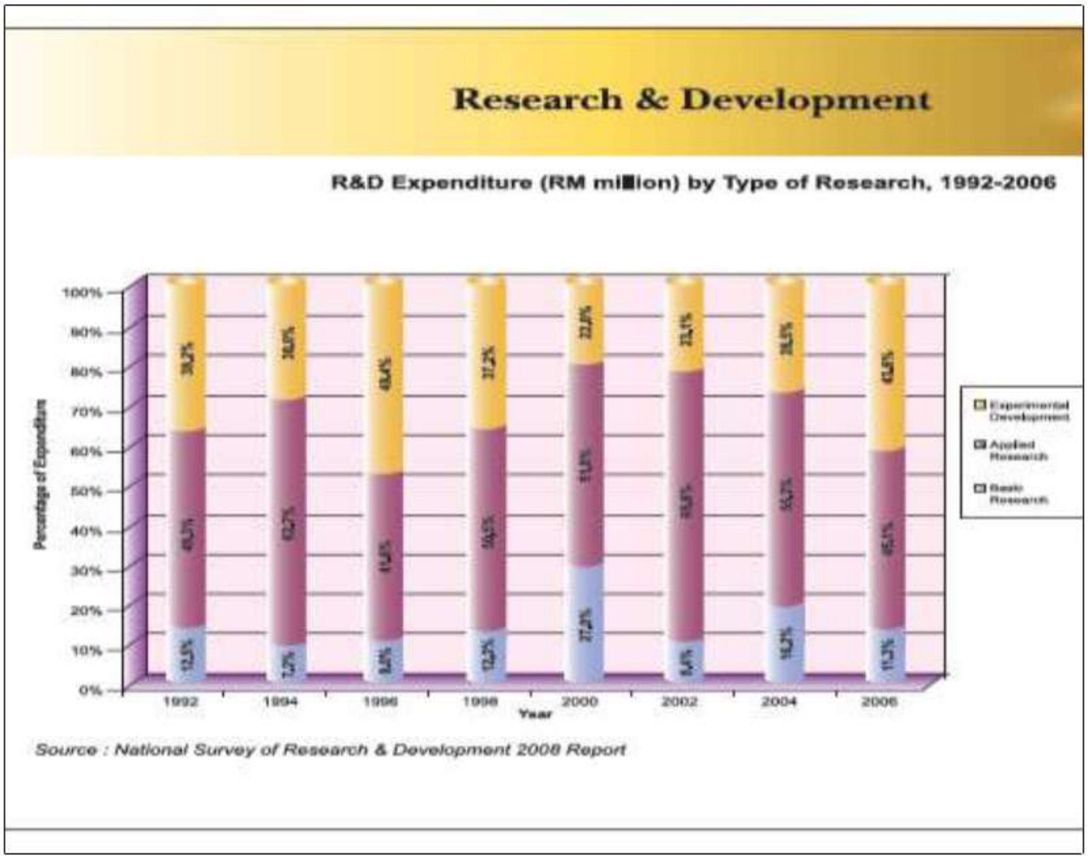
***Table 11*: Extramural R&D Expenditure (RM)**

Contracted out to	Year				
	1992	1994	1996	1998	2000
Government Research Institutes	293,198.00	373,231.00	2,204,584.00	4,789,585.32	5,249,543.00
Private Sector	314,000.00	2,952,619.00	249,747.00	3,322,043.00	10,152,927.00
Institute of Higher Learning	863,223.00	3,178,755.00	2,750,265.00	8,375,856.41	419,445,027.00
Other Malaysian Institutes	68,000.00	383,700.00	60,000.00	73,190.00	1,565,971.00
Overseas	48,346,500.00	34,938,400.00	52,880,018.00	58,643,989.87	132,725,209.00
Total	**49,884,921.00**	**41,826,705.00**	**58,144,614.00**	**75,204,664.60**	**569,138,677.00**

Source: 2000 National Survey of Research & Development

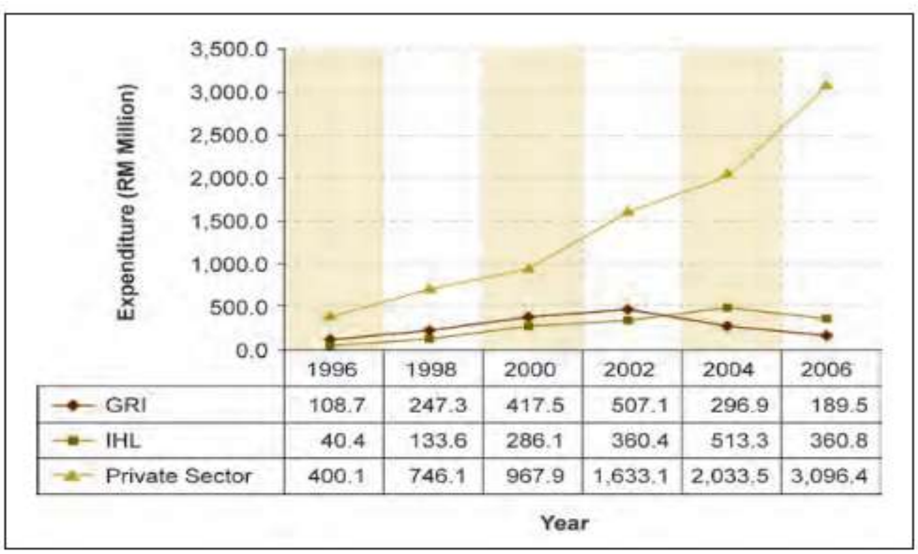
Notably, albeit the R&D expenditures seemed to decline over the period for both GRIs and IHLs, it, however, simultaneously increased almost exponentially for the private sector.

Figure 6. R&D Expenditure (RM Million) by Type of Research in Malaysia, 1992-2006 (sourced from: Interim Report, 2011)



Source: MOSTI Facts and Figures 2008, Pg 21

Figure 7. Trends in the Allocation of R&D Expenditure as per the Different Sectors in Malaysia, 1996-2006 (sourced from: Interim Report, 2011)

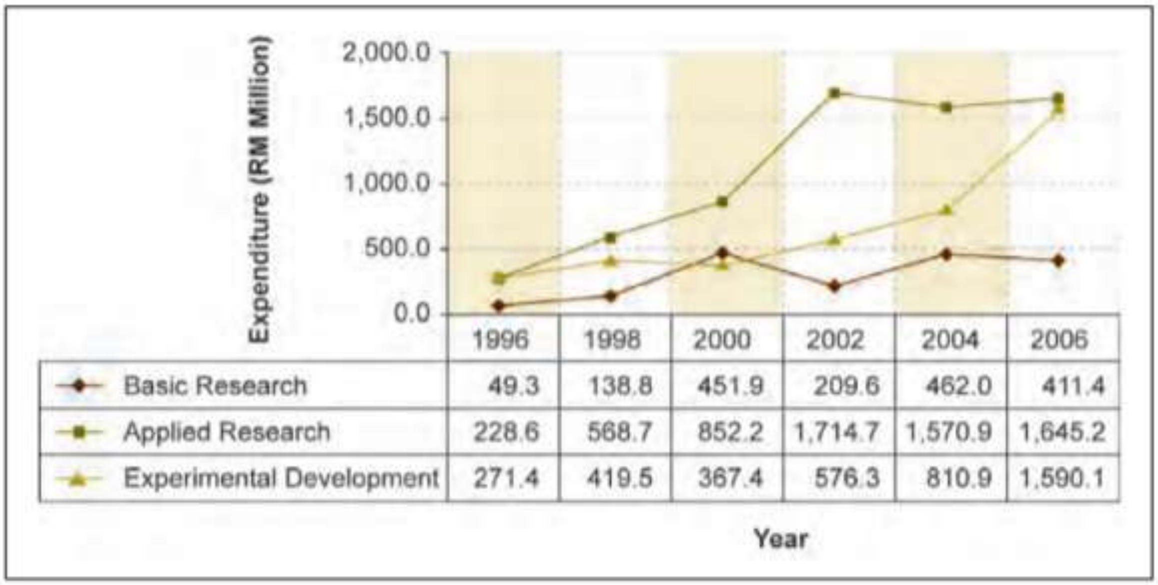


	1996	1998	2000	2002	2004	2006
GRI	108.7	247.3	417.5	507.1	296.9	189.5
IHL	40.4	133.6	286.1	360.4	513.3	360.8
Private Sector	400.1	746.1	967.9	1,633.1	2,033.5	3,096.4

Source: National Survey of Research & Development 2008 Report

Three types of R&D and STI had been indentified and categorized for the allocation of R&D and STI expenditures, including basic research, applied research, and experimental development research.

Figure 8. Trends in the Allocation of R&D Expenditure by Various Types in Malaysia, 1996-2006 (sourced from: Interim Report, 2011)

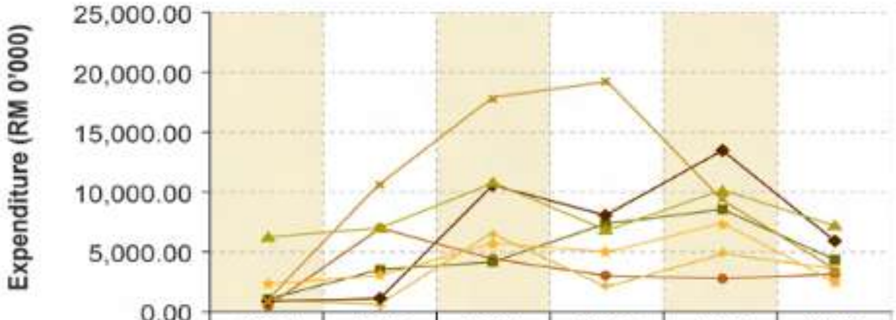


	1996	1998	2000	2002	2004	2006
Basic Research	49.3	138.8	451.9	209.6	462.0	411.4
Applied Research	228.6	568.7	852.2	1,714.7	1,570.9	1,645.2
Experimental Development	271.4	419.5	367.4	576.3	810.9	1,590.1

Source: National Survey of Research & Development 2008 Report

Figure 9. Trends in the Overall R&D Expenditures for the Top Seven Fields of Research in the public (GRIs and IHLs) (a) and the Private Sectors (b) in Malaysia, 1996-2006 (sourced from: Interim Report, 2011)

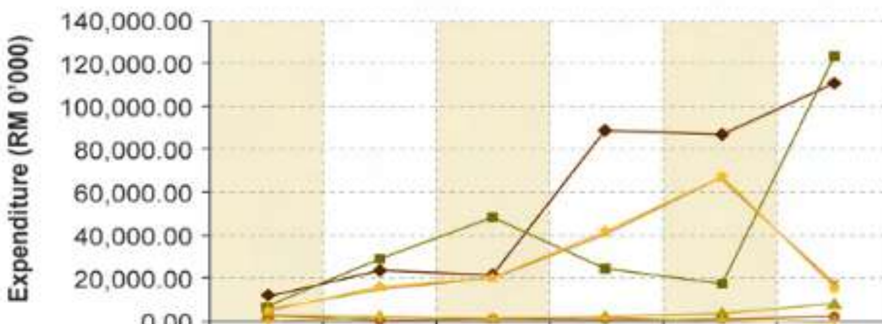
(a)



	1996	1998	2000	2002	2004	2006
Engineering Sciences	1,026.3	1,202.6	10,658.8	8,080.5	13,530.3	6,070.2
Applied Sciences & Technologies	1,017.6	3 ,417.5	4,218.0	7,451.1	8,570.2	4,323.9
Agriculture Sciences	6,258.5	6,960.6	10,878.7	6,927.7	10,439.9	7,310.2
Information, Computer & Communication Technologies	695.6	10,655.6	17,772.7	19,226.3	9,417.2	3,602.6
Biological Sciences	2,371.0	3,089.6	5,752.4	4,998.5	7,254.9	2,462.8
Chemical Sciences	507.6	6,983.0	4,478.7	3, 135.8	2,822.8	3,292.1
Social Sciences	917.85	45.4	6,437	92,147.1	4,924.4	3,525.5

Year
Public Sectors (GRIs and IHLs)

(b)

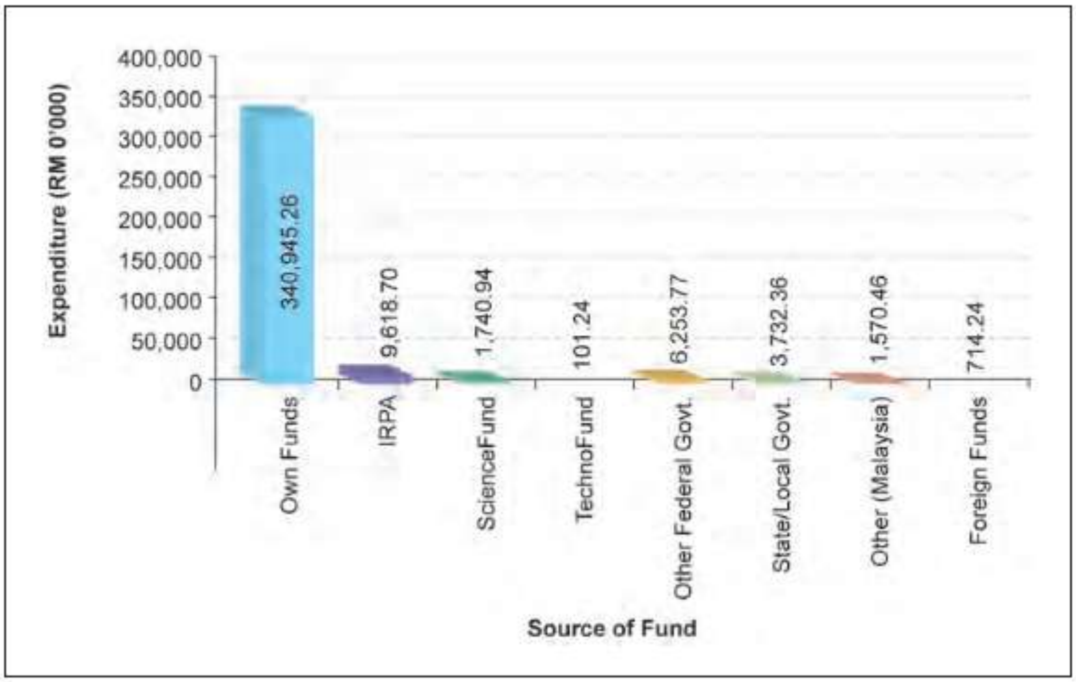


	1996	1998	2000	2002	2004	2006
Engineering Sciences	12,658.87	23,047.46	19,435.64	89,712.03	87,120.29	11,1472.48
Applied Sciences & Technologies	7,464.89	29,173.18	48,613.81	23,940.90	17,516.11	122,178.76
Agriculture Sciences	3,231.87	2,886.90	2,962.06	2,785.04	4,202.90	9,456.98
Information, Computer & Communication Technologies	5,696.11	15,642.69	20,451.32	41,779.84	67,040.83	17,119.11
Biological Sciences	372.71	301.90	1,007.90	413.49	1,591.08	5,089.34
Chemical Sciences	3,374.16	548.55	1,061.57	1,547.09	897.74	2,123.12
Social Sciences	-	985.56	434.36	123.04	199.38	-

Year
Private Sectors

As depicted in Figure10, there do exist several types of funding, such as own funds, IRPA funds, ScienceFunds, TechnoFunds, etc. for supporting R&D and STI. In this context, the main sources of funds, or of the highest expenditures, for purporses of R&D and STI do emerge from own funds or from self-generated funds earned by the respective research agencies, which is followed by other governmental grants, such as IRPA, and other Federal Governmental grants, like ScienceFunds, TechnoFunds, etc.

Figure 10. Sources of Funds (RM) in 2006 Allocated for R&D in Malaysia (sourced from: Interim Report, 2011)



Similar to that of the private institutions, the highest proportions of the expenditures among the GRIs were on applied research, followed by on basic research and experimental developmental research (Figs. 11 and 12).

Figure 11. Total Expenditure by GRIs by Types of Research in Malaysia in 2006
(sourced from: Interim Report, 2011)

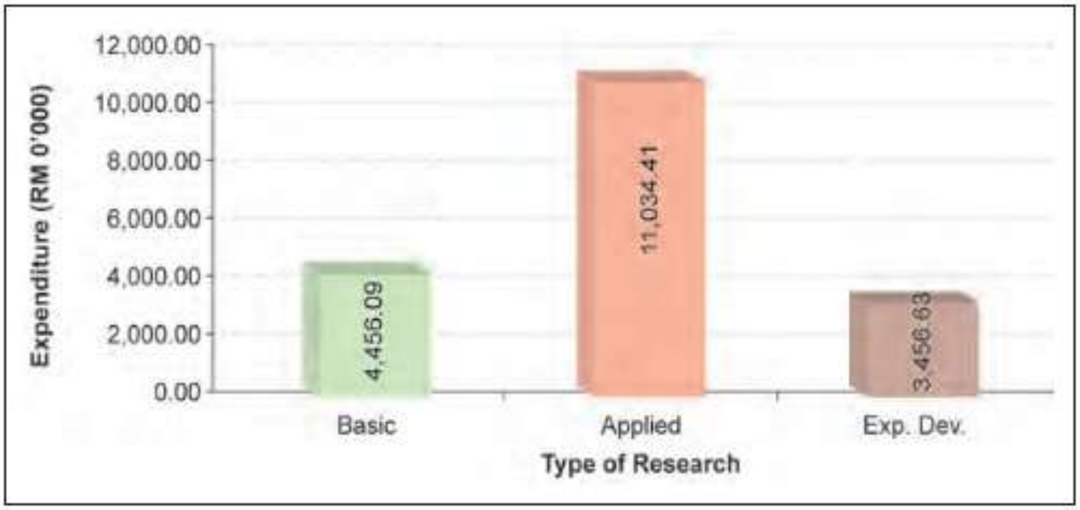
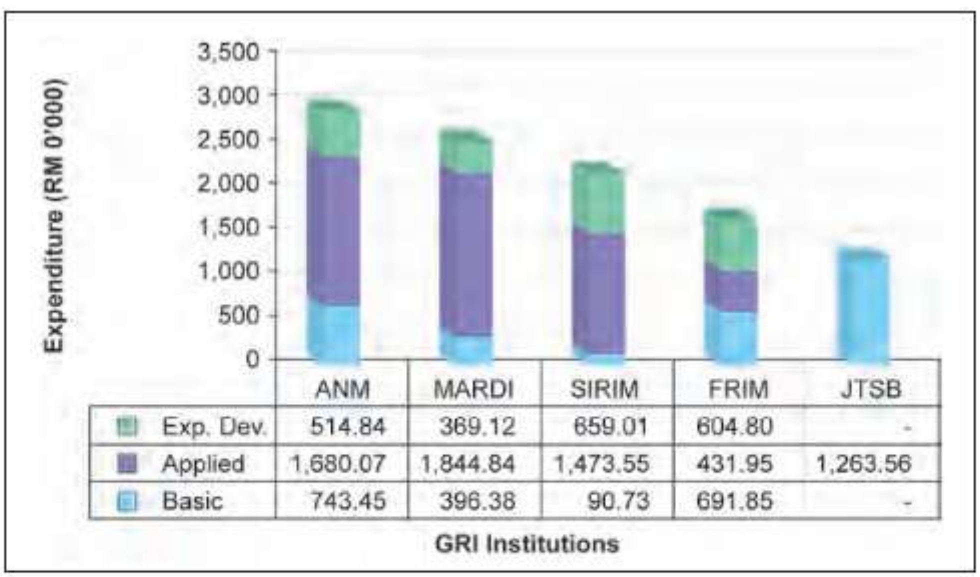
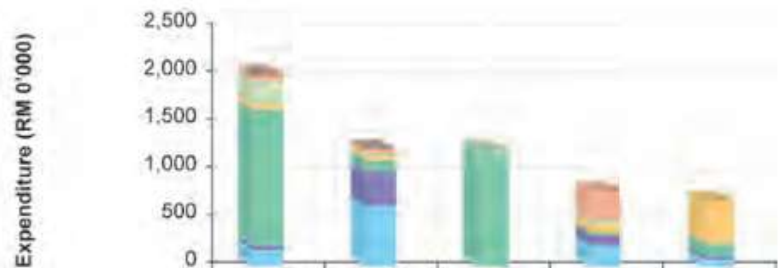


Figure 12. Expenditure by Type of Research by GRIs Institutions in 2006 in Malaysia
(sourced from: Interim Report, 2011)



As indicated in Fig 13, agricultural sciences dominated the expenditures for research among the GRI, with two other research institutions (MARDI and JTSB) also among the leaders.

Figure 13. Expenditure by GRIs by Fields of Research in 2006 in Malaysia (sourced from: Interim Report, 2011)



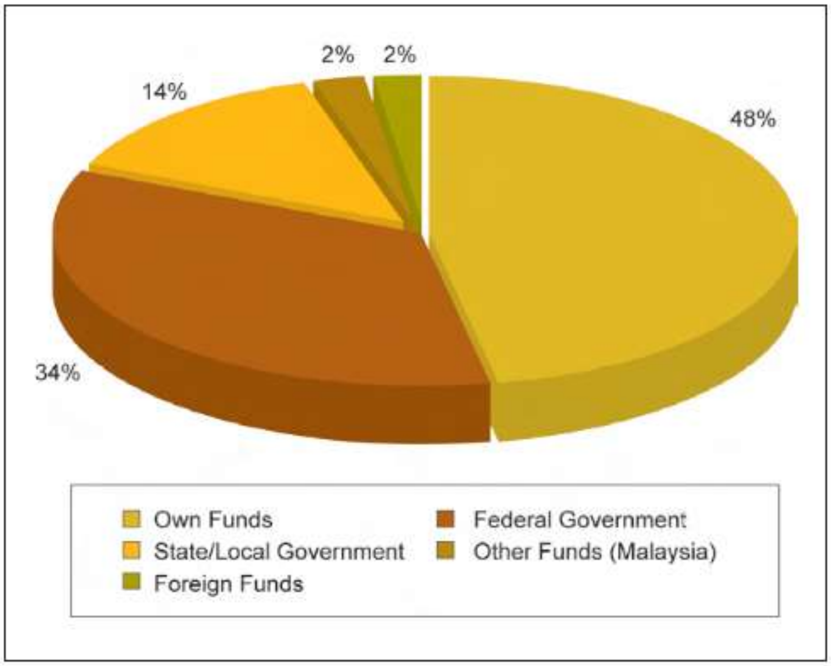
	MARDI	ANM	JTSB	SIRIM	RSM
Social Sciences	5.90	8.27	-	-	-
Chemical Sciences	44.48	24.53	-	256.82	-
Biological Sciences	241.76	16.69	14.73	57.28	-
Information, Computer & Communication Technologies	51.84	51.82	-	91.98	453.60
Agriculture Sciences	1,468.20	121.25	1,248.82	9.49	170.46
Applied Sciences & Technologies	29.78	345.13	-	130.95	21.63
Engineering Sciences	206.02	700.74	-	276.05	91.11

GRI Institutions

Source: National Survey of Research & Development 2008 Report

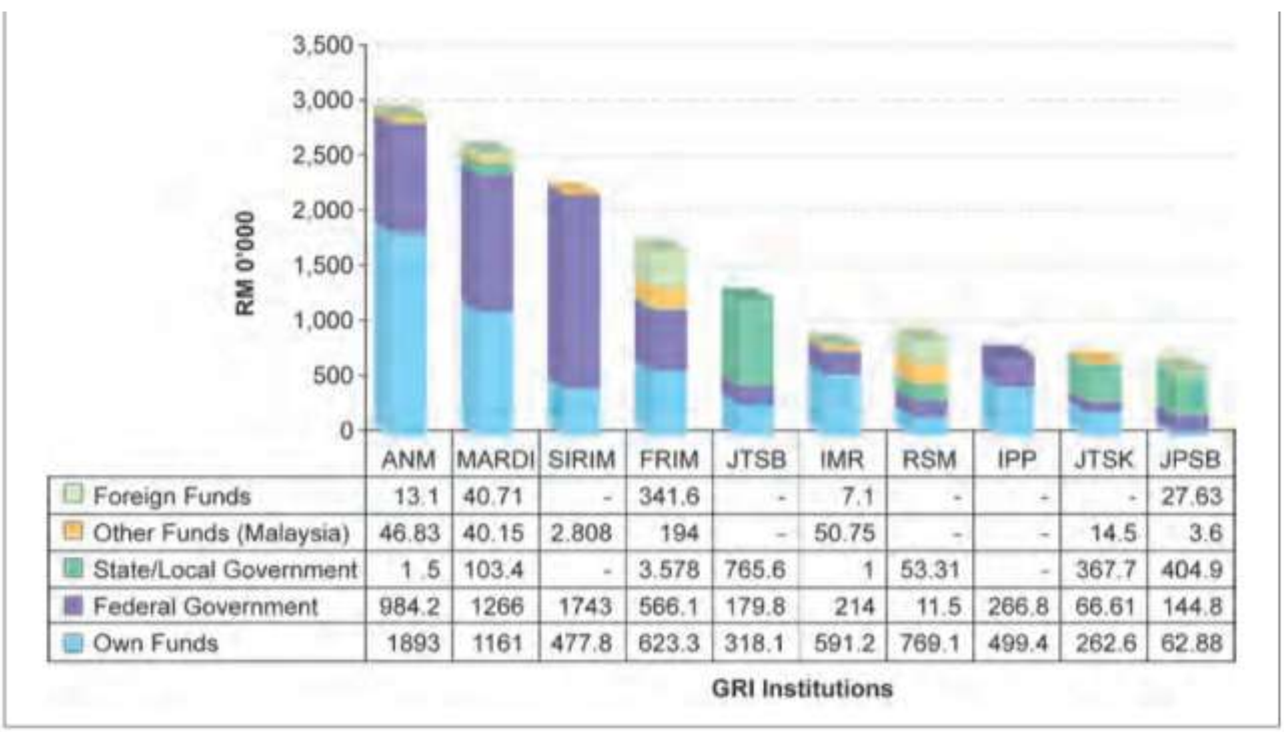
As reported earlier, the private sector depended mostly on its own generated funds for its R&D, which is also similar to the GRIs, where a substantial proportion of funding source comes from their own self- generated income (Fig. 14)

Figure 14. Sources of Funding among GRIs in in Malaysia (2008) (sourced from: Interim Report, 2011)



The Jabatan Perhutanan Sabah (JPSB) emerged as the least funded institution, with an income of RM6.4 million, which came mostly from grants of the state or the local government (Fig. 15).

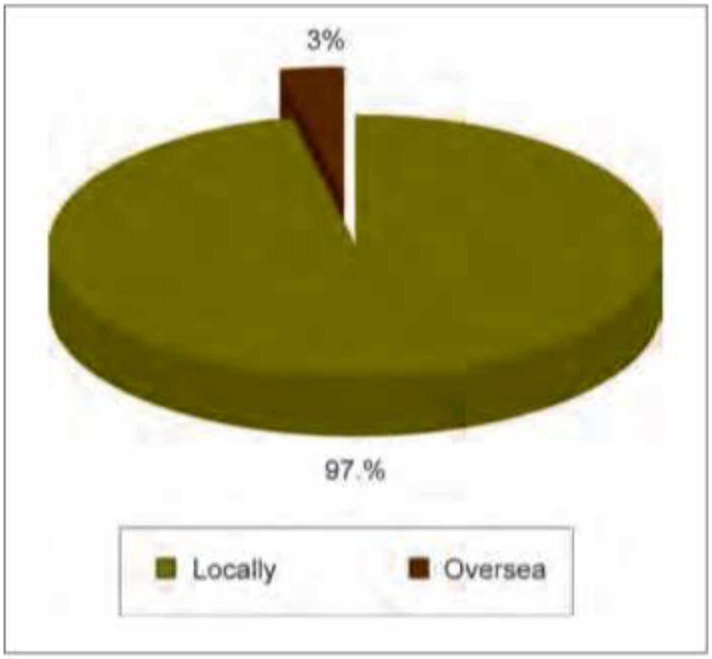
Figure 15. Breakdown of Funding Sources by the Ten Highest Funded GRIs in in Malaysia (2008) (sourced from: Interim Report, 2011)



	ANM	MARDI	SIRIM	FRIM	JTSB	IMR	RSM	IPP	JTSK	JPSB
Foreign Funds	13.1	40.71	-	341.6	-	7.1	-	-	-	27.63
Other Funds (Malaysia)	46.83	40.15	2.808	194	-	50.75	-	-	14.5	3.6
State/Local Government	1.5	103.4	-	3.578	765.6	1	53.31	-	367.7	404.9
Federal Government	984.2	1266	1743	566.1	179.8	214	11.5	266.8	66.61	144.8
Own Funds	1893	1161	477.8	623.3	318.1	591.2	769.1	499.4	262.6	62.88

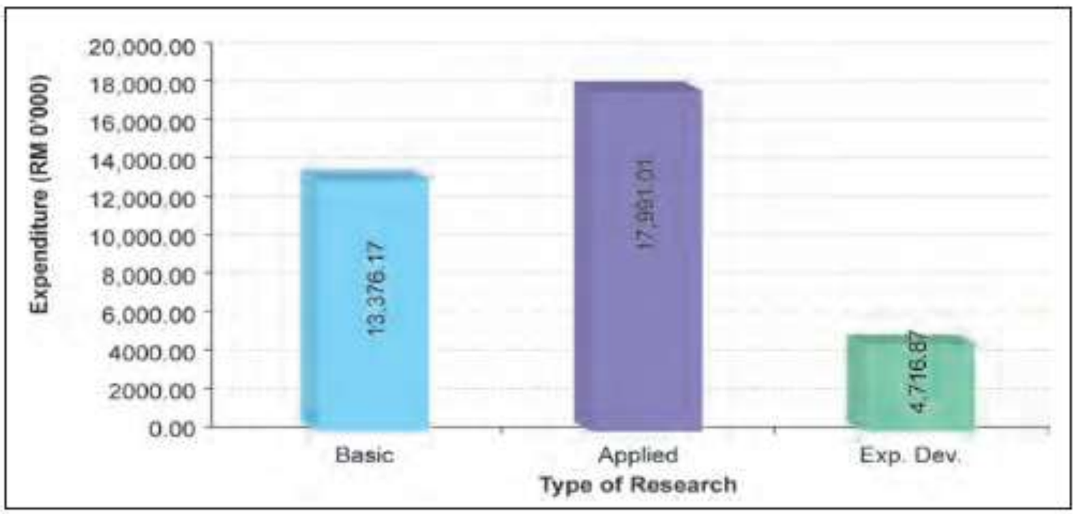
Some of the R&D activities among the GRIs had been outsourced to the providers of R&D locally or from abroad, with the local outsourcing providers dominating the proportion by up to 97% (Fig. 16)

Figure 16. Outsourcing by GRIs to Providers of R&D in Malaysia and Overseas, 2006 (sourced from: Interim Report, 2011)



The trend depicted in the figure indicates that applied research dominated the total expenditures in the IHLs (Fig. 17).

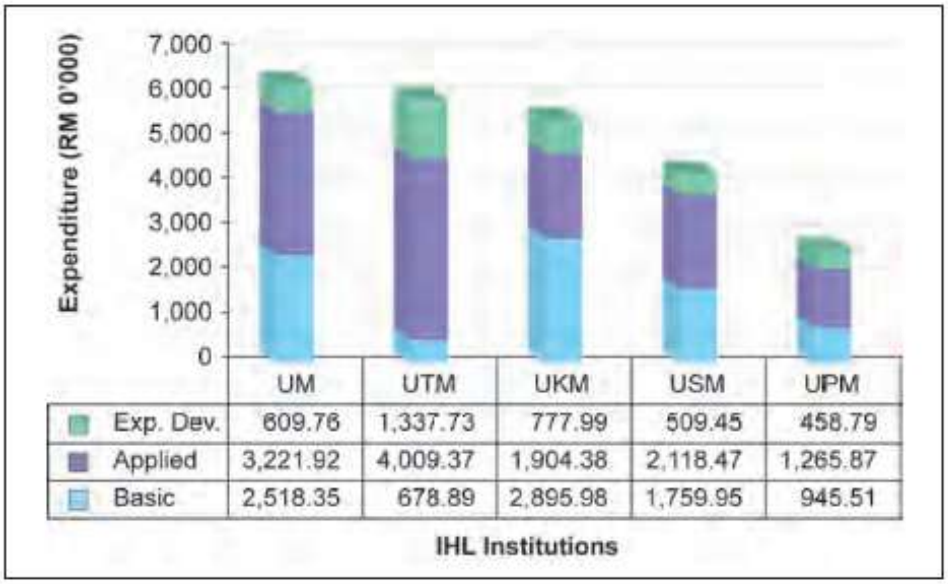
Figure 17. Expenditure in IHLs by Type of Research in 2006 in Malaysia (sourced from: Interim Report, 2011)



Source: National Survey of Research & Development 2008 Report

The distribution trends do indicate that more emphasis is accorded to applied and basic research in most of the institutions (Fig. 18).

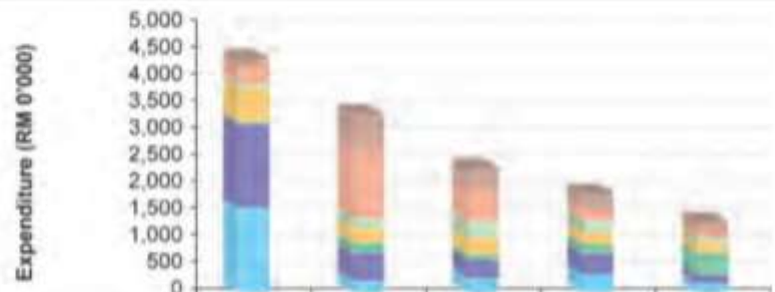
Figure 18. Distrubution of Expenditure in IHLs by Type of Research and IHL Institution in 2006 in Malaysia (sourced from: Interim Report, 2011)



	UM	UTM	UKM	USM	UPM
Exp. Dev.	609.76	1,337.73	777.99	509.45	458.79
Applied	3,221.92	4,009.37	1,904.38	2,118.47	1,265.87
Basic	2,518.35	678.89	2,895.98	1,759.95	945.51

The distribution trends of the expenditures in top 5 IHLs according to the various fields of research, do indicate that the different foci accorded by each of the IHLs on the various types of research, with UPM being the sole university that focuses on agricultural sciences in its expenditures for R&D (Fig. 19).

Figure 19. Distribution of Expenditure in IHLs by Field of Research in Malaysia (2008) (sourced from: Interim Report, 2011)

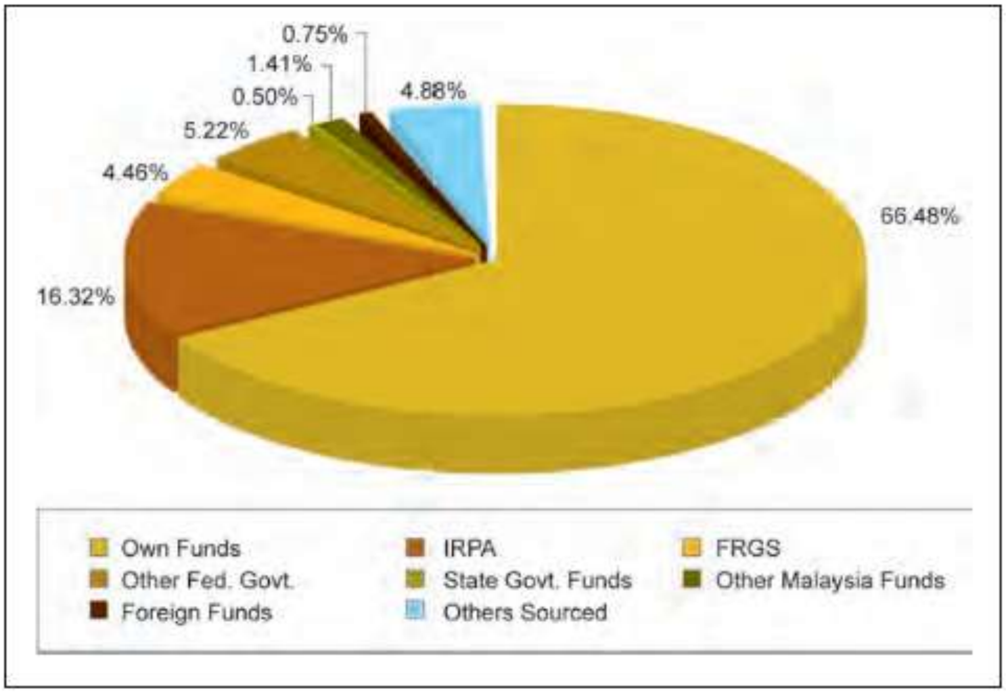


	UTM	UKM	UM	USM	UPM
Social Sciences	142.03	660.05	338.26	275.96	173.56
Chemical Sciences	313.64	1,274.67	657.56	218.27	139.16
Biological Sciences	69.45	182.23	318.62	234.89	98.15
Information, Computer & Communication Technologies	644.34	281.33	311.80	222.74	170.03
Agriculture Sciences	30.90	195.70	101.19	152.57	472.33
Applied Sciences & Technologies	1537.25	463.59	337.21	389.93	150.04
Engineering Sciences	1,695.66	363.65	373.99	445.35	208.25

IHL Institutions

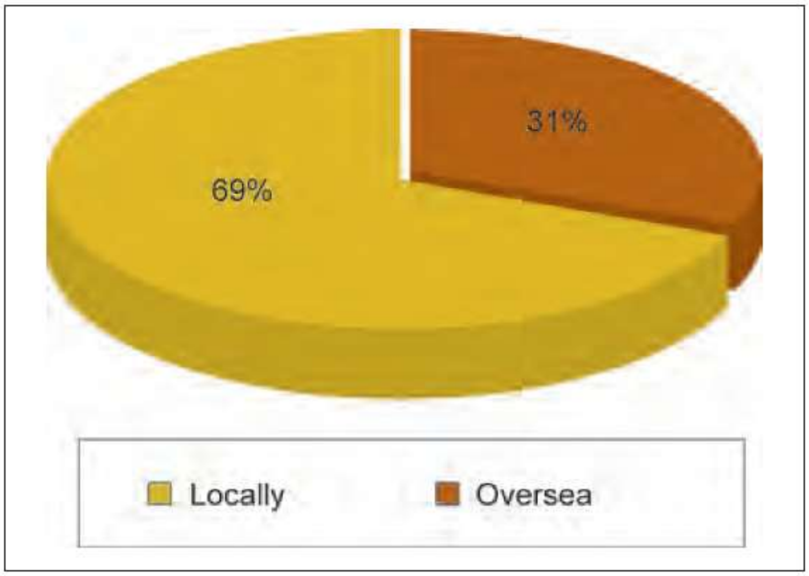
The various sources of funds for R&D in the IHLs, in 2006, with most of the funds for R&D in the IHLs sourced by their own, followed by the IRPA, and the other federal governmental grants (Fig. 20).

Figure 20. The Various Sources of Funds for R&D in the IHLs (2006) in Malaysia (sourced from: Interim Report, 2011)



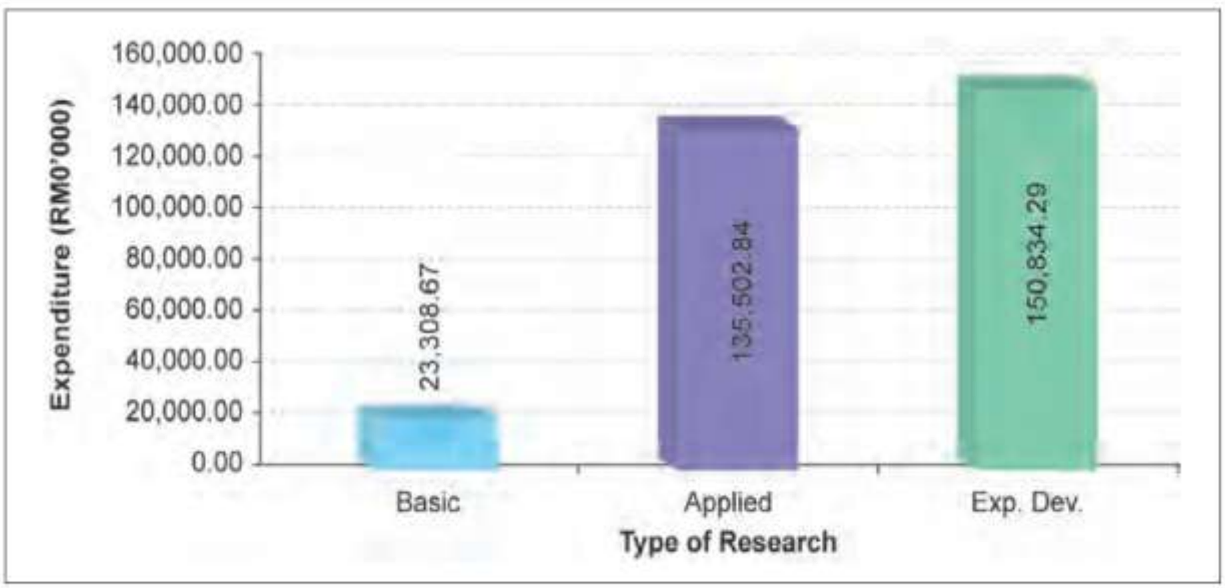
Some 69% of the outsourced R&D in the IHLs was made available to foreign researchers, with only 31% being outsourced locally in 2006 (Fig. 21).

Figure 21. Outsourcing of R&D by IHLs in Malaysia (2006) (sourced from: Interim Report, 2011)



In contrast to the GRIs and the IHLs, the focus on the R&D expenditures among the private sector was allocated more for experimental development research, followed by applied and basic research (Fig. 22).

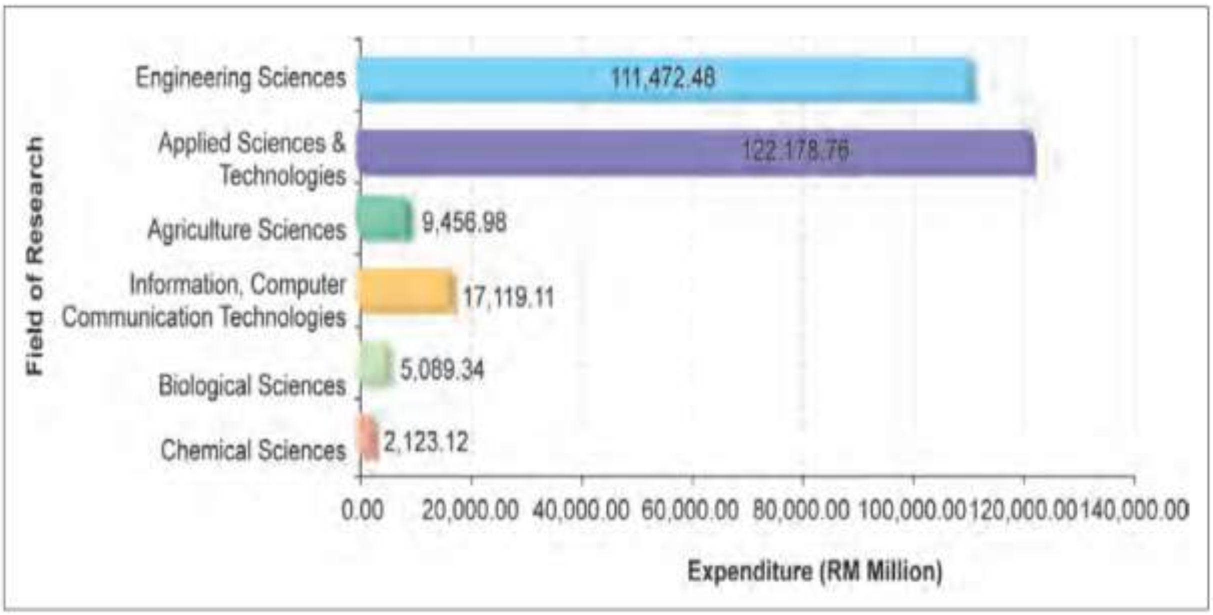
Figure 22. Total Expenditure for R&D in the Private Sector by Type of Research (2006) in Malaysia (sourced from: Interim Report, 2011)



Source: National Survey of Research & Development 2008 Report

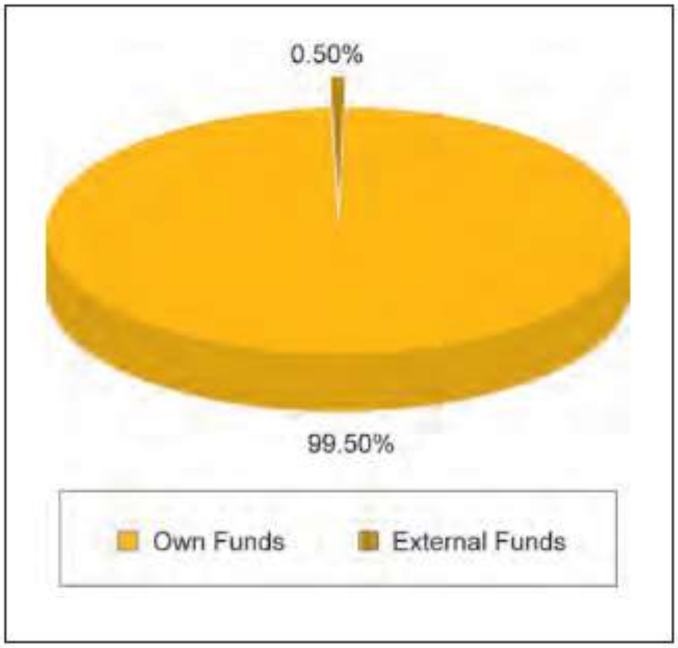
Table 23 indicates that engineering sciences, as well as applied sciences and technologies, were the major areas of research expenditures in the private sector for R&.

Figure 23. Expenditure for R&D in the Private Sector by Field of Research (2006) in Malaysia (sourced from: Interim Report, 2011)



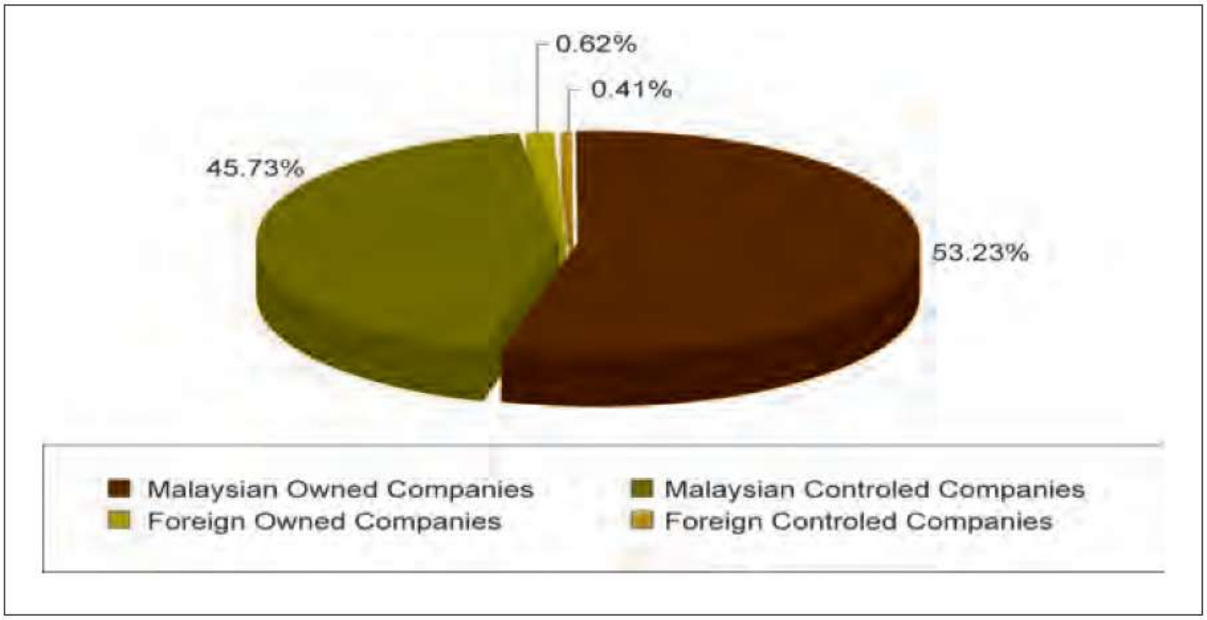
R&D expendidures in the private sector were dependent on two types of sources - either own or self-generated funds, or external funds such as the governmental research grant. For the private most (99.50%) of their funding for R&D was self funded (Fig. 24).

Figure 24. Expenditure for R&D in the Private Sector by Field of Research (2006) in Malaysia (sourced from: Interim Report, 2011)



In terms of outsourcing R&D by the private sector, Malaysian-owned companies recorded a high proportion of outsourcing, and with the proportion involved being higher than those of other Malaysian-controlled companies, foreign companies, and foreign-owned companies (Fig. 25).

Figure 25. Outsourcing of R&D by the Private Sector in Malaysia (2006) (sourced from: Interim Report, 2011)



Source: National Survey of Research & Development 2008 Report

4.4.21 Business Climate

Malaysia's market-oriented economy, supportive government policies and a large local business community that is ready to do business with international corporations have made Malaysia a highly competitive manufacturing and export base. A market-oriented economy and government policies that provide businesses with the opportunity for growth and profits have made Malaysia a highly competitive manufacturing and export base. Malaysia's rapid move towards the k-economy allows companies to do business in an environment that is geared towards information technology.

One of Malaysia's major pull factors is its large pool of young, educated and trainable workforce. Many of Malaysia's university graduates are trained overseas in fields such as engineering, and accountancy, allowing them to adapt easily to an international corporate environment. English is widely used in Malaysia, especially in business thus facilitating the investor's communication with local personnel and suppliers. The country's legal and accounting practices derived from the British system are familiar to most international companies. In addition, Malaysia retained its position as the third best destination in the world for outsourcing activities, after India and China, according to A.T. Kearney's 2007 Global Services Location Index (GLSI).

4.4.22 Attracting International and Private Sector Investors

In recognizing that private sector funding is significant to catalyze the industry, the Malaysian Ministry of Finance strengthened a package of tax incentives for biotechnology ventures in 2006. Key incentive available for qualified biotechnology companies with BioNexus status includes a 100% tax exemption commencing from the first year the company generates profit, a five-year Investment Tax Allowance double deductions on expenditure on R&D and thepromotion of exports.

These fiscal incentives are further strengthened with a set of corporate privileges granted under a Malaysian government Bill of Guarantees including freedom of ownership unrestricted employment of knowledge workers, freedom to source funds globally and further eligibility for competitive incentives and development programmes, grant and other assistance.

4.4.23 Financial Incentives

Malaysia provides competitive financial incentives under existing packages, which are also applicable to biotechnology proposals. Additional attractive incentives to support biotechnology ventures at all stages of development – amongst the incentives are:

- Incentive for the holding company.
- A holding company that fulfills certain conditions can claim a tax deduction for its investment in its approved subsidiary biotechnology company against its profits.
- Tax exemption for biotechnology companies.
- Approved biotechnology companies will be eligible for Pioneer Status: 100% income tax exemption for a period of up to 10 years.
- Investment Tax Allowance: 100% of qualifying investments over a period of 5 years can be set off against profits.
- Dividends distributed from tax exempt biotechnology companies will be treated as tax exempt income for its shareholders.
- Double deduction for qualifying expenditure on R&D, which is broadened to include pre-clinical and clinical trials / testing. However, companies solely undertaking pre-clinical and clinical trials / testing activities are not entitled for double deduction.
- Import duty and sales tax exemption on approved biotechnology equipment and materials.

4.4.24 Policies for the Conservation and Sustainable Use of Biodiversity and Biotechnology in Malaysia.

The 1998 National Biodiversity Policy of Malaysia includes the following stipulated objectives:

i) "To optimize economic benefits from sustainable utilization of the components of biological diversity;

ii) To ensure the long-term food security for the nation;

iii) To maintain and improve environmental stability for proper functioning of ecological systems;

iv) To ensure preservation of the unique biological heritage of the nation for the benefit of present and future generations;

v) To enhance scientific and technological knowledge, and educational, social, cultural and aesthetic values of biological diversity; and

vi) To emphasize biosafety considerations in the development and application of biotechnology".

From the aforesaid perspective, and spurred by the significance globally of Malaysia belonging to the 12 "mega(bio)diverse" countries in the world, the vision of the 1998 National Biodiversity Policy of Malaysia is "To transform Malaysia into a world centre of excellence in conservation, research and utilization of tropical biological diversity (biodiversity) by the year 2020." Additionally, its stated policy statement also reiterates the need "To conserve Malaysia's biological diversity and to ensure that its components are utilized in a sustainable manner for the continued progress and socio-economic development of the nation". Further, its enshrined principles include the following for the conservation and sustainable utilization of the nation's biological diversity:

i. The conservation ethic, including the inherent right to existence of all living forms, is deeply rooted in the religious and cultural values of all Malaysians;
ii. Biological diversity is a national heritage and it must besustainably managed and wisely utilized today andconserved for future generations;
iii. Biological resources are natural capital and their conservation is an investment that will yield benefits locally, nationally and globally for the present and future;
iv. The benefits from sustainable management of biologicaldiversity will accrue, directly or indirectly, to every sector of society;
v. The sustainable management of biological diversity is the responsibility of all sectors of society;
vi. It is the duty of Government to formulate and implement the policy framework for sustainable management and utilization of biological diversity in close cooperation with scientists, the business community and the public;
vii. The role of local communities in the conservation, management and utilization of biological diversity must be recognized and their rightful share of benefits should be ensured;
viii. Issues in biological diversity transcend national boundaries and Malaysia must continue to exercise a proactive and constructive role in international activities;
ix. The interdependence of nations on biological diversity and in the utilization of its components for the well-being of mankind is recognized. International cooperation and collaboration is vital for fair and equitable sharing of biological resources, as well as access to and transfer of relevant technology;
x. Public awareness and education is essential for ensuring the conservation of biological diversity and the sustainable utilization of its components; and
xi. In the utilization of biological diversity, including the development of biotechnology, the principles and practice of biosafety should be adhered to".

Further, the National Policy on Biological Diversity includes the following strategies and action plans:

4.4.24.1 Strategy 1: Improve the Scientific Knowledge Base.

Action Plan:

1. Undertake and intensify biological resource inventories and systematic studies to document species diversity.
2. Strengthen existing herbaria, and establish a Natural History Institute to support documentation of species diversity.
3. Initiate long-term studies on demographic, genetic and environmental variation of indigenous as well as exotic species.
4. Intensify research on the functional aspects of ecosystems and ecological processes therein.
5. Undertake a thorough study to formulate appropriate terms, conditions and safeguards for the identification and extraction of genetic materials and other biological resources.
6. Develop a database of biological diversity and an effective information dissemination system.
7. Establish an inventory of traditional knowledge on the use of species and genetic diversity.
8. Evaluate the economic contributions of biological diversity to the value of goods and services in the national economy.
9. Monitor the status of the components of biological diversity.
10. Survey and document exotic species and populations which threaten biologicaldiversity.
11. Undertake research to develop methodologies and techniques for recovery andrehabilitation of degraded land, *inter alia*, through reintroduction of appropriatespecies.

4.4.24.2 Strategy 2: Ehance Sustainable Utilisationofthe Components of Biological Diversity

Action Plan:

1. Undertake appropriate activities in biological diversity prospecting, via newcrops, pharmaceuticals and other biological products.
2. Develop natural resource accounting methods that promote conservation andsustainable use of biological diversity.
3. Ensure the development of sectoral and cross-sectoral policies, plans andprogrammes which integrate considerations of biological diversity conservationand sustainable use.
4. Ensure sectors performing Environmental Impact Assessments (EIAs) accord duepriority to biological diversity.
5. Undertake research and monitoring of the impacts of resource utilisation onbiological diversity.
6. Provide incentives to encourage conservation of biological diversity andsustainable use of its components.
7. Ensure efficient dissemination of relevant information, together with appropriate extension services, to assist various sectors to conserve and sustainably usebiological resources.
8. Facilitate participation of local communities in traditional sustainable use ofbiological resources.
9. Ensure fair distribution to the nation and local communities of benefits arisingfrom the use of biological resources.

4.4.24.3 Strategy 3: Develop a Centre of Excellence in Industrial Research in Tropical Biological Diversity

Action Plan:

1. Establish a mechanism to harness and develop components of biological diversity into useful products.
2. Harness biological diversity by:
    a. attracting highly competent scientists to develop high technology in thefield of biological diversity;

b. utilising high technology, including biotechnology, to develop pharmaceuticals and other industrial products;

c. training of local scientists and technical personnel in high technology inthe utilisation of biological diversity.

3. Develop the necessary expertise so that such a mechanism facilitates industrialresearch and development in biological diversity in the tropics.

4.4.24.4 Strategy 4: Strengthening the Institutional Framework for Biological Diversity Management

Action Plan:

1. Set up a high level policy formulation, coordination and advisory body witheffective representation from all relevant Federal ministries and agencies andState governments. To assist this committee, a secretariat should be createdat the relevant ministry.
2. Establish a national centre for biological diversity with the task of coordinationof programmes, implementation, monitoring, evaluation, priority setting andinformation management. In the interim period, a technical working committeeshould be established to initiate and undertake this task. This committee couldset up task forces to address relevant issues on biological diversity if and whennecessary.
3. The participation of the private sector and non-governmental organizations (NGOs) should be included where appropriate.
4. Identify, reinforce or establish biological diversity programmes and facilities inexisting institutions.
5. Establish or strengthen resource management units at state and localgovernment levels and promote implementation mechanisms between federal,state and local governments.

4.4.24.5 Strategy 5: Strengthen and Integrate Conservation Programmes

Action Plan:

1. Expand the network of *in-situ* conservation areas to ensure full representationof ecosystems and all ecological processes therein.

2. Strengthen capacity and role of *ex-situ* facilities in conservation activities andresearch, with a view to complementing *in-situ* conservation.
3. Expand *ex-situ* conservation centres to cater for threatened species, forbreeding and selection and as repositories for germplasm i.e. genebanks,botanical and zoological gardens and arboreta.
4. Ensure public involvement in planning and management of protected areas,taking into consideration the involvement of local communities.
5. Develop mechanism for ensuring compatibility between conservation andsustainable development.
6. Determine minimum viable population sizes for species and critical minimum sizeof conservation areas.
7. Review collection activities and the effectiveness of existing regulatory andmanagement arrangements.

<u>4.4.24.6 Strategy 6: Integrate Biological Diversity Considerations into Sectoral Planning Strategies</u>

<u>Action Plan:</u>

1. Ensure biological diversity conservation is a factor in planning and impactassessment of sectoral and cross-sectoral development programmes.
2. Study the impact of national and state policies and priorities on conservationand sustainable use of biological diversity.
3. Develop tools to analyse and evaluate development plans and strategies whichmay have impact upon biological diversity.
4. Review current sectoral policies, plans and programmes to determine the extentto which use of biological resources reflect conservation needs and recommendappropriate measures therein.
5. Ensure that biological diversity issues are incorporated in long-term andmedium-term development plans (e.g. Five Year Development Plans, Outline Perspective Plans, National Development Plans).

6. Ensure efficient dissemination of relevant information and extension services topromote cross- sectoral integration in the sustainable use of biological diversity.
7. Ensure that biological diversity conservation is a major factor in themanagement of our biological resources.

4.4.24.7 Strategy 7: Enhance Skill, capabilities and Competence

Action Plan:

1. Identify critical skill requirements and undertake programmes to develop thehuman resource base in the appropriate areas.
2. Utilise research institutes and universities to build up competence in relevantareas.
3. Enhance research, planning and management capabilities through collaborativeprogrammes amongst local organisations and between local organisations andestablished foreign institutions.
4. Provide reward structures and design reward mechanisms to strengthenappropriate fields for education to achieve conservation and sustainable use ofbiological diversity.
5. Develop or reorientate education and training programmes with specificreference to conservation and sustainable use of biological diversity.
6. Develop training programmes for public participation in biological diversityconservation.

4.4.24.8 Strategy 8: Encourage Private Sector Participation

Action Plan:

1. Facilitate contacts between private sector and public sector in order to improvedesign and transfer of appropriate technology, including biotechnology.
2. Encourage the formation of appropriate joint venture projects with multinationaland other corporations to encourage science and technology transfer inenhancing the economic value of biological diversity.
3. Provide incentives to the private sector to undertake activities in conservationand sustainable utilization of biological resources.
4. Encourage the establishment of consortia to complement government and publicefforts in the conservation of biological diversity.

4.4.24.9 Strategy 9: Review Legislation to Reflect Biological Diversity Needs

Action Plan :

1. Identify existing legislation pertaining to biological diversity and review theiradequacy.
2. Identify areas where new legislation or major enhancements to existinglegislation are needed for :
    a. commitments under the Convention on Biological Diversity and Agenda21;
    b. regulating and managing biological resources including the introductionand implementation of codes of practice for collectors;
    c. intellectual property and other ownership rights;
    d. the development and utilisation of genetically modified organisms withdue regard to provisions ensuring safety procedures in their handling andrelease to the environment;
    e. introduction of alien species or population that threaten ecosystems,species and populations;
    f. management of threatened or endangered species and populations.
3. Review Environmental Impact Assessment (EIA) and other related legislation tostrengthen requirements for assessing direct or indirect biological diversity lossor degradation.
4. Improve the effectiveness of existing legal mechanisms by creating awarenessof conservation regulation and by stricter law enforcement.
5. Review existing state and federal legislation pertaining to biological diversity inorder to promote uniform implementation between states.

4.4.24.10 Strategy 10: Minimize Impacts of Human Activities on Biological Diversity

Action Plan:

1. Identify major sources of biological diversity loss such as forest damage ordegradation, overfishing, pollution of marine resources, development thatdisrupts primary forest or catchment areas, destruction of mangrove areas andcoral reefs, and act to mimimize these sources.

2. Develop methods of evaluating the long- term hazards, as well as the viability ofpopulations and ecosystems, due to development.
3. Develop national emergency response systems for major threats to biologicaldiversity, including early warning systems, notification procedures and salvagingmeasures.
4. Ensure effective enforcement for the compliance of mitigation and rehabilitationmeasures in all activities that present potential dangers to biological diversity.
5. Rehabilitate degraded habitats where biological diversity has been reduced inparticular those within conservation areas and their adjacent areas.
6. Encourage measures to preserve, improve and enrich biological diversity inurban areas.
7. Adopt measures to alleviate the impact of human activities on the displacementof wildlife.

<u>4.4.24.11 Strategy 11: Develop Policies, Regulations, Laws and Capacity Building on Biosafet</u>

<u>Action Plan:</u>

1. Formulate legislation and regulations on biosafety, in relation to activities andproducts arising from biotechnology, especially genetic engineering, includingthe importation, experimentation, storage and release of genetically modifiedorganisms.
2. Ensure measures are taken to prevent the country from becoming a location forhazardous research activities.
3. Establish a committee on biosafety that includes representatives from theenvironment, health and research fields, and keep abreast of developments inthis field in the international arena.
4. Adopt an Environmental Impact Assessment (EIA) procedure for biotechnologyresearch and activities, including assessment on safety and social impacts.
5. Establish an enforcement unit on biosafety within an appropriate governmentdepartment.
6. Develop training programmes in biosafety management and practice.

4.4.24.12 Strategy 12: Enhance Institutional and Public Awareness

Action Plan:

1. Increase awareness within the civil service at both federal, state and localgovernment levels as well as in professional bodies and the private sectorthrough courses and training programmes.
2. Enhance mass media coverage of biological diversity issues.
3. Incorporate the study of biological diversity and related fields into the curriculaof schools and institutions of higher learning.
4. Promote and support the biological diversity activities of nature clubs andsocieties.
5. Incorporate the notion of conservation of biological diversity and sustainableuse of its components as an element of environmental awareness and trainingprogrammes.
6. Recognise the role of non-governmental organisations (NGOs) in theconservation and sustainable utilisation of biological diversity.

4.4.24.13 Strategy 13: Promote Internatinal Cooperation and Collaboration

Action Plan:

1. Identify areas of research and technology requirements where cooperation andcollaboration are needed.
2. Identify and develop collaboration with relevant international and nationalinstitutions involved in biological diversity which would promote mutual benefits.
3. Develop bilateral and multilateral arrangements where appropriate,*inter alia*, forgermplasm exchange, technology transfer, and technical and scientificinformation exchange.
4. Promote regional collaboration in biological diversity, in particular ontransboundary issues e.g. establishment of transfrontier national parks, and theeffects of pollution on biological diversity.
5. Recognise accepted international practices in germplasm exchange andtechnology transfer.

4.4.24.14 Strategy 14: Exchange of Information

Action Plan:

1. Identify and review existing mechanisms to facilitate the exchange ofinformation relevant to the conservation and sustainable use of biologicaldiversity.
2. Establish or strengthen systems for the exchange of such information atnational and international levels through networking, and by establishingdatabases and information centres:
   i. information centres and networks to disseminate relevant informationprepared by government, research and educational institutions, industry,non-governmental organizations (NGOs) and individuals;
   ii. central directories of relevant data sets, information centres andnetworks;
   iii. establishing and enhancing relevant databases and data managementcapabilities.
3. Seek cooperation to address the repatriation of information, in particular thosenot in the public domain.

4.4.24.15 Strategy 15: Establish Funding Mechanisms

Action Plan:

1. Review current funding options relating to biological diversity and identify thepotential for reallocation of resources for implementation of the strategies ofthe National Policy on Biological Diversity.
2. Seek new and additional incentives, funding sources and mechanisms, at boththe national and international levels, for the implementation of the strategies.Funding sources should include government, non-governmental organizations (NGOs) and the private sector.
3. Establish trust funds for the conservation and management of biologicaldiversity.

As a follow up on the implementation of the 1998 National Biodiversity Policy of Malaysia, the Government had identified “biotechnology” as a novel and initiative engine of economic growth for Malaysia. It envisioned that biotechnology would be able to improve the quality of life, generate new wealth and income for both rural and urban populations, and improve the socio-economic status of the population as a whole.

And to fully realize the potentials and the prospects of Malaysia's natural (biodiversity-based) biotechnology, the Government thus embarked on another intervention, aimed at deploying the resources of Malaysia in a much more structured and focused manner. In view of the aforesaid strategic aspiration, the National Biotechnology Policy of Malaysia was launched in 2005. In launching it, the Prime Minister of Malaysia outlined the following nine-pronged initiatives for maximizing the purposeful and meaningful realization of the country's biodiversity-driven biotechnology sector:

<u>Initiative 1</u>: Agriculture Biotechnology Development -Transform and enhance the value creation of the agriculture sector through biotechnology.

<u>Initiative 2</u>: Healthcare Biotechnology Development -Capitalize on the strengths of biodiversity to commercialize discoveries in natural products, as well as to position Malaysia in the bio-generics market.

<u>Initiative 3</u>: Industrial Biotechnology Development -Ensure growth opportunities in the application of advanced bio-processing and bio-manufacturing technologies.

<u>Initiative 4</u>: R&D and Technology Acquisition – Establish Centers of Excellence, in existing or new institutions, to bring together multidisciplinary research teams for coordinated research and commercialization enterprises. Accelerate technological development via appropriate strategic acquisitions.

<u>Initiative 5</u>: Human Capital Development – Build the nation's biotechnology human resource capability in line with market needs, through special schemes, programmes and training.

Initiative 6: Financial Infrastructure Development – Apply competitive "lab to market" funding and incentives to promote committed participation by academia, the private sector as well as government-linked companies. Implement sufficient exit mechanisms for investments in biotechnology.

Initiative 7: Legislative and Regulatory Framework Development - Create an enabling environment through continuous reviews of the country's regulatory framework and procedures in line with global standards and best practices. Develop a strong intellectual property protection regime to support R&D and commercialization efforts.

Initiative 8: Strategic Positioning – Establish a global marketing strategy to build brand recognition for Malaysia biotechnology and benchmark progress. Establish Malaysia as a center for Contract Research Organizations and Contract Manufacturing Organizations.

Initiative 9: Government Commitment – Establish a dedicated and professional implementation agency overseeing the development of Malaysia's biotechnology industry, under the aegis of the Prime Minister and relevant government ministries.
Operationally, the 2005 National Biotechnology Policy of Malaysia was to be implemented in three phases:

Phase 1 (2005-2010) – Capacity Building: will see the establishment of advisory and implementation councils, education and training of knowledge workers, business development and industry creation in agricultural biotech, healthcare biotechnology, industrial biotechnology and bio-informatics.

Phase 2 (2011-2015) – Science to Business: will involve developing expertise in the discovery and development of new drugs based on natural resources.

Phase 3 (2016-2020) – Global Presence: will focus on taking Malaysian companies globally.

At this juncture, it would be worthwhile to present three case studies – viz. on the a) “Sarawak Biodiversity Centre (SBC)”, b) “Forest Research Institute Malaysia (FRIM)”, and c) “Malaysian Agricultural Research and Development Institute (MARDI)” - primarily for the sake of providing an insight into the range, scope and thrust of some of the biodiversity-based R&D and/or STI activities that are currently being implemented in Malaysia.

4.4.25 A Case Study of the Sarawak Biodiversity Centre (SBC)

The Sarawak State Government enacted the Sarawak Biodiversity Centre Ordinance and established the Sarawak Biodiversity Centre (SBC) in 1977, with the initiation of its various biodiversity-related programmes the following year, on the conservation, utilization, protection and sustainable development of biodiversity in the State of Sarawak.Between the setting up of the SBC in 1998 and the year 2003, Sarawak took cognizance of yet another potential in its wealth of biological resources – the potential for intensive biotechnology-based research and product development from the State’s vault of diverse biodiversity. In December 2003, the State Legislative Assembly reviewed the Sarawak Biodiversity Centre (Amendment) Ordinance 2003, and passed the necessary amendments to the Sarawak Biodiversity Regulations of 2004. The amendments also relieved the SBC of its role in conducting of general biodiversity inventories and in regulating general biodiversity research. Instead, the amendments entrusted the SBC to initiate intensive biotechnology- based R&D on Sarawak’s biodiversity, particularly those utilized by communities of indigenous peoples, besides facilitating the SBC in the documentation of the fast disappearing traditional knowledge of the indigenous peoples on the utilization of biological resources.

The vision of the SBC was for it to serve as the focal point for the research, utilization, inventorying, monitoring, education, management and conservation of biodiversity in Sarawak. Meanwhile, the mission of the SBC was operationally defined as follows:

i) To identify, set priorities and initiate programmes for research and sustainable management and utilization of biological resources in Sarawak, including bioprospecting and product development.

ii) To facilitate the documentation of the traditional uses of the biological resources by the local communities in Sarawak.

i) To promote the awareness and appreciation of Sarawak's rich biodiversity among all sectors of society.

ii) To obtain and to disseminate accurate and up-to-date information on the biodiversity of Sarawak.

iii) To establish linkages with local and foreign institutions with similar interests.

The core functions of the SBC include the following:

i) Implementing bioprospecting programmes on the indigenous biodiversity of Sarawak.

ii) Facilitating the documentation of the traditional knowledge of the communities of indigenous peoples in the management and utilization of biodiversity.

iii) Propagating Sarawak's indigenous plants and herbs for conservation and appreciation.

iv) Maintaining biodiversity-related databases.

v) Conducting biodiversity and biotechnology awareness raising and appreciation programmes.

vi) Regulating research on biodiversity with commercial potential in Sarawak through the Research Permit System.

vii) Networking with other organizations with similar interests.

For purposes of realising its vision, mission and function, the SBC has embarked on the following range of programmes:

i) Traditional Knowledge Documentation Programme.

ii) R&D (Bioprospecting) Programme.

iii) Bioinformatics Programme.

iv) Biodiversity Garden Programme.

v) Biodiversity Awareness and Appreciation Programme.

By way of implementing the above mentioned programmes, the SBC plans to:

i) Contribute towards Sarawak’s efforts in the development of the biotechnology industry via a combination of different disciplines, such as chemistry, molecular biology and biochemistry.
i) Provide the communities of local indigenous peoples with capacity building, and to empower them in the documentation of their traditional knowledge on the management and utilization of biological resources.
ii) Establish a bioinformatics data centre for biodiversity R&D, a natural products library and inventory system, and a traditional knowledge database on the uses of indigenous plants by the local communities in Sarawak.
iii) Contribute towards improving the knowledge on, and providing accurate information on, the biodiversity and biotechnology initiatives of Sarawak, thereby contributing to the management and sustainable utilization of Sarawak's rich biodiversity.

One of the unique features of the SBC, besides its work in conserving and sustainably utilizing biodiversity, is its active interaction and involvement of local communities of indigeneous peoples and their traditional knowledge on biodiversity, including their own development

4.4.26 A Case Study of the Forest Research Institute Malaysia (FRIM)

The Forest Research Institute Malaysia (FRIM) is a statutory agency, under the Ministry of Natural Resources and Environment. FRIM promotes sustainable management and optimal use of forests and forest biodiversity, and forest natural resources by generating knowledge and technology through R&D and the application in tropical forestry STI. Its vision is to make FRIM into a world-class tropical forest research institute, while its mission is to achieve excellence in scientific research, development and forestry services.

The objectives of FRIM, which are reflected in its manifold activities, include the following:

i) To generate scientific knowledge on the understanding, management, conservation and utilization of forest resources.
ii) To achieve excellence in R&D through the use of the latest scientific techniques and equipments.
iii) To study biodiversity for producing useful products through intensive R&D.

iv) To develop relevant science and technology to fulfill the needs of the forestry industry.

v) To package R&D findings for their dissemination to clients.

vi) To commercialize R&D findings by technology transfer to all interested parties.

vii) To provide excellent services for meeting the needs of clients.

viii) To create strategic cooperation with appropriate local and international agencies.

ix) To raise public awareness on the significance of the environment and of the conservation and sustainable use of forest biodiversity.

FRIM is comprised of five research divisions, including i) The Forestry and Conservation Division; ii) The Forestry Product Development Division; iii) The Forestry Biotechnology Division; iv) The Forestry Biodiversity and Environment Division; and v) The Community Forestry Services Division.

The services made available by FRIM include, inter alia, an arboreta which serves as reference for forestry education, a herbarium established in 1908 with over 200,000 specimens, a variety of training courses, ranging from landscaping to wood identification to the development of rattan and bamboo products, a nursery, a library and a venue for local and international conferences. Further, FRIM also offers a broad spectrum of state of the art facilities for research, including the management of six field research stations in different areas, each with different types of forests in different parts of Malaysia.

FRIM's forest tour packages provide opportunities for outdoor recreation and public education in its grounds. It is a popular spot for picnickers, joggers, cyclers, tourists and nature study groups, for family day events, treasure hunts, camping, bird watching, and jungle trekking and nature photography. The ground, which began as degraded land in the form of sterile mining pools, scrubby wasteland and barren vegetable farms, long-abandoned, is today a treasure of relatively unpolluted air, cooler temperatures and quiet serenity.

Although FRIM is well recognized as a centre for excellence for its work on forestry, not many are aware that FRIM is also engaged in a wide range of other biodiversity related activities (eg. ornamental plants, new varieties of orchids, biotechnology)

4.4.27 A Case Study of the Malaysian Agricultural Research and Development Institute (MARDI)

The Malaysian Agricultural Research and Development Institute (MARDI) is a statutory body that was established with the primary objective of generating and promoting new, appropriate and efficient technologies towards the advancement of the food, agriculture, food-based and agro-based industries. Further, its Scientific Council ensures that the technical programmes of MARDI are of the highest quality and level of competence.

MARDI is mandated to fulfill a wide range of objectives, including thefollowing:

i. To conduct R&D in the fields of science, technology and socio-economyon integrated farming, and also on the production, utilization andprocessing of all crops (excepting for rubber, oil palm and cocoa) andlivestock.
ii. To serve as a resource center for the collection and dissemination of information and advice on scientific, technical and economic matters, especially on those associated with food, agriculture and agro-based industries. These are accomplished through several avenues, including by the publication of papers, reports and manuals, and also by the organizing of exhibitions, conferences, seminars and lectures.
iii. To serve as a one-stop-center that provides expert services on food, agriculture and agro-based industries, such as consultancies, laboratory analyses, quality assurances and contract R&Ds, including on:
    a. The provision of trainings for the development of food, agriculture and agro-based industries.
    b. The provision of grant-in-aid funds for the pure and applied scientific, technical and economical research and development related to food, agriculture and agro-based industries.

iv. To maintain liaison with local and foreign public and private organizations engaged in scientific, technical, economical and social research associated with food, agriculture and agro-based industries.
v. To conduct commercially-oriented research, development and production.
vi. To document, promote and exploit suitable research findings.
vii. To provide extension services to the agricultural, food and agro-based industries, MARDI envisages a leadership role that evolves from capacity building, establishment of farming and cropping systems towards the commercialization of technology, total quality management, and the attainment of a culture of excellence at the national and international level.

Further, the vision of MARDI is to become a world-renowned R&D organization in food, agriculture and agrobio-based industries by 2015, while the mission of MARDI is to create, innovate, transfer and apply knowledge, competencies and services for transforming the national food agriculture and agrobio-based industries towards the ever increasing challenges of commercialization and competitiveness.

In this context, the business plans of MARDI have been specificallydesigned to:

i) Carry out research to generate innovative technologies for the development of the food and agriculture industries.
ii) Provide consultancy and technical services to support the development of the food and agriculture industries.
iii) Offer joint ventures and licensing arrangements for thecommercialization of the research findings.

Meanwhile, the R&D and STI of MARDI are primarily targeted at:

i) Technology development to enhance competitiveness in the food processing industry.
ii) Technology development in the production of fruits, vegetables, flowers, cereals and other crops.
iii) Technology development related to the livestock industry.

iv) Technology development in biotechnology and mechanization, as well as in naturalresource and environmental management.
v) Socio-economical and technological management aspects in the food and agriculture industries.
vi) Transfer of technology and commercialization for purposes ofimproving agricultural productivity and food quality, as well as for the creation of viable agri-businesses.

As farm mechanizations are the main enablers for overcoming labour shortages, and for increasing productivity and timeliness, adaptations of mechanization would tend to decrease production cost, improve quality, and lessen human interventions. Mechanization could also be further boosted by incorporating automation into the farming processes. And by having the Mechanization and Automation Research Centre as one of its main research centres, MARDI acquired the necessary efforts for introducing aspects of mechanization and automation in the agricultural and food production practices in Malaysia.

Additionally, the R&D and the STI being implemented in the production and mechanization programmes of MARDI are also intended at addressing the following:

i) Crop and livestock production.
ii) Mechanization needs and related problems, which includes mechanization and automation problems of crop production systems involving operation from land preparation, crop maintenance, harvesting and in-field collection handling.
iii) Non-food processing mechanization of bio-materials into value-added industrial products.

The R&D and STI in the Electronic System and in the Building Environment Programme of MARDI include, inter alia, the following thrust areas:

i) Mechanization and automation problems of crop and livestock production under the agricultural structures and the building environments.
ii) Productivity improvement and labour saving through automation and the use of sensors in agricultural and food production systems.

MARDI therefore strategically puts a rather high priority on R&D and Commercialization (R&D&C). Hence, automation in the agricultural and food industries is one of its critical R&D&C areas. It implies the replacing of the manual human labour force with computer-controlled automated systems. It is needed in virtually every aspect of agriculture, starting from ploughing, seeding and spraying to harvesting and post-harvesting, so as to replace the decreasing availability of labour. Automation also tends to produce better quality products and higher yields as the processes are controlled and regulated with higher precision and lower error. Some of the automation areas that are currently explored by MARDI are sensor, instrumentation, mechatronic and Information and Communication Technology (ICT).

Additionally, the building environment is also a major focal area of R&D at MARDI. It adopts control systems to enable the control of the environments inside buildings. Environmental parameters, such as temperature, humidity, gases and ventilation, are suitably controlled so that high-value crops, such as tomatoes and broccolis and livestock, can be produced commercially. The production of crops under greenhouses can also assist in reducing the dependence of labour on the maintenance of crops, because the fertigation inside the building is automated. Automation of fertigation also produces higher quality produces, since the quantity, timing and frequency of the application of fertilizers and fertigations are all set depending on the growth of the plants, as opposed to the conventional practices which may end up over or under fertilizing the plants.

Currently, the principal focal sectors of R&D and STI at MARDI include the following:

i. Agricultural Engineering.
ii. Food and Post-Harvest Engineering.

iii. Agricultural-Based Industry (Non-Food).
iv. Animal Feed.
v. Agricultural Biodiversity.
vi. Agricultural Biotechnology.
vii. Agricultural Economics.
viii. Agricultural Environment.
ix. Food Science & Technology.
x. Fruits.
xi. Herbs.
xii. Industrial Crops.
xiii. Livestock Production.
xiv. Ornamentals/Floriculture & Landscape Plants.
xv. Potential Crops.
xvi. Rice.
xvii. Technology Management.
xviii. Vegetable Crops.
xix. Organic Farming.

Besides its well known works on biodiversity related agricultural food crops, MARDI is also pioneering works on lifestock.

5.MAJOR ISSUES AFFECTING STI IN THE SECTOR/SUBSECTORS

5.1 The Malaysian Constitution

The Constitution of Malaysia, comprising 181 articles, is the supreme law of Malaysia. It was drafted, based on the advice of "The Reid Commission", and came into force on 27 August, 1957.
And with regard to the environment, biodiversity and natural resources, Chapter 1, on the "Distribution of legislative powers", under Part VI, on the "Relations Between The Federation and the States", is of particular interest in the Constitution of Malaysia, as it deals with their respective jurisdiction over certain "Federal", "State" and "Concurrent" imperatives.

In this context, more so as it also cover matters of jurisdiction relating to national policies, national obligations to international MEAs, lands, forests (often the vault of biodiversity), coastal waters, rivers, minerals, religions, etc) the following Articles are noteworthy as enshrined in the appropriate Chapters, under Part VI, of the Constitution of Malaysia:

5.1.1 Article 73

In exercising the legislative powers conferred on it by this Constitution

1. Parliament may make laws for the whole or any part of the Federation and laws having effect outside as well as within the Federation;

2. The Legislature of a State may make laws for the whole or any part of that State.

5.1.2 Article 74

1. Without prejudice to any power to make laws conferred on it by any other Article, Parliament may make laws with respect to any of the matters enumerated in the Federal List of the Concurrent List (that is to say, the First or Third List set out in the Ninth Schedule).

2. Without prejudice to any power to make laws conferred on it by any other Article, the Legislature of a State may make laws with respect to any of the matters enumerated in the State List (that is to say, the Second List set out in the Ninth Schedule) or the Concurrent List.

3. The power to make laws conferred by this Article is exercisable subject to any conditions or restrictions imposed with respect to any particular matter by this Constitution.

4. Where general as well as specific expressions are used in describing any of the matters enumerated in the Lists set out in the Ninth Schedule the generality of the former shall not be taken to be limited by the latter.

<u>5.1.3 Article 76</u>

1. Parliament may make laws with respect to any matter enumerated in the State List, but only as follows, that is to say:

    i. for the purposed of implementing any treaty, agreement or convention between the Federation and any other country, or any decision of an international organization of which the Federation is a member; or
    ii. for the purpose of promoting uniformity of the laws of two or more State; or
    iii. if so requested by the Legislative Assembly of any State.

2. Subject to Clause (4), a law made in pursuance of paragraph (b) or paragraph (c) of Clause (1) shall not come into operation in any State until it has been adopted by a law made by the Legislature of that State, and shall then be deemed to be a State law and not a federal law, and may accordingly be amended or repealed by a law made by the Legislature.

3. Parliament may, for the purpose only of ensuring uniformity of law and policy, make laws with respect to land tenure, the relations of landlord and tenant, registration of titles and deeds relating to land, transfer of land, mortgages, leases and charges in respect of land, easements and other rights and interests in land, compulsory acquisition of land, rating and valuation of land, and local government; and Clauses (1) (b) and (3) shall not apply to any law relating to any such matter.

5.1.4 Article 77

1. The Legislature of a State shall have power to make laws with respect to any matter not enumerated in any of the Lists set out in the Ninth Schedule, not being a matter in respect of which Parliament has power to make laws.

5.1.5 Article 78

1. In so far as any law made by Parliament or any regulation made in pursuance of such a law restricts the rights of a State or its residents to the use for navigation or irrigation of any river wholly within that State it shall not have effect in that State unless it has been approved by a resolution of the Legislative Assembly of that State supported by a majority of the total number of its members.

5.2 The Development Paradigm of Malaysia.

Malaysia's vision and driving force of attaining the status of a fully "developed" country by 2020 has set its development paradigm on a twin-edged trajectory of rapid economic growth, urbanisation and modernisation, and in the process often adversely impacting the quality and quantity of the environment and its natural resources, including of biodiversity, besides also aggravating the existing and emerging divides between the haves and the have nots.

Hence, the framework or the roadmap, emerging from the Study, would be strategically and pro-actively utilized for the identification of the type and quantity of STI required, and also of the sectors of R&D where STI could be applied to steer the development agenda of Malaysia in a manner that generates and maximizes sustained economic growth, wealth and prosperity for the country, but without compromising on the conservation of the wealth of biodiversity in Malaysia.

Notably, to initiate and to mainstream such a biodiversity-oriented development agenda, the Government of Malaysia would need to first and foremost consciously and judiciously review and revise, as required, the economic sectors which had been earmarked in the IMP2 and the IMP3, while also analyzing the extent of the STI applications and of their appropriateness and optimality in realizing the development paradigms of the multi-racial Malaysians from all levels of society. In this context, the overarching framework for operationalizing the development perspectives, plans and policies of the Government of Malaysia for all Malaysians should be innovatively formulated to enable and to foster the scientific, engineering and technological inputs and imperatives into national development strategies and targets of the country by way of:

i. Assessing and analyzing the global drivers of national development and the critical role of innovation in national development. Global drivers include the worldwide concern over climate change, etc and their impacts on sustainability, the shift towards a knowledge-based economy where the intangibles dominate, the growing power of innovations to be sustaining competitiveness, concern over poverty, and the fate of the environment and the millennium development goals;

ii. Undertaking a review and analysis of the Government's various development policies, such as the 5-Year Development Plans, Industrial Master Plans 2 & 3, Outline Perspective Plans, S&T Policy II, K-Economy Master Plan, National Education Policy, National Higher Education Policy, National Agriculture Policy, etc vis-à-vis sustained national development;

iii. Assessing and determining the economic, social and environmental targets as outlined in the relevant plans and policies, so as to reflect the 3 dimensions of sustainability and of the multi-sectoral nature of sustained national development; and

iv. Addressing the policies, strategies and action plans to be implemented over the period 2011–2050 (10th–18th Malaysia Plans).

v. Enhancing the amounts of funds made available to R&D and S,T&I for the conservation, sustainable use and wealth creation from biodiversity (as evident in Table 45, developed countries tend to allocate much larger percentage of their GDP to R&D ans S,T&I, eg. 2.36% in Singapore, 2.52% in Taiwan, 3.17% in Japan, 2.67% in USA, but only 0.64% in Malaysia)

5.3 The Significance and Status of Environment, Including Biodiversity.

For a variety of development-priority, governance and globalization push-pull reasons, the environment in general and biodiversity in particular, ranks relatively low in significance and stature, when compared to other sectors, like the Economic growth, Gross Domestic Product, Foreign Direct Investment, trade, foreign exchange, manufacturing, mechanization, urbanization, modernization, ultra-infrastructure, increasing export earning, adopting unsustainable patterns of production, consumption and lifestyle, pursuing the rich, powerful and industrialized country developmental paradigm, etc. The aforesaid trend is evident and reiterated in the ten-yearly Operative Perspective Plan of Malaysia, the five-yearly Development Plan of Malaysia, the yearly National Budget of Malaysia, the allocation of human and monetary resources to the different ministries, departments, agencies, projects and subsidies in Malaysia. However, an inherent spin-off from such policies and priorities is its vortex of short-term and long-term inimical impacts and implications on the environment, especially on biodiversity, and their interdependent peoples and communities. Fortunately, there are now several checks and balances that could be wisely utilized to mitigate or to preclude the unfolding of any ensuing unwelcomed detrimental scenarios.

6. POLICIES AND REGULATIONS OF THE SECTOR – CURRENT /PROPOSED

6.1 National Biodiversity-Related Instruments in Malaysia:

There already exist a number of National-level or Federal-level policies, acts, plans, etc, which have bearings, directly or indirectly, on the conservation, sustainable use and management, some of which can also serve for purposes of commercialization and wealth generation, of the richness of terrestrial and marine biodiversity in Malaysia, including the following examples:

6.1.1 National Policies

- The National Policy on Biological Diversity
- A Common Vision on Biodiversity
- The National Waters Act
- The National Animal Act
- The National Aboriginal People Act
- The Land Conservation Act
- The National Land Code
- The National Protection of Wild Life Act
- The National Environmental Quality Act
- The National Pesticides Act
- The National Local Government Act
- The National Town and Country Planning Act
- The National Parks Act
- The National Forestry Act
- The National Fisheries Act
- The National Heritage Act
- The National New Plant Variety Protection Act
- The National Biosafety Act
- The National Wildlife Conservation Bill
- The Access and Benefit Sharing of Biodiversity and Genetic Resources Act (in preparation)
- The Science and Technology Act (in preparation)
- The National Biotechnology Policy
- The National Agricultural Policy
- The National Environment Policy
- The National Tourism Policy
- The National Forestry Policy

- The National Oceans Policy (in preparation)
- The National Wetlands Policy
- The National Urbanisation Policy
- The 10 year OPP (Operative Prospective Plan 3) and its 5 year Development Plans (RMK 10)
- The National Physical Plan

6.1.2 Sabah Policies

- Sabah Biodiversity Enactment
- The Land Ordinance Cap
- The land Acquisition Ordinance
- The Mineral Enactment
- The Interpretation of native Ordinance
- Fauna Conservation Ordinance
- Forest Enactment
- Forest Rules
- Sabah Forestry Development Authority Enactment
- Parks Enactment
- Native Court Enactment
- Native Court (Native Customary Laws) Rules
- Wildlife Conservation Enactment
- Cultural Heritage (Conservation Enactment)
- Sabah Water Resources Enactment
- Environment Protection Enactment
- Environment Protection (Prescribed Activities Order)
- Environment Protection (Prescribed Activities)(Environmental Impact Assessment) Order

6.1.3 Sarawak Policies

- Sarawak Biodiversity Regulations
- State Local Authorities Ordinance
- Forest Ordinance
- Forest Rules
- Native Courts (Amendment) Ordinance
- Natural Resources and Environment (Amendment) Ordinance
- Public Parks and Green Ordinance
- Sarawak River Ordinance
- Water Ordinance
- Sarawak Forest Corporation Ordinance
- State Land Code Ordinance
- Forest (Planted Forest) Rules
- Wild Life Protection Ordinance

- National Parks and Nature Reserves Ordinance
- Protection of Public health Ordinance
- State Verterinary Public Health Ordinance
- Sarawak Biodiversity Centre (Amendment) Ordinance

6.2 International Biodiversity-Related Instruments.

Besides the above-mentioned National-level or Federal-level biodiversity-related instruments, there also exist a number of International or Multilateral Environmental Agreements (MEAs), most of which Malaysia is a party to by virtue of their ratification, that are linked, directly or indirectly, to the status and significance of terrestrial and/or marine biodiversity, including the following examples:

1. The Convention on Biological Diversity (CBD).
2. The Cartagena Protocol on Biosafety.
3. The Ramsar Convention on Wetlands.
4. The Convention on the International Trade in Endangered Species (CITES).
5. The CBD Cross-Cutting Initiative on Biodiversity for Food and Nutrition.
6. The International Undertaking on Plant Genetic Resources.
7. The International Tropical Timber Organization (ITTO).
8. The UNESCO Man and the Biosphere Programme.
9. The Law of the Sea and Various Marine Regional Seas Agreements.
10. The UN Framework Convention on Climate Change (UNFCCC).
11. The Kyoto Protocol.
12. The Bali Action Plan on Climate Change.
13. The Copenhagen Accord on Climate Change.
14. The Rio Declaration on Environment and Development, and Agenda 21.
15. The UN Convention on Combating Desertification (UNCCD).
16. The Stockholm Convention on Persistent Organic Pollutants (POPs).
17. The Basel Convention on Hazardous Wastes.
18. The Nagoya Protocol on Access and Benefit Sharing
19. The Convention on the Conservation of Migratory Species of Wild Animals
20. The Convention on the Protection of the World Cultural and Natural heritage

21. The Convention on the Conservation of Antarctic Marine Living Resources
22. The International Convention for the Conservation of Atlantic Tunas
23. The International Convention for the Regulation of Whaling
24. The United Nations Convention to Combat Desertification
25. The United Nations Convention on Laws of the Sea
26. The International Undertaking on Plant Genetic Resources
27. The Bali Plan of Action on Climate Change
28. The Political Declaration and its Plan of Implementation adopted at the World Summit of Sustainable Development, Johannesburg

6.3 The Convention on Biological Diversity (CBD),The Cartagena Protocol on Biosafety (CPB) and The Nagoya Protocol on Access and Benefit Sharing (NPABS)

6.3.1 The Convention on Biological Diversity (CBD)

The overarching UN Convention on Biological Diversity (CBD), which was signed by 150 government at the United Nations Conference on Environment and Development (UNCED), or popularly called "the Earth Summit", in June 1992, enshrines the following three main goals:

i) The conservation of its biological diversity;
ii) The sustainable use of its components; and
iii) The fair and equitable sharing of the benefits from the use of its genetic resources.

In practice, the objectives of the CBD are to be pursued in accordance with its relevant provisions, are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by the appropriate access to genetic resources and by the appropriate transfer of relevant technologies, taking into account all the rights over the appropriate resources, the appropriate technologies, and the appropriate funding.

The full text of the CDB per se can be found in its 1 Preamble, its 42 Articles and its 3 Annexes, as listed below:

Preamble

The CBD's Article 10, on the "Sustainable Use of Components of Biological Diversity", stipulates that:

"Each Contracting Party shall, as far as possible and as appropriate:

> (a) Integrate consideration of the conservation and sustainable use of biological resources into national decision-making;
>
> (b) Adopt measures relating to the use of biological resources to avoid or minimize adverse impacts on biological diversity;

(c) Protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements;

(d) Support local populations to develop and implement remedial action in degraded areas where biological diversity has been reduced; and

(e) Encourage cooperation between its governmental authorities and its private sector in developing methods for sustainable use of biological resources."

Further, the CBD's Article 19, on the "Handling of Biotechnology and Distribution of its Benefits", reiterates that:

1. Each Contracting Party shall take legislative, administrative or policy measures, as appropriate, to provide for the effective participation in biotechnological research activities by those Contracting Parties, especially developing countries, which provide the genetic resources for such research, and where feasible in such Contracting Parties.

2. Each Contracting Party shall take all practicable measures to promote and advance priority access on a fair and equitable basis by Contracting Parties, especially developing countries, to the results and benefits arising from biotechnologies based upon genetic resources provided by those Contracting Parties. Such access shall be on mutually agreed terms.

3. The Parties shall consider the need for and modalities of a protocol setting out appropriate procedures, including, in particular, advance informed agreement, in the field of the safe transfer, handling and use of any living modified organism resulting from biotechnology that may have adverse effect on the conservation and sustainable use of biological diversity.

4. Each Contracting Party shall, directly or by requiring any natural or legal person under its jurisdiction providing the organisms referred to in paragraph 3 above, provide any available information about the use and safety regulations required by that Contracting Party in handling such organisms, as well as any available information on the potential adverse impact of the specific organisms concerned to the Contracting Party into which those organisms are to be introduced."

Notably, as far as the CBD is concerned, the following is a “Summary of Provisions of the CBD on Access to Genetic Resources, on the Knowledge, Practices and Innovations of Local and Indigenous Communities and on Benefit Sharing”.

6.3.2 The Cartagena Protocol on Biosafety (CPB)

Pursuant to Article 19, paragraph 3, of the Convention on Biological Diversity (CBD), the Conference of the Parties (COP), by its decision II/5, established an Open-ended Ad Hoc Working Group on Biosafety to develop a draft an international protocol on biosafety, specifically focusing on transboundary movement of any living modified organism resulting from modern biotechnology that may have adverse effect on the conservation and sustainable use of biological diversity.

And on 29 January, 2000, the COP to the CBD adopted a supplementary agreement to the CBD, called the Cartagena Protocol on Biosafety (CPB). The CPB seeks to protect biological diversity from the potential risks posed by living modified organisms (LMOs/GMOs) resulting from modern biotechnology. It establishes an advance informed agreement (AIA) procedure for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to the import of such organisms into their territory. The Protocol contains reference to a “precautionary approach” and “reaffirms the precaution language in Principle 15 of the Rio Declaration on Environment and Development”. The CPB also establishes a Biosafety Clearing-House to facilitate the exchange of information on living modified organisms and to assist countries in the implementation of the Protocol.

The full text of the CPB comprises 1 Preamble, 40 Articles and 3 Annexes, as listed below:

Preamble.

Article 1. Objective

Article 2. General Provisions

Article 3. Use of Terms

Article 4. Scope

Article 5. Pharmaceuticals

Article 6. Transit and Contained Use

Article 33. Monitoring and Reporting

Article 34. Compliance

Article 35. Assessment and Review

Article 36. Signature

Article 37. Entry Into Force

Article 38. Reservations

Article 39. Withdrawal

Article 40. Authentic Texts

Annex I. Information Required in Notifications Under Article 8, 10 and 13

Annex II. Information Required Concerning Living Modified Organisms Intended for Direct Use as Food or Feed, or for Processing Under Article 11

Annex III. Risk Assessment

6.3.3 The Nagoya Protocol on Access and Benefit Sharing(NPABS)

Since the "fair and equitable sharing of the benefits arising out of the utilization of genetic resources" is one of the three objectives of the Convention on Biological Diversity (CBD), the "Nagoya Protocol on Access and Benefit Sharing" (NPABS) – or the "The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization" - to the CBD is an international protocol, which aims at sharing the benefits arising from the utilization of genetic resources in a fair and equitable way, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding, thereby contributing to the conservation of biological diversity and the sustainable use of its components. It was adopted by the COP to the CBD at its Tenth Meeting on, 29 October, 2010, in Nagoya, Japan. The NPABS would be open for signature by Parties to the CBD, from 2 February, 2011, until 1 February, 2012, at the United Nations Headquarters in New York, USA.

The NPABS will create much greater legal certainty and transparency for both providers and users of genetic resources by:

i) Establishing more predictable conditions for access to genetic resources;
ii) Helping to ensure benefit-sharing when genetic resources leave the contracting party providing the genetic resources; and
iii) Helping to ensure benefit-sharing, the NPABS creates incentives to conserve and sustainably use genetic resources, and therefore enhances the contribution of biodiversity to development and human well-being.

The NPABS applies to genetic resources that are covered by the CBD, and to the benefits arising from their utilization. Further, the NPABS covers traditional knowledge (TK) associated with genetic resources that are covered by the CBD and the benefits arising from its utilization. The NPABS also sets out core obligations for its contracting Parties to take measures in relation to access to genetic resources, benefit-sharing and compliance.

Domestic-level access obligations under the NPABS include the following:

i) Creating legal certainty, clarity and transparency;
ii) Providing fair and non-arbitrary rules and procedures;
iii) Establishing clear rules and procedures for prior informed consent and mutually agreed terms;
iv) Providing for issuance of a permit or equivalent when access is granted;
v) Creating conditions to promote and encourage research contributing to biodiversity conservation and sustainable use;
vi) Paying due regard to cases of present or imminent emergencies that threaten human, animal or plant health; and
vii) Considering the importance of genetic resources for food and agriculture for food security.

Benefit-sharing obligations under the NPABS include the following:

Domestic-level benefit-sharing measures are to provide for the fair and equitable sharing of benefits arising from the utilization of genetic resources with the contracting party providing genetic resources. Utilization includes research and development on the genetic or biochemical composition of genetic resources, as well as subsequent applications and commercialization. Sharing is subject to mutually agreed terms. Benefits may be monetary or non-monetary such as royalties and the sharing of research results.

Compliance obligations under the NPABS include the following:

Specific obligations to support compliance with the domestic legislation or regulatory requirements of the contracting party providing genetic resources, and contractual obligations reflected in mutually agreed terms, are a significant innovation of the Nagoya Protocol. Contracting Parties are to:

i) Taking measures providing that genetic resources utilized within their jurisdiction have been accessed in accordance with prior informed consent, and that mutually agreed terms have been established, as required by another contracting party;
ii) Cooperating in cases of alleged violation of another contracting party's requirements;
iii) Encouraging contractual provisions on dispute resolution in mutually agreed terms;
iv) Ensuring an opportunity is available to seek recourse under their legal systems when disputes arise from mutually agreed terms;
v) Taking measures regarding access to justice; and
vi) Taking measures to monitor the utilization of genetic resources after they leave a country including by designating effective checkpoints at any stage of the value-chain: research, development, innovation, pre-commercialization or commercialization;

It is critical that the NPABS does specifically address traditional knowledge associated with genetic resources, with provisions on access, benefit-sharing and compliance. It also addresses genetic resources where indigenous and local communities have the established right to grant access to them. Contracting Parties are to take measures to ensure these communities' prior informed consent, and fair and equitable benefit-sharing, keeping in mind community laws and procedures, as well as of customary use and exchange.

The full text of the NPABS is composed of 1 Preamble, 36 Articles and 1 Annex, as listed below:

Article 25. Financial Mechanism and Resources

Article 26. Conference of the Parties Serving as the Meeting of the Parties to this Protocol

Article 27. Subsidiary Bodies

Article 28. Secretariat

Article 29. Monitoring and Reporting

Article 30. Procedures and Mechanisms to Promote Compliance with this Protocol

Article 31. Assessment and Review

Article 32. Signature

Article 33. Entry Into Force

Article 34. Reservations

Article 35. Withdrawal

Article 36. Authentic Texts

Annex. Monetary and Non-Monetary Benefits

As the overarching international convention biodiversity, the Convention on Biodiversity also includes the following key articles as indicated in the following Table 47:

Table 47. Summary of Provisions of the CBD on Access to Genetic Resources, on the Knowledge, Practices and Innovations of Local and Indigenous Communities and on Benefit Sharing

Article 8 (j)	Promote the wider application of the knowledge, innovations and practices of indigeneous and local communities with their approval and involvement and encourage the equitable sharing of the benefits arising from the utilization of the knowledge, innovations and practices of indigeneous and local communities
Article 15.1	Sovereign rights of states over their natural resources: the authority of national governments to determine access to genetic resources
Article 15.2	Endevour to create conditions to facilitate accessto genetic resources for environmentally sound uses by other Contracting Parties and not to impose restrictions that run counter to the objectives of the CBD

Article 15.3	Articles 15, 16 and 19 apply only to genetic resources acquired “in accordance with this Convention”: eg. they do not apply to those obtained prior to its entry into force or from non Parties
Article 15.4	Access, where granted, to be on mutually agreed terms and subject to the provisions of article 15
Article 15.5	Access to genetic resources to be subject to prior informed consent of the Contracting Party provoding such resources, unless otherwise determined by that Party
Article 15.6	Endevour to develop and carry out scientific research based on genetic resources provided by other Contracting Parties with the full participation of, and where possible in, such Contracting Parties
Article 15.7	Take legislative, administrative or policy measures, as appropriate…with the aim of sharing in a fair and equitable way the results of research and development and the benefits arising from the commercial and other utilization of genetic resources with the Contracting Party providing such resources. Such sharing to be upon mutually agreed terms.
Article 16.3	Acces to and transfer of technology using genetic resources to countries providing the genetic resources
Article 19.1	Effective participation by providers of genetic resources in biotechnological research on the genetic resources they provide
Article 19.2	Priority access on a fair and equitable basis by countries (especially developing countries) providing genetic resources to the results and benefits arising from biotechnologies based on them. Such access to be on mutually agreed terms

6.4 Background Paper for the UNGA High-Level Meeting on Biodiversity.

More recently, on 22 August, 2010, as a contribution to the International Year of Biodiversity, the UN Secretary-General, Ban Ki Moon, transmitted a background paper to the UN General Assembly (UNGA) for the “UNGA's High-Level Meeting on Biodiversity”, to be held on 22 September, 2010, at the UN Headquarters in New York.

The background paper listed the five principal pressures that were directly driving the loss of biodiversity, viz. i) habitat change, ii) over-exploitation, iii) pollution, iv) invasive species, and v)climate change. It added that these five pressures were either constant or were increasing in intensity. Further, it stated that the change in the abundance and distribution of species, compounded by climate change, posed serious consequences for human beings and communities, as ecosystems were moving ever so closer to their “tipping points,” beyond which their services would be significantly undermined. Such tipping points included i) the deforestation of vast forested areas, ii) the interactions of climate change, iii) the outbreak of fires, iv) and the multiple collapses of coral reefs and other marine ecosystems due to a combination of ocean acidification, bleaching by warmer waters, overfishing and pollution by nutrients.

The background paper summarizes the findings of the third edition of the Global Biodiversity Outlook (GBO-3), published in May 2010, which highlighted that "the missions of keeping climate change within limits that minimize the risks to human societies, and of avoiding the further loss of biodiversity that provided the critical ecosystem services upon which human societies are interdependent, are in fact two sides — the scientific and the political — of the same coin." It also underscored the manifold linkages between the loss of biodiversity and some of the most central concerns of society, including the tackling of poverty, the improvement of health, and the coping of climate change.

However, the background paper also underscored that "the options for addressing the crisis are much wider than those in earlier projections", and that actions towards the conservation and sustainably use of biodiversity "would reap rich rewards," such as, inter alia, contributing to mitigating climate change by enabling ecosystems to be absorbing and storing more carbon, and supporting peoples adaptation to climate change by enhancing the resilience of ecosystems, thereby rendering them to become less vulnerable.

Additionally, the background paper outlines the format of the September 2010 High-Level Meeting on Biodiversity, which would deal with the following core issues and initiatives, viz. i) the framing of the post-2010 biodiversity strategy; ii) the ensuring of the means of implementing the post-2010 biodiversity strategy; iii) the deriving of benefits from biodiversity for the fostering of development and poverty alleviation; iv) and the realization of measures for facilitating that the objectives of the CBD (biological diversity convention) and the UNFCCC (climate change convention) are mutually reinforcing. On the strategic relationship between biological diversity and climate change, the High-Level Meeting on Biodiversity is scheduled to discuss three specific inter-related topics, including i) the management of biodiversity and ecosystems in a manner that contributes constructively towards national climate change mitigation and adaptation strategies, including the REDD+ (reducing emissions from deforestation and forest degradation), the conservation and sustainable use of forests, and the enhancement of stocks of carbon; ii) the promotion of the synergies among and between the "three Rio Conventions" and other biodiversity-related instruments at the national level, besides making available the foundation needed by their Conferences of the Parties (COPs) and the outcomes of the 20-year review of the Rio Summit at the national level; and iii) the avenues for ensuring that the oceans do continue to serve their role as blue carbon sinks.

(***NB*** ***In Malaysia, at the domestic level, the national equivalents to 1. The Convention on Biological Diversity, 2. The Cartagena Protocol on Biosafety and 3. The Nagoya Protocol on Access and Benefit Sharing are the 1. Various national policies, perspectives and plans on biodiversity; 2.The Biosafety Act of 2007 and 3. The still in preparation Act on Access and Benefit Sharing***)

7. CURRENT AND PROPOSED HUMAN RESOURCE NEEDS AND CAPACITY BUILDING

After ten years since its launch, it is timely to review the implementation of NPBD. NPBD currently does not provide targets or timeframes, nor does it delegate duties of implementation to relevant agencies. The results of a review may enhance its implementation and to re-strategise its emphasis over the next ten years. In addition, there are also gaps and overlaps in existing laws and regulations that govern conservation and sustainable use of biodiversity.

Coordination among the different implementing agencies for biodiversity for the different thematic areas of biodiversity (Table 48) can be further strengthened, especially to improve policy planning and implementation programmes specific to CBD. Consultation with state governments, and guidance and assistance from the federal government in terms of implementation could be further improved.

Systematic implementation of the NPBD at the States level could be improved. Most of the states do not have an "active" platform to implement NPBD systematically and in a strategic manner, although some of the states address the issue of biodiversity indirectly in forums such as *Majlis Tindakan Negeri* where its main focus may not be biodiversity. Further, the various graphics portrayed in Appendix XIXprovides an overview of the thematic assessment matrices from the standpoint of the strengths, constraints, root causes and needs of the human capital required for the biodiversity sector in Malaysia”.

Table 48. Implementing Agencies for the CBD in Malaysia as per its Thematic Programmes and Cross Cutting Issues (NCSA, 2008)

Thematic Areas	Lead Ministry	Related Agencies*
Agricultural Biological Diversity	Ministry of Agriculture and Agro-based Industries (MOA)	Department of Agriculture (DOA) Department of Agriculture - Sabah Department of Agriculture - Sarawak Department of Fisheries (DOF) Department of Veterinary Service (DVS) Malaysian Agricultural Research and Development Institute (MARDI) NRE Ministry of Plantation Industries and Commodities (MPIC) Forest Research Institute Malaysia (FRIM) Malaysian Palm Oil Board (MPOB)

Table 48 (continued)

Thematic Areas	Lead Ministry	Related Agencies*
		Malaysian Cocoa Board Malaysian Rubber Board UPM, UMS, UNIMAS, UITM, USM, UM Sabah Park Sabah Biodiversity Centre Sarawak Biodiversity Centre (SBC)
Forest Biological Diversity	Ministry of Natural Resource and Environment (NRE)	Division of Forestry Development Forestry Department of Peninsular Malaysia (JPSM) Sabah Forestry Department Sarawak Forest Department Sarawak Forestry Corporation (SFC) State Forestry Departments Department of Wildlife and National Parks (Perhilitan) Wildlife Department Sabah Institute for Environment and Development, UKM (LESTARI) Protected Area Management Authorities - Johor National Parks Corp, Perak State Park Corporation, Selangor State Park Corporation, Sabah Parks FRIM Department of Orang Asli Affairs (JHEOA) Sabah Biodiversity Centre SBC
Mountain Biological Diversity	NRE	
Inland Waters Biological Diversity	MOA	DOF Department of Irrigation and Drainage (DID) Department of Environment (DOE) Sarawak Rivers Board
Marine and Coastal Biological Diversity	DOF	State Governments DID Department of Marine Parks Malaysia (DMPM) DOE Sarawak Forest Department/SFC Wildlife Departments
Islands Biological Diversity	NRE	DMPM State/Local Governments Langkawi Development Authority Labuan Development Authority Tioman Development Authority DOE
Invasive Alien Species	MOA	DOA DOA Sabah

Table 48 (continued)

Thematic Areas	Lead Ministry	Related Agencies*
		DOA Sarawak DOF DMPM MARDI Sabah Forestry Department Sarawak Forest Department/SFC State Forestry Departments FRIM Perhilitan Sabah Wildlife Department
Ecosystem Approach	NRE	Division of Forestry Development JPSM Sabah Forestry Department Sarawak Forest Department/SFC State Forestry Departments Perhilitan Sabah Wildlife Department Protected Area Management Authorities - Johor National Parks Corp, Perak State Park Corporation, Selangor State Park Corporation, Sabah Parks FRIM DMPM MARDI (agro-ecosystem)
Global Taxonomy Initiative	NRE	FRIM MARDI DOA Perhilitan DOF SFC Sabah Biodiversity Centre SBC
Global Strategy on Plant Conservation	NRE	FRIM State Forestry Departments DOA MARDI Perhilitan Sabah Biodiversity Centre SBC
Protected Areas	NRE	Please refer to "ecosystem approach"
Scientific Assessment	NRE	FRIM Forestry Department of Peninsular Malaysia (JPSM)

Table 48 (continued)

Thematic Areas	Lead Ministry	Related Agencies*
		Sabah Forestry Department Sarawak Forest Department/SFC State Forestry Departments MARDI Perhilitan DOF Sabah Biodiversity Centre SBC
Indicators	NRE	All related implementing agencies
Technology Transfer & Cooperation	NRE	All related implementing agencies
Economic, Trade, Incentives	Ministry of International Trade and Industry (MITI)	EPU CEMD State EPUs
Sustainable Use	NRE	EPU CEMD State EPUs
Tourism and Biodiversity	NRE	Perhilitan Sabah Forestry Department Sarawak Forest Department/SFC State Forestry Departments Protected Area Management Authorities - Johor National Parks Corp, Perak State Park Corporation, Selangor State Park Corporation, Sabah Parks, Sarawak Forestry Corporation DMPM
Access and Benefit-Sharing, & Traditional Knowledge	NRE	Ministry of Domestic Trade and Consumer Affairs Sabah Biodiversity Centre SBC
Liability & Redress	NRE	All related implementing agencies
Financial Resource & Mechanism for CBD	NRE	EPU Ministry of Finance State EPU & Treasury

Table 48 (continued)

Thematic Areas	Lead Ministry	Related Agencies*
National Reports	NRE	All related implementing agencies
Education & Public Awareness	NRE	All related implementing agencies
Clearing House Mechanism	NRE	FRIM All related implementing agencies

It is a challenge to apply economic instruments for conservation of biodiversity. Applying economic incentives requires greater understanding of how these mechanisms work, and confidence that these have been designed and developed correctly in the Malaysian context.

There is a need for an overall and comprehensive monitoring mechanism for the implementation of NPBD by relevant implementing agencies and also status governments.

Lack of framework that guides research and development related to biodiversity at the macro-level in a coherent manner. There is duplication and overlap in research work that has been carried out. Funding from various sources is not managed at the "macro" level to ensure efficient use of research funds. Furthermore there is no dedicated funding from the National Science Fund for biodiversity.

Universities courses are biased towards applied sciences and do not offer courses to produce enough experts. There is a lack of experts, particularly taxonomists in marine and freshwater fishes, arthropod and pathogens. This is not effectively addressed by JPA, local universities and research institutions. For instance, promotion opportunities within government institutions for taxonomists are rather limited within their field of expertise.

Awareness of the importance and significance of biodiversity conservation and management could be improved. Technical officers may not relate their work in terms of contributing towards conservation of biological diversity. Mainstreaming and allocation and financial resources for issues related to biodiversity conservation could be increased.

The benefits sharing aspect of "Access and Benefits Sharing" is not well developed and regulated in Malaysia. The Access and Benefits Sharing Bill has not been passed as a law. When it passes as a law, capacity building will be needed to implement the law.

Conservation of marine biodiversity is not as advanced as conservation of terrestrial ecosystems. Currently in Peninsular Malaysia, the conservation of marine biodiversity is carried out by the Department of Marine Parks Malaysia and the Department of Fisheries. Integration of activities related to conservation of marine diversity with other related agencies could be further enhanced.

Protected areas are gazetted under specific state or federal laws (e.g. state enactment, Forestry Act, National Park Act, etc.) and are managed by various implementing agencies. Governance of PA management can be further improved and harmonised with a national guideline or policy.
Mechanisms to recognise local and indigenous peoples as custodians of biodiversity could be improved. Their traditional knowledge should be protected, together with the ecosystem (terrestrial or marine) and habitats that house biodiversity.

In this context, in order to identify the priority capacity needs and opportunities in the sector of biodiversity was undertaken by the Ministry of Natural Resources and Environment in 2008 through a National Capacity Action Plan (NCAP), the results of which are presented in Table 49

Table 49 Conservation of Biological Diversity – Capacity Development (NCSA, 2008)

No	Capacity Development Activity
1	**Review the implementation of National Policy on Biological Diversity.** • Assess the achievement of policy implementation. • Revise strategies and action plans to improve implementation based on thematic areas. • Establish timeframe to achieve certain targets. • Assign implementation to relevant agencies. • Develop performance indicators (based on thematic areas such as forestry, agricultural etc.) • Strengthen the institutional capacity of CEMD as focal point of CBD. • Improve the implementation mechanisms of the National Policy in Biological Diversity. a. Re-activate National Committee on Biodiversity, b. Review and streamline existing governance structure of MBBN, National Committee on Biodiversity, and the Biotechnology Directorate to improve effectiveness of coordinating meetings and improve decision making c. Consider restructuring of MBBN: - whether Biodiversity and Biotechnology should share one council.
2	**Fine tune and harmonise legislations and regulations to effectively implement conservation and sustainable use of biodiversity.** • Review and harmonise key federal legislations related to conservation and sustainable use of biodiversity such as the National Forestry Act 1984 or Protection of Wild Life Act 1972 to expand existing list of protected species and their habitat. • Review key regulations and guidelines related to biodiversity and natural resources in every state.
3	**Streamline mandates and roles of implementing agencies.** • Streamline, formalise and assign mandates to government agencies that are involved in the implemented programmes of work for CBD. • Develop secondment programme and cadre positions within public sector to encourage transfer and exchange of skills and knowledge from other sectors.
4	**Activate State Biodiversity Councils or equivalent bodies to implement NPBD at state level.** • Formulate state policy and action plan to implement NPBD. • Recommend institutional framework for implementation. • Monitor and report on implementation status. • Enhance coordination mechanism between state and federal level agencies and stakeholders in management and conservation of biodiversity.
6	**Establish regular reporting framework on the implementation of NPBD.** • Develop a reporting framework on the implementation status of NPBD. • Improve and enhance clearing house mechanism to facilitate effective information sharing of inventories and databases for decision making, research and management.
7	**Develop a framework to coordinate research among implementing agencies, research institutions and universities.** • Take stock of R&D related to biodiversity and identify priority areas. • Develop sustainable funding for R&D. • Facilitate effective collaboration between research institutions and implementing agencies to ensure that R&D outputs will be used for conservation management.

Table 49 (continued)

8	**Develop a programme to systematically address the shortage of experts in the country related to biodiversity, particularly taxonomists.** • Improve incentive schemes (remuneration packages, career paths and banded services) to encourage and retain people in this field. • Develop scholarship schemes with other institutions (e.g. MARA, JPA) for biodiversity related courses to address the shortage of local experts.
9	**Mainstream CBD and promote its importance and significance to integrate biodiversity consideration into decision making and planning.** Target groups: • Decision makers • Government agencies (Federal, State, Local Government) • Local communities
10	**Develop and implement a programme for Access and Benefits Sharing (ABS).** • Explore possible approaches for implementing programmes at national level. • Carry out relevant capacity building activities in order to establish and implement a legal framework for ABS in Malaysia.
11	**Enhance and strengthen Marine Biodiversity Conservation.** • Review and revise laws and regulations to improve conservation of marine and coastal biodiversity effectively. • Harmonise roles and improve coordination of implementing agencies including such agencies as the Marine Maritime Enforcement Agency (APMM). • Establish a network of centres of excellence to support marine biodiversity conservation.
12	**Strengthen the network of Protected Areas management in Malaysia.** • Identify synergies among various authorities that manage protected areas in Malaysia to develop a common management framework. • Establish a secretariat to harmonise the governance and management of protected areas in different states. • Develop a reporting framework with relevant indicators.
13	**Establish a national programme on traditional knowledge related to conservation of biodiversity.** • Formulate a coherent national programme with regards to the protection and maintenance of traditional knowledge related to biodiversity.

In this context, the Malaysian government has identified capacity gaps a challenges for capacity develeopment action as stated in Table 50.

Table 50. Biodiversity related Capacity Gaps and Proposed Action Plans for Malaysia (sourced from: NRE, 2010b)

Capacity Gaps / Challenges	Capacity Development Actions
1. After 10 years since its launch, it is timely to review the implementation of NPBD. NPBD currently does not provide targets and timeframe, nor does it delegate duties of implementation to relevant agencies. The results of a review may enhance its implementation and to re-strategise its emphasis over the next ten years.	Review implementation of National Policy on Biological Diversity (NPBD).
2. There are gaps and overlaps in existing laws and regulations that govern conservation and sustainable use of biodiversity.	Fine tune and harmonise legislations and regulations to effectively implement conservation and sustainable use of biodiversity.
3. Coordination among implementing agencies can be further strengthened especially to improve policy planning and implementation programmes specific to CBD. Consultation with state governments, and guidance and assistance from federal government in terms of implementation could be further improved.	Streamline mandates and roles of implementing agencies.

Table 50 (continued)

Capacity Gaps / Challenges	Capacity Development Actions
4. Systematic implementation of the NPBD at the States level could be improved. Most of the states do not have an "active" platform to implement NPBD in a systematic and strategic manner, although some of the states address the issue of biodiversity indirectly in forums such as the State Action Council where its main focus may not be on biodiversity.	Activate State Biodiversity Councils or equivalent relevant bodies for implementation of NPBD at state levels.
5. It is a challenge to apply economic instruments for conservation of biodiversity. Applying economic incentives require greater understanding of how these mechanisms work, and confidence that these have been designed and developed correctly in the Malaysian context.	Develop incentive scheme for states to conserve biodiversity.
6. There is a need for an overall and comprehensive monitoring mechanism for the implementation of NPBD by relevant implementing agencies and also state governments.	Establish regular reporting framework on the implementation on NPBD.
7. Lack of framework that guides research and development related to biodiversity at macro-level in a coherent manner. There is duplication and overlap in research works that had been carried out. Funding from various sources is not managed at the "macro" level to ensure efficient use of research funds. Furthermore there is no dedicated funding from the National Science Fund for biodiversity.	Develop a framework to coordinate research among implementing agencies, research institutions and universities.
8. University courses are biased towards applied sciences and do not offer courses to produce enough experts. There is lack of experts, particularly taxonomists in marine and freshwater fishes, arthropods and pathogens. This is not effectively addressed by the Public Services Department, local universities and research institutions. For instance, promotion opportunities within government institutions for taxonomists are rather limited within their field of expertise.	Develop a programme to systematically address the shortages of experts in the country related to biodiversity in the country, particularly taxonomists.
9. Awareness of the importance and significance of biodiversity conservation and management could be improved. Technical officers may not relate their work in terms of contribution towards conservation of biological diversity. Mainstreaming and allocation of financial resources for issues related to biodiversity conservation could be increased.	Mainstream CBD and promote its importance and significance so that conservation issues can be integrated into decision making and planning.
10. The benefits sharing aspect of "Access and Benefits Sharing" is not well developed and regulated in Malaysia. The Access and Benefits Sharing Bill has not been passed as a law. When it passed as a law, capacity building will be needed to implement the law.	Develop and implement a programme for ABS.

Table 50 (continued)

Capacity Gaps / Challenges	Capacity Development Actions
11. Conservation of marine biodiversity is not as advanced compared to terrestrial ecosystems. Currently in Peninsular Malaysia, the conservation of marine biodiversity is carried out by Department of Marine Park Malaysia and the Department of Fisheries. Integration of activities related to conservation of marine diversity with other related agencies could be further enhanced.	Enhance and strengthen marine biodiversity conservation.
12. Protected areas are gazetted under specific state or federal laws (e.g. state enactment, National Forestry Act, National Park Act, etc.) and are managed by various implementing agencies. Governance of protected area management can be further improved and harmonised with a national guideline or policy.	Strengthen the network of Protected Areas management in Malaysia.
13. Mechanisms to recognise local and indigenous peoples as custodians of biodiversity could be improved. Their traditional knowledge should be protected, together with the ecosystem (terrestrial or marine) and habitat which houses biodiversity.	Establish a national programme on traditional knowledge related to conservation of biodiversity.

The availability of adequate numbers of suitably trained and skilled innovative human resources, especially of field/laboratory scientists/researchers at the experimental level, and of sufficient numbers of appropriately and currently informed/updated pioneering decision-makers at the policy level, are the building blocks of stimulating and mainstreaming frontier R&D and STI in science and technology for the sustainable conservation and utilization of biodiversity, including for sustained wealth generation and development.

Unfortunately, due to the realities of market forces and of the prospects of salaried employment careers, scientists/researchers belonging to some categories/disciplines of science and technology, particularly at the higher and more senior levels, who tend to be represented among the fundamentals or the building blocks of biodiversity, have, over time, steadily declined in numbers to be hardly in existence or are still available in today's quota of professionals. Such scarce categories of scientists/researchers include taxonomists, specialists in lesser known or lesser commercial-worthy species, and/or their symbiotic/parasitic counterparts, of flora and fauna, biologists, microorganisms, ecologists, etc, whose numbers and capacities need to be consciously expanded, including for the sake of inventorying and understanding the different elements of biodiversity.

At a "Workshop on Human Resource Needs for the Management and Conservation of Biodiversity in Malaysia", held on 14 December 2004 coordinated by the Ministry of Natural Resources and Environment among the major issues identified included the following:

1. The need to address the highly fragmented nature of the institutional structures for biodiversity conservation and management.
2. The need for policy consistency for biodiversity management and conservation.
3. The need for improved capacity within the agencies concerned for biodiversity management and conservation
4. The need to enhance present federal-state relationships for biodiversity management and conservations.
5. The need to address the fragmented nature of current management systems, the lack of coordination between agencies, poor information exchange and data flow, and limited monitoring and enforcement.
6. The need to address the poor grasp of biodiversity requirements in terms of the necessary skills among the agencies and the inadequate human resource planning in the field.
7. The absence of adequate tools to enable effective human resource planning and development.
8. The absence of awareness of the importance and the significance of biodiversity conservation and management at the school level, including the possible development and incorporation of an Environmental Education Policy in school syllabus/curriculum.
9. The absence of awareness of the importance and significance of biodiversity conservation and management at the civil service level.
10. The current university courses are too focused and should therefore be made much more interdisciplinary in nature and scope.

In the findings of the workshop, it was recognised that the following human resource sectors were critical for biodiversity management and conservation:

i. Molecular biologist

ii. Taxonomists (more so since taxonomy deemed as non marketable and non profitable science)
iii. Population biologists
iv. Resource managers

In addition, it might also be advantageous to build Malaysia's human resource capacity for biodiversity management and conservation in the following sectors:

i. Environmental economics including full cost accounting, carbon trading, perverse subsidies, cradle to grave accounting, internalizing externalities including services provided by ecosystems, biodiversity based, including ecosystem-based management, planning (eg, Strategic Environmental Assessment, SEA), development (eg. Mellinium Ecosystem Development approaches), conservation, sustainable use and commercialization (eg. full cost accounting and cradle to grave costings and implications).
ii. Mainstreaming capacitybuilding for human capital, institutional capital and financial capital for biodiversity conservation, sustainable utilization and commercialization into the already mainstreamed capacity building for development planning
iii. Promoting education and awareness for all sectors of society of the significance of biodiversity to our present and future livelihoods which should in turn affect their attitude, behaviour and stewardshipfor the conservation, sustainable use and commercialization of biodiversity.
iv. Promulgating, implementing and enforcement of institutions and comprehensive legislations which would ensure the effective and appropriate safeguards for the conservation, sustainable use and commercialization of biodiversity.
v. Exploring opportunities for the commercialization and wealth creation from biodiversity in a manner that would not compromise the conservation and sustainable use of biodiversity in Malaysia.
vi. Enhancingand documenting the traditional knowledge available in Malaysia, particularly among local communities and indigeneous peoples, especially in the areas of human health, food security, access and benefit sharing, biosafety, safeguards against biopiracy,

agriculture, disease treatment and control, and of traditional wisdom and in the setting up of nurseries.

vii. Identifying and building the skills in biodiversity-related sectors and, providing the training required for the conservation, sustainable use and commercialization of biodiversity in Malaysia.

Further, the following thirteen activities, under the umbrella of the National Capacity Action Plan (NCSA), in the thematic area of the conservation and sustainable use of biological diversity have been identifiedfor further improvement and capacity building, both in terms of their policies and institutions, as well as on their prevailing strengths, constraints, root causes and needs (see Table 49).

i. Reviewing implementation of Malaysia's National Policy on Biological Diversity (NPBD)
ii. Fine tuning and harmonizing legislation and regulation to effectively implement conservation and sustainable use of biodiversity
iii. Streamlining mandates and roles of the implementing agencies
iv. Activating State Biodiversity Councils or their equivalent bodies to implement NPBD at the state level
v. Developing incentive schemes for states to conserve biodiversity
vi. Establishing regular reporting frameworks on the implementation of the NPBD
vii. Developing a framework for coordinating research among the implementing agencies, research institutions and universities
viii. Developing a programme to systematically address the shortage of experts in the country related biodiversity, particularly of taxonomists
ix. Mainstreaming the Convention on Biodiversity and promoting its importance and significance to integrate biodiversity considerations into decision making and planning
x. Developing and implementing a programme for Access and Benefit Sharing (ABS)
xi. Enhancing and strengthening marine biodiversity conservation
xii. Strengthening the network of Protected Areas management in Malaysia

xiii. Establishing a national programme on the traditional knowledge related to the conservation of biodiversity

8. USE OF ECONOMIC ISSUES AND INSTRUMENTS FOR DECISION MAKING

As reiterated earlier, sustained growth or sustainable development comprises three inter-related and mutually reinforcing dimensions - its social, its economical and its environmental imperatives. However, in policy and in practice, and for the better or for the worse, it is often the economical imperatives that tend to predominate decision making, especially "in the spirit of being the first among the equals". And even more so, when it involves the paradigm, scope and thrust of the present ASM MSF Study on the Biodiversity Sector in Malaysia, which aims to formulate a road map and an action plan for the simultaneous conservation of biodiversity, sustainable utilization of biodiversity and wealth creation of biodiversity, thereby enhancing the role and responsibility of biodiversity in its contribution towards the GNP/GDP of Malaysia in its pursuit of becoming a fully developed country by the year 2020\2050 and beyond.

At a cursory glance, the use ofeconomical issues and initiatives appears to be a simple and straightforward assignment for the development and the decision-making, particularly in steering the direction and the speed for Malaysia's own sustainable growth and it achieving the status of a fully industrialized country in the near future. However, the proper calculations and the judicious applications of economical issues and initiatives are in reality far more complex, multi-faceted and integrated than meets the eyes of the stakeholders and the decision-makers.

From a biodiversity standpoint, among the economical issues and initiatives that need to be addressed and articulated by the decision-makers, are included, *inter alia*, the following

1. Costing of full cost accounting.
2. Costing of internalizing externalities.
3. Costing of incentives and costing of disincentives.
4. Costing of short-term, reactive and end of the pipeline-oriented remedial measures *vis a vis* the costing of long-term, proactive and up-steam source-oriented preventative mechanisms.
5. Costing of subsidies and the costing of 'perverse subsidies".

6. Costing of raw, tangible goods and products and the costing of value-added, intangible services and functions of natural ecosystems versus the costing of anthropogenic ecosystems (eg. costing of natural forests ecosystem *vis a vis* the costing of plantations and likewise also for the costing of other terrestrial, aquatic, marine and coastal ecosystems and their biodiversity *vis a vis* the costing of their anthropogenic alternates).
7. Costing of individual and isolated impacts, initiatives and interventions and the costing of multiple and cumulative
8. Costing at the genetic, species and ecosystem levels, including the costing of their conservation, sustainable utilization, wealth creation and loss or extinction.
9. Costing of actions now versus the costing of inactions now and their costing for the ensuing costs later.
10. Costing of *quid pro quo* interventions andthe costing of Federal-Federal and/or Federal-State arrangements, including costing of royalties.
11. Costing of innovative and novel approaches, including, *inter alia*, the costing of carbon stocking, carbon trading, carbon offsets, Reducing Emissions from Deforestation and Degradation of Forests (REDD), industrial symbiosis, Clean Development Mechanisms (CDM), strategic environmental assessment (SEA), payments for ecosystem services (PES), debt for nature swaps, biotechnology, nanotechnology, bio-informatics for biodiversity databases, remote sensing, camera trapping, identifying, inventorying, etc.
12. Costing for effective and meaningful enforcement, monitoring and evaluation of the concerned policies, plans, laws, rules and regulations and the costing of the lack and inadequacy of the same checks and balances including the costing of Malaysia fulfilling its obligations under the relevant Multilateral Environmental Agreements (MEAs).
13. Costing for preservation, documentation and fostering of the unique, valuable and threatened status of the traditional knowledge, the traditional skills and the traditional lifestyles of the local communities, particularly of the indigenous peoples throughout Malaysia, whose existence and is closely linked to and interdependent on biodiversity and its natural resources.
14. Costing of contribution of the GDP/GNP of Malaysia and the costing for its equitable distribution to all sectors of society, especially for the marginalised, vulnerable and

relatively impoverished local communities including the costing for preservation, documentation and fostering of the unique, valuable and threatened status of the traditional knowledge, the traditional skills and the traditional lifestyles of the local communities, particularly of the indigenous peoples throughout Malaysia.

15. Costing for establishing and operationalizing the National Biodiversity Centre, and the National History Institute in Malaysia, building the types and priorities of their required national human resource capitals, infrastructures and support systems, and the basic and applied R&D and S,T&I ventures to be adopted, promoted and coordinated and the costing for opting to adhere to the business as usual scenarios.

In the final analysis, given the predominance of economical imperatives in decision making, including in the development, globalisation, modernization, urbanization and sustainable growth of the country, as well as the scope, thrust and pace of the R&D and S,T&I in Malaysia forging ahead to become a fully industrialised country by 2020, from a sustainability stance, it would be judicious to improvise, incorporate, consolidate and mainstream the prudent and cogent economical indicators, *vis a vis* their social and environmental indicators, that would pave the way of a win-win-win outcome when ii involves the concurrent trifold goals of the conservation of biodiversity, the sustainable utilization of biodiversity and the wealth creation from biodiversity. Besides the case studies implemented in various other countries, Malaysia too has its own case studies on the use of economic evaluation for decision making (refer to Table 28).

9. <u>COUNTRY MODELS</u>

Given the significance of biodiversity (at all its three levels of genetic, species and ecosystems) on the welfare and well being of people and the environment, a wide variety of country models have been developed for the conservation and sustainable utilization of biodiversity, and from which Malaysia could extract and adapt appropriate strategies and mechanisms that are conducive to the Malaysian scenario. For instance, in British Clumbia their success in this initiative is based on a March 2009 Compendium of Conservation Science to support action in biodiversity (also available in CD-ROM) which embraces a commitment towards the achievement of the following 3 goals:

Goal 1: Conserving the Elements of Biodiversity – To maintain the diversity of genes, species and ecosystems, prevent elements of biodiversity from becoming at risk and contribute to global efforts for biodiversity conservation

Goal 2: Increasing Awareness of the Importance of Biodiversity and Respect for the Natural Environment – To increase the awareness and understanding about the value of biodiversity and encourage British Columbians to undertake action on conserving Biodiversity

Goal 3: Providing Tools and Incentives to Enable Biodiversity Conservation – To provide tools and incentives to enable governments (including First Nations), industry, conservation organizations and citizens to improve the conservation of British Clumbia's diversity.

Likewise in the case of Costa Rica, its success in the conservation and sustainable use of Biodisversity is fostered by the following factors:

1. The establishment of the Ministry of Environment and Energy (MINAE), and more specifically to the national system of conservation areas (SINAC) which is responsible for the conservation and sustainable use of the country's biodiversity. SINAC has 11 Conservation Areas distributed throughout the country and is headed by a Directorate that provides technical support.

2. The mandating by MINAE of the 11Conservation Areas, in different regions, to undertake a decentralized management of biodiversity, with the active participation of the communities surrounding the protected wildland areas. This participation is of vital importance for the conservation and sustainable use of biodiversity at the local, national and global level. INBio has worked very closely with SINAC since its foundation, and especially from 1998 onwards, through the INBio-SINAC Joint Program.
3. Over 25% of Costa Rica's territory in under some category of protection, and the percentage is increasing with the support of the private sector which has created several private reserves dedicated mainly for ecotourism and research (see below for details on Costa Rica's ecotourism ventures).
4. The knowledge obtained through inventories and scientific studies and their appreciation by society, plays an essential role in ensuring the long-term conservation of the country's protected areas and natural resources. Studies have been conducted to provide both basic and applied information on the country's biological riches (what exists, where, what it can be used for, conservation status, etc.), prepared by numerous public and private institutions, as well as by NGOs.
5. Costa Rica has a very comprehensive legal framework for the conservation and sustainable use of biodiversity. This has been strengthened with the enactment of the Biodiversity Law, approved in 1998, and the formulation of the National Strategy for the Conservation and Sustainable Use of Biodiversity, using a highly participatory process at the local and national levels. The National Strategy was completed and officially adopted in 1999. The Biodiversity Law establishes that the National Commission for Biodiversity Management (CONAGEBIO), together with SINAC, is responsible for the administration of the country's natural resources.

In the case of Malaysia as a country model, the following could represent some of its ingredients and interventions for the conservation of sustainable use, commercialization and wealth creation from biodiversity.

9.1 Ecotourism Industry

In Malaysia itself there are clear instances where different approaches to tourism have resulted in different outputs and outcomes. For instance, at the better known turtle sanctuary at Rantau Abang, the number of turtles nesting and drawing visitors has dramatically declined over the years due to the overexploitation of its tourism resources. However, in the Sabah Parks Turtle Island, turtle related tourism is still a viable industry due to its adherence to best practices, particularly carrying capacity principles.

Likewise, in Australia ecotourism industry at the Great Barrier Reef is managed by differential zonation, with different zones of the Great Barrier Reef allocated and permitted only for specific activities (eg. snorkeling, diving, coral viewing, etc.) whereas other zones are protected as “no take zones”.

Another example of sustainable ecotourism can be found in Costa Rica. One of the highlights of the ecotourism industry involves the inclusion of stakeholders from various backgrounds, including international aid and financial institutions, government, NGOs and grassroots organizations, private sector and tourists. Additionally, Costa Rica has also established the Certificate for Sustainable Tourism (CST) certification programme. The ecotourism programme of Costa Rica and its sustainability is based on the following principles (Blamey, 2001):

1. Using resources sustainably
2. Reducing over consumption and waste
3. Maintaining biodiversity
4. Integrating tourism into planning
5. Supporting local economies
6. Involving local communities
7. Consulting stakeholders and the public
8. Training staff
9. Marketing tourism responsibly
10. Undertaking research

9.2 Pharmaceutical Industry

Figure 26. World Pharmaceutical Market, 1996 (sourced from: ten Kate & Laird, 2000)

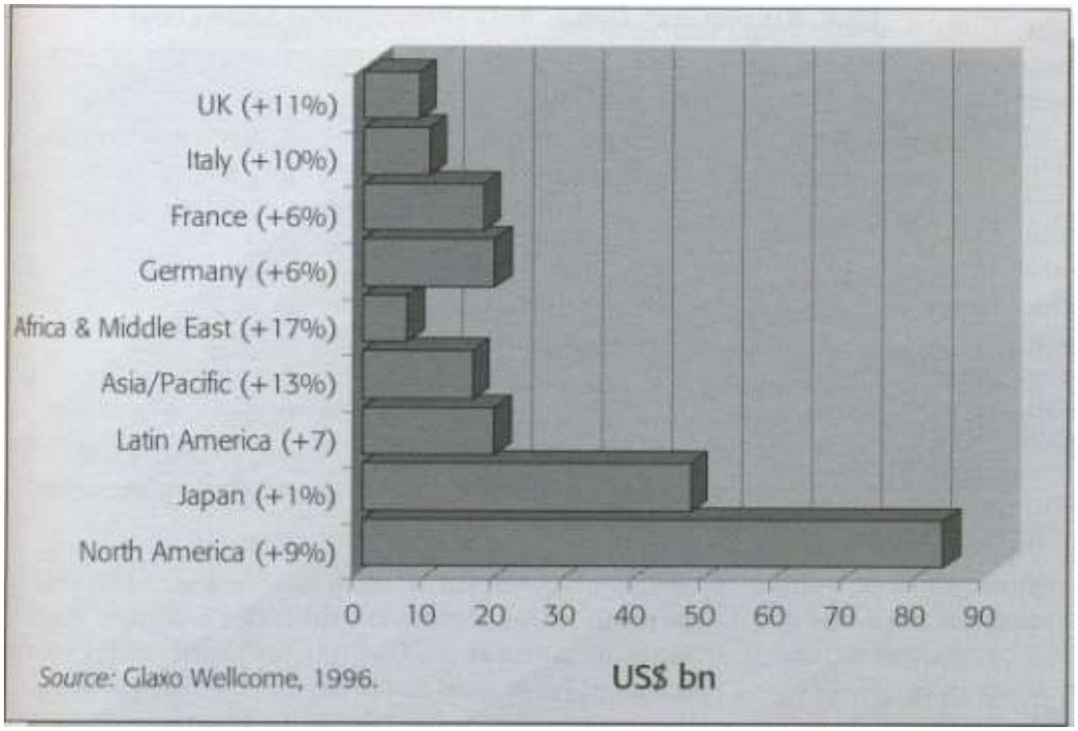


Table 51. The World's Top Ten Pharmaceutical Companies, 1998 (sourced from: ten Kate & Laird, 2000)

Company	1998 Forecast sales ($US bn) Pharmaceuticals	Group
Merck & Co** (USA)	15,971	27,439
Glaxo Wellcome** (UK)	14,010	14,010
Novartis** (Switzerland)	13,433	23,685
Bristol-Myers Squibb** (USA)	12,220	18,341
Pfizer** (USA)	10,689	13,682
Roche** (Switzerland)	10,553	18,784
American Home Products* (USA)	10,549	14,657
Johnson & Johnson* (USA)	8,925	25,365
SmithKline Beecham** (UK)	8,688	14,100
Hoechst** (Germany)	8,173	30,072

** = companies with natural products discovery programmes
* = companies with wholly-owned subsidiaries conducting natural product discovery

Table 52. Top Ten Pharmaceutical Companies, USA, Europe and Japan, 1997 (Prescription Sales Only (sourced from: ten Kate & Laird, 2000)

USA	Europe	Japan
Merck & Co	Glaxo Wellcome	Sankyo
Bristol-Myers Squibb	Novartis	Takeda
Pfizer	SmithKline Beecham	Yamanouchi
Eli Lilly	Roche	Daiichi
Johnson & Johnson	Astra	Eisai
American Home Products	Rhône-Poulenc Rorer	Shionogi
Schering Plough	Zeneca	Fujisawa
Pharmacia & Upjohn	Hoechst Marion Roussel	Chugai
Abbott	Bayer	Banyu
Warner Lambert	Schering AG	Ono Pharmaceuticals

Table 53. Mergers and Acquisitions that have Re-shaped the Drug Industry Over the Past Decade (sourced from: ten Kate & Laird, 2000)

Year	Merger or acquisition	New company name
1998–9	Astra AB and Zeneca Group	AstraZeneca
	Sanofi and Synthelabo	
	Hoechst and Rhône-Poulenc	Aventis
	American Home Products and SmithKline Beecham (collapsed)	
	SmithKline Beecham and Glaxo Wellcome (collapsed)	
	American Home Products and Monsanto (collapsed)	
1997	Roche and Boehringer Mannheim	Roche
1996	Ciba Geigy and Sandoz	Novartis
1995	Glaxo and Burroughs Wellcome	Glaxo Wellcome
	Hoechst-Roussel and Marion Merrell Dow	Hoechst Marion Roussel
	Upjohn and Pharmacia	Pharmacia & Upjohn
	Rhône-Poulenc Rorer and Fisons	Rhône-Poulenc Rorer
1994	American Home Products and American Cyanamid	American Home Products
	Hoffmann-La Roche and Syntex	Hoffmann-La Roche
	Pharmacia and Erbamont	Pharmacia
	Sanofi and Sterling (prescription drugs)	Sanofi
	SmithKline Beecham and Sterling (OTC)	SmithKline Beecham
1991	SmithKline and Beecham	SmithKline Beecham
1990	Pharmacia and Kabi	Pharmacia
	Rhône-Poulenc and Rorer	Rhône-Poulenc Rorer
1989	American Home Products and AH Robins	American Home Products
	Bristol-Myers and Squibb	Bristol-Myers Squibb
	Merrell Dow and Marion	Marion Merrell Dow

Table 54. Biopharmacueticals (sourced from: ten Kate & Laird, 2000)

Biotechnology pharmaceuticals ('biopharmaceuticals' or 'biologicals') refer to human therapeutic products produced using biotechnology techniques. Major categories of biopharmaceutical products include proteins and vaccines made using recombinant DNA (rDNA) techniques, and monoclonal antibodies, produced by cell fusion.

In 1998, there were 75 biopharmaceuticals on the market, and 35 more slated for FDA approval. Over 350 biopharmaceuticals produced by 140 pharmaceutical and biotechnology companies are currently under development (see too Table 3.2, p38). Combined annual sales of therapeutic proteins in 1998 were some US$13 billion. Biopharmaceuticals currently contribute 11 per cent of the sales of 'blockbuster' drugs (8.2 per cent of the top 25 sellers). However, the proportion and value of biopharmaceuticals in the market is likely to increase rapidly. US biopharmaceutical sales are expected to grow at an average annual rate of 12 per cent, from US$6.5 billion in 1995 to US$20.4 billion in 2005.

The therapeutic area of biopharmaceuticals that is currently the most significant is cancer, as can be seen from two of the most important cancer products currently on the market. The first, **alpha-interferon**, is used to treat hairy cell leukemia, AIDS-related Kaposi's sarcoma, hepatitis A and hepatitis C. The second, **granulocyte colony stimulating factor (G-CSF)** is used to treat neutropenia in cancer patients undergoing radiation and chemotherapy treatments. Sales in the anti-cancer category are expected to grow at an average annual rate of 13 per cent, from US$2.2 billion in 1995 to US$7.4 billion in 2005. A third blockbuster biopharmaceutical, **erythropoietin (EPO)**, is used to treat anaemia in kidney dialysis patients. Sales in the blood and cardiovascular area of biopharmaceutical therapy are expected to grow at an average annual rate of 11 per cent, from US$2.1 billion in 1995 to US$6.2 billion in 2005. The combined sales of alpha-interferon, G-CSF and EPO represent close to half of total biopharmaceutical sales.

There are over 2,000 biotechnology companies in the world, including 1,300 in the USA and 700 in Europe. At least half are involved in biopharmaceutical discovery and development. Roughly three-quarters have 50 employees or less, although there are some biopharmaceutical companies with multinational scope. For example, Chiron created the first genetically engineered human vaccine for Hepatitis B, and has cloned the Hepatitis C genome and sequenced the entire HIV genome. The company has over 7,000 employees, facilities on four continents, and markets products in 97 countries. In 1997, its revenues were US$1.2 billion. Biopharmaceutical products – such as insulin, interferon, human growth hormone, and hepatitis B vaccine – also contribute significantly to revenues at large pharmaceutical companies like SmithKline Beecham, Merck, Eli Lilly, Schering-Plough, and Roche.

Many analysts believe that molecular biology and genetic engineering will become an important, and possibly, the predominant, approach to drug discovery and development in the 21st century. Based on their analysis of the number of pharmaceutical products in the discovery phase in biotechnology companies, the analysts Lehman Brothers predict in their *PharmPipelines* report that biopharmaceutical products will supply at least half of the technology for new drugs in the next decade. Biotech products are forecast to increase their proportion of blockbuster sales from 11 per cent to 17 per cent of the pharmaceutical market by the end of the decade.

Biopharmaceuticals require access to genetic resources, but in different ways from traditional natural products discovery programmes. The resources in question are usually human genes, or genes from domestic animals. These genes are readily available in collections, laboratories, and hospitals world-wide, and there is usually no need to collect exotic genetic resources from around the world.

Table 55. Examples of Plants Yielding Pharmacuetical Compounds (sourced from; ten Kate & Laird, 2000)

Catharanthus roseus

This species yielded the alkaloids vincristine and vinblastine. Traditionally used by various cultures for the treatment of diabetes, these compounds were first discovered as part of an investigation of the plant as a possible oral hypoglycemic. Originally native to Madagascar, this species is now widespread and common. The vinca alkaloids are used in the treatment of childhood leukemia and Hodgkin's disease.

***Podophyllum* spp**

The two active ingredients – etoposide and teniposide – are semisynthetic derivatives of the natural product epipodophyllotoxin, which was isolated as the active anti-tumour agent from the roots. These species were long used by indigenous peoples in America and Asia, including for the treatment of skin cancers and warts. Etoposide generates US$100–200 million in revenues for the manufacturer, Bristol-Myers Oncology. The combination of cumulative demand and loss of habitat led to the placement of *Podophyllum hexandrum* on Appendix II of the CITES list in January 1990.

Taxus brevifolia

Collected in Washington State, USA as part of a random collection programme by the US Department of Agriculture (USDA) for the NCI, paclitaxel was isolated from the bark of this species. Indigenous peoples in North America used this species for the treatment of some noncancerous conditions. The needles of *Taxus baccata*, in which paclitaxel is found, are used in traditional Ayurvedic medicines, with one reported use being for cancer. Paclitaxel is now marketed under the brand name Taxol by Bristol-Myers Squibb.

Camptotheca acuminata

This species is an ornamental tree in China, and has yielded the clinically active agents topotecan, irinotecan, and 9-aminocamptothecin, which are semisynthetically derived from camptothecin, isolated from this tree. Camptothecin is now marketed under the generic name 'Topotecan' and the brand name 'Navelbine' by SKB.

Chondrodendron tomentosum

This species, used by indigenous peoples in South America in an arrow poison known as *curare*, yields the compound d-tubocurarine, which is used as the model for a series of similar synthetic neuromuscular-blocking agents, such as succinylcholine, now commonly employed as an anesthetic in surgical operations. Recently, synthetics such as vencuronium and atracurium have completely replaced the natural product for clinical use.

Rauwolfia serpentina

Known as the Indian snakeroot, with a long history of traditional medical use, including for the treatment of mental disorder, snake bites, and as a tranquiliser, this species yields the antihypertensive compound reserpine. The alkaloid reserpine revolutionised Western medical treatment of hypertension in the 1950s, and caused massive over-harvesting of wild populations in India, leading to its inclusion on CITES Appendix II in 1990. Estimated sales of reserpine in 1989 were US$42 million in the USA alone. The Indian Ministry for Environment and Forests estimated sales of antihypertensives derived from the Indian snakeroot at more than US$260 million in 1994.

***Chincona* spp**

The bark of this species yields quinine, a treatment for malaria. In the 1940s the principal alkaloids were isolated and synthesised for the pharmaceutical market, but its use in international markets had been established hundreds of years earlier.

Table 56. Claimed Activity of Selected Top-Selling Botanical Medicines (sourced from: ten Kate & Laird, 2000)

Product	Plant part	Activity
Ginseng	root	increases energy and sex drive
Siberian ginseng	root	defuses nervous tension and fights fatigue
Kava	root	combats anxiety and stress
Green tea	leaves	a powerful anti-oxidant and cholesterol-reducer
Milk thistle	fruit	protects from toxins – eg alcohol, pesticides
St John's wort	herb	anti-depressant
Psyllium	seeds	anti-constipation; helps with weight loss
Hawthorn	fruit	lowers blood pressure and fights arthritis
Saw palmetto	seeds	treats prostate problems
Valerian	root	relieves insomnia, anxiety, menstrual cramps, headaches
Liquorice	root	treats ulcers and stomach disorders
Wild yam	roots	alleviates PMS and menopausal symptoms
Aloe	leaves	treats wounds and skin problems
Camomile	flowers	alleviates moods and skin problems; calming
Feverfew	leaves	relieves migraine headaches
Bilberry	leaves	improves eyesight
Cranberry	fruit	keeps the urinary tract healthy
Garlic	bulb	boosts the immune system; lowers cholesterol
Calendula	flowers	soothes skin; fights bacterial, viral and fungal infections
Echinacea	roots, flowers	boosts immune system; prevents colds
Ginger	rhizomes	treats nausea; inflamed joints
Elderberry	flowers, fruit	remedy for head colds
Ginkgo	leaves	improves energy, mood, and brain function

Figure 27. Allocation of Domestic US Research and Development by Function, 1996 (sourced from: ten Kate & Laird, 2000)

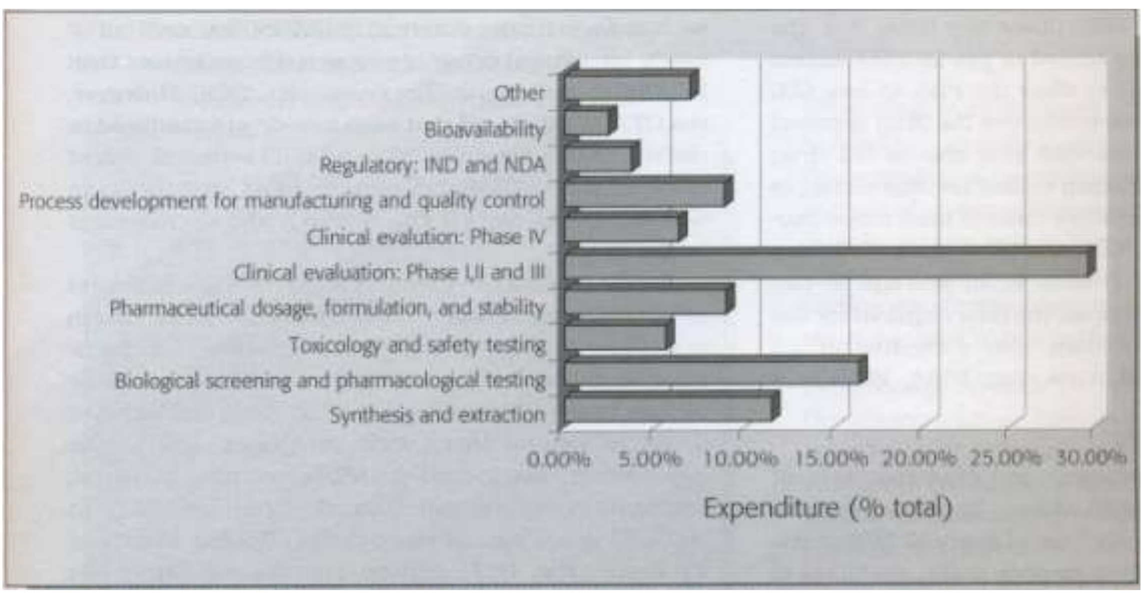


Table 57. Historic and Projected Growth for Botanical Medicine Markets in Selected Countries (sourced from: ten Kate & Laird, 2000)

Country	1985–90	1990–95	1995–9
Germany	8	6	7
France	6	8	9
UK	15	14	16
Italy	15	11	13
Denmark	8	10	14
Spain	15	9	11
Netherlands	8	13	16
Belgium	15	8	10
Portugal	15	9	11
Greece	5	12	15
Ireland	12	10	9
Luxembourg	5	6	8
India	20	25	15
Pakistan	10	8	12
Japan	15	15	10
Taiwan	12	15	15
Korea	15	13	15
Singapore	12	9	10
Malaysia	10	8	10
Indonesia	10	8	10
Philippines	0	0	0
Thailand	8	5	10

10. Work Packages

In order to achieve the expected outputs and outcomes of the study report, on the conservation, sustainable use and wealth creation from Malaysia's biodiversity, the following ten work packages were created and each one elaborated to fulfill its requirements.

Work package	*Key Study/Research (Theme)*
WP1	**Global perspectives: Biodiversity-related industries, market volumes and economic impacts** Expanding on the Mellinium Ecosystem Assessment Report (2005), the following are some of the significant biodiversity related commercial industries include the following: • Food and Agriculture • Bioprospecting • Pharmaceuticals and Bioactive compounds • Indigenous Knowledge • Ecotourism • Horticulture and Agricultural Seeds • Biotechnology • Personal Care and Cosmetics • Feed and Livestock • Ornamental Plants and Animals • Biomimicry • Appropriate Biomass Based Fuels • Industrial Symbiosis • Biodegradable Products • Biological Control and Crop Protection) • Bioremediation • Biomonitoring • Ecological Restoration • Bacterial Enzymes • Biological Mining

Table 58. Origins of Top 150 prescription drugs in the USA
(sourced from: ten Kate and Laird, 2000)

Origin	Total no of compounds	Natural Product	Semi-synthetic	Synthetic	%
Animal	27	6	21	–	23
Plant	34	9	25	–	18
Fungus	17	4	13	–	11
Bacteria	6	5	1	–	4
Marine	2	2	0	–	1
Synthetic	64	–	–	64	43
Total	150	26	60	64	100

Table 59. Large International Seed Companies Globally(sourced from: ten Kate and Laird, 2000)

Company	Main activity	HQ	Some main subsidiaries and/or main brands	Seed turnover (US$ m)[1]	Some core seed products
Pioneer Hi-Bred International	seeds	USA		1,800	maize, oilseeds, alfalfa, cereals
Monsanto	chemistry	USA	Holdens, Dekalb, Cargill Seed International, Asgrow Agricultural Seeds, PBI, Hybritech, Delta & Pine Land, Agroceres	1,200	maize, oilseeds, cotton, vegetables
Novartis Seeds	seeds	Switzerland	Northrup King, Hilleshög, Sluis & Groot, Rogers	900	maize, oilseeds, cereals, sugar beet, vegetables and ornamentals
Groupe Limagrain	seeds	France	Force Limagrain, Maïs Angevin, Nickerson, Vilmorin, Tézier, Clause, Oxadis, Ferry Morse, Harris Moran	700	maize, oilseeds, cereals, vegetables and ornamentals
Advanta	seeds	Netherlands	Van der Have, Zeneca Seeds, SES, Mommersteg, Pacific Seeds	460	maize, forage crops, sugar beet, cereals, oilseeds
AgriBio Tech	seeds	USA	Clark Seeds, Burlingham & Sons, Olsen-Fennell Seeds, Oseco, Germain's Seeds, W-L Research, Zajac Performance Seeds	460	forage crops and turf
KWS	seeds	Germany	Betaseed, Lochow Petkus, SDME, Great Lakes Hybrids, CPB-Twyford	390	sugar beet, cereals, maize, forage crops, oilseeds, protein crops
Seminis Vegetable Seeds	seeds	USA	Asgrow Vegetable Seeds, Petoseed, Royal Sluis, Bruinsma	380	vegetables, ornamentals
Takii	seeds	Japan		310	vegetables, ornamentals
Sakata	seeds	Japan	Samuel Yates	280	vegetables, ornamentals
Kaneko Seeds	seeds	Japan	Tat Tohumculuk	280	maize, forage crops and turf, vegetables, ornamentals
AgrEvo	chemistry	Germany	Cargill Hybrid Seeds N America, Nunhems, Sunseeds, Leen de Mos, AgrEvo Cotton Seed International	250	maize, oilseeds, cotton, vegetables
Mycogen	biotech	USA	Dinamilho, Hibridos Colorado, FT Biogegetica de Milho	230	maize, oilseeds, alfalfa
Pennington	seeds	USA		180	forage crops and turf
Ball	seeds	USA		180	ornamentals
Pau Euralis	ag trade	France	Rustica Prograin Génétique	175	maize, oilseeds
Barenbrug	seeds	Netherlands	New Zealand Agriseeds, Heritage Seeds, Tourneur, Palaversich	160	forage crops and turf
Sigma	ag trade	France	Semences de France, Ringot, Serasem	160	cereals, protein crops, maize, oilseeds, forage crops and turf, sugar beet
Saatenunion	seeds	Germany		155	cereals, maize, oilseeds, forage crops
DLF	seeds	Denmark		150	forage crops, sugar beet, oilseeds
RAGT	ag trade	France	Semillas Monzon, Joordens Zaaden	140	maize, oilseeds, forage crops, cereals
Svalöf/Weibull	seeds	Sweden	Semundo, New Field Seed, Sursem	140	sugar beet, cereals, maize, oilseeds
CEBECO	ag trade	Netherlands	Procosem, International Seeds, Seed Innovations, Van Engelen, Wiboltt, la Maison des Gazons	140	protein crops, maize, oilseeds, cereals, forage crops and turf, vegetables
Total				9,220	

1 Estimates based on annual reports, press releases, personal communication, FIS. Susceptible to change according to exchange rates

Table 60. World Export Value for Ornamental Horticulture Products (sourced from: ten Kate and Laird, 2000)

	UK	Netherlands[1]	EU total	Israel	Kenya	Colombia	USA	World
Nursery stock	1.65	212.82	436.88					
Pot plants	5.44 (both)	891.94	1,745.64 (both)	19.71	4.6	0.66	68.33	2,430.8
Bedding plants								
Cut flowers	13.58	1,793.04	2,086.61	120.23	85.41	384.37	183.96	3,481.79
Bulbs (dormant)	12.41	470.97	507.51					

1 NB Approximately 25% of floral exports from The Netherlands are re-exports

Table 61. The Top Five Importers of Cut Flowers, Cur Foliage and Indoor Plants, 1996 (sourced from: ten Kate and Laird, 2000)

	Country	Value of imports (US$ bn)
1	World	5.99
2	Netherlands	3.09
3	Colombia	0.54
4	Italy	0.25
5	Denmark	0.22
6	Israel	0.20

Table 62. Turnover of the Principal Exporting Countries of Vegetables and Flowers in 1994 (sourced from: ten Kate and Laird, 2000)

Country	Turnover (US$ m)
USA	200
Netherlands	200
France	100
Japan	40
Germany	35
Denmark	20
Belgium/Luxembourg	n/a
Italy	30
Chile	25
New Zealand	6
Others	459
Total	1.12 bn

Figure 28. Global Markets for Crop Protection Products, 1997 (sourced from: ten Kate and Laird, 2000)

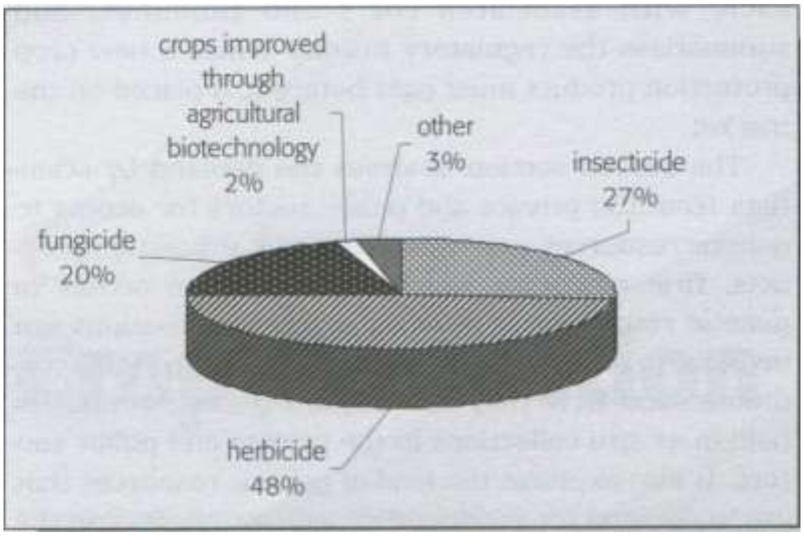


Figure 29. Global Sales of Crop Protection Products by Region, 1997 (sourced from: ten Kate and Laird, 2000)

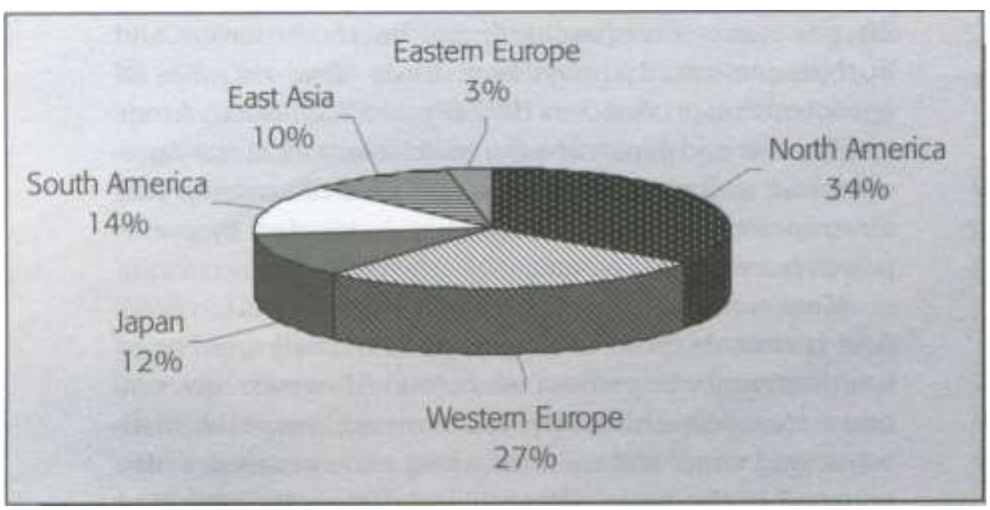


Table 63. "Ballpark" Estimates for Annual Markets for Various Categories of Products Derived from Genetic Resources (sourced from: ten Kate and Laird, 2000)

Sector	Market (US$ bn) LOW	Market (US$ bn) HIGH	Notes/Chapter where estimates developed
Pharmaceuticals	75	150	Some products derived from genetic resources. Low estimate: natural products form 25 per cent of global market. High estimate: 50 per cent. Ch 3.
Botanical medicines	20	40	All products derived from genetic resources. Low estimate for global botanical medicine markets; high estimate includes botanical medicines, minerals, and vitamins. Ch 4.
Agricultural produce (commercial sales of agricultural seed)	300+ (30)	450+ (30)	All products derived from genetic resources. Low estimate: final value of produce reaching consumer 10x commercial sales of seed to farmers. High estimate: 15x commercial sales of seed to farmers. Ch 5.
Ornamental horticultural products	16	19	All products derived from genetic resources. Low estimate: based on available data. High estimate: allows for unreported sales and products. Ch 6.
Crop protection products	0.6	3	Some products derived from genetic resources. High estimate includes wholly synthesised analogues, as well as semi-synthesised products. Ch 7.
Biotechnologies in fields other than healthcare and agriculture	60	120	Some products derived from genetic resources. Low and high estimates based on assessments of environmental biotechnologies. Ch 8.
Personal care and cosmetics products	2.8	2.8	Some products derived from genetic resources. Reflects 'natural' component of the market. Ch 9.
Rounded total	500	800	

Table 64. Prices for Selected genetic Resources and Derivatives (sourced from: ten Kate and Laird,2000)

Commodity (in *italics* if not derived from genetic resources)	Retail price[4] per kg or litre (US$)
Human growth hormone	20,000,000
Taxotere/docetaxol	12,000,000
Vincristine sulphate	11,900,000
Cocaine	150,000
Camptothecin	85,000
Lear's Macaw	24,000
Gold	*10,000*
Dry bear gall bladders	7,000
HIV protease inhibitor	*5,000*
Saffron	6,500
Tiger bones	3,000
Italian truffle	650
Shark fin (personal care)	550
Coffee	10
Cotton	1.5
Petrol	*1.0*

Table 65. Top 12 Importing and Exporting Countries of "Pharmaceutical Plants", 1992-1996 (sourced from: ten Kate, 2000)

Countries	Average Annual Volume (tones), 1992-1996	Average Annual Value (US$), 1992-1996
Importing Countries		
Hong Kong	80,550	331,700
Japan	57,850	158,300
USA	51,600	118,400
Germany	45,400	107,100
Rep Korea	34,200	53,350
France	19,800	46,350
Pakistan	12,550	12,650
Italy	10,400	39,100
China	9,300	35,950
Singapore	8,500	60,350
UK	7,400	24,450
Spain	7,350	24,400
Exporting Countries		
China	140,450	325,550
India	35,650	53,450
Germany	14,900	72,550
Singapore	14,400	62,750
Chile	11,700	26,350
USA	11,650	120,200
Egypt	11,300	13,650
Pakistan	8,500	5,450
Mexico	8,250	9,400
Bulgaria	7,350	12,250
Morocco	7,150	11,970
Albania	7,100	13,750

Figure 30. Number of Biodiversity Related Products Originating From Overseas Companies in Some Countries (sourced from: Interim Report, 2011)

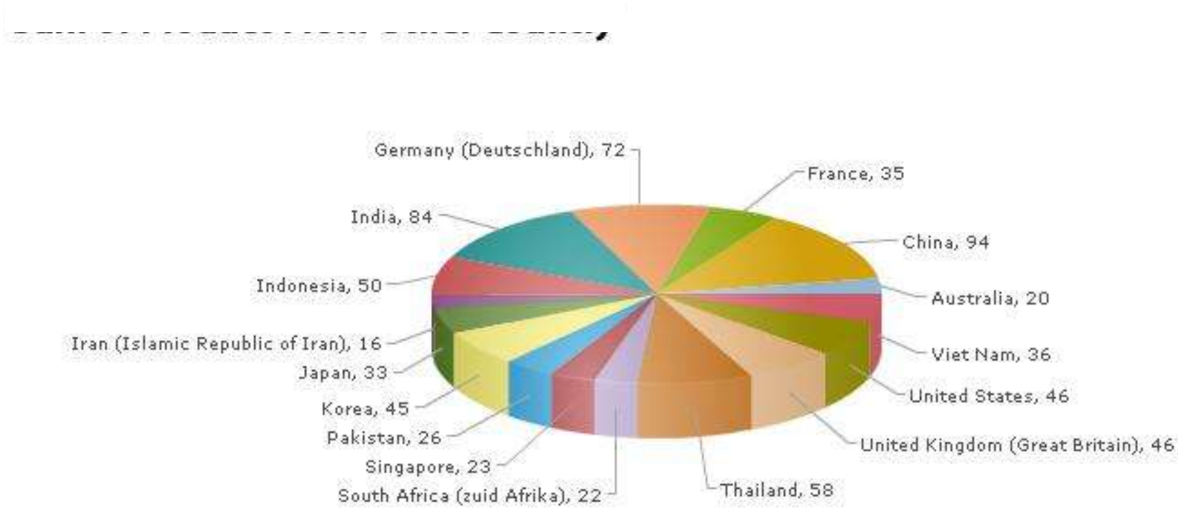
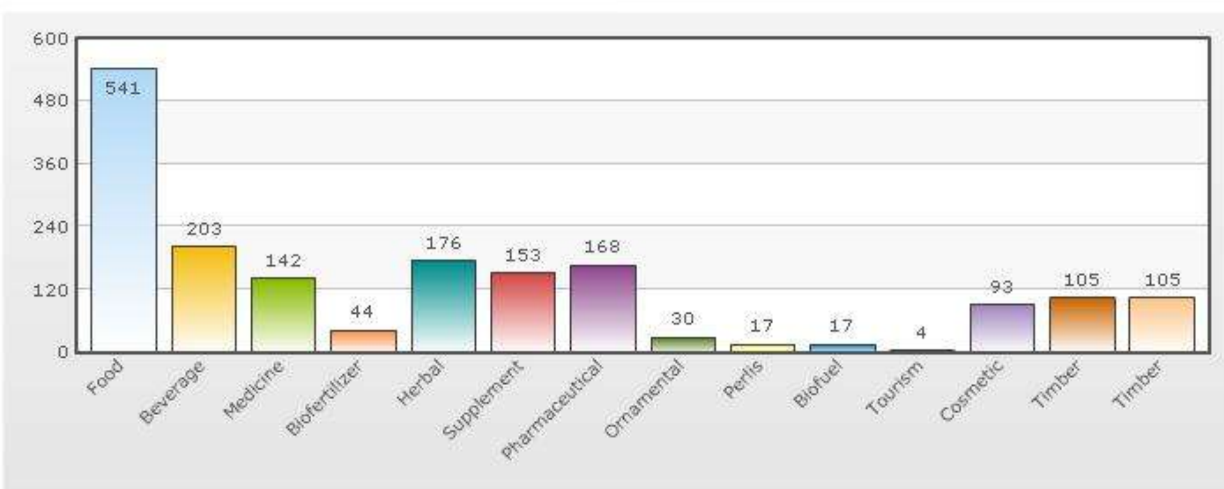


Figure 31. Different Categories of Biodiversity Based Products Originating From Some Companies (sourced from: Interim Report, 2011)



According to an Earthscan report,entitled “The Commercial use of Biodiversity-Access to Genetic Resources and Benefit Sharing” (ten Kate and Laird, 2000), it is stated that a crude estimate of the combined annual markets for products derived from genetic resources in the sectors relating to pharmaceuticals, botanical medicines, major crops, horticulture, crop protection products, applications of biotechnology in fields other than healthcare, agriculture, cosmetics and personal care products was estimated to be in the range of US$500 billion to US$800 billion. In addition, it has been estimated that the economic value of the services provided by ecosystems for the entire biosphere was in the range of US$16-54 trillion per year, with an average of US$33 trillion a year, compared with the annual global gross national product of US$18 trillion. Notwithstanding the aforesaid commercial value of biodiversity, many experts around the world agree that biodiversity is in fact declining rapidly rather than it being conserved and sustainably utilized. For instance, besides the losses in genetic diversity and ecosystem diversity, the corresponding loss in global species diversity, recorded in 2000, ranged between 8 million and 100 million species, with 10-13 million species being considered as a "best estimate", although only some 1.4 million species had been scientifically identified.

The Earth's diverse species are crucial for the functioning of ecosystems, which in turn provide essential services and goods on which people, business and global economies rely. There is growing awareness of the impact and dependency that business operations have on biodiversity and ecosystem services, and the business risks that poor management at the global level include the following(UNEP, 2010):

- The economic cost of biodiversity loss and ecosystem degradation globally is estimated to be between US$2 and 4.5 trillion.
- Many of the world's aquifers are becoming depleted or polluted, and it is estimated that by 2030 almost half of the world's population will be living under severe water stress.
- Coral reefs are in danger of dying out in the next 20 years, despite providing services worth up to US$189,000 per hectare per year for natural hazard management.
- The cost of environmental degradation related to water loss in the Middle East and North Africa has been estimated at some US$9 billion a year, or 2.1 – 7.4% of their national GDP.

Specific examples of economic impacts on ecosystems and their related biodiversity are given below (http://www.guardian.co.uk/environment/2010/may/21/un-biodiversity-economic-report, sourced July 2011):

- **Forests, Japan**
  Concerned about widespread abandonment and degradation of forests in Japan, the national Science Council carried out a study of the benefits of taking action to save them. Their report put the total value of the ability to absorb carbon dioxide; use of wood instead of fossil fuels; reduction of erosion and flooding; regulation of and cleaner rivers, and health and recreation, at ¥70 trillion (£535bn) every year. This evidence was used in many prefectures to introduce a new annual tax of ¥500-1,000 a person and ¥10,000-80000 for businesses specifically to fund restoration and enhancement.

- **Mineral waters, France**
  So contaminated was the land around Vittel's natural mineral water source in the Vosges mountains of eastern France, the Nestlé brand was forced to consider moving to a new location. Instead, they paid farmers to solve the problem for them. For payments of €150,000 (£130,000) to cover new equipment and another €200 per hectare of land each year, farmers agree to stop using agrochemcials, compost animal waste and reduce

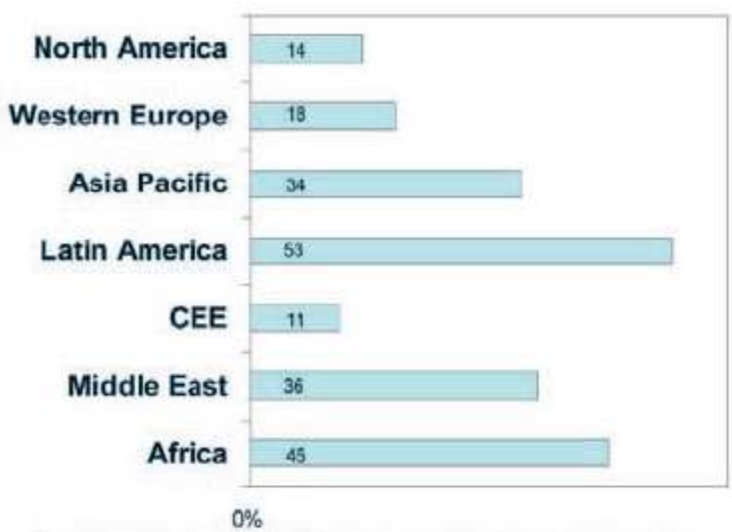
stocking rates for two to three decades. From 1993 to 2000 the total cost to Vittel for the 5,100 hectare area was €17m - a fraction of the company's mineral multi-billion Euro mineral water sales.

- **Sea turtles, Tanzania**
  Numbers of sea turtles on Tanzania's Mafia Island have surged since local people began to be paid to stop eating them. Anybody who finds and reports a nest gets a fixed payment up front, followed by a second payment depending on how many eggs hatch - as an incentive not to poach them. When the scheme began in 2001 every one of the 150 nests on the island of 41,000 suffered poaching - a figure which fell to less than 1% in 2004. Over that time the number of hatchlings increased from 1,200 to more than 10,000, although this probably includes the effect of higher discovery rates too.

- **Local, organic and unprocessed food for meals, Scotland**
  All schools and nurseries in East Ayrshire county council have joined a pioneering scheme to use more. The scheme, supported also by the Scottish Executive, costs an extra 10-15p for each of 8-9,000 lunches served on school days. An independent report for the local authority, meanwhile, estimated that benefits such as lower food miles, extra employment and income for the local economy and reduced future health risks (especially cancers) were worth six times the project's cost.

- **Medicinal plants, India**
  Around the world there is concern about corporations exploiting free natural resources, often used by traditional local communities, by turning them into food, drugs and other consumables for bigger markets. To address the problem, scientists in India's Tropical Botanical Garden and Research Institute worked with people from the Kani tribe in the southern state of Kerala and developed a drug from the locally popular Arogyapacha plant, a herb with heart-shape green leaves and small white flowers. In return, the institute and the tribe shared a Rs1m (£14,752) payment and 2% of the royalties from the commercial pharmaceutical company.

- **Forests, China**
  Over the period 1949-1981 China logged some 75 million hectares, 92% of which were natural rather than plantation forests, to satisfy demand for timber for construction and other uses. The ensuing rapid deforestation resulted in the loss of ecosystem services, notably watershed protection and soil conservation. In 1997, severe droughts caused the Yellow River to dry up for 267 days, affecting industrial, agricultural and residential water users in northern China. The following year, devastating flash flooding occurred in the Yangtze and other major river basins, resulting in the loss of 4,150 lives, displacement of millions of people, and economic damages estimated at 248 billion Yuan (approximately US$ 30 billion). China's government determined that deforestation and farming on steep slopes caused these tragic events. In 1998, the government banned logging under the Natural Forest Conservation Program (NFCP). Timber harvests fell from 32 million m^3 in 1997 to 12 million m^3 in 2003, reflected in a 20-30% increase in timber prices at the Beijing wood market over the period 1998-2003. The forest

	ecosystem services lost due to deforestation in China over the entire period 1950-98 were estimated to be worth as much as US$ 12 billion per year, including climate regulation, timber and fuel supply, agriculture productivity, water regulation, nutrient cycling, soil conservation and flood prevention. About 64% of this loss can be attributed to the supply of timber to the construction and materials sector. The value of forest ecosystem services lost due to timber production may be expressed in terms of the market price of timber. This suggests that the 'true' marginal cost of timber production in China may have been almost three times greater than the prevailing market price, far more than the modest price increase that resulted from the logging ban. Note that the logging ban resulted in increased imports of timber to China from other countries, suggesting that the environmental costs of timber consumption may have been shifted at least in part to non-Chinese forests (sourced from: TEEB, 2010) Figure 32. Views of global CEOs on the threats to business growth from biodiversity loss (sourced from: TEEB, 2010) 
N.B.	The Global Perspectives for "STI in Biodiversity Utilization and Commercialization" (WP2) and "R&D in Biodiversity Utilization and Commercialization" (WP3) are interdependent and therefore the Work Packages (WP) have been combined to reflect their inherent linkages
WP2	Global perspectives: STI in biodiversity utilization and commercialization
WP3	Global perspectives: R&D in biodiversity utilization and commercialization
WP2 & 3	**<u>Global Perspectives: STI and R&D in biodiversity utilization and commercialization</u>** 1. In 1986, botanists from the Sarawak Forestry Department, the University of Illinois and

the Harvard University's Arnold Arboretum collected specimens from the bintangor tree or *Calophyllum langigerum* from the forest of Sarawak. They were prospecting for routine collections for the screening of potential drugs for the National cancer Institute of the USA.In their laboratory, they found that one of the components of the bintangor tree, Calonolide A was effective against the HIV virus responsible for AIDS.Subsequently, a small company in Chicago, Medichem Research was given the right to test and develop the potential drug. Medichem Research then formed a joint partnership with the Government of Sarawak for the development and commercialization of the drug. In 2007, clinical trials took place in the US and Malaysia. Another related species of tree, *Calophyllum teysmanii* was found to have another chemical, Calonomide B which also has anti-viral properties (sourced from: Biodiversity in Malaysia, 2nd Edition. Minsitry of Natural Resources and Environment, Malaysia. 2007.)

2. Recently, an investigation was conducted by a team of British scientists at the Great Barrier Reef in Austalia as to how the intertidal corals and their related flora and fauna could tolerate and survive their exposure to the prevailing high temperatures and UV radiation, particularly during low tides. The study indicated that it was the microalgae associated with the corals produced a bioactive compound which provided the aforesaid protection. Further research by the British scientists, in collaboration with their Australian counterparts have isolated the bioactive compound and are presently in the process of incorporating the bioactive compound in sun/UV block creams for immediate use as well as to produce capsules containing the bioactive compound which could provide similar protection for the whole for periods extending for a week or more. (sourced from: Al Jazeera News, 20/21/22 September 2011, www.aljazera.com)

3. Plantation forests, or planted forests, are cultivated forest ecosystems established by planting or/and seeding in the process of afforestation and reforestation, primarily for wood biomass production but also for soil and water conservation or wind protection. Though the total area of plantation forest (187 million ha) represents only 5% of the global forest cover (FAO, 2001), their importance is rapidly increasing as individual countries move to establish sustainable sources of wood fibre to meet the increasing demand for wood and pulp. This is particularly the case in Asia, where an estimated 62% of the global plantation forest estate is located. Industrial plantations (supplying industrial wood and fibre) account for 48% of the global plantation estate; these typically consist of intensively managed, even-aged and regularly-spaced stands of a single tree species (indigenous or exotic), often genetically improved, and are characterised by relatively short rotations when compared with natural forests.

   Non-industrial plantations, established for fuelwood, soil and water conservation (e.g., watershed rehabilitation), and wind protection, account for 26% of the world's plantation forests, while an additional 26% of plantation forests are established for other, unspecified, purposes. During the past decade, while natural forest and total forest areas have continued to decline at the global level, forest plantation areas have increased in both tropical (+20 million ha) and nontropical (+12 million ha) regions. In both tropical and non-tropical regions, the conversion of natural forests and reforestation of non-forest areas have contributed in roughly similar proportions to these increases in forest plantation areas during this period. It is worth noting that between 1990-2000,the rate of conversion of natural to plantation forests in tropical regions was about equal to the increase in natural forest resulting from natural reestablishment (i.e., forest succession) of nonforest areas, and only 7% of the area of natural forest converted to non-forest land uses. In nontropical areas the net increase in natural forest areas was more than three times the rate of conversion of natural to plantation forests. About 60 % of plantation forests are located in four countries (China, India, Russian Federation and the United States) (Table 66). Species in the genera Pinus and Eucalyptus are the most commonly used in plantations (30%), though the overall diversity of planted tree species is increasing (FAO, 2001).

Table 66. Plantation Forests Area by Region (FAO, 2001)

Region	Total forest area (million ha)	Natural forest area (million ha)	Forest plantation area (million ha)	% of total plantation area
Africa	650	642	8	4
Asia	548	432	116	62
Europe	1039	1007	32	17
North & Central America	549	532	18	9
Oceania	198	194	3	2
South America	886	875	10	6
World total	**3869**	**3682**	**187**	**100**

4. In 2008, the European Commission Research (http://ec.europa.eu/research/) initiated an innovative project on industrial crops for the extraction of value added oils from plants for the production of novel chemicals (ICON). It is generally recognised that fossil oil reserves are finite leading to increased research looking for substitutes for petroleum based products.While there are a wide range of alternatives to using fossil fuels for energy production, only biological materials can replace lubricants and industrial chemicals derived from fossil oil. Processing of fossil oils is an energy intensive process. Cracking fossil hydrocarbons and building the desired chemicals using advanced organic chemistry usually requires many times more energy than is contained in the final product, energy that could be saved by developing innovative oil crops that produce special oils for specific requirements. Thus, using plant material in the chemical industry does not only replace the fossil material contained in the final product but also saves substantial processing energy.From a chemical viewpoint the long chain fatty acids in plant seed oils are similar in composition to fossil hydrocarbons making various seeds oils of particular interest. Such seed oils show a wide variation in composition between different plant species. Many of the oil qualities found in wild species would be very attractive for the chemical industry if they could be obtained at moderate costs in bulk quantities and with a secure supply. The use of genetic engineering of vegetable oil qualities in existing high yielding oil crops could in a relatively short time frame make such products available.This project aims at developing such added value oils in existing industrial oil crops mainly in form of various wax esters particularly suited for use in lubrication. This project will develop knowledge of plant lipid cellular metabolism, using specialist

expertise of the scientific groups assembled as the truly global scientific endeavor (in addition to 12 European partners in the project, 13 other come from China, USA, Canada and Australia). This should enable the incorporation of a wide range of new oil properties of industrial interest in oil crops. Since the genetic engineering technologies that are used in the project continue to raise public concern in Europe, the project intends to communicate its ideas, expectations and results to the public, engaging in an open debate on methods, ethics, benefits, risks and risk assessment.

The expected impacts of the project include thatif the results of the ICON project are brought to the marketplace it should result in the amount of additional raw materials for the lubrication industry while global demand for high value industrial oils could also benefit farmers receiving premium prices for these new crops. In contrast to the cultivation of energy crops, the relatively small area needed to grow industrial oilseed crops should not divert any significant land use to affect food production. As far as commercial impact in Europe is concerned, this will reflect existing and future trends in the attitude to cultivation of genetically modified crops in Europe. In this context, it is important to note that ICON has selected two crops for the project, *Crambe abyssinica* and *Brassica carinata*, which are not used in food production due to their high content of erucic acid. They do not easily intercross with related food crops, such as rapeseed or other *Brassica* crops and hence have a higher chance of being seen as a positive example of the opportunities offered by modern plant breeding techniques.

Notably, the expected results from ICON wouldinvolve the application of recent developments in plant biotechnology to genetically engineer oil crops to produce oils with the desired qualities of interest to the industries concerned. It would also produce strains of *Crambe abyssinica* and *Brassica carinata* modified to switch from producing triglycerides to making wax esters that are much more resistant to high temperatures and pressures than normal plant oils. The resulting plant oils are planned to be used as lubricants, a use reflecting their high oxidation and hydrolytic stabilities. Additionally, their genetic modification would also yield a range of different wax ester qualities with varying melting points and other features, besides improving their uses as lubricants. Further, the ICON project would also develop novel uses of plant seed leftovers remaining after oil extrusion, including as **renewable** and **eco-friendly bioplastics**.

5. In India, revolutions in biology has occurred particularly in the field of biotechnology, including techniques developed to produce rare and medicinally valuable molecules, to change hereditary traits of plants and animals, to diagnose diseases to produce useful chemicals and, to clean up and restore the environment. In this way biotechnology has great impact in the fields of health, food/agriculture and environmental protection especially in India. Further, the approved products in the pipeline and their renewed public confidence make them to be one of the most promising areas of potential economic growth. The following are some examples of the commerciable and biodiversity based biotechnology industry in India.

Health care

Biotechnology derived proteins and polypeptides form the new class of potential drugs. For example, insulin was primarily extracted from slaughter animals. Since 1982, human insulin (Humulin®) has been produced by microorganisms in fermenters. Similarly, hepatitis B vaccines *viz.*, Recombivax HB® (from Merk), Guni® (from Shantha Biotechnics Ltd, Hyderabad), Shanvac® (Biological E. Laboratory), etc. are the genetically engineered vaccines produced biotechnologically. Since 1987, the number of biotechnology derived new protein drug has surpassed the new chemical drugs. Even as early as 1996, there were about 35 biotechnology derived therapeutics and vaccines approved by the USFDA alone for medical use, and more than 500 drugs and vaccines to reach in market. Similarly, about 600 biotechnology diagnostics are worldwide available in clinical practices. About 130 gene therapy protocols have been approved by the US authorities.

Agriculture

Biotechnology is making new ground in the food/agriculture area. Public debates in 1996 about BSTC, bovine somatotropin (a hormone administered to cows to increase milk production) typifies an example of biotechnology product testing public acceptance. Similarly, the FlavrSarv™ tomato (produced by transgenic plants engineered by antisense technology to preserve flavor, texture and quality) is a new breed of value added foods. Food biotechnology offers valuable and viable alternative to food problems, and a solution to nutritionally influenced diseases such as diabetes, hypertension, cancer, heart diseases, arthritis, etc. Biopesticides are coming to the market and their sales are increasing (see *Biological Control of Plant Pathogens, Pests and Weeds*). *Molecular Pharming* is a new concept where therapeutic drugs are produced in farm animals, for example therapeutic proteins secreted in goat milk. There are about a dozen companies that produce lactoferrin, tPA, haemoglobin, melanin and interleukins in cows, goat and pigs.

Environment

The natural biodegradability of pollutants present in environment has increased with the use of biotechnology. Bioremediation technologies have been found successful to combat with pollution problem (see *Environmental biotechnology).*

Biological Control of Plant Pathogens, Pests and Weeds
Biological control of plant pathogens
- ⇒Inoculum
- ⇒Historical background
- ⇒Phyllosphere-phylloplane and rhizosphere-rhizoplane regions
- ⇒Antagonism
  - ⇒Amensalism (antibiosis and lysis)
  - ⇒Competition
  - ⇒Predation and parasitism : Mycoparasitism, nematophagy and mycophagy
- ⇒Application of biological control
  - ⇒Crop rotation

	⇒Irrigation ⇒Alteration of soil pH ⇒Organic amendments ⇒Soil treatment with selected chemicals ⇒Introduction of antagonists : Seed inoculation, vegetative part inoculation and soil inoculation ⇒Use of mycorrhizal fungi ⇒Genetic engineering of biocontrol agents Biological control of insect pests ⇒Microbial pesticidies ⇒Bacterial, viral and fungal pesticides ⇒Viral pesticides ⇒Mycopesticides Biological control of weeds ⇒Mycoherbicides ⇒Insects as biocontrol agents Biotechnology & Environment Biomass : A Renewable Source of Energy ⇒Energy sources : A general account ⇒Nuclear energy ⇒Fossil fuel energy ⇒Non-fossil and non-nuclear energy ⇒Biomass as source of energy ⇒Composition of biomass ⇒Cellulose ⇒Hemicellulose ⇒Lignin ⇒Terrestrial biomass ⇒Aquatic biomass ⇒*Salvinia* ⇒Water hyacinth ⇒Wastes as renewable source of energy ⇒Composition of wastes ⇒Sources of wastes (Industries, agriculture, forestry, municipal sources) ⇒Biomass conversion ⇒Non-biological process ⇒Direct combustion-hog fuel ⇒Pyrolysis ⇒Gasification ⇒Liquefaction ⇒Biological process ⇒Enzymatic digestion ⇒Anaerobic digestion

	⇒Aerobic digestion Biomass Energy (Bio-energy) ⇒Energy plantations ⇒Social forestry ⇒Silviculture energy farms (short rotation forestry) ⇒Advantages of short rotation management ⇒Petroleum plants (Petroplants) ⇒Hydrocarbon from higher Plants ⇒Hevea Rubber ⇒*Euphorbia* ⇒Guayule and Russian dandalion ⇒Aak ⇒Algal hydrocarbons ⇒Alcohols : the liquid fuel ⇒General account ⇒Ethanol production ⇒Fermentable substrate ⇒Hydrolysis of lignocellulosic materials ⇒Effect of substrate composition on hydrolysis ⇒Fermentation ⇒Recovery of ethanol ⇒Gaseous fuels : biogas and hydrogen ⇒What is biogas ⇒Biogas technology in India ⇒Benefits from biogas plants ⇒Feed stock materials ⇒Biogas production anaerobic digestion ⇒Solubilization ⇒Acidogenesis ⇒Methanogenesis-methanogens, mechanism of methane production ⇒Biogas production from different feed stocks ⇒*Salvinia* ⇒Water hyacinth ⇒Municipal wastes ⇒Factors affecting methane formation ⇒Hydrogen : a new fuel ⇒Photobiological process of H_2 production ⇒Hydrogenase and H_2 production ⇒Halobacteria Environmental Biotechnology ⇒Bioremediation ⇒*In situ* bioremediation

	⇒Intrinsic bioremediation ⇒Engineered *in situ* bioremediation ⇒*Ex situ* bioremediation ⇒Solid phase system (composting, composting process) ⇒Slurry phase system (aerated laggons, low shear airlift reactor) ⇒Factors affecting slurry phase bioremediation ⇒Bioremediation of hydrocarbon ⇒Use of mixture of bacteria ⇒Use of genetically engineered bacterial strains ⇒Bioremediation of Industrial wastes ⇒Bioremediation of dyes ⇒Bioremediation of heavy metals ⇒Bioremediation of coal waste through VAM fungi ⇒Bioremediation of xenobiotics ⇒Microbial degradation of xenobiotics ⇒Gene manipulation of pesticide-degrading microorganisms ⇒ Utilization of sewage, and agro-wastes ⇒ Production of single cell protein ⇒ Biogas from sewage ⇒ Mushroom production on agro-wastes ⇒ Vermicomposting ⇒ Microbial leaching (bioleaching) ⇒ Microorganisms used in leaching ⇒ Chemistry of leaching ⇒ Direct leaching ⇒ Indirect leaching ⇒ Leaching process (slope leaching heap leaching *in situ* leaching) ⇒ Examples of bioleaching ⇒ Copper leaching ⇒ Uranium leaching ⇒ Gold and silver leaching ⇒ Silica leaching ⇒ Hazards of environmental engineering ⇒ Survival of released GMMs in the environment ⇒ Adaptive mutagenesis in GMMs ⇒ Gene transfer from GMMs into other microorganisms ⇒ Gene transfer via conjugative transposons ⇒ Effect of environmental factors on gene transfer ⇒ Ecological impact of GMMs released into the environment ⇒ Growth inhibition of natural strains ⇒ Growth stimulation of indigenous strains ⇒ Replacement of natural strains

⇒ Monitoring of GEMs in the environment

⇒ Risk assessment of the GEMs released into the environment

Scope of Biotechnology

The scope of biotechnology in India is given in Table 67.

Table 67. Areas of biotechnology in India

Area of interest	Products
1. Recombinant DNA technology(genetic engineering)	Fine chemicals, enzymes, vaccines, growth hormones, antibiotics, interferon.
2. Treatment and utilization of bio-materials (biomass)	Single cell protein, mycoprotein, alcohol and biofuels.
3. Plant and animal cell culture	Fine chemicals (alkaloids, essential oils, dyes, steroids), somatic embryos, encapsulated seeds, interferon, monoclonal antibodies.
4. Nitrogen fixation	Microbial inoculants (biofertilizers)
5. Biofuels (bioenergy)	Hydrogen (via photolysis), alcohols (from biomass), methane (biogas produced from wastes and aquatic weeds).
6. Enzymes (biocatalysts)	Fine chemicals, food processing, biosensor, chemotherapy.
7. Fermentation	Acids, enzymes, alcohols, antibiotics, fine chemicals, vitamins, toxins (biopesticides).
8. Process engineering	Effluent, water recycling, product extraction, novel reactor, harvesting.

The DBT is making effort in promoting post graduate education and research. Special M.Sc. courses in Biotechnology in selected group of institution with scholarship is provided by the DBT. The selection of students is done via National Test. In addition, it also provides trained manpower for the rapidly growing biotech industry. It has also raised the level of biology education in certain areas of biotechnology in the country. Moreover, a considerable amount of basic biochemical andmolecular biology is impaired in these courses.

The United Nations Industrial Development Organization (UNIDO) recognized the potential of genetic engineering and biotechnology for promoting the economic progress of the developing countries. The initiation taken by UNIDO has led to the foundation of International Center for Genetic Engineering and Biotechnology (ICGEB). In 1981, in a meeting convened by UNIDO it was proposed to establish an international center of excellence to foster biotechnology in the developing world. In 1982, this concept was approved by a high level conference of developed and developing nations in Belgrade. The statutes of the center were signed by 26 countries with the entry into force of statutes on 3 February1994. The ICGEB has become a fully autonomous international organization composed of at present 33 member states. The ICGEB has two centers, one located in Trieste (Italy), and the other in Jawaharlal Nehru University, New Delhi (India). The Trieste component is currently occupying about 5,700m^2 area, whereas the New Delhi component is occupying about 10,000m^2 area. This center is functioning in a proper way since 1982.

The organs of ICGEB are the Secretariat, the Board of Governors and the Council of Scientific Advisors. The secretariat component is the Director, two Heads of the components and the scientific and administrative staff operating with the framework of the ICGEB programme. The Board of Governors consists of a representative of each Member State. The Council of Scientific Advisors is composed of eminent scientists and overseas scientific excellence of ICGEB. Funds are provided by the government of Italy and India. From 1999, all Member States have started to finance ICGEB through a scale of assessment adopted by the Board of Governors.

The activities of ICGEB are aimed specifically at strengthening the R&D capability of its member States by:

(i) providing the developing countries with a necessary 'critical mass' environment to pursue and advance the research in biotechnology; host research facilities that are technology and capital demanding and, therefore, inaccessible to the great majority of developing countries,

(ii) training schemes and collaborative research with affiliated centers to ensure that significant members of scientists from Member states are trained in state-of-art technology, in areas of direct relevance to the specific problems of their countries,

(iii) acting as the coordinating hub of network of affiliated centers that serve as localized nodes for distribution of information and resources located at ICGEB.

Many public and private institutions working under the Government departments and organizations have advised the DBT to formulate the biotechnology programmes under the following areas :

(i) Plant molecular biology and agricultural biotechnology,
(ii) Biochemical engineering, process optimization and bioconversion,
(iii) Aquaculture and marine biotechnology,
(iv) Fuel, fodder, biomass and green cover,
(v) Medical biotechnology,
(vi) Microbial and industrial biotechnology,
(vii) Large scale use of biotechnology,
(viii) Integrated systems in biotechnology,
(ix) Veterinary biotechnology and
(x) Infrastructural facilities.

A workshop of ICGEB was organized in New Delhi during 18-22 September 1988, in which about 60 scientists from 15 countries participated and discussed the problems. The recommendations made by them on research priority and thrust are as below:

	(i) Genome organization and vector for transfer of recombinant DNA to plants, for example, (a) development of diagnostic tools especially for identifying the tropical plants disease, (b) identification of plant genes involved in disease resistance, (c) restriction fragment length polymorph (RFLP) mapping of a major agricultural crop, (d) plant-bacterial interaction, and (e) microbial fermentation of plant gene products. (ii) Genes of agricultural importance, for example (a) disease resistant genes, (b) drought resistant genes, (c) salt resistant genes, (d) high temperature resistant genes. (iii) Molecular biology and genetic engineering of nitrogen fixation. (iv) Plant cell culture, differentiation, regulation and transformation.
WP4	**Global perspectives: International policies, strategies and plans in biodiversity & STI** Existing regional and international policies, strategies, and plans based on biodiversity, with implications for potential STI, include the following: i. The Convention on Biological Diversity ii. The CBD Cross-Cutting Initiatives on Biodiversity for Food and Nutrition iii. The Cartagena Protocol on Biosafety iv. The Nagoya Protocol on Access and Benefit Sharing v. The Convention on the Conservation of Migratory Species of Wild Animals vi. The Ramsar Convention on Wetlands of International Importance vii. The Convention on the Protection of the World Cultural and Natural heritage viii. The Convention on International Trade in Endangered Species of Wild Fauna and Flora ix. The Convention on the Conservation of Antarctic Marine Living Resources x. The International Convention for the Conservation of Atlantic Tunas xi. The International Convention for the Regulation of Whaling xii. The United Nations Convention to Combat Desertification xiii. The UN Framework Convention on Climate Change xiv. The United Nations Convention on Laws of the Sea xv. The International Tropical Timber Organisation Objective xvi. The International Treaty on Plant Genetic Resources for Food and Agriculture xvii. The International Undertaking on Plant Genetic Resources xviii. The UNESCO Man and the Biosphere Programme xix. The Kyoto Protocol

	xx. The Bali Plan of Action on Climate Change xxi. The Copenhagen Accord on Climate Change xxii. The Declaration on Environment and Development and its Agenda 21 of the United Nations Conference on Environment and Development, Rio de Janeiro xxiii. The Political Declaration and its Plan of Implementation adopted at the World Summit of Sustainable Development, Johannesburg xxiv. The Stockholm on Persistent Organic Pollutants xxv. The Basel Convention on Hazardous Waste xxvi. The Law of the Seas and various other Marine Related Global/Regional Seas Agreement and Protocols (eg. MAPOL)
WP5	**National perspectives: Biodiversity resources, utilization and commercialization** Although Malaysia is considered to be one of the twelve mega(bio)diverse countries in the world its R&D and STI for the conservation, sustainable use and commercialization of biodiversity is only confined to a limited number of flora and fauna focusing on terrestrial biodiversity rather than on marine biodiversity as well. Further, much of the R&D and STI on biodiversity in Malaysia is basic and fundamental rather than applied, innovative and cutting edge in its nature and scope. Some examples of the former include ornamental flowers, food and plantation crops without reference to food security, aquaculture species without adequate environmental considerations, screening of bioactive compounds without any follow up, tourism without carrying capacity studies, while some examples of the latter include biomimicry, cancer markers, following up on screening with the application of bioactive compounds, taking stock of Malaysia's biodiversity resources and also establishing seed banks for their germplasm, biomonitoring, bioremediation, ecological restoration, new and cutting edge biotechnologies. Therefore it is imperative for Malaysia to redefine and refine its priorities, scope, nature, technologies and application of R&D and STI and biodiversity based biotechnology to be much more strategic, competitive, value added, innovative, commercially oriented and marketable for enhancing the role of biotechnology in contributing to conservation, sustainable use and commercialization for enhancing the wealth creation and sustainable livelihoods of Malaysia and its people. For further details refer also to: i. The earlier section on Research and Developmentand the other WP's in this document ii. Ministry of Natural Resources and Environment Malaysia (2010). 4th National report to the convention on biological diversity. 94 pp. iii. Tenth Malaysia Plan (2011-2015).
N.B.	The national perspectives for "STI in Biodiversity Utilization" and "R&D in Biodiversity Utilization" are interdependent and therefore the Work Packages (WP 6 & 7) have been combined to reflect their inherent linkages.
WP6	National perspectives: STI in Biodiversity Utilisation (combined with WP7)

<table>
<tr><td>WP7</td><td>National perspectives: R&D in Biodiversity Utilisation (combined with WP6)</td></tr>
<tr><td>WP6 & 7</td><td>

<u>National perspectives: R&D and STI in biodiversity utilization</u>

The combined linkages between the R&D and STI of Biodiversity Utilisation should ideally be implemented within the framework of the Second National Science and Technology Policy (STP), the key priorities and their accompanying specific initiatives are as follows:

1. <u>Strengthen research and technological capacity and capability</u>
   - Increase public and private sector investments in R&D including infrastructure development targeting for gross national R&D expenditure level of at least 1.5% of national GDP.
   - Regular prioritising of research and technology development programmes including basic research in the new and emerging technologies through initiatives such as Technology Foresight/Technology Mapping and other similar methodologies to ensure focus in areas which can yield highest socioeconomic payoffs.
   - Invest in upgrading the infrastructure for S& T development including establishment of new major research/ technology development institutions/facilities/initiatives e.g. BioValley Initiative in the Multimedia Super Corridor.
   - Jointly launch, with industry associations new programmes in selected sectors to strengthen indigenous technological capabilities of local corporations in existing as well as new and emerging technologies through partnerships with universities and public research institutes (PRls) as well as through creative engineering.
   - Stimulating private sector investment in R&D technology development through:
     - Enhancing access to public research facilities
     - Financial contribution from the private sector
     - Ensuring that the fund is used solely for R&D purposes for that particular industry
     - Yearly report to ensure accountability
     - Supporting industry initiatives including those of industry associations to develop specific facilities to strengthen technological capabilities
     - Promoting competitiveness through science, technology and innovation
     - Reviewing existing fiscal and financial incentives for R&D so that they would promote greater industry investments in R&D as well as attract significant R&D projects to Malaysia; and
     - Enlarging allocations for industry grant schemes e.g. Industry Research and Development Grant Scheme (lGS), Multimedia Super Corridor Research and Development Grant Scheme (MGS), Demonstrator Application Grant Scheme (DAGS).

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- Aggressive and strategic implementation of existing Technology Acquisition Programme under the smart partnership framework with Malaysian companies and government-controlled agencies.

- Establishing strong linkages with regional and international centres of excellence in collaborative R&D as well as co-development of technology

2. Promoting commercialization of research outputs

- Establishment of Business Development Unit within MOSTE to develop strategies and programmes aimed at enhancing the commercialization and diffusion of research findings generated from public funded research organisations. Such programmes include, among others:
  - The introduction of a new Reach Out programme to support the efforts of Business I Innovation units in universities and PRls;
  - Establishing new mechanisms (e.g. IMCNation Centres I Best Practice Centres) to provide universities and PRls with support in commercialising research outputs;
  - Establishment of a pre-seed capital fund for universities. PRls and Innovation/ Best Practice Centres which are to be allocated on a competitive basis;
  - Study on establishment of holding company under MOSTE to promote commercialization of research findings from universities and PRls; and
  - Improving incentives for researchers to commercialize their findings.

- Introduce, in collaboration with Association for Small and Medium Enterprises (SMEs), a Public Sector-Industry PartnershiP programme where researchers will spend some time providing technical assistance to companies.

- lncorporate within existing procurement practices, programmes to support innovation and development of indigenous technology development.

- Apply self-financing targets (operating budget) for all public research institutions (30 per cent by 2005) and universities (/5 per cent by 2005).

3. Developing human resource capacity and capability

- lntensify development of critical mass for S&T through:
  - Adoption of 60:40 ratio of students pursuing science, technical and engineering disciplines in upper secondary schools and universities;
  - Adopting a different approach to education that is, from an examination oriented and rote learning to hands on and innovation oriented approach;
  - Increasing the number of post-graduate students in science, technical and engineering disciplines to at least 10 per cent of the undergraduate population by 2005 through measures such as:
  - Establishment of a post-graduate research S& T university; and

	o Introduction of attractive incentives to entice more students to pursue science, technical and engineering disciplines at under-graduate and post-graduate levels. o Introduction of Book Allowance Support programme for students pursuing science at upper secondary school level; and o Review of syllabi and teaching approaches for science and technical/ vocational subjects in primary and secondary school levels with emphasis accorded to development of creative thinking and problem solving skills. • Expand implementation of S&T Human Resource Development (HRD) Fund to: o Enhance Human Resources Development and other incentives to achieve national S&T human resource objectives; o Increase the number of post-doctoral fellowships; o Initiate brain pool programme through collaboration with renowned researchers; and o Establish, in collaboration with industry, Distinguished Visiting Scientist programme in universities and PRls. • Strengthen and expand Teaching Company Scheme and other student attachment programmes to build long-term relationships for technology transfer and training between university and industry. • lmprove the career prospects and mobility of scientists and research workers. • Re-examine programme on Retuming Malaysian Scientists to make it more attractive through targeted fiscal and non-fiscal incentives. • Review the Skills Development Fund to finance industry-training programmes. This would be jointly managed by the private sector and the Government, with manufacturing industries contributing one per cent of their total payroll to the Fund. Existing facilities at industrial training and other institutes can be made available for fUnd-supported programmes, and in-house training programmes may also qualify for support. Serious consideration can also be given to private sectororganisations opting to set up their own separate training facilities under this scheme, as well as to the privatisation of existing government training facilities. • Enhance and modernise the existing system of certification of technical personnel and classification of skills. This will greatly facilitate the development of a technically proficient and mobile workforce. • Expand adult and continuing education programmes, particularly in technical subjects, to upgrade the skill base in specific areas. The provision of adequate facilities has to go hand in hand with an enlightened management and the realisation that personal fulfilment leads to greater job satisfaction and a positively motivated employee. • Strengthen the effectiveness of mechanisms to allow industry to contribute to course

design and curriculum review in institutions of higher learning and industrial training institutes. Each institute should set up a committee with adequate representation from the public and private sectors. Continuous consultation will ensure that course content does not become obsolete with changes in technology. or irrelevant with respect to industry needs.

- Ensure that Malaysian graduates acquire training and skills that are fully relevant to national needs, particularly with respect to the choice of elective subjects and post-graduate programmes and fields of research.

- Enhance and institutionalise linkages for industrial training between industry and educational establishments. Courses at institutions of higher learning should include a high degree of exposure to practical situations through relevant practical training opportunities.

- Strengthen the role of tertiary institutions in advanced technology research and innovation. This could be achieved through:
    - Providing special development budget allocations in areas related to targeted new and emerging technologies; and
    - Increasing the industry orientation of post-graduate courses related to Science and Technology.

This would help provide effective support for the acquisition of competence in the new key technologies.

- Ensure an effective role for institutions of higher learning in all proposed technology parks and innovation centres. Special attention must be given to the cultivation of skills related to technological reproduction, adaptation and innovation. Universities must adopt a more commercial stance in developing technologies.

4. Promoting a culture for science, innovation and techno-entrepreneurship

- Expand the scope and coverage of S& T promotion activities in collaboration with S& T, NGOs and industry. Such measures to include, among others:
    - Blending S& T with the performing arts; and
    - Support for professional and science oriented organisations.

- Establish five Regional Science Centres by 2010 to elevate S& T awareness among the populace.

- Promote techno-entrepreneurship through:
    - Provision of techno-entrepreneurship courses to all science, technology and engineering undergraduates;
    - Conduct, in collaboration with Malaysian Technology Venture Association or other sponsors. annual techno-entrepreneurship competition;
    - Amendments to university/PRI personnel service scheme that enable selected

	staff to take sabbatical leave with no loss of seniority in order to commercialize a research finding; o Ensuring existing public venture capital funding and banking system to provide window for early seed financing as well as support for technology development; o Establishment of Malaysian Technology Credit Guarantee Scheme (MTCGS) through existing mechanism to support formation of new technology based firms (NTBFs); Other measures include: o Introduce a more innovative mode of financing such as debt ventures funding with flexibility in the lending facilities; o Encourage local corporations to set up Angel investment funds by publicising the incentives through seminars, workshops and newsletters; o Create an avenue to showcase companies to Angel Investors and Venture Capitalists; and o Review achievement of ventures capital fund and other incentives to encourage commercialization of R&D output. • Inculcate Science and Technology awareness and appreciation at all levels of government. The objective is the permeation of a Science and Technology consciousness into the structure for national decisionmaking and implementation of development programmes. This can be achieved by a wide ranging series of measures, including special courses on S & T at public seNice institutes and the appreciation on the S & T dimension in general courses at such institutes. • Raise S&T awareness and appreciation by inculcating S&T culture in the education system. This would involve: o programme to intensify creative thinking and problem-solving skills. in primary education; o Research grants to schools; o Redesigning of syllabi to achieve a balance of S&T. the arts and humanities; o Increasing the vocational and technical skills content in secondary schools; and o Intensifying efforts to increase S&T language competence to facilitate the flow of information. • Use the mass media to heighten public awareness and appreciation of Science and Technology. This will involve not only an expansion of the S&T content in the mass media, but also steps to improve the standard of science journalism. • Enhance the scope and coverage of the Science and Technology Week programme and other promotional activities. Such promotions not only raise S&T awareness, but also provide the S&T community with a definite focus and identity. The National Science Centre should aim at being one of international standard to heighten the image of Science and Technology as an exciting and relevant facet of everyday life.

- Encourage the formation and development of centres of excellence in science. The government should promote the development of viable professional and science-oriented societies by providing them with financial assistance.

- Promote the formation of guilds for technical personnel with activities that are specially focussed on technical and professional issues. These associations represent an important part of informal education and training framework. They can help upgrade skills and promote sound industry-wide codes of practice through a wide range of industrial activity. They can also elevate the social standing of blue-collar skills.

- Support the Malaysia Design Council that aims to create and maintain a fund to be used for encouraging the creation. design. development, financing.manufacture and utilisation of Malaysian inventions, research results and other intellectual property. In addition, a series of award could be implemented to provide additional impetus to specific target groups, or in specific areas of technology including product design, invention and innovation. This would raise the prestige of scientific accomplishments generally.

5. Strengthening institutional framework and management for S&T and monitoring of S&T policy implementation

- Strengthen the Ministry of Science. Technology and the Environment (MOSTE) by endowing it with necessary resources to ensure effective S&T policy formulation and implementation.

- Review the role of Majlis Penyelidikan Kemajuan Sains Negara - MPKSN (National Council for Scientific Research and Development) to ensure effectiveness of S&T advisory and coordination system.

- Expand efforts to develop effective information gathering, monitoring and evaluation and transmission mechanism to track the nation's performance in S&T as well as development of new technical developments I technologies.

- Promote adoption of sound research management practices including intellectual property management and commercialization of research outputs in all PRls and universities.
- Enhance the management of intellectual property rights including patent advisory and other services. To review existing legislation or to develop new legislation related to policy. Enact legal provisions to allow for the securitization of intellectual property where intellectual property rights can be used as collateral for loans.

- Develop mechanisms and codes of practice to ensure that development of S&T accords emphasis to preventive approaches as well as being consistent with acceptable societal norms and ethics.

- Enhance the management of the technology intelligence and information system. This would facilitate rapid and effective dissemination of information on research within the country. The system would also be a source for information on international research. The existing system already in place in various research institutes, universities and colleges, and specialised and general libraries, would be the nucleus on which to build the National Science and Technology Intelligence System.
- Require public sector R&D institutes to draw up five-year budget plans detailing research programmes and priorities. The budget should be reviewed annually by the ministry responsible for Science and Technology. This will help create greater awareness in key public and private sector organisations, about research programmes underway or being planned.

- Enhance the system of contract research as a first step towards corporatisation of all industrial research institutes. The objective is to encourage market-driven research through a clear understanding of priority areas, the monitoring of R&D performance. and the introduction of a degree of competitiveness in research activities.

- Aim for a greater degree of financial autonomy for R&D institutes. The decision-making process could thus be speeded up. manpower and skills would be better utilised. and R&D programmes would be more clearly geared towards performance.

6. Ensure widespread diffusion and application of technology, leading to enhanced market-driven R&D to adapt and improve technologies

- Enhance quality awareness and design in industry through on-going programmes. Quality and Standards play an important role in building up international competitiveness, and the level of quality awareness must therefore permeate the full range of activities in Malaysian industry. Competence must also be built in industrial design, engineering design and product design so that ideas can be translated into workable systems or products to improve efficiency and effectiveness in manufacturing activities.

- Form a special technical committee to propose specific and concrete measures to enhance the capability of the engineering and technical services sector. This would help in the development of a system of commercially driven engineering support services to meet the requirements of industrialisation.

- Ensure the effectiveness of the Industrial Technical Assistance Fund. This can be achieved by extending its scope to include a larger range of activities including automation and R&D in targeted areas; broadening coverage to include all firms, while retaining the emphasis on small and medium scale enterprises; increasing the maximum level of matching grant for R&D.

- Gear public procurement policy firmly to stimulating innovation and product development for local firms to help them be more competitive in regional and international markets. Close dialogue between suppliers and procurement agencies would encourage forward planning. Procurement agencies should also be more supportive of innovative local firms.

- Strengthen linkages between firms by encouraging R&D and product development programmes between purchasers and suppliers and developing vendor support systems. International Procurement Operations (IPO) centres should be given incentives to set up in Malaysia.

- Undertake a detailed scrutiny with a view to implementation of the product group Action Profiles in the key industry sectors such as Advanced Manufacturing, Advanced Materials, Electronics, Information and Communication Technology and Multimedia Technology, Biotechnology, Energy, Aerospace, Nanotechnology, Photonics as well as other key technologies.

7. Build competence for specialisation in key emerging technologies

- Develop a secure knowledge base in the key technology areas to sustain technology support for Malaysian industry:
  - Advanced Manufacturing;
  - Advanced Materials;
  - Microelectronics;
  - Biotechnology;
  - Information and Communication Technology;
  - Multimedia Technology;
  - Energy;
  - Aerospace;
  - Nanotechnology;
  - Photonics; and
  - Pharmaceuticals.

- Prioritise research programmes in the new and emerging technologies to ensure focus in areas that yield the highest economic pay-offs. Malaysia cannot afford to support a full range of skills and capabilities in all these fields. Specific areas must be selected based on relevance, a demonstrated need, the availability of a natural advantage and constraints of manpower and budget allocations.

- Institute special measures to encourage the formation and development of new technology-based firms engaged in the promotion or commercialization of technological innovations. These small to medium sized firms, highly entrepreneurial in nature, will emphasise knowledge intensive R&D activities allied to business skills.

- Set up national focal points for each of the new and emerging technologies. These would serve as the hub of R&D activity in the respective fields.

	• Enhance exposure to international developments in the new technologies, and exploitation of foreign research expertise where necessary.
WP8	**<u>National perspectives: Domestic policies, strategies and plans in biodiversity & STI</u>** 1. Addressing any Federal and State obligations in the national constitution, including any overlaps or contradictions in jurisdiction and governance, especially with regard to matters pertaining to land, forests, rivers and minerals. Notably, Malaysia's commitment for the conservation and sustainable utilization of its biodiversity for achieving the "provisional framework of goals, targets and indicators to assess progress towards the 2020 Biodiversity Targets", are as indicated below: Goal 1. Promoting the conservation of the biological diversity of ecosystems, habitats and biomes Goal 2. Promoting the conservation of species diversity Goal 3. Promoting the conservation of genetic diversity Goal 4. Promoting sustainable use and consumption Goal 5. Reducing pressures from habitat loss, land use change and degradation and unsustainable water use Goal 6. Controlling threats from invasive alien species Goal 7. Addressing challenges to biodiversity from climate change and pollution Goal8. Maintaining capacity of ecosystems to deliver goods and services that support livelihoods Goal9.Maintaining socio-cultural diversity of indigeneous and local communities Goal 10. Ensuring the fair and equitable sharing of benefits arising of the use of genetic resources Goal 11. Improving Malaysia's financial, human, scientific, technical and technological capacity to implement the Biodiversity 2020 Targets In addition, the Biodiversity 2020 Targets also include the following operational and strategic goals (SG) for the conservation and sustainable utilization of biodiversity: SG1. Addressing the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society SG2. Reducing the direct pressures on biodiversity and promoting sustainable use SG3. Improving the status of biodiversity by safeguarding ecosystems, species and genetic diversity SG4. Enhancing the benefits to all from biodiversity and ecosystem services SG5. Enhancing implementation through participatory planning, knowledge management andcapacity-building.

	2. The legal and regulatory framework for the conservation, sustainable use and commercialization of biodiversity in Malaysia include the following acts, policies, etc.: <u>National</u> The National Policy on Biological Diversity A Common Vision on Biodiversity The National Waters Act The National Animal Act The National Aboriginal People Act The Land Conservation Act The National Land Code The National Protection of Wild Life Act The National Environmental Quality Act The National Pesticides Act The National Local Government Act The National Town and Country Planning Act The National Parks Act The National Forestry Act The National Fisheries Act The National Heritage Act The National New Plant Variety Protection Act The National Biosafety Act The National Wildlife Conservation Bill The Access and Benefit Sharing of Biodiversity and Genetic Resources Act (in preparation) The Science and Technology Act (in preparation) The National Biotechnology Policy The National Agricultural Policy The National Environment Policy The National Tourism Policy The National Forestry Policy The National Oceans Policy (in preparation) The National Wetlands Policy The National Urbanisation Policy The National Energy Policy The National Fuel Diversification Policy The National Five-Fuel Diversification Policy National Biofuel Policy The National Automotive Policy Framework The 10 year OPP (Operative Prospective Plan 3, 2001-2010) and its 5 year Development Plans (RMK 10) The National Physical Plan The National Environmental Quality Clean Air Regulation The National Environmental Quality Prescribed Activities Regulation (The EIA Order)

Sabah

Sabah Biodiversity Enactment
The Land Ordinance Cap
The land Acquisition Ordinance
The Mineral Enactment
The Interpretation of native Ordinance
Fauna Conservation Ordinance
Forest Enactment
Forest Rules
Sabah Forestry Development Authority Enactment
Parks Enactment
Native Court Enactment
Native Court (Native Customary Laws) Rules
Wildlife Conservation Enactment
Cultural Heritage (Conservation Enactment)
Sabah Water Resources Enactment
Sabah Biodiversity Enactment
Environment Protection Enactment
Environment Protection (Prescribed Activities) Order
Environment Protection (Prescribed Activities)(Environmental Impact Assessment) Order

Sarawak

Sarawak Biodiversity (access, Collection and Research) Regulations
State Local Authorities Ordinance
Forest Ordinance
Forest Rules
Native Courts (Amendment) Ordinance
Natural Resources and Environment (Amendment) Ordinance
Public Parks and Green Ordinance
Sarawak River Ordinance
Water Ordinance
Sarawak Forestry Corporation Ordinance
State Land Code Ordinance
Forest (Planted Forest) Rules
Wild Life Protection Ordinance
National Parks and Nature Reserves Ordinance
Protection of Public health Ordinance
State Verterinary Public Health Ordinance
Sarawak Biodiversity Centre (Amendment) Ordinance

3. In operationalising the National Policy on Biological Diversity, the Malaysian government has adopted the following strategies for action:
    i. Improving the scientific knowledge base
    ii. Enhancing sustainable utilization of the components of biological diversity
    iii. Developing a centre of excellence in industrial research in tropical biological

	diversity iv. Strengthening the institutional framework for biological diversity management v. Strengthening and integrating biological diversity conservation programmes vi. Integrating biological diversity components into sectoral planning strategies vii. Enhancing skills, capabilities and competence viii. Encouraging private sector participation ix. Reviewing legislation to reflect biological diversity needs x. Minimizing impacts of human activities on biological diversity xi. Developing policies, regulation, laws and capacity building on biosafety xii. Enhancing institutional and public awareness (participation) xiii. Promoting international, cooperation and collaboration xiv. Exchanging information xv. Establishing funding mechanisms 4. Implementation of the Convention of Biological Diversity (CBD) in Malaysia. The programmes of work for the thematic areas and the cross cutting thematic issues under the CBD in Malaysia are coordinated by various ministries, which are in turn supported several implementing agencies for instance the Department of Agriculture is the lead agency for invasive alien species within the Ministry of Agriculture and agro-based industry (MOA) coordinate with other agencies dealing directly or indirectly with invasive alien species such as the Department of Fisheries, MARDI, FRIM and WildLife Department. 5. Notably, in a national capacity needs self assessment (undertaken in April 2009) on improving and enhancing the United Nations Convention on Biological Diversity (and also on the UN Framework Convention on Climate Change and the UN Convention to Combat Desertification), the Malaysian Government has identified the following strengths, constraints and needs as well as their required remedial actions. 6. The National Science and Research Council was recently resurrected with a reconstituted membership and it is chaired by the scientific advisor to the government of Malaysia. The council provides advice to the government on strategies and priorities of scientific R&D and to help identify and resolve bottlenecks in implementation of R&D in Malaysia including weaknesses in the infrastructure for R&D. 7. The Second National Science and Technology Policy provides a framework for improved performance and long-term growth of the Malaysian economy including the following: • Increasing the national capability and capacity for research and development (R&D), technology development and acquisition; • Encouraging partnerships between public funded organizations and industry as well as between local and foreign companies for the co-development of technologies with a view to increasing indigenous technology capability: • Enhancing the transformation of knowledge into products, processes, services or solutions that add value across every industry for maximum socio-economic benefit:

- Positioning Malaysia as a technology provider in the key strategic knowledge industries such as biotechnology, advanced materials, advanced manufacturing, microelectronics, information and communication technologies, aerospace, energy, pharmaceuticals, nanotechnology and photonics:
- Fostering societal values and attitudes that recognize S&T as critical to future prosperity, including the need for life-long learning:
- Ensuring that the utilisation of S&T accords emphasis towards approaches that are in conformity with sustainable developmental goals including alignment with societal norms and ethics: and
- Developing new knowledge based industries

8. National funds for R&D and STI comes primarily from Malaysian government ministries especially Ministry of Science Technology and Innovation , Ministry of Natural resources and Environment, Ministry of Higher Education, Ministry of Agriculture, Ministry of Tourism, corporations, agencies, Malaysia Life Science Capital Fund.

9. A number of bodies have been established in Malaysia for promoting, consolidating and managing R&D and STI in the sector of biodiversity, including the following:
    - Academy of Science Malaysia (ASM)
    - Agricultural Research Institute (ARI)
    - Centre for Biodiversity Law (CEBLAW)
    - Department of Wildlife and National parks (DWNP)
    - Fisheries Research Centre Sabah (FRC Sabah)
    - Fisheries Research Institute (FRI)
    - Fisheries Research Institute Sarawak (FRI Sarawak)
    - Forest Research Institute Malaysia (FRIM)
    - Freshwater Fisheries Research Centre (FFRS)
    - Institute for Strategic and International Studies (ISIS)
    - Institute of Medical Research (IMR)
    - Malaysia Agro-Biotechnology Institute (ABI)
    - Malaysia Genome Institute (GENOMalaysia)
    - Malaysia Institute of Pharmaceuticals & Nutraceuticals (IPharm)
    - Malaysian Agricultural Research and Development Institution (MARDI)
    - Malaysian Cocoa Board (MCB)
    - Malaysian Institute for Nuclear Technology Research (MINT)
    - Malaysian Institute of Maritime Affairs (MIMA)
    - Malaysian Palm Oil Board (MPOB)
    - Marine Fishery Resources Development and Management Department (MFRDMD)
    - National Fish Health Centre (NaFish)
    - Rubber Research Institute Malaysia (RRIM)
    - Sabah Biodiversity Centre (SaBC)
    - Sarawak Biodiversity Centre (SBC)

	• Turtle and Marine Ecosystem Centre (TUMEC) • Universities (public and private) • Veterinary Research Institute (VRI)
WP9	<u>**Identification and economic analyses of future economic growth opportunities in various areas in biodiversity sector**</u> 1. Exploring and diversifying agriculture in the use of traditional varieties of rice, vegetables (including varieties of ulam, yam, tapioca, sweet potato, etc.), wild and traditional fruits, livestock (cattle, goat, buffalo, pigs, duck, poultry, etc.), potential new sources of staple food (including turkey, ostrich, deer, wild boar, etc.), "vegetarian meats". 2. Expanding aquaculture methods sustainably for freshwater, brackish water and marine fisheries, including fish, crustaceans (prawns, crabs, stomatopods, etc.), bivalves (including mussels, etc.), gastropods (balitong, etc.), squids, sea cucumbers, seaweeds and other sources of food and uses. 3. Prioritising and mainstreaming tourism that would contribute towards the conservation and sustainable use of biodiversity in Malaysia rather than to deplete or to destroy it. This can be achieved by promoting homestay programmes and providing experiences into the lifestyles and artifacts of indigeneous people (especially given its inherent links to the articles in the UN Convention on Biological Diversity), traditional farmers and traditional fishermen, practitioners of cottege industries without compromising on their values and believes, forest canopy walkways, submarine view of marine habitats and their resources, exploring caves, hills and mountains, jungle tracking over long distances, showcasing the diversity of all racial cultures and their practices in Malaysia [eg. dances, games (congkak, giant kites, sepak takraw, kabbadi, chingai), house designs, documenting and disseminating stories, fables and "pantuns" which portrays the linkages between biodiversity and people, food types, festivals, ceremonies and others, eg. batik and wayang kulit] 4. Import and export strategies and policies of Malaysia, and their underlying financial mechanisms, should reflect its commitments towards the conservation and sustainability of biodiversity and appropriate MEAs (eg. the use of reduce impact logging and forest plantations for the extraction of timber; the introduction of invasive species from ballast water from ships transporting materials imported into Malaysia). Malaysia should also strategically intervene at the fora like WTO, WIPO, IMF, WB, etc. for frameworks and decisions that would not impinge on its biodiversity while promoting its sustainable utilization and commercialization. 5. Malaysia is known to be home to a wide variety of medicinal plants, herbs, including extracts from plants and animals for therapeutic purposes *[Burkhill, I.H. (1936). A Dictionary of the Economic Products of the Malay Peninsula. Vol. 1& II. Republished by Ministry of Agriculture Malaysia 2002; Kamarudin, M-S. & A. Latiff (eds.) (2002). Tumbuhan Ubatan Malaysia. Pusat Pengurusan Penyelidikan, Universiti Kebangsaan Malaysia;Bandaranayake, W.M. (2002). Bioactivities, bioactive compounds and chemical constituents of mangrove plants, Wetlands Ecology and Management 10: 421–452*]. Follow up efforts on such potential resources should include intensification of capapcity

building for R&D and STI, bioprospecting, screening, testing, testing for efficacy and safety, prospects for commercialization, production and marketing (domestically and internationally). Some examples of the use of medicinal plants are given below:

Plant species (Family), (Voucher specimens number)	Local name	Plant part and traditional claims
Agathis borneensis Warb Synonym, *Agathis alba* Foxw, *Agathis loranthifolia Salisb*, *Agathis dammara* (lambert) L.G Richard (Araucariaceae), (FRI45957)	Raja kayu, Damar laut, Kayu Damar Bukit	The powdered wood is used to treat headache and myalgia
Aralidium pinnatifidum (Cornaceae), (FRI45577)	Hempedu buaya, Tampong tulang, Tentulang, and Tampong tulang.	The leaves are placed on abdomen of children having fever. They are mixed with coconut oil and heated and placed on the skin to break the fever by causing perspiration.
Ardisia crispa Thunb. Synonym, *Ardisia littoralis* Andr., *Ardisia humilis* Vahl (Myrsinaceae), (FRI45481)	Mata itik, Mata ayam, Mata pelanduk, Daun bisa hati.	The leaves or the roots are used to treat fever, diarrhoea and liver poisoning.
Blumea balsamifena, Synonym, *Conyza balsamifera* L. (Asteraceae), (FRI45482)	Sembong, Sembuh, Sembing, telinga kerbau, Capa, sapu.	Leaf, entire plant or the root is used as antiplasmodial and the decoction of the leaves is used for coughs, fever and influenza.
Croton argyratum Blume, Synonym, *Croton argyratum* Blume (Euphorbiaceae), (FRI43118)	Semangkok, Hujan panas, Cenderai, Melokan.	The decoction of the leaves are used to treat fever.
Goniothalamus macrophyllus (Blume) Hook.f.et Thomson synonym, *Unona macrophylla*, *Polyalthia macrophylla* (Blume) (Annonaceae), (MP38)	Selada, akar beranak gajah, penawar hitam, lada hutan	The decoction of the roots are used to relieve colds and to treat fever.
Goniothalamus scortechinii King (Annonaceae), (FRI45437)	Selada putih, Akar gajah beranak, Bunga chenang	The plant has been reported to treat fever.

[source: Noor Rain, A., *et al.* (2007). Antispasmodial Properties of some Malaysian Medicinal Plants. Tropical Biomedicine, 24(1): 29-35]

Botanical Name	Traditional Uses	Tested For
Acanthus ilicifolius***	as an aphrodisiac, blood purifier, diuretic, treatment of asthma, diabetes, dyspepsia, hepatitis, leprosy, neuralgia, paralysis, ringworms, rheumatism, skin diseases, snake bites, stomach pains, leukemia, (B, Fr, L, R)	analgesic, anti-inflammatory, leishmanicidal and antiviral activity, activity towards leukemia virus and erythroleukemic Swiss mice, biotoxicity on fingerlings of fish, and mosquito larvae, (B, Fr, L, S, Fl, W, R)
Acrostichum aureum**	to treat wounds boils andrheumatism, (L, Rhizome).	biotoxicity on fingerlings of fish, (Fr, L, S, Sd, R)
Aegiceras corniculatum***	cure for asthma, diabetes, rheumatism, and as a fish poison, (B, L, S)	antiviral activity, toxicity to fish and influence on the growth of fungi, (B, Fr, Fl, L, S, R, W)
Avicennia alba***	treatment of antifertililty, skin diseases, tumors, ulcers, (Resin)	
Avicennia marina***	treatment of rheumatism, small pox, ulcers, fodder for livestock; (S)	analgesic and antiviral activity, (B, Fl, Fr, L, R, S,W)
Bruguiera cylindrica***	treatment of hepatitis, (Fr, L, R).	antiviral and larvicidal activity, biotoxicity on tobacco mosaic virus and fingerlings of fish, (B, Fr, L, W)

(L= Leaves; R=Roots; Fr=Fruits; B=Bark; W=Whole Plant)

[Adapted from: Bandaranayake, W.M. (2002). Bioactivities, bioactive compounds and chemical constituents of mangrove plants, Wetlands Ecology and Management 10: 421–452]

6. Well structured and managed plantations (eg, coconut, sugarcane, pineapple, palm oil, rubber) and farms (for fish, poultry, frog, duck, turkey, pigs, wild boar, deer, goats, cows, ostrich, quail, swallow) that would mimimize their implication for the conservation and sustainable use of biodiversity
7. Organizing stakeholder consultations and surveys to decide which ornamental plants and animals are worthwhile for sustainable commercialization, but without undermining Malaysia's biodiversity and the requirements of the Convention on International Trade and Endangered Species (CITES). For successful candidates the necessary processes, rules and regulations should be applied such that the qualified ornamental plants and animals can generate value added income from domestic and international markets. Such endevour should be mainstreamed by undertaking strategic showcasing of Malaysia's ornamental plants and animals (for eg., the annual tulip fair and the Kirkenhoff flower fest

from the Netherlands, the packaging and marketing practices at Thai airports, etc.). (Fig 6.1, Tables 6.3&6.4 pg 162 – ten Kerry)

8. Sustainable biotechnology for improving selected traits, with the necessary controls and safeguards, that is beneficial to people, socio-economy and environment of Malaysia, besides enhancing their prospects for commercialization and wealth generation. In the biotechnology industry there are presently some 350 biotechnology companies, working predominantly in the sectors of agriculture, industry and healthcare, as well as of genomic science, stem cells, biodiesel and medical devices. Progress in R&D by biotechnology companies have resulted in the yielding of 650 patents in Malaysia.

Figure 33. Number of Biodiversity Based Companies Identified in Malaysia (sourced from: Interim Report, 2011)

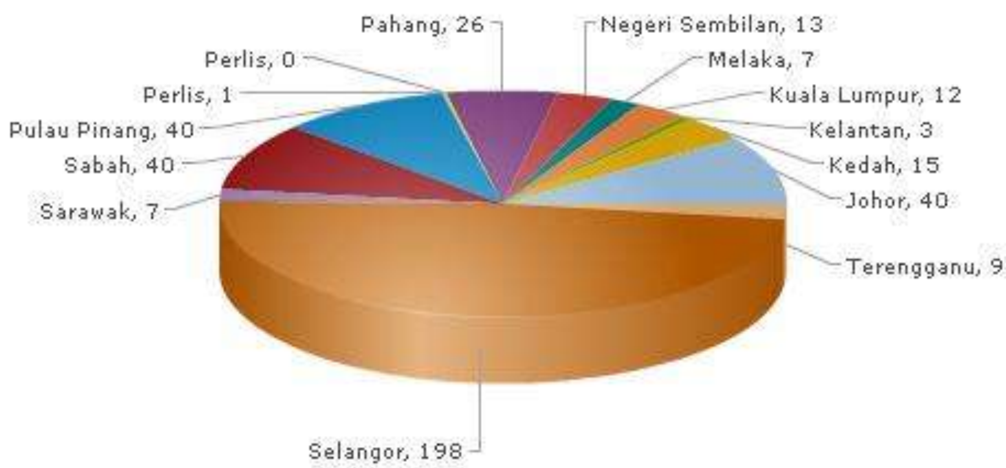
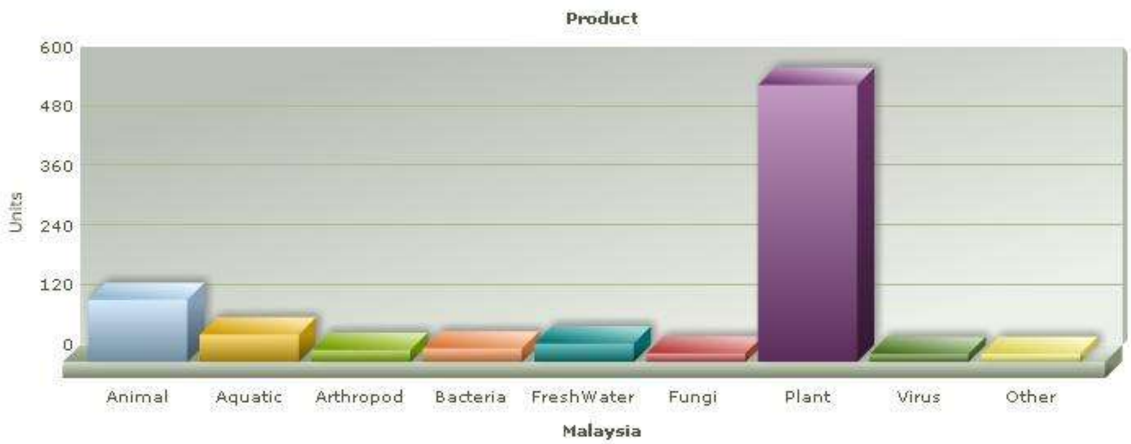


Figure 34. Some Kinds of Biodiversity Utilised by Biodiversity Based Companies in Malaysia to Develop Biodiversity based Marketable Products (sourced from: Interim Report, 2011)



9. The development of new infrastructure for the future economic growth opportunities for commercialization and wealth creation in the biodiversity sector should include adequate checks and balances which does not impinge on the integrity of the natural resources of Malaysia
10. Mega-development projects, including infrastructure projects should adopt the precautionary principle to mimimize their impacts on the conservation and sustainable use of biodiversity
11. The strategies and priorities for future economic growth in the biodiversity sector should ideally be based on long term principles and policies which ensure their sustainability.
12. Any or all approaches towards wealth creation from biodiversity in Malaysia should be pursued and implemented in a manner which does not undermine the welfare and well-being of the people of Malaysia from all sectors of present and future generations, of their socio-economic status and the environmental quality.
13. The challenges of commercializing biodiversity, while also conserving and sustainably utilizing it, are also often compounded by the different perspectives as perceived by profit motivated companies on one hand, and by the conservation and sustainable utilization imperatives of countries and of their communities on the other hand (Table 68).

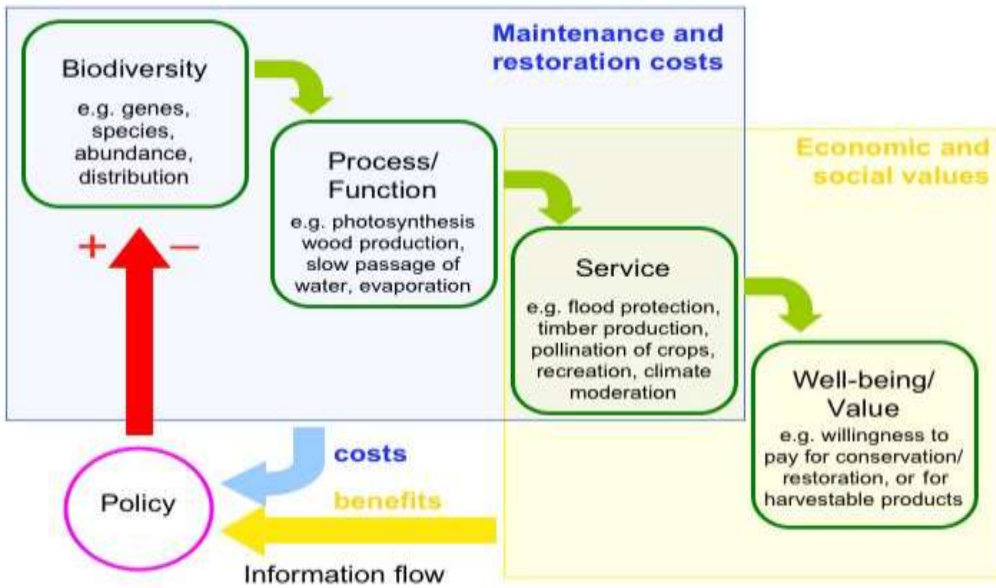
Table 68. Countries and Companies: A Sketch of the Different Perspectives (sourced from: ten Kate, 2000)

Source Countries and communities think…	Companies think….
• Companies make millions from genetic resources sourced from countries and can afford to help the countries pay to conserve them. • Companies don't acknowledge the contribution of the genetic resource to the final product. • For hundreds of years, the North has been profiting at the expense of the South, and the time has come to correct inequitable practices	• The third world countries are trying to make money from something they do not contribute to. • You don't hear them sharing the risks, only the benefits • It is not the role of the private sector to conserve genetic resources or to correct historical inequities.
• A naturally-derived product could never be discovered if it were not for the genetic resource on which it is based. • Genetic resources are hardly "valueless", but rather hold the genetic and biochemical key to product development. It's fair to ask for benefits in return for granting access to them	• It is ten or more years of research and development, considerable financial risk and several hundred millions of dollars invested in it that converts a "valueless" genetic resource into a final product. • Source countries value their raw genetic resources too highly and ask too much for them
• Patents create monopolies at the expense of those who provided the original material and much of the development. Patents give an unfair advantage to those who took the last step along the road of development. This step often barely satisfies any reasonable test of "inventiveness" or "novelty" • Patents result in final product sold back at vastly inflated prices to countries where the material came from.	• Patents on products and processes are the only what to recoup the investment needed for product development • Patent don't influence access to the original material, and Plant Breeders' Rights don't stop others from using protected varieties for breeding.
• Companies send teams of collectors to scour the world in search of new drugs, etc. They do not reach proper agreements and are "ripping" off countries. • Companies make massive profits from exploiting genetic resources, witness the 30%profit margin of the pharmaceutical industry. • Companies' demand for samples is so high that they will pay high access fess, such as the US$1m paid by Merck to INBio in Costa Rica	• Companies have plenty of genetic resources within their own collections or available for free from *ex situ* collections in their own countries, and many approaches to product discovery other than using genetic resources. • It is impossible for companies to pay more than they currently do for the raw materials, or natural product research will become uncompetitive. • Companies cannot and will not pay "access fees" of any great magnitude for raw samples. Merck paid INBio to conduct an agreed work programme.

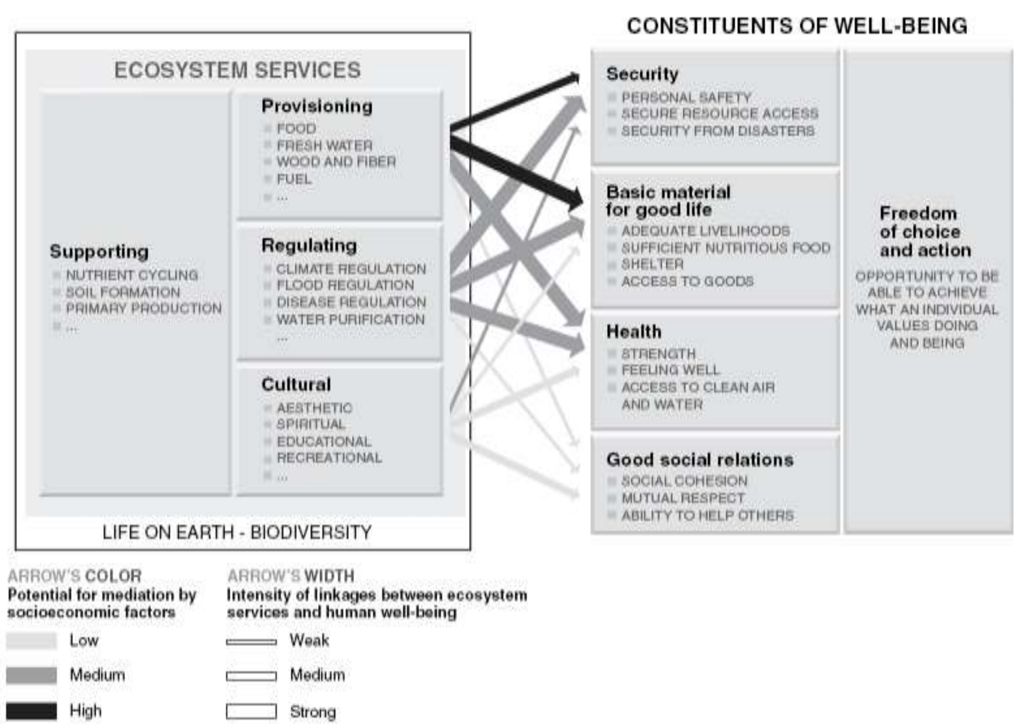
14. Interactions of Biodiversity at the Ecosystem Level and Human Well Being

Figure 35. The linkages between Biodiversity & Ecosystem Services, Well-being and its Consequences (A, B, C & D) [source: The Mellinium Ecosystem Assessment (2004)]

A

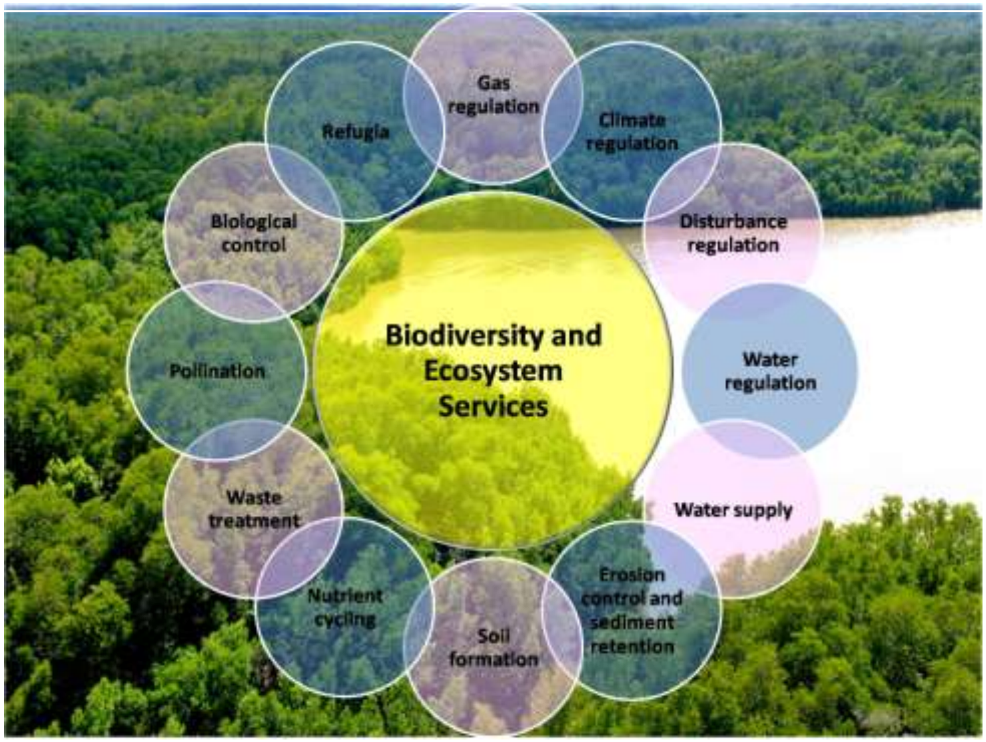


B

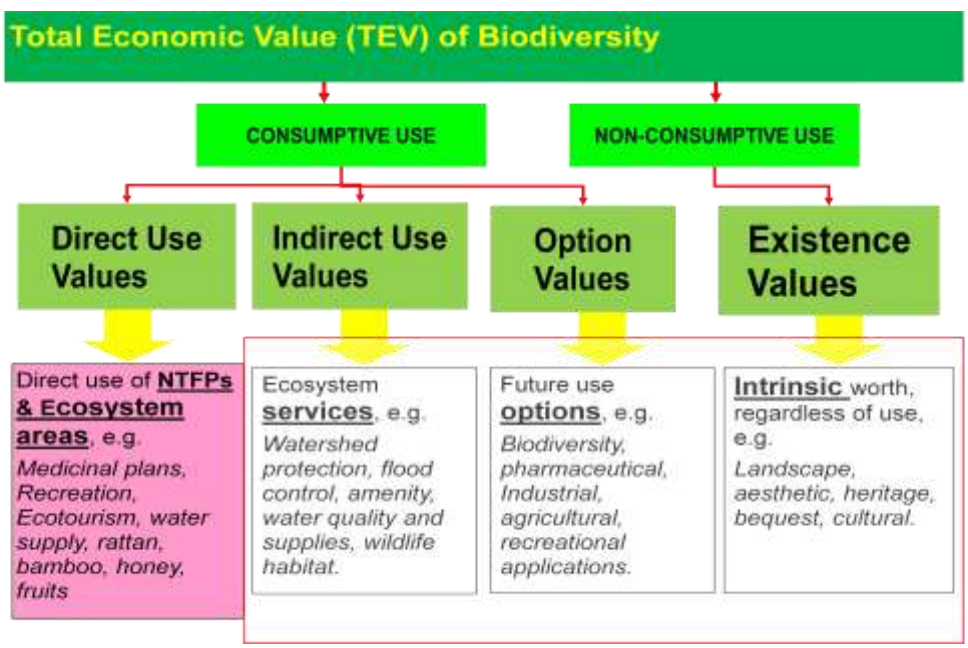


Cost of Action vs Inaction in The Short and Long Term (adapted from The Mellinium Ecosysten Assessment Mellinium by Awang Nor Ghani (2011)

C



D



WP10	**<u>Wealth Creation From Biodiversity</u>:** • Enhancing awareness and perception which would trigger appropriate knock-on changes in the attitudes, mindsets and actions of society including by incorporating the significance of biodiversity in Malaysian schools, colleges, universities, government, industry, public, media, decision makers at all levels, to promote conservation, sustainable use and commercialization of biodiversity and environmental resources (encouraging the use of biodegradable materials, popularising energy efficiency) while discouraging their decline and loss (eg. dissuading consumption of shark fin soup, turtle eggs, souveniers and trinkets made from parts of endangered species). • Adoption of the Precautionary Principle,is an approach to risk management that has been developed in circumstances of scientific uncertainty, which reflects the need to take prudent and pro-active action in the face of potentially serious risk without having to await the further completion of scientific research conclusions. One of the most broadly accepted definitions of the Precautionary Principle, in this context is embodied in Principle No. 15 of the Declaration on Environment and Development, which emerged from the United Nations Conference Environment and Development (UNCED) held in in Rio de Janiero in June 1992: "*In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of fullscientific certainty shall not be used as a reason for postponing cost-effective measures to preventenvironmental degradation*." It is therefore imperative that Malaysia adopts and implements the use of the precautionary principle in its efforts to conserve, to sustainably utilise and to commercialize biodiversity in Malaysia. • *In situ* and *Ex situ* application ofBiotechnology in line with the National Policy on Biological Diversity, Biosafety Act, Genetic Modification Advisory Committee/National Biosafety Board, Access and Benefit Sharing Act (in progress), CBD, Cartagena Protocol, Nagoya Protocol, etc. • Food security (conservation of agrobiodiversity (genetic erosion, monoculture, farm machinery) and coastal and marine biodiversity, agrochemicals (herbicides, pesticides, fertilisers), antibiotics, growth hormones, feed, germ plasm storage, organic farming, adaptation). Besides works to produce better quality and quantity of work, including R&D, on rice, selected vegetables and livestocks the bulk of R&D related to food and agriculture seems confined to selected species of fisheries and animals. For instance, examples of R&D is focused on fish and animals are provided in Table 69 and Table 70.

Table 69. Specialization and Facilities at Fisheries Research Institutes/Centres (sourced from NRE, 2010b)

Fisheries Research Institute / Centre	Field of Specialisation	Wet Laboratory	Specimen Collection Room	Database Storage	Live Specimen Holding Facility
Fisheries Research Institute	Marine Fauna and Flora Fisheries Gear Technology Biotechnology	√	√	√	√
National Fish Health Research Centre	Micro organisms Invasive Alien Species	√	√	√	√
Freshwater Fisheries Research Centre	Freshwater Fauna and Flora Freshwater Ecosystem Biotechnology	√	√	√	√
Marine Fishery Resource Development Management Department	Marine water Fauna and Flora Freshwater Fauna and Flora Oceanography Biotechnology	√	√	√	
Turtle and Marine Ecosystem Centre	Marine Fauna (marine mammals, sea turtles and invertebrates) Freshwater Fauna (Terrapins) Marine ecosystem	√	√	√	
Fisheries Research Institute Sarawak	Marine Fauna and Flora Ecosystems Biotechnology	√	√	√	
Fisheries Resource Centre Sabah	Marine Fauna and Flora Freshwater Fauna and Flora Ecosystems Biotechnology	√	√	√	√

Table 70. Breeds and Major Cross Breeds in Malaysia (sourced from NRE, 2010b)

Species	Breeds and Major Crossbreeds
Cattle	Australian Friesian Sahiwal, Australian Milking Zebu, Bali*, Boran X, Brahman & crosses, Brakmas, Charolais X, Charoke, Chianina X, Droughtmaster, Girlando, Hereford X, Holstein Friesian and crosses, Jersey and crosses, Kedah-Kelantan, Limousin X, Local Indian Dairy*, Mafriwal, Nelore, Red Friesian X, Sahiwal Friesian and Sabah Sahiwal-Friesian, Seladang*, Selembu*, Simbrah
Buffalo	Borneo Buffalo, Kerbau Sawah, Murrah*
Sheep	Barbados Blackbelly, Dorper X, Dorset X, Dorsimal*, Long Tail, Malin*, Morada Nova X, Santa Inés, Segurena X, Southdown X, Suffolk X, Sufrimal*, Sussex X
Goat	Alpine, Anglo Nubian, Australian Feral Goat, Boer, Jermasia, Jamnapari, German Fawn, Kambing Gurun*, Katjang*, Saanen, Toggenburg
Chicken	Ayam Hutan, Ayam Kampong, Ayam Sabong, Ayam Serama/Kapan, Ayam Sutera (Silky), Commercial Broiler Chickens, Commercial Layer Chickens
Duck	Belibis, Itik Jawa, Itik Kampong, Khaki Campbell, Muscovy, Pekin, Serati/Nila
Geese	Angsa Kampong, France White Rhine
Quail	Bob White, Japanese Quail, Puyuh IKTA (Male line), Puyuh IKTA (Female line),
Ostrich	Black Neck, Blue Neck
Turkey	Turkey British United Turkey, Bronze Turkey
Pig	Duroc, Iban, Landrace, Large White Yorkshire, Sarawakian Bearded Pig, South China Pig*
Horse	Arabs, Bimo Siam, Kuda Padi, Miniature Horses, Polo Horses, Quarter Horses, Saddlebred, Shetland Ponies, Thoroughbred
Deer	Axis, Sambar, Sika, Red Deer, Timorensis
Rabbits	Californian, Carolina, Giant White Bouscat, Hyplus, New Sigmonoire, New Zealand White

* Breeds thought to be at risk

In addition, given the scope and significance of forest and timber to the biodiversity and the economy of the country Malaysia has established sites for the conservation of the genetic resources of selected timber species as documented in Table 71.

Table 71. Wealth Creation - Genetic Resources of Timber (sourced from: NRE, 2010b)

In its efforts to conserve various forest and ecological types in their original conditions, Malaysia has set aside pockets of virgin forest throughout the country. These pockets, known as Virgin Jungle Reserves (VJRs), were established to serve as permanent nature reserves and natural arboreta; as control plots for comparing with harvested and silviculturally treated forests; and as undisturbed natural forests for ecological and botanical studies.

Malaysia has also established two Genetic Resources Areas (GRAs), one in the Ulu Sedili Forest Reserve in Johor, covering 4806 ha and the other one in Semengoh Forest Reserve in Sarawak. The GRAs in Johor and Sarawak have initially targeted 8 and 14 commercial species for genetic conservation, respectively. These species are by no means exclusive and research is in progress to identify additional species for genetic conservation.

FRIM has generated the ecological genetics information for a rare and predominantly outcrossed dipterocarp (*Shorea lumutensis*), a rare and predominantly selfing dipterocarp (*Hopea bilitonensis*), and a widespread endemic and predominantly outcrossed dipterocarp (*Neobalanocarpus heimii*) to set conservation strategies so to prevent the common species from becoming an endangered plant and to protect the rare species against extinction.

At present, Malaysia has many *ex-situ* conservation areas and examples in various states. Collections are conserved mainly in arboreta of research institutions, universities and government agencies. The universities include Universiti Malaya, Universiti Putra Malaysia and Universiti Kebangsaan Malaysia, and government funded research centres include Semengoh in Sarawak and at Sepilok and Poring in Sabah. Of the research institutions, the Forest Research Institute Malaysia (FRIM), the Malaysia Palm Oil Board, the Malaysia Rubber Board and the Malaysian Agricultural Research and Development Institute have arboreta for various groups of wild species. For example, the arboreta of FRIM have a collection of more than 500 forest plant species, including 150 dipterocarp species. The largest groups of forest plant species under *ex-situ* conservation are orchids, followed by fruit trees, timber species and medicinal plants.

Seed genebanks for forest species are not appropriate as most of the plants produce recalcitrant seeds, which cannot be stored for long. Various institutes in the country are carrying out research to explore the possibilities of using cryogenic and *in vitro* techniques for long-term gene conservation of tree species. Some of the species that have been successfully cryo-preserved for *ex-situ* conservation are *Dipterocarpus alatus, Dipterocarpus intricartus, Swietenia macrophylla, Pterocarpus indicus, Thyrosostachys siamenis, Bambusa arundinacea, Dendrocalamus membranaceus and Dendrocalamus brandissi*. Tissue culture through *in vitro* techniques has been widely studied in *Swietenia macrophylla, Shorea leprosula, Shorea ovalis, Shorea parvifolia, Shorea macrophylla, Hopea odorata,* and *Calamus manan*.

Wealth Creation - Ecotourism

- Nature tourism and ecotourism, comprising terrestrial, coastal and marine resources should be based on relevant MEAs and principles like carrying capacity.
  - The tourism industry generated more than $1 trillion globally in 2010 (World Tourism Organization, WTO). Seven countries (Czech Republic, Hungary, Poland, Romania, Serbia, Slovakia and Ukraine) which are parties to the Carpathian Convention have signed, on 27May 2011 a protocol on sustainable tourism based on the CBD Guidelines on Biodiversity and Tourism Development, Arrhus Convention, Convention on Migratory Species, World Heritage Convention, Climate Change Convention, Ramsar Convention, European Landscape Convention, etc. Even more so, since tourism is a key element for the sustainable development of the Carpathian region and also of Malaysia.
  - According to the FAO and the Collaborative Partnership on Forests (CPF) report, ecotourism is one of the fastest growing segments of the tourism industry worldwide increasing at a pace of more than 20% annually (2 or 3 times faster than the tourism industry overall), and failure to limit the number of tourists can lead to permanent damage of fragile ecosystems (including carrying capacity). The increasing demand for ecotourism can play a vital role in saving endangered forest and wildlife, while also warning of the potential damaging effects if its expansion if not effectively managed. Besides providing a source of income generation and livelihoods for local communities, properly planned and implemented ecotourism can also contribute towards Malaysia's GDP.
  - As per the FAO-CPF report, the benefits of ecotourism flowing to local businesses are dramatically much higher than those from mass tourism, thereby providing incentives for local communities to take care of their environment. More so, as tourism can motivate local communities to maintain and protect forests and wildlife by showing that their income generation is directly linked to the preservation of their environment. For example such an approach on sustainable ecotourism, involving local communities in Rwanda, Uganda and Democratic Republic of Congo, undertaken by the Great Apes Partnership (GRASP), has given rise to an increase in the number of gorilla populations.
  - As recently stated by the UN Secretary General "At a time of profound global economic uncertainty, tourism's ability to generate socioeconomic opportunities and help reduce the gap between rich and poor, is more important than ever" (UN News; 27 September 2011). In this context, he suggested that The UN Global Code of Ethics for Tourism be incorporated for promoting the development of

sustainable and responsible tourism. Growth in tourism, which includes responsibilities for minimizing any potential negative impacts on the cultural assets and heritage of mankind, especially since about 940 million tourists crossed international borders in 2010.

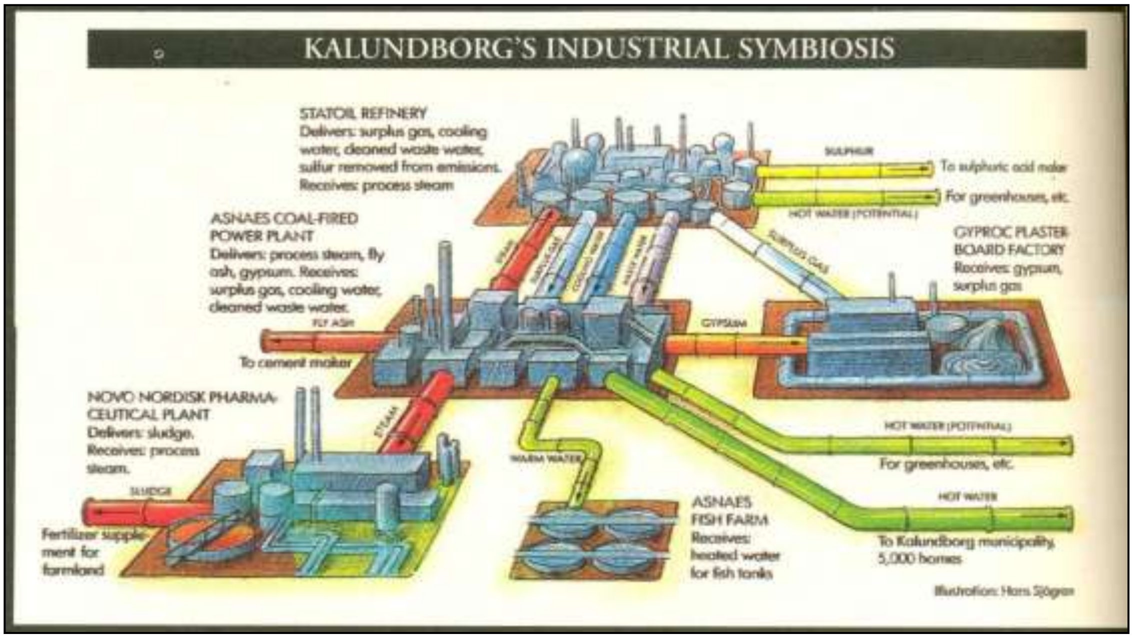
- Wealth Creation – Fishery and Aquaculture Resources
    - Promoting sports fishing, as well as the zones and the types of sports and fishes, permissible at designated zones.
    - Utilising appropriate fishing gears, net types and net sizes for purposes of sustainable fishing.
    - Conserving and enhancing appropriate and critical fisheries habitats (eg. mangroves, corals, sea grasses, mudflats, shallow coastal waters).
    - Enforcing fisheries and aquaculture related legislation including CITES and also those on marine parks and no take zones.
    - Enhancing tourism related export/import of ornamental fishes but with adequate controls on curbing potentially invasive species
    - Encouraging fishery-friendly campaigns (eg. no sharks fin soup)
    - Establishing aquaria for increasing public awareness and action on fisheries and aquaculture
    - Screening and testing the feasibility of bioactive and medicinal compounds extracted from fisheries.
    - Ensuring that existing and expansion of aquaculture is pursued in a sustainable, integrated and environment-socio-economically friendly manner that does not harm the environment or peoples, including the implementation of aquaculture in the seas themselves.
    - Pursuing the breeding and propagation, both naturally and biotechnologically, of fisheries with selected traits for sustainability.
    - Exploring the use of fisheries as biological control agents against pathogens and their larvae/eggs/ of diseases.
    - Experimenting with novel and environmentally friendly methods for disease control among high density fisheries stocks, eg. as in aquaculture.
    - Diversifying the range and scope of fisheries currently utilized for fishing, aquaculture and human consumption. Exploring currently underutilized fisheries resources from mangroves for example the Ariidae (ikan duri), Sciaenidae (gelama), Scatophagidae (ketang), Mugilidae (loban, belanak), etc.
    - Strengthening R&D and building capacity on fishery resource biological diversity
    - Enhancing information dissemination, networking and controlling the harvesting and trade in fisheries
    - Controlling and managing fisheries invasive species (existing and potential)
    - Checking and preventing bio-piracy of fisheries species
    - Ensuring the adoption of appropriate bio-safety approaches in the practice of fisheries aquaculture
- Coastal and marine ecosystems including coral reefs, mangroves, Large Marine Ecosystems (LMEs), sea grasses, macro algae (seaweeds), microalgae (diatoms).
- Screening for bioactive compounds from biodiversity for pharmaceuticals, enzymes and

cosmetics.

- <u>Wealth Creation – Innovative Approaches</u>
  - Bioprospecting from biodiversity for sustainably usable sources of food, fuel and fibre
  - Strategic preservation, documentation and use of traditional knowledge for the conservation and sustainable use of biodiversity, including those practiced by indigeneous peoples.
  - Identifying and marketing sustainably suitable and value added ornamental flora and fauna
  - Promoting the extraction of timber and related wood industry from quick growth forest plantations, both for domestic use and also for export (especially in the **<u>vast idle lands</u>** of Malaysia), and not from existing forests and mangroves.
  - Mutually reinforcing legislation & policies, with particular emphasis on their policing, enforcement and punitive measures, such as on SEA, EIA (PEIA & DEIA) - cumulative and integrated effects versus site specific and isolated effects
  - The implementation of spatial and temporal zones for the different utilisation of terrestrial and marine biodiversity (eg. critical hot spots, no "take" zones and seasons)
  - Ensuring the use of economic instruments strategically, (eg. SEA, Integrated EIA) for the conservation, sustainable use and commercialization of biodiversity, ecosystems and their services, including economic incentives and disincentives, cost of action versus cost of inaction, full cost accounting, evaluating and internalising environmental cost and services in developmental planning, sustainable production, consumption and disposal of environmentally friendly processes and products, removal of "perverse subsidies".
  - Monitoring and control of invasive species (existing and potential)
  - Ensuring adequate corridors, habitats and safeguards in Malaysia for the conservation of migratory species
  - Revival of endangered or extinct endemic species and their habitats (eg. Giant clams, turtles, tortoises, etc.)
  - Protection of so-called flagship species of special concern (tigers, tapir, elephants, orang utans, rhino, seladang, rafflesia, etc.)
  - Appropriate measures for controlling the over-exploitation of biodiversity unproven uses contributing to their loss and possible extinction (eg. Tongkat Ali, Kacip Fatimah, *Ganoderma* mushroom, gamat, corals, wild orchid, gaharu, etc.)
  - Biodiversity and Climate change Dynamics (eg. REDD, REDD+, carbon loading and trading, waste disposal, agriculture, open burning and forest clearance, golf courses, emission of greenhouse gases from Industry and transport, livestock, mitigation and adaptation measures)
  - Exploring, exploiting and expanding innovative approaches and technologies, including renewable sources of energy, "industrial symbiosis" (planning and development of various industries such that the waste products from one industry becomes the raw material for its adjoining industry, thereby increasing the efficient use of resources and minimising the amount of waste generated, for example the Kalundborg Industrial Complex in Denmark, (Fig. 35), basic and applied science & technology, research & development which do not have negative impact on the quantity and quality of

biodiversity and ecosystems of Malaysia

Figure 36. Kalundborg's Industrial Symbiosis (Teoh & Abraham, 1996).



- Wealth Creation - Biomimicry
  - Developing sustainable human technologies, inspired by nature, which is called biomimicry, biomimetics or bionics. For millions of years nature had tried and tested, through evolution properties, processes and products of organisms, from which human beings could learn and mimic. More so with Malaysia being is a mega(bio)diverse country, rich in biodiversity, it should at least in principle provide Malaysia with a greater deal of opportunity to learn from the variety of nature and her products which could be biomimicked to produce sustainable environmentally friendly products. Some proven examples of biomimicry (sourced from http://brainz.org/15-coolest-cases-biomimicry/) include the following:

    1. Velcro
    2. Passive Cooling
    3. Gecko tape
    4. Lotus effect hydrophobia
    5. Self-healing plastics
    6. The golden streaming principle
    7. Artificial photosynthesis
    8. Morphing aircraft wings
    9. Friction-reducing shark skin
    10. Diatomaceous nanotech

11. Glo-fish
12. Insect-inspired autonomous robots
13. Butterfly-inspired displays
14. Whale power wind turbine

1. Velcro

The most famous example of biomimicry was the invention of Velcro brand fasteners. Invented in 1941 by Swiss engineer George de Mestral, who took the idea from the burrs that stuck tenaciously to his dog's hair. Under the microscope he noted the tiny hooks on the end of the burr's spines that caught anything with a loop - such as clothing, hair or animal fur. The 2-part Velcro fastener system uses strips or patches of a hooked material opposite strips or patches of a loose-looped weave of nylon that holds the hooks.

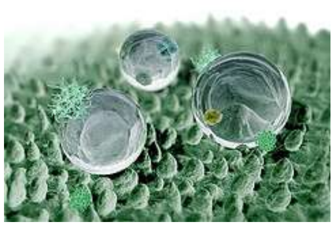
2. Passive Cooling

The high-rise Eastgate Centre building in Harare, Zimbabwe was designed to mimic the way that those tower-building termites in Africa construct their mounds to maintain a constant temperature. The insects do this by constantly opening and closing vents throughout the mound to manage convection currents of air - cooler air is drawn in from open lower sections while hot air escapes through chimneys. The innovative building uses similar design and air circulation planning while consuming less than 10% of the energy used in similar sized conventional buildings!

3. Gecko Tape

Ever wanted to walk up walls or across ceilings? Gecko Tape may be the way to do it. The tape is a material covered with nanoscopic hairs that mimic those found on the feet of gecko lizards. These millions of tiny, flexible hairs exert van der Waals forces that provide a powerful adhesive effect. Applications include underwater and space station uses, so researchers from a number of institutions are working hard. They won't be mass producing gecko tape sneakers and gloves any time soon, so Spiderman wannabes will have to wait awhile longer, while hoping other biomimetic researchers get around to inventing the necessary web-throwers.

4. Lotus Effect Hydrophobia



They call it "superhydrophobicity," but it's really a biomimetic application of what is known as the Lotus Effect. The surface of lotus leaves are bumpy, and this causes water to bead as well as to pick up surface contaminates in the process. The water rolls off, taking the contaminates with it. Researchers have developed ways to chemically treat the surface of plastics and metal to evoke the same effect. Applications are nearly endless, and not just making windshield wipers and car wax jobs obsolete. Lots of researchers are working on it, and General Electric's Global Research Center is busy developing coatings for commercial application right now.

5. Self-Healing Plastics

Consider the body's power to heal itself of scrapes and cuts. The value of the same sort of process in light polymer composites that can be used to produce things like aircraft fuselage becomes obvious. The new composite materials being developed are called self-healing plastics. They are made from hollow fibers filled with epoxy resin that is released if the fibers suffer serious stresses and cracks. This creates a 'scab' nearly as strong as the original material. Such self-healing materials could be used to make planes, cars and even spacecraft that will be lighter, more fuel efficient, and safer.

6. The Golden Streamlining Principle

A company called PAX Scientific out of San Rafael, California has been developing air and fluid movement technologies based on such beautiful and recurring natural designs as the Fibonacci sequence, logarithmic spirals and the Golden Ratio. These shapes align with the observation that the path of least resistance in this universe isn't a straight line. Put all this together and you get the "Streamlining Principle," being applied to fans, mixers, impellers and such that move air and liquids around in systems. Such fans on motors, compressors and pumps of all sizes and in all applications could save at least 15% of all the electricity consumed in the US.

7. Artificial Photosynthesis

We all learn about photosynthesis in school, the way that green plants use chlorophyll to convert sunlight, water and carbon dioxide into carbohydrates and oxygen. The quest to reproduce the process technologically is called Artificial Photosynthesis, and is envisioned as a means of using sunlight to split water into hydrogen and oxygen for use as a clean fuel for vehicles as well as a way to use excess carbon dioxide in the atmosphere. The process could make hydrogen fuel cells an efficient, self-recharging and less expensive way to create and store energy applicable in home and industrial systems.

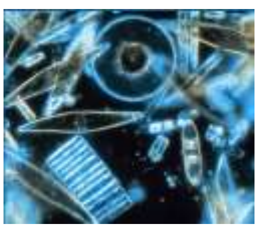
8. Morphing Aircraft Wings

Using inspiration from both birds and fish, scientists from Penn State University developed Morphing Airplane Wings that change shape depending on the speed and duration of flight. Different birds have differently shaped wings useful for the speeds at which they fly, as well as for sustaining flight speeds over long distances using the least amount of energy. The scientists built a compliant, shape-changing truss understructure for the wings, then covered it with scales that can slide over one another to accommodate the in-flight shape changes. When deployed in new aircraft (and drone) models, the wings are expected to conserve fuel and enable faster flights over longer distances.

9. Friction-Reducing Sharkskin

One of the best ways to reduce reliance on fossil fuels is to achieve more efficient use of the energy we do consume. Inspired by the evolved ability of shark's skin to reduce drag by manipulating the boundary layer flow as the fish swims, researchers are developing coatings for ship's hulls, submarines, aircraft fuselage, and even swimwear for humans. Based on the varying shape and texture of shark's skin over its body, Speedo's Fastskin FSII swimsuits made their appearance at the Bejing Olympics and may have helped US swimmer Michael Phelps to his record eight gold medals in that competition, and the rest of the team as well.

10. Diatomaceous Nanotech

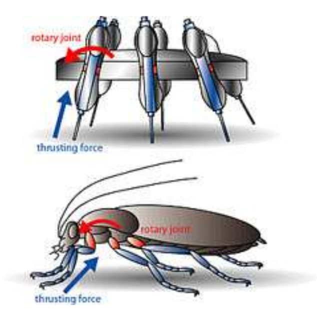


They call it Biosilification, and it's the genetic engineering of the tiny, single-celled algae known as diatoms in order to mass produce silicon-based nanodevices and nanotubes for specific uses. Living diatoms reliably manufacture working valves of various shapes and sizes that can be used in nanodevices to deliver drugs to specific targets in the body, as chemostats in chemical engineering applications, and in colonies as nanotubes for solar collectors and artificial photosynthetic processes. Their silicon skeletons can provide specialized sensors and filters for uses in chemical engineering and defense applications.

11. Glo-Fish

Glow-in-the-dark aquarium fish may not fulfill a needful ecological role at the present time, but they're a fun - and lucrative - application of fluorescent proteins discovered in jellyfish while researchers are busily developing further biochemical tools from this Nobel Prizewinning discovery. The protein can be attached to other molecules of interest so they can be followed for understanding of their functions in living organisms, very useful in medical research. For the fish, the proteins serve the purpose of simply being very cool - they come in several colors!

12. Insect-Inspired Autonomous Robots

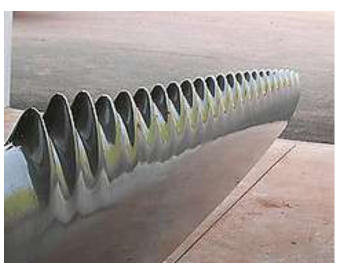


While most of us are accustomed to thinking about futuristic robotics as something that looks and moves just like a human, humans are probably not the best biological model for really useful robots. For mobility, insect-like ability to cover varied terrain, climb surfaces and provide stability seems to work better. Insect eyes offer greater resolution and panoramic range for exploring places people cannot go, and the ability to quickly adapt to changing environments (or even to spy on enemies undetected) make those annoying toy insect robots a forerunner for future applications in exploration and defense.

13. Butterfly-Inspired Displays

By mimicking the way light reflects from the scales on a butterfly's wings, the Qualcomm company has developed Mirasol Displays that make use of the reflected light principle with an understanding of how human beings perceive that light. Using an interferometric modulator [IMOD] element in a two-plate conductive system, the display uses near-zero power whenever the displayed image is static while at the same time offering a refresh rate fast enough for video. Perfect for 'smart' hand-held devices, already deployed in many, and a battery-saver extraordinaire!

14. Whalepower Wind Turbine



Inspired by the flippers humpback whales use to enable their surprising agility in the water, WhalePower has developed turbine blades with bumps called tubercles on the leading edge that promise greater efficiency in applications from wind turbines to hydroelectric turbines, irrigation pumps to ventilation fans. Compared to smooth surface fins, the bumpy humpback ones have 32% less drag and an 8% increased lift in their movement through air or water. Using such blades to catch the wind as communities and nations switch to renewable sources could provide a 20% increase in efficiency that will help to make wind power generation fully competitive with other alternatives.

- Formulating and applying effective and verifiable indicators for the conservation and sustainable use of biodiversity in Malaysia, including addressing upstream at source rather than end of the pipe line imperatives
- Replicating or adapting of proven national, regional and international success stories and lessons learned of innovative methods and mechanisms for the conservation, sustainable use and commercialization of biodiversity
- Undertaking an Mellinium Ecosystem Assessment for Malaysia to indentify Malaysia's biodiversity and its hotspots to be preserved for posterity. All the more reason considering the significance of biodiversity at the ecosystem level as indicated in Table 72.

Table 72. Importance of Ecosystems (sourced from NRE, 2010b)

Thematic areas	**Importance for human well-being**	**Importance for other values**	**Importance for ecosystem integrity**
Forests Biodiversity Mountain Biodiversity Inland waters Biodiversity	- Fresh water supply - Source for hydro-electricity - Food - Human habitat - Timber products - Non-timber products (ornamental plants, fishes, etc.) - Medicine and herbs - Education - Recreation - Tourism - Fisheries and aquaculture	- Animals and insects for pollination - Agricultural pest control - Watershed - Greenhouse gas regulation/ Carbon storage - Micro-climatic functions (e.g. flood mitigation) - Transportation - Nutrient recycling - Runoff regulation - Biodiversity values - Pharmaceutical values - Cultural and Heritage values	- Home to endemic species, including threatened species - Prevention of transmission of diseases - Food security - Adaptation to climate change - Gene pool - Existence value
Marine and coastal Biodiversity Islands Biodiversity (*please refer to forests for non-marine related ecosystems*)	- Human habitat - Ornamental fishes - Medicine and Herbs - Timber and Non-timber forest products (coastal forests) - Education - Recreation and Tourism - Fisheries and aquaculture	- Nursery ground for near-shore fisheries - Storm protection - Prevention of coastal erosion - Nutrient recycling - Biodiversity values - Pharmaceutical values - Cultural and Heritage values	- Home to endemic species, including threatened species - Food security - Support for migratory birds - Gene pool - Existence value - Adaptation to climate change
Agricultural Biodiversity	- Human habitat - Fisheries and aquaculture - Agriculture products - Source for fuel wood - Timber and non-timber products - Medicine and Herbs - Education - Recreation - Agro-tourism	- Animals and insects for pollination - Agricultural pest control - Greenhouse gas regulation / Carbon storage - Micro-climatic functions - Nutrient recycling - Biodiversity values - Pharmaceutical values - Cultural and heritage values	- Food security - Soil erosion control - Pest control - Prevention of transmission of diseases - Gene pool for agricultural production - Existence value - Adaptation to climate change

- As a party to several biodiversity related conventions, protocols and agreements Malaysia is accountable to and should therefore fulfil its obligations in meeting the missions and mandates of the various MEA's related to the conservation and sustainable use of biodiversity (at the genetic, species and ecosystem levels), including socio-economic, cultural and spiritual diversity

- The Operative Perspective Plan (10 years) and the The Malaysia Plan (5 years) should include separate chapters on biodiversity conservation and sustainability, public participation, equitable distribution of wealth for all sectors of society. As a follow up, Malaysia's GDP should also be calculated by incorporating biodiversity related imperatives (quantify biodiversity in terms of taxa and monetary value in terms of its total value and in the GDP)
- Being one of the 12 mega(bio)diverse countries in the world, Malaysia should take initiative and lead in negotiating for MEA's targeted at conserving and sustainably utilising biodiversity, including its scope for potential commercialization.As a follow up to protect and conserve Malaysia's wealth of biodiversity and its natural resource assets, the Government has adopted the Common Vision on Biodiversity, which promotes a three- pronged implementation approach and outreach strategy that consists of:
  - i. strengthening the Protected Areas System;
  - ii. managing landscapes and seascapes for biodiversity;
  - iii. mainstreaming of biodiversity.

  Further, the nine specific trusts identified in the national biotechnology policy of Malaysia include the following:

  i. Agriculture biotechnology
  ii. Healthcare biotechnology
  iii. Industrial biotechnology
  iv. R&D and technology acquisition
  v. Human capital development
  vi. Financial infrastructure
  vii. Legislative and regulatory framework
  viii. Strategic positioning
  ix. Government commitment

- <u>National Biodiversity Centre (NBC) including the Natural History Institute</u>
- **National Biodiversity Centre for coordinating and consolidating all aspects of conservation and sustainable use of Biodiversity in Malaysia** including relevant policies, strategies and plans, R&D and STI, utilisation, commercialization, seed banks, genetic profiling of all taxa, capacity building for more Malaysian taxanomists, etc. For instance, despite the existence of United Nations Environment Programme, Global Environment Facility and the environmental sections of other UN agencies like FAO, UNDP, IFAD, WHO, etc., recently the executive director of UNEP announced the establishment of The International Platform on Biodiversity and Ecosystem Services (IPBES) as a separate UN agency. IPBES which aims to reflect the UN-backed Intergovernmental Panel on Climate Change (IPCC) will focus on the following four areas, knowledge generation, assessment, policy support, capacity building in a manner where the best science would be brought to bear on informing policy-making at the global, regional and national levels.

- **National History Institute to be an iconic world class centre of excellence**, it will need to be staffed and equipped with the state of the art facilities and its performamces must be benched marked against leading natural history museums of the world including the following:

1. Excellent physical facilities for the secure storage of scientific specimens
2. Rapid buildup ofscientific collections
3. Creative programmes in the exhibition and the other public outreach activities
4. Long term programmes of research and development by its own staff and associated scientists
5. Modern laboratories for taxonomy
6. Scientific relations with leading natural history museums overseas
7. Biodiversity informatics with national and international linkages
8. Comprehensive library and database facilities
9. Collaborative programmes with universities and institutes
10. A peer reviewed scientific publications programme
11. Mainstreaming biodiversity conservation in development planning, including its prospects and its and potential for contributing to Malaysia’s GDP
12. Inventorising species and habitats including reference specimens
17. Identifying gaps in biodiversity protected areas
18. Securing finances for the conservation and sustainable use, including for commercialization of biodiversity in Malaysia
19. Promoting public education and community participation in the conservation and sustainable use of biodiversity including on its interfaith ethics, practices and culture
20. Facilitating cooperation and collaborations in R&D with proven and world class institutes which are also involved in the conservation, sustainable use and commercialization of biodiversity

11. KEY (SPECIFIC) RECOMMENDATIONS: IMMEDIATE, MID-TERM & LONG-TERM

Value-added and competitive-edge wealth generation from biodiversity should not be at the expense of non conservation and non sustainably use of biodiversity. Among the key immediate, mid-term & long-term recommendations in the biodiversity sector, the following interventions would be included:

a. Establishing a high-level centre of scientific excellence in Biodiversity to oversee and coordinate the activities and interventions that need to be undertaken. Such a high-level centre should be based at a competent institution. It should have representatives from Ministries of the Malaysian Government, and appropriate experts academicians from different disciplines.

b. Conducting, documenting and coordinating a detailed and country-wide inventory of the multitude of terrestrial and the aquatic floral and faunal biodiversity in Malaysia by a team of appropriate scientists, along the lines of the Mellinium Ecosystem Assessment and the Intergovernmental Panel on Climate Change. This is best executed centrally such as through a National Natural History Institute.

c. As a follow up on the Global Millennium Ecosystem Assessment study and report, coordinating a similar study and report at the national level in Malaysia. Notably, the National Millennium Ecosystem study and report of Malaysia, would furnish a country-wide overview of the critical ecosystems and habitats in Malaysia, which ought to be conserved for present and future generations and for prosperity.

d. For relatively quick returns on biodiversity-based wealth generation, R&D and STI priorities should be focusing on the following biodiversity-sectoral areas:

i. Sustainable timber and non-timber products for forestry.

ii. Food crops and fruit vegetation for agriculture, food security and as sources of nutrients.

iii. Industrial crops for fuels and industries.

iv. Medicinal herbs and plants, as well as venomous animals and biomass, for the production of pharmaceuticals, lotions, antidotes, vaccines, as well as for their use in the preparation of bio-fertilizers and bio-pesticides.

v. Marine, brackish and freshwater fisheries and aquaculture and their related biodiversity (corals, mangroves, seagrasses, etc.)

vi. Novel and value added consumer products and processes through innovative R&D and ST&I like biotechnology and other strategic technologies.

vii. Enhance interventions in biodiversity which would support the obligations of Article 8j of the (UN) CBD, which also includes the recently commenced negotiations for the Nagoya Protocol on Access and Benefit Sharing (NPABS) of biodiversity.

viii. The propogation and sale of ornamental plants and flowers domestically and for export.

e. The present study endorses the priorities and recommendations of the government of Malaysia, as stated in its 2005 National Biotechnology Policy, which includes the following nine strategic thrusts areas:

i. Thrust 1: Agriculture biotechnology development.
ii. Thrust 2: Healthcare biotechnology development.
iii. Thrust 3: Industrial biotechnology development.
iv. Thrust 4: R&D and technology acquisition.
v. Thrust 5: Human capital development.
vi. Thrust 6: Financial infrastructure development.
vii. Thrust 7: Legislative and regulatory framework development.
viii. Thrust 8: Strategic positioning.
ix. Thrust 9: Government commitment.

In addition, other sectors worth pursuing in this context should include the following:

a. Enhancing the bioprospection, collection, indentification, documentation and conservation of germplasm resources from flora and fauna which could be subsequently utilized and commercialize with appropriate R&D and ST&I. The storage for conservation of the germplasm or the seeds of all forms of biodiversity can be enhanced *ex-situ* in gene banks, or else done *in-situ* in farms itself. Such initiatives could also contribute towards maximizing the wealth created from the germplasm.

b. Exploiting forestry and plantation biodiversity for REDD, carbon locking, carbon trading, carbon offsets, etc, as well as for other options and opportunities for climate change mitigation and adaptation.

c. Facilitating and fostering strategic cooperation and collaboration with like-minded and renowned biodiversity-based R&D and STI institutions, either local and foreign.

d. Raising public awareness on the status and significance of the environment and its natural resources, with special reference to the conservation and sustainable use of biodiversity.

e. Following up on its international obligations on biodiversity, the Malaysian government has agreed to the decisions adopted by the various country delegates to the Ninth Conference of Parties (COP-9) to the (UN) Convention on Biological Biodiversity (CBD), held in Bonn, Germany, 9-13 May, 2008, particularly those on agricultural biodiversity, forestry biodiversity, sustainable agriculture, invasive species, traditional knowledge, indigenous peoples, bio-prospecting, access and benefit sharing (ABS), plant breeders rights, biodiversity and climate change, etc.

f. Exploring and expanding the use of ionnovative methods and mechanisms and emerging technologies, including Reducing Emissions from Deforestation and Degradation of Forests (REDD), industrial symbiosis, Clean Development Mechanisms (CDM), strategic environmental assessment (SEA), payments for ecosystem services (PES), debt for nature swaps, biotechnology, nanotechnology, genomics, proteomics, biomimicry, naturotehnology, industrial symbiosis, environmental economics, bio-informatics for biodiversity databases, remote sensing, camera trapping, identifying, inventorying, etc.

g. Increasing the acerage of protected areas of forest, watersheds, wetlands, marine and coastal ecosystems, marine parks, coral reefs segrass, mangroves, etc to targeted levels.

h. Upgrade and extend timber and non-timber extraction, processes and products to higher standards sustainability through better systems of supervision and surveillance.

i. Syetmatically undertaking a national bioprospecting program for pharmaceuticals, neutracuticals and other useful products.

j. Enforcing regulations on the sale of wild (especially endangered) flora and fauna by traders including by indigeneous peoples

Table 73. Summary of Recommendations – Immediate, Mid-Term & Long-Term

Immediate	**Mid-Term**	**Long-Term**
1. Establish a National Biodiversity Centre (NBC) 2. Ensure the required human capacity, financial, institutional, technological, regulatory and other needs for the NBC 3. Initiate a country wide Mellinium Ecosystem Assessment 4. Document a country wide inventory of terrestrial and aquatic fauna and flora 5. Map critical ecosystems and habitats	1. Undertake interim steps towards the strengthening of the NBC 2. Map critical ecosystems and habitats 3. Continue the country wide Mellinium Ecosystem Assessment 4. Continue the country wide inventory of terrestrial and aquatic fauna and flora 5. Continue raising public awareness on the status and significance of biodiversity	1. Sustainability of the NBC 2. Country wide Mellinium Ecosystem Assessment and terrestrial and aquatic inventorised and documented 3. Continue raising public awareness on the status and significance of biodiversity 4. Continue focusing on R&D and S,T&I particularly on sustainable timber/non timber products; food and fruit vegetation; industrial enzymes; medicinal herbs and plants and

6. Focus R&D and S,T&I particularly on: sustainable timber/non timber products; food and fruit vegetation; industrial enzymes; medicinal herbs and plants and venomous animals; traditional knowledge; ornamental plants and flowers; biotechnology; marine and inland fisheries; and aquaculture 7. Establish *in situ* and *ex situ* gene banks 8. Exploit forestry and plantations for REDD, carbon locking, carbon trading, etc Research collaboration with like minded institutions for R&D and S,T&I in Malaysia and elsewhere 9. Raise public awareness on the status and significance of biodiversity 10. Ensure enforcement, and establish where necessary, appropriate rules and regulations for the conservation, sustainable use and wealth creation of marine and terrestrial biodiversity	6. Continue focusing on R&D and S,T&I particularly on sustainable timber/non timber products; food and fruit vegetation; industrial enzymes; medicinal herbs and plants and venomous animals; traditional knowledge; ornamental plants and flowers; biotechnology; marine and inland fisheries; aquaculture and other emerging issues and initiatives 7. Research collaboration with like minded institutions for R&D and S,T&I in Malaysia and elsewhere 8. Continue human capacity, financial, institutional, technological, regulatory and other needs for the NBC and for other needs of biodiversity related institutions	venomous animals; traditional knowledge; ornamental plants and flowers; biotechnology; marine and inland fisheries; aquaculture and other emerging issues and initiatives 5. Research collaboration with like minded institutions for R&D and S,T&I in Malaysia and elsewhere 6. Continue human capacity, financial, institutional, technological, regulatory and other needs for the NBC

12. ROADMAP AND ACTION PLAN

With regard to the scope and thrust of the S&T and R,D&I to be pursued in Malaysia, scientists and researchers in the country must be prepared to strategically transform their mindsets and paradigms, such that they can shift gears from their own preferred sectors of research, development and innovation to the nationally driven priority sectors of research, development and innovation (viz. from "REsearch" to "reSEARCH"), particularly in the sector of biodiversity and its conservation, sustainable use and commercialization cum wealth creation. In addition, please refer to WP 6 and 7 on "National perspectives: R&D and STI in biodiversity utilization", and to WP 8 on "National perspectives: Domestic policies, strategies and plans in biodiversity & STI".

Further, as depicted in the attached flowcharts (Appendix I and Appendix II) there are fundamentally two different pathways of commercialization and wealth generation from biodiversity-based R&D and STI. One pathway is to adopt the business as usual global trends and its global hubs, while the other pathway is to depart from the beaten track and to venture into pursuing the global trends and its global gaps. The former pathway is obviously conventional and conservative in terms of its inputs and outputs, whereas the latter pathway is definitely innovative and ingenious in terms of its associated inputs and outputs. Likewise, the latter pathway is also far more likely to deliver cutting-edge and value-added rewards for the pioneering investors, while the former pathway is far more likely to deliver predictable and proven rewards for the traditional investors. In conclusion, Appendix III provides an overview snapshot of the proposed road map and action plan for the conservation, sustainable use and commercialization (or wealth creation) that are linked to the mega(bio)diversity of Malaysia. In order to pursue the new pathway for the conservation, sustainable use and wealth creation of/from biodiversity, Malaysia needs to enhance appropriately its sustainable development, human resource needs and institutional capacity.

Roadmap Timeframe

2010 – 2020

- Fulfill Malaysia's obligation under the CBD, CPB, NPABS, etc.
- Establish infrastructure for National Biodiversity Centre (NBC) and its Natural History Institute (NHI)
- Build human resource capacity in biodiversity
- Enhance R&D and ST&I in the relevant biodiversity sectors
- Consolidate biodiversity information, expertise and knowledge exchange including institutions, documents, specimens and genetic resources
- Create a centralized germplasm bank that coordinates with other storages of germplasm (*in situ* and *ex situ*)
- Inventorise fauna and flora at all levels (genetic, species, ecosystems)
- Prevent the entry and propagation of invasive species
- Sustainably conserve genetic materials of crops and livestock that contribute to Malaysia's GDP

2020 - 2030

- Fulfill Malaysia's obligation under the CBD, CPB, NPABS, etc.
- Sustainably undertake bioprospecting and germplasm collection and documentation
- Build human resource capacity in biodiversity
- Strengthen further information, expertise and knowledge exchange
- Enhance R&D and ST&I in the relevant biodiversity sectors
- Inventorise fauna and flora at all levels (genetic, species, ecosystems)
- Sustainably explore biodiversity for commercialization and wealth creation
- Strengthen further information, expertise and knowledge exchange
- Prevent the entry and propagation of invasive species
- Sustainably conserve genetic materials of crops and livestock that contribute to Malaysia's GDP
- Popularise awareness,

2030 - 2040

- Fulfill Malaysia's obligation under the CBD, CPB, NPABS, etc.
- Enhance R&D and ST&I in the relevant biodiversity sectors
- Sustainably undertake bioprospecting and germplasm collection and documentation
- Build human resource capacity in biodiversity
- Inventorise fauna and flora at all levels (genetic, species, ecosystems)
- Sustainably explore biodiversity for commercialization and wealth creation
- Prevent the entry and propagation of invasive species
- Conserve genetic materials of crops and livestock that contribute to Malaysia's GDP
- Strengthen further information, expertise and knowledge exchange
- All sectors of society in Malaysia are adequately aware, action oriented and advocating for the conservation and sustainable use of

2040 - 2050

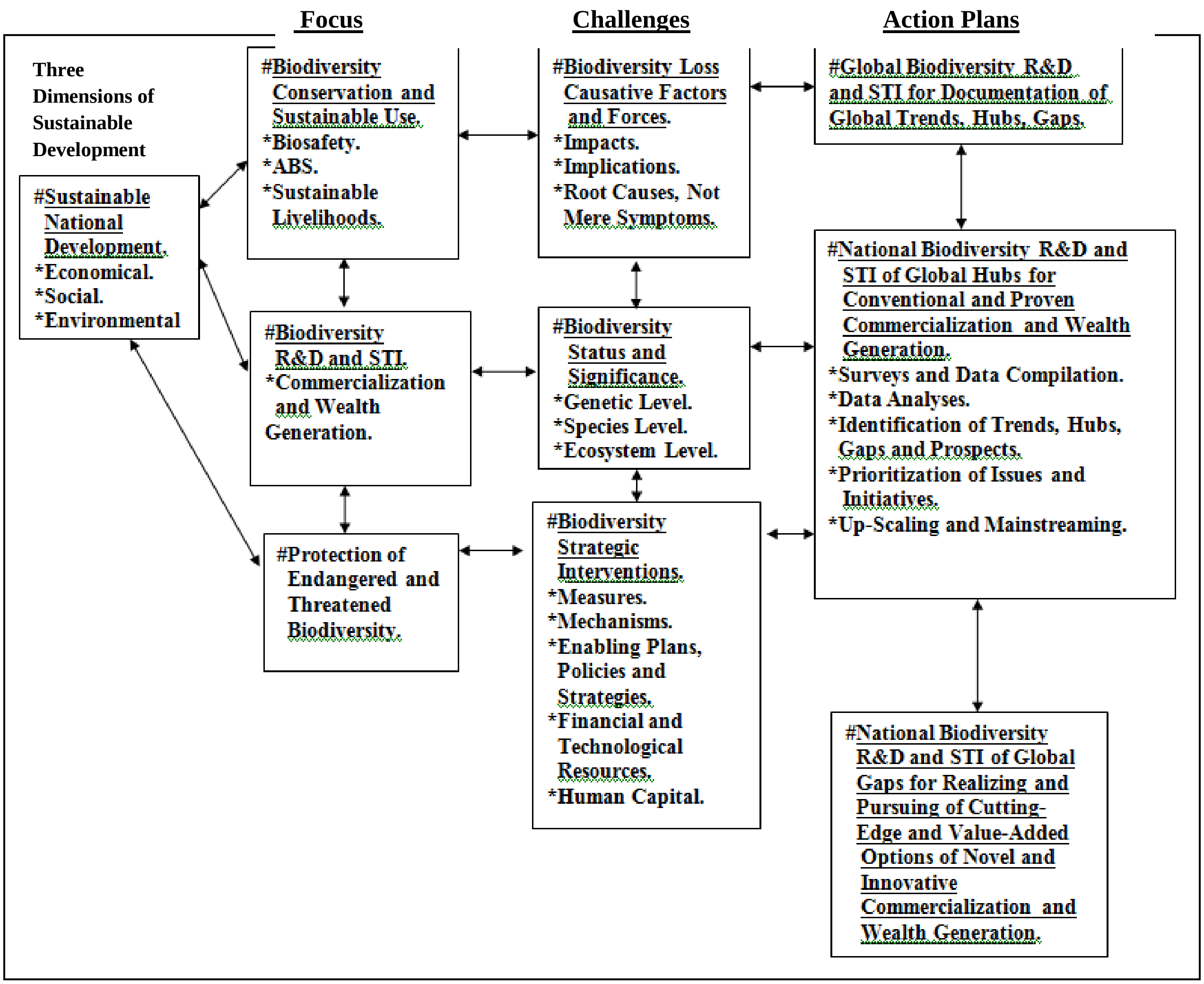
- Fulfill Malaysia's obligation under the CBD, CPB, NPABS, etc.
- NBC and NHI fully operational and functional and recognized for its high level expertise in Tropical Biodiversity
- Strengthen further information, expertise and knowledge exchange and recognized as a centre of excellence in Biodiversity Informatics
- Enhance R&D and ST&I in the relevant biodiversity sectors as well as into emerging cutting edge technologies
- Biodiversity based interventions prominently entrenched in the policies, R&D, ST&I and wealth creation of Malaysia
- All sectors of society in Malaysia are fully committed towards the conservation and susutainable use of biodiversity
- Build human resource capacity in biodiversity
- Sustainably undertake bioprospecting and germplasm collection and documentation

• Popularise awareness, action and advocacy on the significance of biodiversity among all sectors of society • Sustainably explore biodiversity for commercialization and wealth creation	action and advocacy on the significance of biodiversity among all sectors of society	biodiversity	• Inventorise fauna and flora at all levels (genetic, species, ecosystems) • Sustainably explore biodiversity for commercialization and wealth creation • Prevent the entry and propagation of invasive species • Sustainably conserve genetic materials of crops and livestock that contribute to Malaysia's GDP

13. APPENDICES

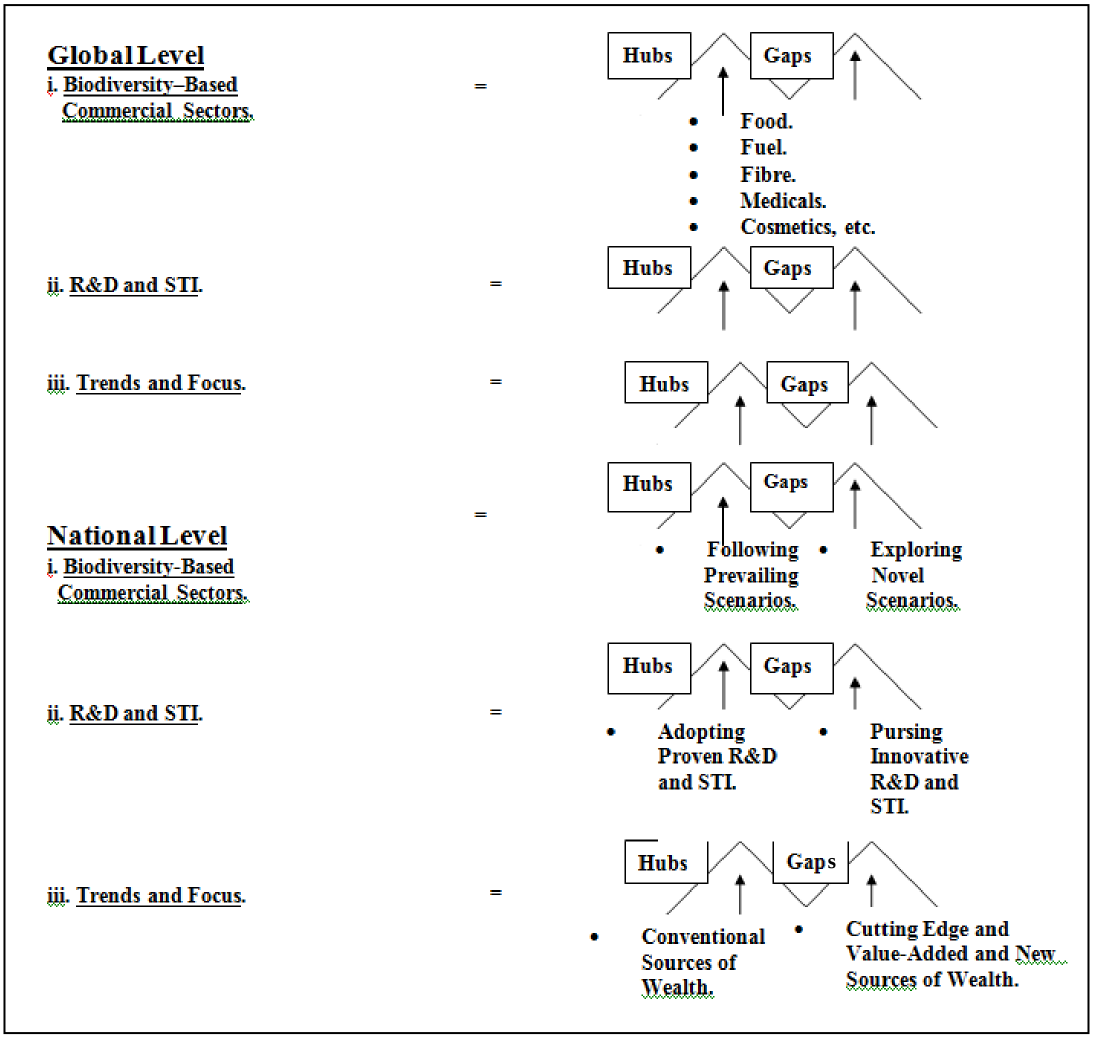
APPENDIX I

Flowchart 1 - Biodiversity-Based R&D and STI Linkages to Wealth Generation (Copyright: Martin Abraham, 2011).



APPENDIX II

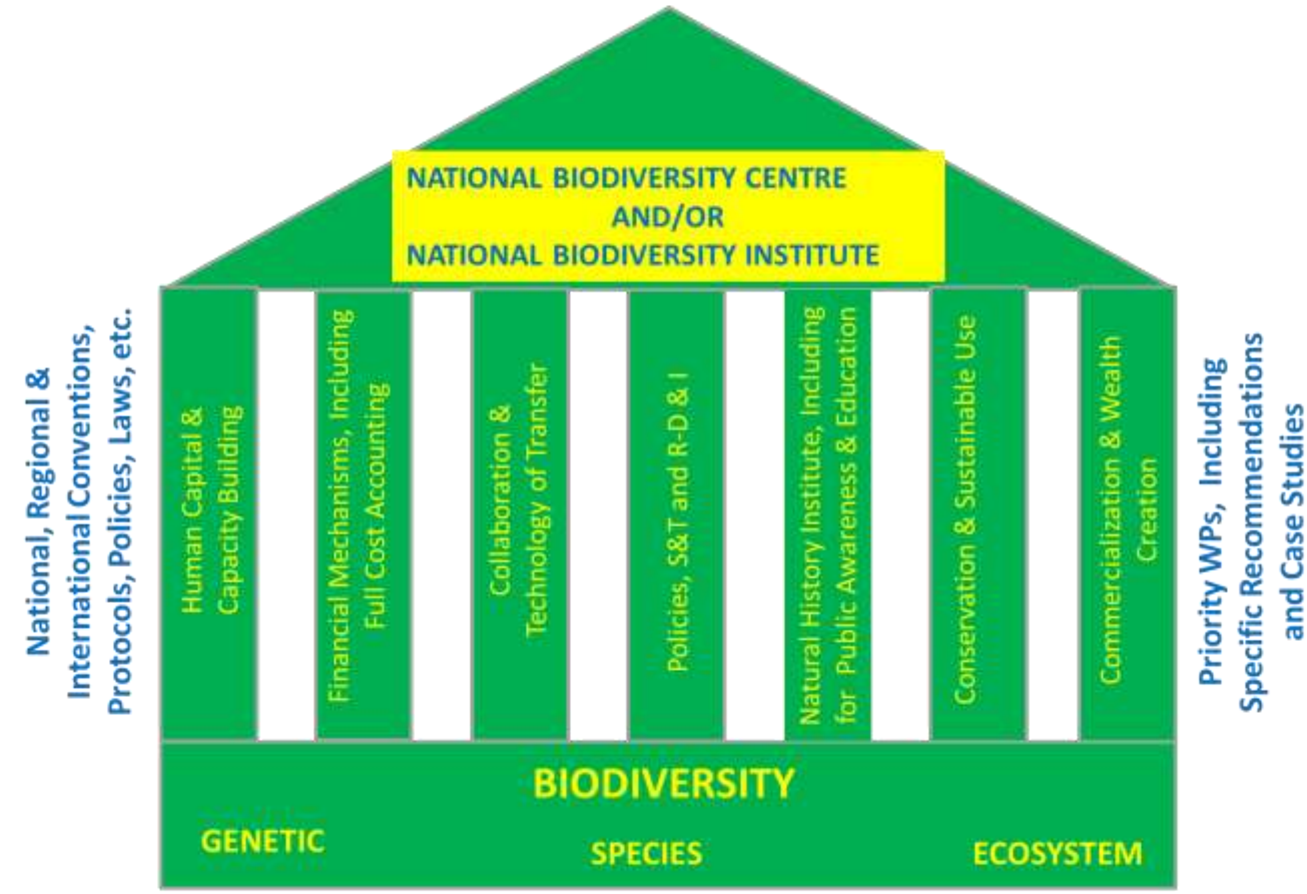
Flowchart 2 – Biodiversity-Based Trends of R&D and STI Hubs and Gaps of Wealth Generation (copyright: Martin Abraham, 2011)



Hubs – Mainstream of R&D and ST&I Globally in the Biodiversity Sector
Gaps – Other as yet to be explored areas in of R&D and ST&I in the Biodiversity Sector

APPENDIX III

Overview Snapshot of the Proposed Institutional Framework for the Conservation, Sustainable Use and Commercialization (or Wealth Creation) Linked to the Mega(bio)diversity of Malaysia (Copyright: Martin Abraham & Harinder Rai Singh, 2011)



The National Biodiversity Centre (NBC) including its Natural History Institute (NHI) is supported by 7 pillars for the conservation, sustainable use and wealth creation from biodiversity at the genetic, species and ecosystem levels. The proposed NBC and its NHI are guided by the priority Work Packages (WPs, pgs. 166 – 229) and biodiversity related national, regional and international conventions, protocols, policies, laws, etc.

The 7 supporting pillars include the following:

1. Natural History Institute and Public Awareness – to enable the public to gain first hand experiential knowledge on the many facets of biodiversity
2. Conservation & Sustainable Use – to provide incites into the various dimensions of biodiversity at the genetic, species and ecosystem levels.
3. Commercialization & wealth creation – to harvest biodiversity sustainably and commercially in a manner that contributes towards the country's GDP
4. Human Capital & Capacity Building – to strengthen the critical needs and to foster the required expertise for the biodiversity sector
5. S&T and R,D&I – to identify and to hone the skills required for undertaking the appropriate S&T and R,D&I in biodiversity
6. Financial Mechanisms – to secure adequate funds for the relevant S&T and R,D&I in biodiversity
7. Technology Transfer – to facilitate the transfer of technologies needed for the conservation, sustainable use and commercialization of biodiversity

However if the NBC ends up being merged with a preexisting Biodiversity related Institute, the NHI

	might be located elsewhere from the NBC while maintaining close operational and administrative linkages. The NHI is intended to collect, document, preserve and showcase specimens of all species of flora and fauna (living, dead and fossilized) in Malaysia, which could also serve as an avenue for both taxonomical, taxidermal, curatorial, paleontological, documentational (bioinformatics) research and development as well as for public outreach, indigeneous and traditional knowledge, media and education.

APPENDIX IV

Status of Agreed Subsidiary Targets to the 2010 Biodiversity Target (sourced from: GEO3,

Goal 1. Promote the conservation of the biological diversity of ecosystems, habitats and biomes	
1.1: At least 10% of each of the world's ecological regions effectively conserved.	Not achieved globally, but more than half of terrestrial eco-regions meet the 10% target. However, management effectiveness is low for some protected areas. Marine and inland water systems lack protection, though this is increasing.
1.2: Areas of particular importance to biodiversity protected.	Not achieved globally, but an increasing proportion of the sites of importance for conserving birds, and those holding the last remaining populations of threatened species, are being protected.
Goal 2. Promote the conservation of species diversity	
2.1: Restore, maintain, or reduce the decline of populations of species of selected taxonomic groups.	Not achieved globally as many species continue to decline in abundance and distribution. However, some efforts have resulted in the recovery of targeted species.
2.2: Status of threatened species improved.	Not achieved globally, as species are on average at increasing risk of extinction. However some species have moved to lower risk categories as a result of actions taken.
Goal 3. Promote the conservation of genetic diversity	
3.1: Genetic diversity of crops, livestock, and of harvested species of trees, fish and wildlife and other valuable species conserved, and associated indigenous and local knowledge maintained.	Not achieved globally. Information on genetic diversity is fragmentary. Progress has been made towards conserving genetic diversity of crops through ex situ actions, however agricultural systems continue to be simplified. While the genetic diversity of wild species is more difficult to ascertain, the overall decline of biodiversity presented in this report strongly suggests that genetic diversity is not being maintained. Genetic resources in situ and traditional knowledge are protected through some projects, but continue to decline overall.
Goal 4. Promote sustainable use and consumption	
4.1: Biodiversity-based products derived from sources that are sustainably managed, and production areas managed consistent with the conservation of biodiversity.	Not achieved globally but progress for some components of biodiversity such as forests and some fisheries. Globally sustainable use does not account for a large share of total products and production areas.
4.2: Unsustainable consumption, of biological resources, or that impacts upon biodiversity, reduced.	Not achieved globally. Unsustainable consumption has increased and continues to be a major cause of biodiversity loss.
4.3: No species of wild flora or fauna endangered by international trade.	Not achieved globally. Wild flora and fauna continue to decline as a result of international trade, but successes achieved particularly through implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).
Goal 5. Pressures from habitat loss, land use change and degradation, and unsustainable water use, reduced	
5.1: Rate of loss and degradation of natural habitats decreased.	Not achieved globally as many biodiversity-sensitive regions continue to decline, but some progress in reducing the rate of loss in some areas.
Goal 6. Control threats from invasive alien species	
6.1: Pathways for major potential alien invasive species controlled.	Not achieved globally as the introduction of invasive alien species continues to increase as a result of greater transport, trade, and tourism. However, national action related to global agreements on plant protection and ballast water promises to reduce the risk of new invasions in some countries and ecosystems.
6.2: Management plans in place for major alien species that threaten ecosystems, habitats or species.	Not achieved globally, though some management plans are in place. Most countries lack effective management programmes.

APPENDIX IV

Goal 7. Address challenges to biodiversity from climate change, and pollution

7.1: Maintain and enhance resilience of the components of biodiversity to adapt to climate change.	Not achieved globally, as limited action has been taken to reduce other pressures and thus enhance the resilience of biodiversity in the face of climate change. However, the establishment of biodiversity corridors in some regions may help species to migrate and adapt to new climatic conditions.
7.2: Reduce pollution and its impacts on biodiversity.	Not achieved globally but mixed results. Measures to reduce the impacts of pollution on biodiversity have been taken, resulting in the recovery of some previously heavily degraded ecosystems. However, many previously pristine areas are being degraded. Nitrogen deposition continues to be major threat to biodiversity in many regions.

Goal 8. Maintain capacity of ecosystems to deliver goods and services and support livelihoods

8.1: Capacity of ecosystems to deliver goods and services maintained.	Not achieved globally, given the continuing and in some cases escalating pressures on ecosystems. However, there have been some actions taken, to ensure the continued provision of ecosystem services.
8.2: Biological resources that support sustainable livelihoods, local food security and health care, especially of poor people.	Not achieved globally, as many of the biological resources which sustain livelihoods, such as fish mammals, birds, amphibians and medicinal plants, are in decline, with the world's poor being particularly affected.

Goal 9. Maintain socio-cultural diversity of indigenous and local communities

9.1: Protect traditional knowledge, innovations and practices.	Not achieved globally, as long-term declines in traditional knowledge and rights continue, despite the actions taken to protect them in some areas.
9.2: Protect the rights of indigenous and local communities over their traditional knowledge, innovations and practices, including their rights to benefit sharing.	Not achieved globally but an increasing number of co-management systems and community-based protected areas have been established, with the greater protection of the rights of indigenous and local communities.

Goal 10. Ensure the fair and equitable sharing of benefits arising out of the use of genetic resources

10.1: All transfers of genetic resources are in line with the Convention on Biological Diversity, the International Treaty on Plant Genetic Resources for Food and Agriculture and other applicable agreements.	Not achieved globally but increasing number of material transfer agreements have been developed under the Treaty.
10.2: Benefits arising from the commercial and other utilization of genetic resources shared with the countries providing such resources.	Not achieved globally. There are few examples of the benefit arising from the commercial and other utilization of genetic resources being shared with the countries providing such resources. This can be partially attributed to the fact that the Access and Benefit Sharing Regime was being developed from 2002, when the biodiversity target was adopted, until 2010, the deadline set by the CBD for final agreement on this issue.

Goal 11. Parties have improved financial, human, scientific, technical and technological capacity to implement the Convention

11.1: New and additional financial resources are transferred to developing country Parties, to allow for the effective implementation of their commitments under the Convention, in accordance with Article 20.	Not achieved globally. While resources continue to be lacking there have been modest increases in official development assistance related to biodiversity.
11.2: Technology is transferred to developing country Parties, to allow for the effective implementation of their commitments under the Convention, in accordance with its Article 20, paragraph 4.	Not achieved globally. From country reports it is clear that some developing countries have mechanisms and programmes in place for technology transfer. However, it is also clear that the limited access to technology is an obstacle to implementation of the Convention and reaching the 2010 biodiversity target in many developing countries.

Not achieved globally — Not achieved globally but some progress — Not achieved globally but significant progress

APPENDIX V
Trends Shown by Agreed Indicators of Progress Towards the 2010 Biodiversity Target (sourced from: GEO3, 2010)

Status and trends of the components of biological diversity

Trends in extent of selected biomes, ecosystems, and habitats	Most habitats in most parts of the world are declining in extent, although forest area expands in some regions, and the loss of mangroves has slowed significantly, except in Asia.
Trends in abundance and distribution of selected species	Most species with limited population size and distribution are being further reduced, while some common and invasive species become more common. (but limited number of taxa assessed)
Change in status of threatened species	The risk of extinction increases for many threatened species, although some species recovery programmes have been very successful. (for those species assessed)
Trends in genetic diversity of domesticated animals, cultivated plants, and fish species of major socio-economic importance	It is likely that the genetic variety of cultivated species is declining, but the extent of such decline and its overall impacts are not well understood. (although many case studies with a high degree of certainty are available)
Coverage of protected areas	There has been a significant increase in coverage of protected areas, both terrestrial and marine, over the past decade. However, many ecological regions, particularly in marine ecosystems, remain underprotected, and the management effectiveness of protected areas remains variable.

Ecosystem integrity and ecosystem goods and services

Marine Trophic Index	Despite intense pressure the Marine Trophic Index has shown a modest increase globally since 1970. However there is substantial regional variation with declines being recorded in half of the marine areas with data. Although the global increases may indicate a recovery it is more likely a consequence of fishing fleets expanding their areas of activity, thus encountering fish stocks in which larger predators have not yet been removed in large numbers.
Connectivity – fragmentation of ecosystems	Most terrestrial and aquatic ecosystems are becoming increasingly fragmented, despite an increased recognition of the value of corridors and connections, especially in climate change adaptation.
Water quality of aquatic ecosystems	Most parts of the world are likely to be suffering from declines in water quality, although quality in some areas has improved through control of point-source pollution.

Threats to biodiversity

Nitrogen deposition	Human activity has doubled the rate of creation of reactive nitrogen on the planet's surface. Pressure on biodiversity from nutrient pollution continues to increase, although some measures to use nutrients more efficiently, to reduce their release into water and the atmosphere, are beginning to show positive effects.
Trends in invasive alien species	The number and rate of spread of alien species is increasing in all continents and all ecosystem types. (although many case studies with a high degree of certainty are available)

Sustainable use

Area of forest, agricultural and aquaculture ecosystems under sustainable management	There are considerable efforts under way to increase the extent of areas of land under sustainable management. Regional efforts on sustainable forest management are expected to contribute to this. Traditional agricultural practices are being maintained and revitalized as the demand for ethical and healthy products increases. However, these are still relatively small niches and major efforts are required to substantially increase the areas under sustainable management.
Ecological footprint and related concepts	The ecological footprint of humanity is increasing. Efforts at increasing resource efficiency are more than compensated by increased consumption by a growing and more prosperous human population.

Status of traditional knowledge, innovations and practices

Status and trends of linguistic diversity and numbers of speakers of indigenous languages	A large number of minority languages are believed in danger of disappearing, and linguistic diversity is very likely declining. (although case studies with a high degree of certainty are available)

Status of access and benefit sharing

? Indicator of access and benefit-sharing to be developed	The need and possible options for additional indicators are being examined by the Ad Hoc Open-ended Working Group on Access and Benefit-sharing.

Status of resources transfers

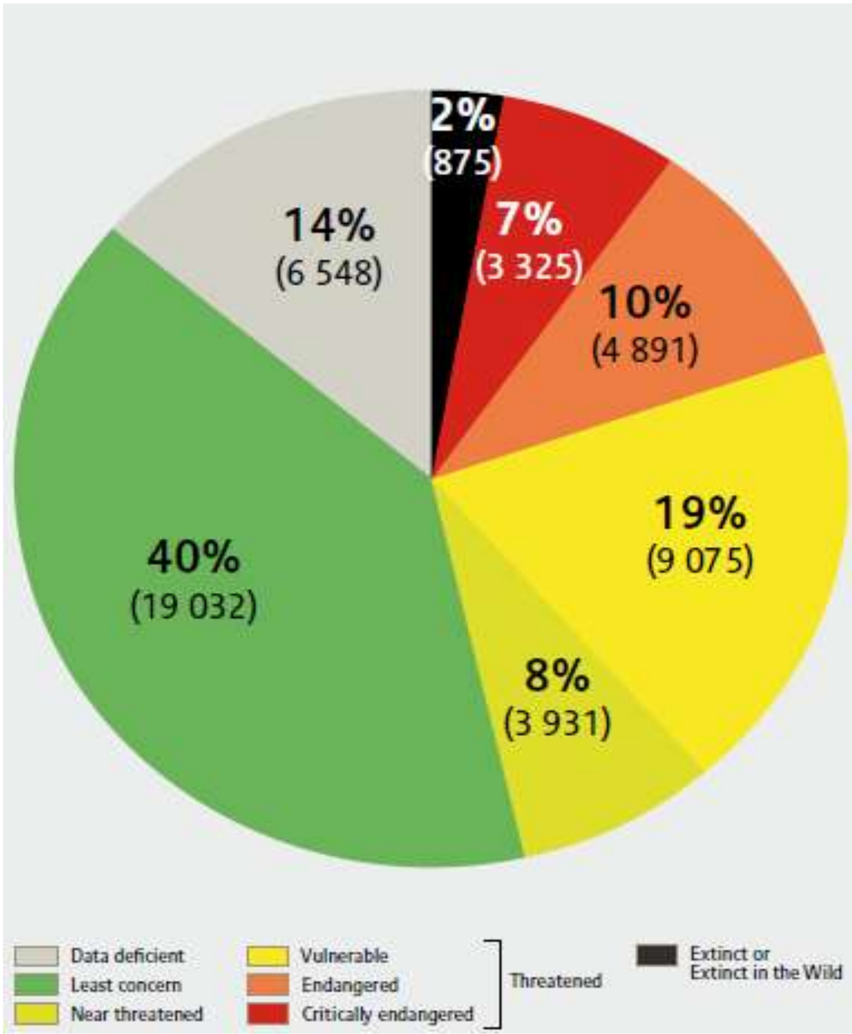
Official development assistance (ODA) provided in support of the Convention	The volume of ODA for biodiversity has increased over the past few years.

Negative changes — Positive changes — No clear global trend. Positive and negative changes are occurring depending on the region or biome considered — ? Insufficient information to reach a definitive conclusion.

Degree of certainty: Low — Medium — High

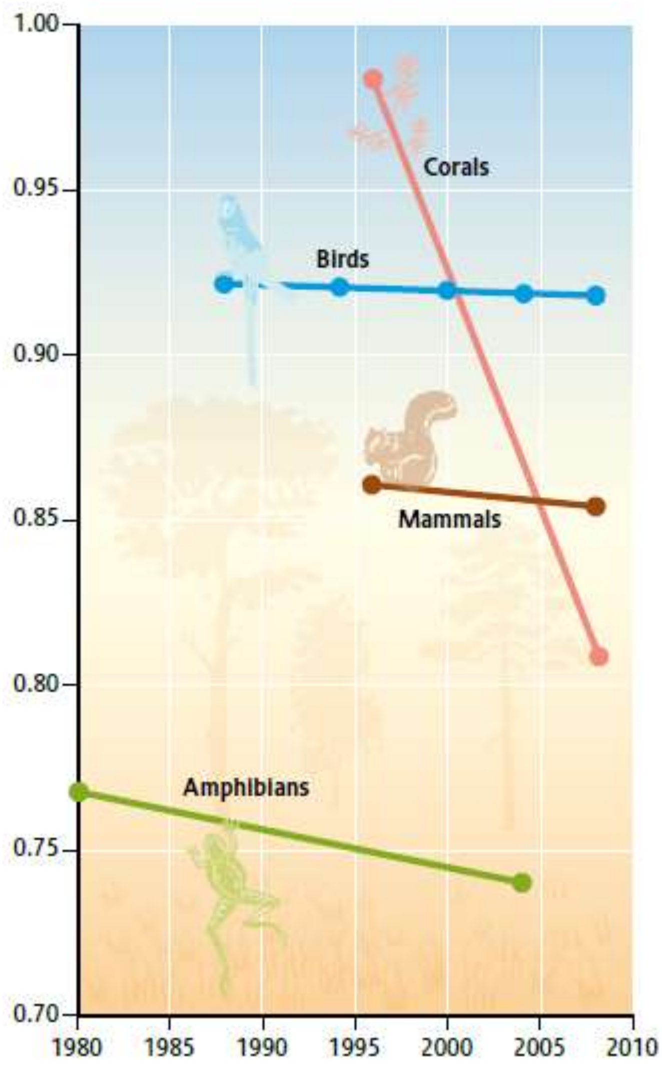
APPENDIX VI

Proportion of Species In Different Threat Categories (sourced from: GEO3, 2010)



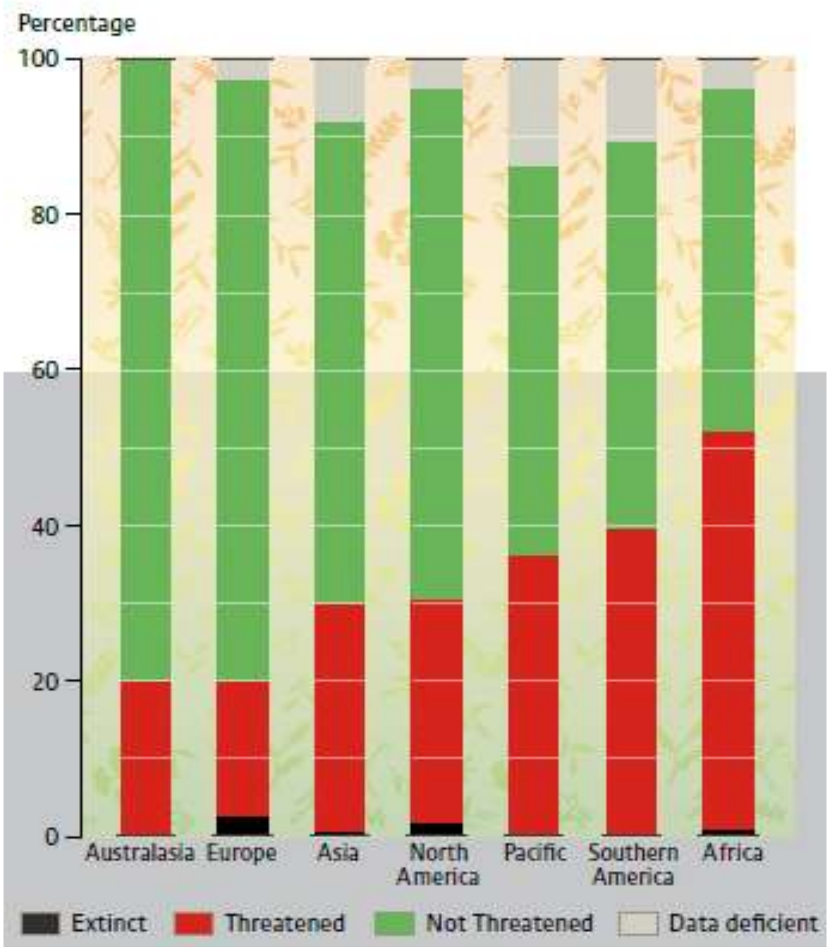
APPENDIX VII

Red List Index (sourced from: GEO3, 2010)

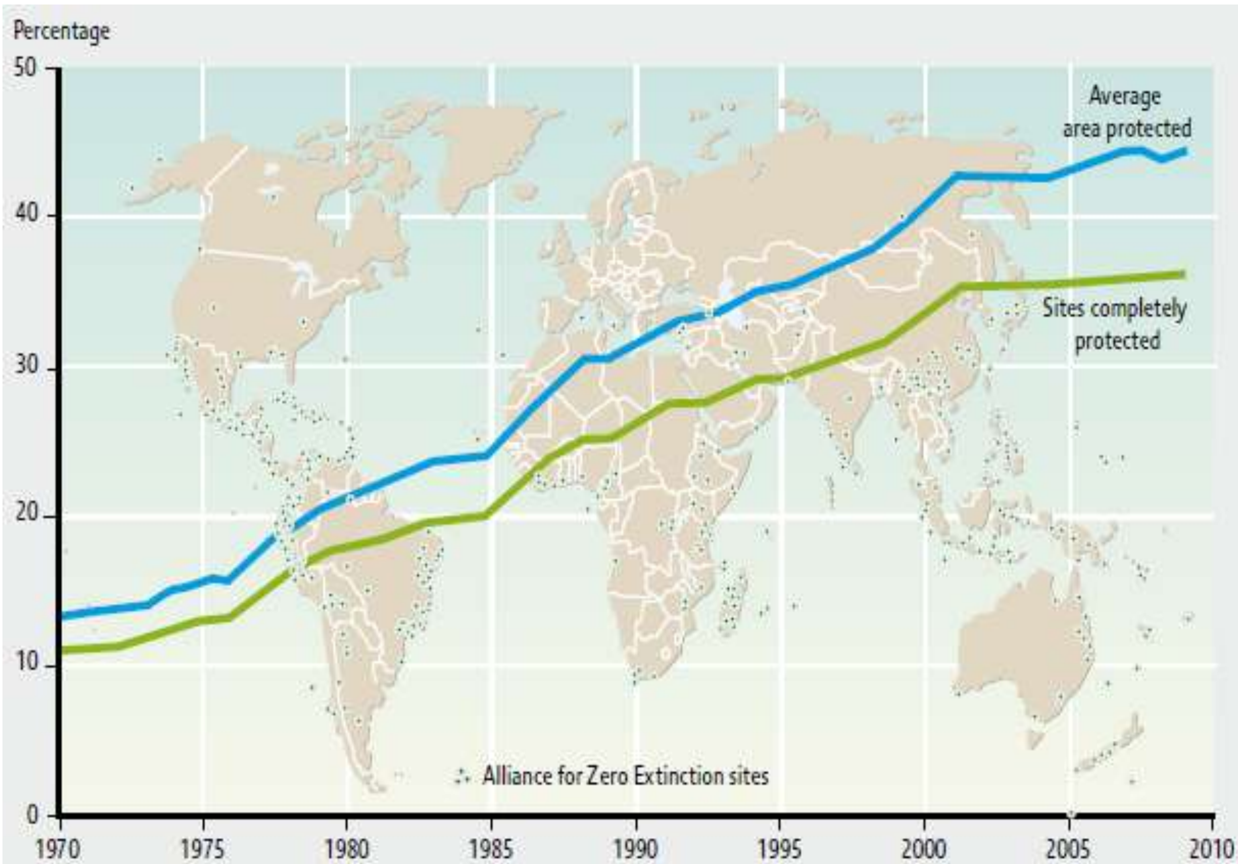


APPENDIX VIII

Conservation Status of Medicinal Plants Species in Different Geographic Regions (sourced from: GEO3, 2010)



APPENDIX IX
Protection of Critical Biodiversity Sites (sourced from: GEO3, 2010)



APPENDIX X

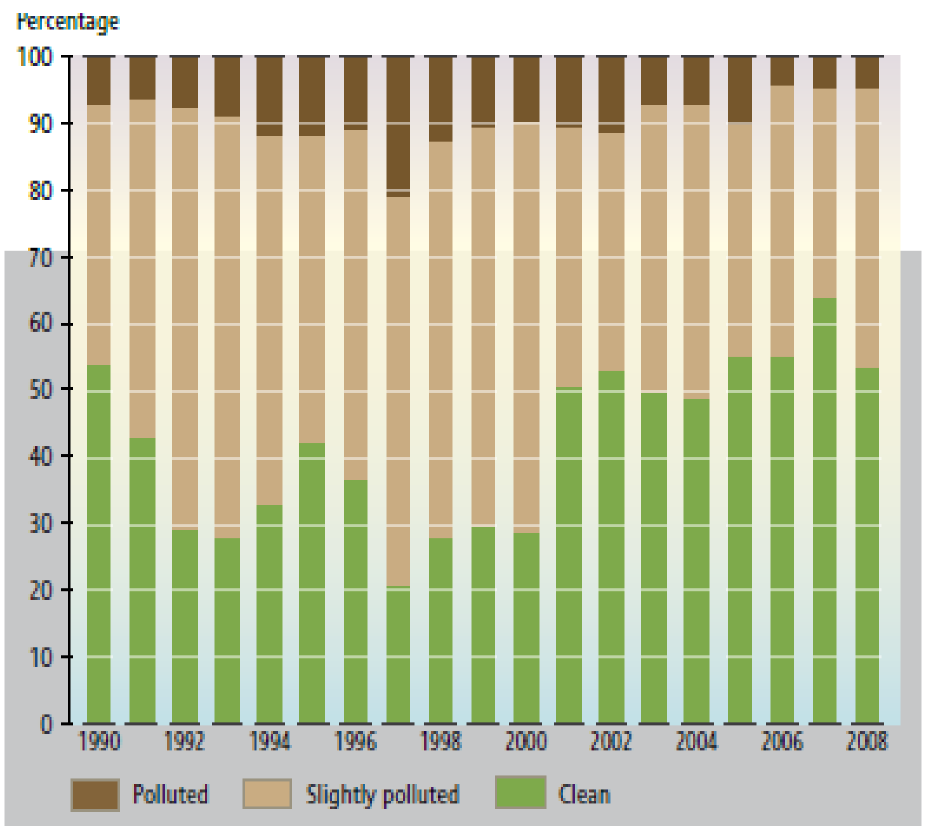
What is at Stake – Some Estimated Values of terrestrial Biodiversity (sourced from: GEO3, 2010)

Some estimated values of terrestrial biodiversity

- The Southern Africa tourism industry, based to a large extent on wildlife viewing, was estimated to be worth US$ 3.6 billion in 2000.
- It has been estimated that the real income of poor people in India rises from US$ 60 to $95 when the value of ecosystem services such as water availability, soil fertility and wild foods is taken into account – and that it would cost US$ 120 per capita to replace lost livelihood if these services were denied.
- Insects that carry pollen between crops, especially fruit and vegetables, are estimated to be worth more than US$ 200 billion per year to the global food economy.
- Water catchment services to New Zealand's Otago region (pictured below) provided by tussock grass habitats in the 22,000 hectare Te Papanui Conservation Park are valued at more than US$ 95 million, based on the cost of providing water by other means.

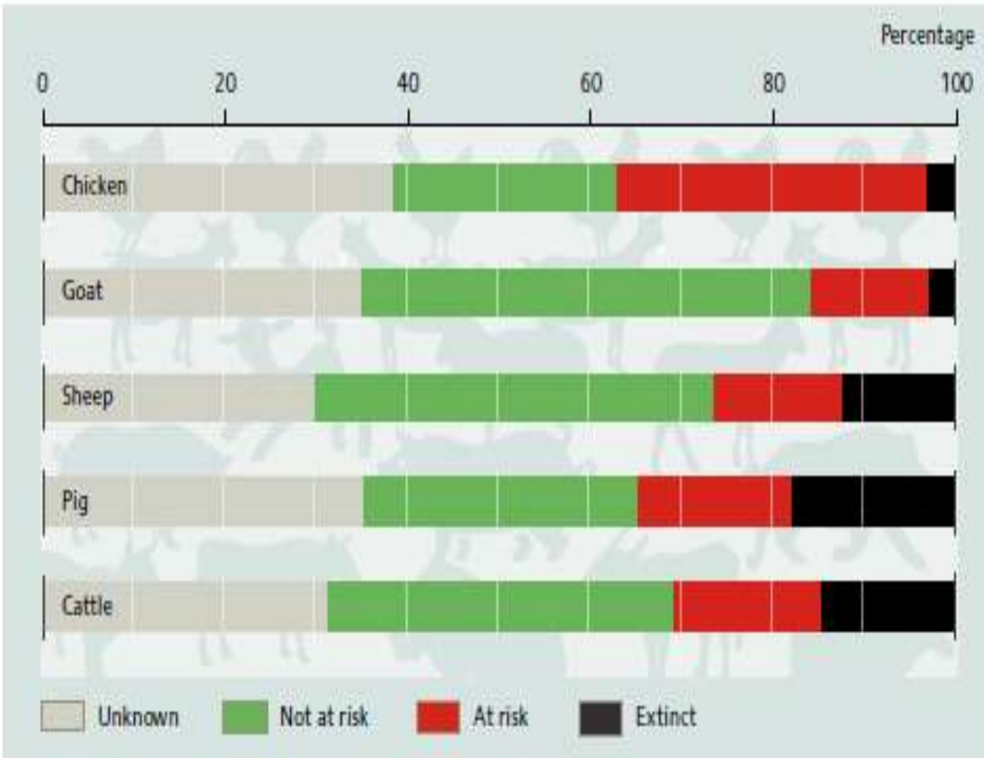
APPENDIX XI

Malaysian River Basin Quality from 1990-2008 (sourced from: GEO3, 2010)



APPENDIX XII

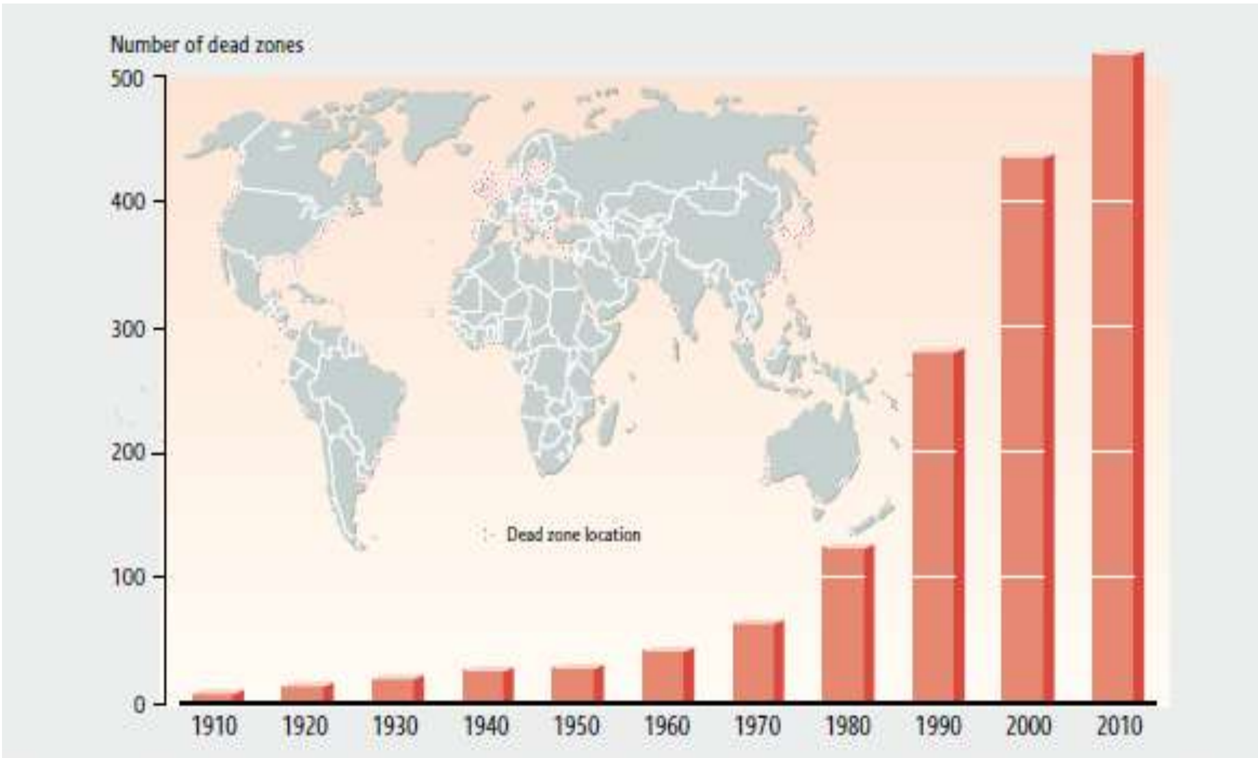
Extinction Risk of Five Major Species of Livestock (sourced from: GEO3, 2010)



Large numbers of breeds of the five major species of livestock are at risk from extinction. More generally, among 35 domesticated species, more than one-fifth of livestock breeds, are classified as being at risk of extinction.
Source: FAO

APPENDIX XIII

Marine "Dead Zones" Globally from 1910 to 2010 (sourced from: GEO3, 2010)



The number of observed "dead zones", coastal sea areas where water oxygen levels have dropped too low to support most marine life, has roughly doubled each decade since the 1960s. Many are concentrated near the estuaries of major rivers, and result from the buildup of nutrients, largely carried from inland agricultural areas where fertilizers are washed into watercourses. The nutrients promote the growth of algae that die and decompose on the seabed, depleting the water of oxygen and threatening fisheries, livelihoods and tourism.

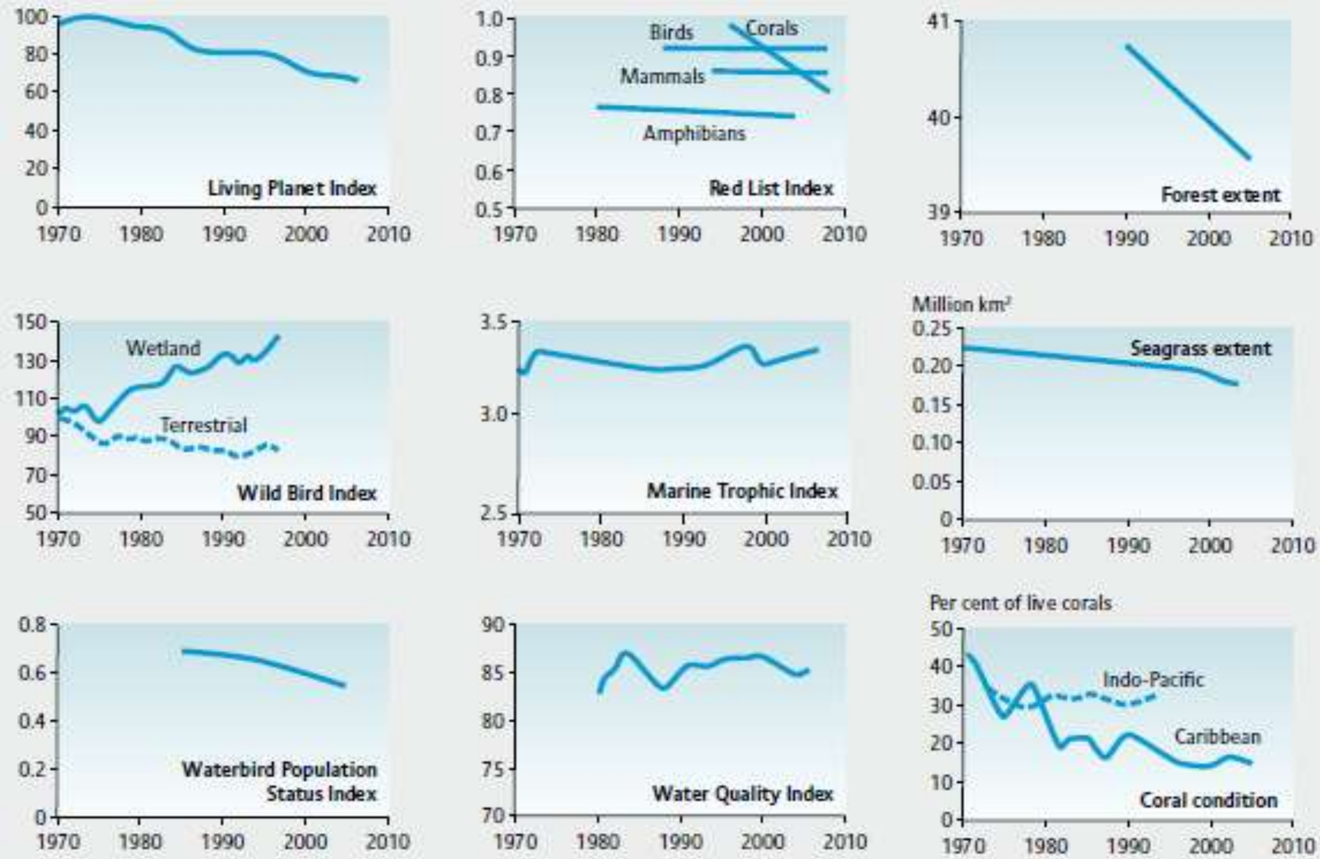
APPENDIX XIV

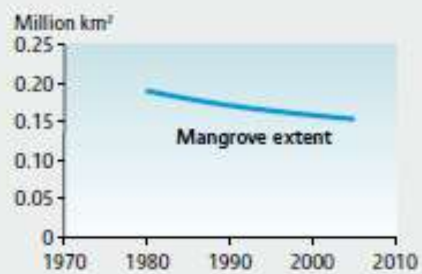
Trends in the Loss of Indigenous Languages (sourced from: GEO3, 2010)

Indigenous languages transmit specialized knowledge about biodiversity, the environment and about practices to manage natural resources. However, determining the status and trends of indigenous languages at the global level is complicated by the lack of standardized methodologies, the absence of shared definitions for key concepts and limited information. Where such information exists there is evidence that the extinction risk for the most endangered languages, those with few speakers, has increased. For example:

- Between 1970 and 2000, 16 of 24 indigenous languages spoken by less than 1,000 people in Mexico lost speakers.
- In the Russian Federation, between 1950 and 2002, 15 of 27 languages spoken by less than 10,000 people lost speakers.
- In Australia, 22 of 40 languages lost speakers between 1996 and 2006.
- In an assessment of 90 languages used by different indigenous peoples in the Arctic, it was determined that 20 languages have become extinct since the 19th century. Ten of these extinctions have occurred since 1989, suggesting an increasing rate of language extinctions. A further 30 languages are considered to be critically endangered while 25 are severely endangered.

APPENDIX XV
Summary of Biodiversity Indicators: Pressure, Responses and Benefits (1970-2010)
(sourced from: GEO3, 2010)





These graphs help to summarize the message from the available indicators on biodiversity: that the state of biodiversity is declining, the pressures upon it are increasing, and the benefits derived by humans from biodiversity are diminishing, but that the responses to address its loss are increasing. They reinforce the conclusion that the 2010 biodiversity target has not been met.

Most indicators of the state of biodiversity show negative trends, with no significant reduction in the rate of decline.

There is no evidence of a slowing in the increase of pressures upon biodiversity, based on the trend shown by indicators of humanity's ecological footprint, nitrogen deposition, alien species introductions, overexploited fish stocks and the impact of climate change on biodiversity.

The limited indicators of the benefits derived by humans from biodiversity also show negative trends.

In contrast, all indicators of the responses to address biodiversity loss are moving in a positive direction. More areas are being protected for biodiversity, more policies and laws are being introduced to avoid damage from invasive alien species, and more money is being spent in support of the Convention on Biological Diversity and its objectives.

The overall message from these indicators is that despite the many efforts taken around the world to conserve biodiversity and use it sustainably, responses so far have not been adequate to address the scale of biodiversity loss or reduce the pressures.

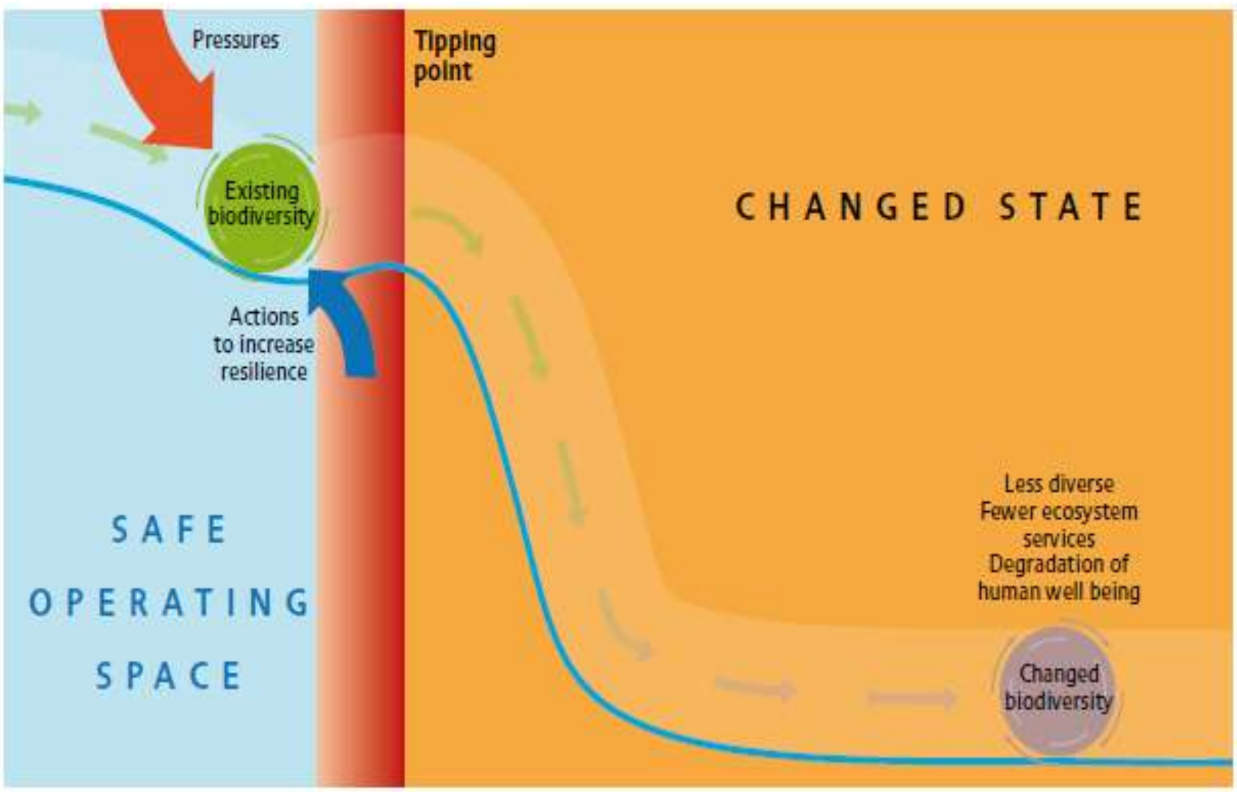
APPENDIX XVI

What is a Tipping Point and Illustration to the Concept of Tipping Points (sourced from: GEO3, 2010)

A tipping point is defined, for the purposes of this Outlook, as a situation in which an ecosystem experiences a shift to a new state, with significant changes to biodiversity and the services to people it underpins, at a regional or global scale. Tipping points also have at least one of the following characteristics:

- The change becomes self-perpetuating through so-called positive feedbacks, for example deforestation reduces regional rainfall, which increases fire-risk, which causes forest dieback and further drying.
- There is a threshold beyond which an abrupt shift of ecological states occurs, although the threshold point can rarely be predicted with precision.
- The changes are long-lasting and hard to reverse.
- There is a significant time lag between the pressures driving the change and the appearance of impacts, creating great difficulties in ecological management.

Tipping points are a major concern for scientists, managers and policy–makers, because of their potentially large impacts on biodiversity, ecosystem services and human well-being. It can be extremely difficult for societies to adapt to rapid and potentially irreversible shifts in the functioning and character of an ecosystem on which they depend. While it is almost certain that tipping points will occur in the future, the dynamics in most cases cannot yet be predicted with enough precision and advance warning to allow for specific and targeted approaches to avoid them, or to mitigate their impacts. Responsible risk management may therefore require a precautionary approach to human activities known to drive biodiversity loss.



The mounting pressures on biodiversity risks pushing some ecosystems into new states, with severe ramifications for human wellbeing as tipping points are crossed. While the precise location of tipping points is difficult to determine, once an ecosystem moves into a new state it can be very difficult, if not impossible, to return it to its former state.

APPENDIX XVII

Possible Scenarios of the Dramatic Loss of Biodiversity and Degradation of Services from Marine and Coastal Ecosystems (sourced from: GEO3, 2010)

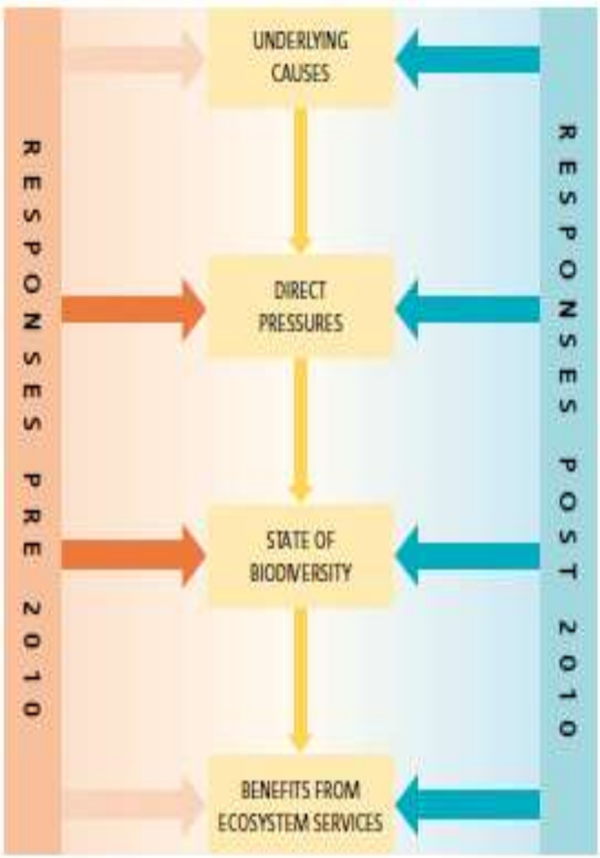
- **The combined impacts of ocean acidification and warmer sea temperatures make tropical coral reef systems vulnerable to collapse.** More acidic water (brought about by higher carbon dioxide concentrations in the atmosphere) decreases the availability of the carbonate ions required to build coral skeletons. At atmospheric carbon dioxide concentrations of 450 parts per million (ppm), the growth of calcifying organisms is inhibited in nearly all tropical and sub-tropical coral reefs. At 550 ppm, coral reefs are dissolving. Together with the bleaching impact of warmer water, and a range of other human-induced stresses, reefs increasingly become algae-dominated with catastrophic loss of biodiversity.

- **Coastal wetland systems** become reduced to narrow fringes or are lost entirely, in what may be described as a "coastal squeeze". This is due to sea level rise, exacerbated by coastal developments such as aquaculture ponds. The process is further reinforced by greater coastal erosion created by the weakened protection provided by tidal wetlands. Further deterioration of coastal ecosystems, including coral reefs, will also have wide-ranging consequences for millions of people whose livelihoods depend on the resources they provide. The physical degradation of coastal ecosystems such as salt marshes and mangroves will also make coastal communities more vulnerable to onshore storms and tidal surges.

- **The collapse of large predator species in the oceans,** triggered by overexploitation, leads to an ecosystem shift towards the dominance of less desirable, more resilient species such as jellyfish. Marine ecosystems under such a shift become much less able to provide the quantity and quality of food needed by people. Such changes could prove to be long-lasting and difficult to reverse even with significant reduction in fishing pressure, as suggested by the lack of recovery of cod stocks off Newfoundland since the collapse of the early 1990s.The collapse of regional fisheries could also have wide-ranging social and economic consequences, including unemployment and economic losses.

APPENDIX XVIII

Why the 2010 Biodiversity Target Was Not Met and What Needs to be Done in the Future (sourced from: GEO3, 2010)



One of the main reasons for the failure to meet the 2010 Biodiversity Target at the global level is that actions tended to focus on measures that mainly responded to changes in the state of biodiversity, such as protected areas and programmes targeted at particular species, or which focused on the direct pressures of biodiversity loss, such as pollution control measures.

For the most part, the underlying causes of biodiversity have not been addressed in a meaningful manner; nor have actions been directed ensuring we continue to receive the benefits from ecosystem services over the long term. Moreover, actions have rarely matched the scale or the magnitude of the challenges they were attempting to address. In the future, in order to ensure that biodiversity is effectively conserved, restored and wisely used, and that it continues to deliver the benefits essential for all people, action must be expanded to additional levels and scales. Direct pressures on biodiversity must continue to be addressed, and actions to improve the state of biodiversity maintained, although on a much larger scale. In addition, actions must be developed to address the underlying causes of biodiversity loss, and to ensure that biodiversity continues to provide the ecosystem services essential to human wellbeing.

Source: Secretariat of the Convention on Biological Diversity

APPENDIX XIX

Thematic Assessment Matrix for the Implementation of the Convention of Biological Diversity (CBD) in Malaysia (NCSA, 2008)

Strengths	Constraints	Root Cause	Needs
Many legislations and mechanisms that addressed the issues of CBD were in place before Malaysia signed CBD. The National Policy on Biological Diversity strengthened the implementation of CBD. It provides direction to implement strategies and action plans for conservation and management of biodiversity. Currently, the deliberation and decision-making for biodiversity matters at the country level are institutionalised in the form of a National Steering Committee on Biological Diversity, and National Biodiversity and Biotechnology Council (MBBN).	The National Policy on Biological Diversity does not provide targets, nor directly assign implementation of certain action plans to relevant agency(ies).	The review process of the National Policy on Biological Diversity is not commissioned on a regular basis.	Review National Policy on Biological Diversity (NPBD), particularly the strategies and action plans, to improve its contents and also implementation: • Assign implementation to relevant agencies (including clarifying the role of CEMD as the focal point of CBD, which should include monitoring and evaluation of the implementation of the Policy.) • Develop performance indicators and time frame to measure the level of implementation of strategy and action plans.
	MBBN also address bio-technology related issues which are considered under the umbrella heading of biodiversity. There is concern that biotechnology issues would be given more emphasis over conservation and sustainable use of biodiversity.	MBBN was established in 2001 when both biodiversity and biotechnology were the responsibilities of one ministry i.e. Ministry of Science, Technology and Environment (MOSTE).	Prioritise the importance of conservation and sustainable use of biodiversity as the basis for other applications/utilisation such as biotechnology, agriculture, water resources etc. Rationalise and streamline the function of MBBN, National Steering Committee on Biological Diversity and also National Biotechnology Directorate to effectively implement national policies related to biodiversity.
Implementation of CBD is addressed by many specific laws and regulations which are implemented and enforced by federal and state agencies covering sectors such as forests, wildlife sanctuaries, water catchment areas, rivers, coastal areas, marine protected areas, agricultural biodiversity, etc.	There are gaps and overlaps in existing laws and regulations that govern conservation and sustainable use of biodiversity'. Examples: • Insufficient laws on protection of plant species (the existing law only covers food crops), or ecosystems per se. • Provision in the specific laws and regulations (e.g. Wildlife Protection Act and Aboriginal Peoples Act) may be contradictory causing institutional and operational gaps among the implementing agencies.	Conservation of biological diversity is fragmented due to institutional arrangements. Implementation of projects needs to be coordinated. Biodiversity is not mentioned in constitution.	Review, fine tune and harmonise constitution, legislations, regulations, guidelines (federal & state) to effectively promote conservation and sustainable use of biodiversity. For instance: • • Review and revise National Forestry Act or Protection of Wild Life Act to expand the existing list of protected species. • Streamline mandates and roles of implementing agencies. This will create relevant positions within key implementation agencies. • Create positions/appoint officers to address biodiversity issues at key government agencies such as Town and Country Planning Dept, Dept of Environment, Department of Works, Local Councils, Ministry of Tourism.

APPENDIX XIX

Strengths	Constraints	Root Cause	Needs
Many states are supportive and are aware of the action plans of the National Policy on Biological Diversity. Sarawak and Sabah for instance have established State Biodiversity Councils. Johor has established Majlis Biodiversiti & Bioteknologi Negeri. States in Peninsular Malaysia have at least a State Executive Committee member in charge of the environment generally.	The implementation of the National Policy on Biological Diversity at the state level is limited and ad hoc.	The implementation capacity and institutional support at the state level to address conservation of biological diversity may not be sufficient. Most of the states do not have an "active" platform to operationalise the Policy in a coherent and strategic manner, although some of the states do address the issue of biodiversity indirectly in forums such as Majlis Tindakan Negeri where its main focus may not be biodiversity.	Each state to establish a **platform for implementation of conservation and sustainable use of biodiversity**. For example – a state steering committee. Some of its functions and roles should include: • Formulation of state policy and action plans • Outline the scope and coverage of the action plan • Enhancement of existing institutional framework • Appoint advisors to guide the implementation of state action plans • Oversee the status of implementation of action plan, monitor the availability and value of biodiversity resources at state level.
	Coordination between federal and state agencies can be further strengthened, especially to improve policy planning and implementation programmes specific to CBD • Inadequate coordination among the various department/agencies in programme implementation	Further institutional strengthening among implementing agencies (federal and state) at state level is required.	Enhance coordination mechanism/platform at state level involving all stakeholders (state and federal government.) in management and conservation – with focus on priority setting, implementation, monitoring, evaluation, and information management.
	• Limited number of specialised personnel available in country • Lack of trained personnel to conduct programme monitoring and evaluation • Lack of monitoring mechanism • No proper manual or monitoring protocol developed	Consultation with state governments, and guidance and assistance from federal government in terms of implementation could be further improved.	Operationalise consultation process between and within federal and state government agencies. Share knowledge and experience on best practices of conservation & sustainable use of biodiversity. Federal agencies to provided guidance and assistance to States towards implementation of State Policy and Action Plans. • Assistance can be in the form of coordination, advisory, financial support and also economic incentives to State Governments to implement conservation management

APPENDIX XIX

Strengths	Constraints	Root Cause	Needs
Demonstration projects on tools for sustainable financing of conservation of biological diversity in terms of the following : • User pay principle • Market-based economic incentives • Payments for environmental services • Conservation financing • Trust funds	Challenges in implementing these tools because some stakeholders are not supportive of these instruments and approaches. Example: In Taman Negara Pahang, the entrance fee is RM1.	Implementation of these require greater understanding of how these mechanisms work, and confidence that these have been designed and developed correctly in the Malaysian context.	Pilot Projects to develop incentives: • for states to conserve biodiversity in order to achieve a win-win situation for federal and state governments. • for states and also agencies to apply market based incentives, economic instruments and conservation financing. Example: 1. Providing grants for conservation in states, similar to that for maintaining state roads, e.g. based on acreage of protected areas. 2. Reimbursement of a portion of service taxes from the Federal Government to the State Government based on specific criteria. 3. Encourage states to collect conservation taxes/conservation fees/tourist room surcharges. 4. Identify and remove perverse incentives that are against the conservation and sustainable use of natural resources and biodiversity. 5. Promote payments for environmental services for ecological services such as raw water, etc.
			Establish trust funds and institutional framework for the conservation and management of biological diversity. For instance: • Devise programmes/procedures to tap into existing pools of funding such as state cess, national cess, and also trust funds to carry out relevant activities such as scientific research, community and conservation activities. • Create an institutional framework for collaborative partnerships such as a National Biodiversity Trust Fund that will coordinate the partnership and contributions of corporate and NGOs, and channel funds to NGOs and CBOs to carry out conservation, R&D activities.

APPENDIX XIX

Strengths	Constraints	Root Cause	Needs
Programmes and activities are being implemented. These are monitored individually. FRIM is already taking the lead to develop a clearing house mechanism (CHM) for biodiversity. MARDI has developed a National Information Sharing Mechanism (NISM) on the implementation of the Global Plan of Action (GPA) for the conservation and sustainable utilization of the plant genetic resources for food and agriculture in Malaysia.	Lack of overall and comprehensive **monitoring** mechanisms for the implementation of CBD based on the **National Policy on Biological Diversity** of relevant implementing agencies and also **implementation status in various states.** Lack of information may present an issue in quantitative analysis of programmes.	Lack of systematic and effective reporting framework at state and federal level to provide relevant information for better decision making and management.	Strategic benefits of improving monitoring and evaluation because this will allow better **decision-making**. • Establish an annual reporting framework on the implementation of National Policy on Biological diversity/CBD based on a standardised format. • Develop framework for information sharing of existing inventories and databases for decision making, management of protected areas (establishing conservation areas) and also research (such as a dedicated information portal with relevant structure,
There are various research institutions and universities conducting research on biodiversity. Research funding for biodiversity is allocated from MOSTI. R&D projects under 9MP adhere to clusters which are: • Biotechnology • Industry • ICT • Science and Technology Services • Sea to Space MOSTI does not specifically allocate funding for R&D in biodiversity conservation, but prospective applicants in these fields could still forward applications to be considered under Science and Technology Services.	• Research needs of policy makers for decision making are not met. • Results of research are not used by policy makers • There is duplication and overlap in terms of research or repeating research that has already been carried out • Funding from various sources not managed at "macro" level to ensure efficient use of research funds	• Lack of framework that guides research and development related to biodiversity at macro-level in a coherent manner • Improvement in terms of matching the needs of research for decision making, and also articulating the results of research that can be applied for decision making for implementation of CBD.	Establish a committee to increase the application of research results to support the implementation of CBD (for instance the quantification of ecosystem services, scientific data to protect specific area of ecological and biological diversity). Develop a framework to coordinate research among implementing agencies, research institutions and universities related to biodiversity and also conservation of natural resources. This system should streamline: • Identification of priority areas for research and also conservation which balances between the need to inventorise, conserve and utilise natural resources • Allocation of funding to relevant institutions (e.g. research on terrestrial wildlife, marine

APPENDIX XIX

Strengths	Constraints	Root Cause	Needs
			biodiversity, forests) • Facilitate cooperation between research institutions and implementing agencies to ensure that research outputs will be used/ translated for conservation management (e.g. forestry department, Perhilitan, state EPUs, DID, etc) • Facilitate cooperation among research institutions • Facilitate establishing of more biodiversity stations in protected areas to promote research in these areas.
There are experts in natural sciences such as taxonomists in timber species/forestry	Lack of taxonomists in marine and freshwater fish, arthropod, pathogen. Universities do not offer courses to produce enough taxonomists. Courses are biased towards applied sciences.	HR needs are specific to research institutions. This is not effectively addressed by JPA, local universities and research institutions. Promotion opportunities within government institutions for taxonomists are rather limited within their field of expertise/skills track.	Develop a scholarship scheme (together with sufficient funding) to train and retain taxonomists in Malaysia. Scholarships should focus on priority in biodiversity research, and should bond the scholar to relevant research institutions. The selection should be determined by expert opinion of research institutions. Partner with institutions offering scholarships (e.g. Public Service Department, MARA, Petronas, etc.) to include biodiversity courses in their list of sponsored courses. This will encourage top scholars to take up biodiversity-related studies. Restructure technical departments within civil service to have more positions for taxonomists, as well as to allow for vertical promotion within an organisation so that expertise can be retained.
Implementation of conservation of biological diversity is carried out by several key government agencies at the federal and state levels.	Absence of awareness of the importance and significance of biodiversity conservation and management at other governmental agencies: a) government agencies – e.g. that are approving infrastructure and development projects near pristine and fragile ecosystems b) local communities	Not enough mainstreaming of issues related to biodiversity conservation Not enough allocation of financial resources for implementation Poor dissemination of information/networking	**Mainstream** the need and benefits for biodiversity conservation to relevant agencies in order to include biodiversity conservation in their scope of work. Develop or re-orientate education and training programmes with specific reference to conservation and sustainable use of biological diversity. Involve local community in sustainable use and conservation of biological diversity
Some institutions and local communities already implementing projects that contribute towards implementation of CBD	These stakeholders may not be aware of its relevance to CBD. Technical officers may not relate their (specific) work in terms of contribution towards conservation of biological diversity.		

APPENDIX XIX

Strengths	Constraints	Root Cause	Needs
The Access and Benefits Sharing Bill is being developed to address the Access and Benefits Sharing issue of CBD.	The benefits sharing aspect of "Access and Benefits Sharing" is not well developed and regulated in Malaysia.	Access and Benefits Sharing Bill has not been passed as a law. Even if it is passed as a law, it will take some time to operationalise the law.	Review draft version of Access and Benefits Sharing Bill. Establish a system to implement the Access and Benefit Sharing Act
	The focus of conservation of marine biodiversity in Peninsular Malaysia is weak compared to terrestrial ecosystems. Marine Park Advisory Council meets once a year. This platform is restricted to address marine biodiversity in areas gazetted as marine parks. Transboundary aspects of protecting migrating species (and their habitats) such as dugong, whale sharks are not addressed.	Conservation of marine diversity is not emphasised enough in the Fisheries Act Lack of designated research institute on sustainable use and conservation of marine biodiversity. Currently in Peninsular Malaysia, the conservation of marine biodiversity is limited to Marine Parks and Fisheries Protected Areas. These are enforced by different agencies.	Marine Biodiversity Conservation needs to be re-strategized. Some of these are addressed in the new Marine Parks Act. Strengthen Marine Park Conservation by: • Review and revise laws and regulations to improve conservation of marine and coastal biodiversity to effectively address jurisdiction and enforcement issues related to conservation of marine biodiversity • Based on new legislations, expand the Marine Park Advisory Council to address marine biodiversity issues beyond the Marine Parks • Address the absence of a central coordinating body on funding and scientific research
	Protected Area Management (Terrestrial and Marine) • Currently there is no standard definition of PA within Malaysia (whether it includes permanent reserved forests) • PAs are gazetted under specific state or federal laws (e.g. state enactment, Forestry Act, National Park Act, etc.) and are managed by various implementing agencies	Lack of National guidelines or policy on management and governance of protected area.	Harmonisation of the management of PA in Malaysia to address: - protected areas under the (various) jurisdiction of different agencies such as forestry department, wildlife department, state park corporations, etc. - protected areas in different states
Various efforts to document and inventorise traditional knowledge on the use of natural resources and genetic diversity.	These are carried out by different agencies such as Sarawak Biodiversity Centre, Ministry of Domestic Trade, universities and research institutions.	Information not shared in a harmonised and integrated manner.	Establish a "national system" to inventorise traditional knowledge. Lessons learned, best practices and also template for documentation could be shared
	In terms of biotechnology, there is not much reference to rights of indigenous communities and intellectual rights.	Lack of a mechanism to recognise local and indigenous peoples as custodians of biodiversity and their traditional knowledge should be protected, together with the ecosystem (terrestrial or marine) and habitat which houses biodiversity.	Establish a mechanism for recognition and protection of locals and the indigenous community, and their system of governance in the process of prospecting and harvesting the country's rich biodiversity resources.

APPENDIX XIX

Strengths	Constraints	Root Cause	Needs
Many government agencies and NGOs are involved in promotion of awareness and also dissemination of information on conversation of biological diversity. WWF is currently collaborating with Ministry of Education, relevant government agencies, and universities to develop an Environmental Education Kit for the purpose of replication to Malaysian schools by 2011. MNS has published a teaching guide for teachers to infuse Environmental Education in co-curricular activities in schools.	Absence of a system to promote awareness of the importance and significance of biodiversity conservation and management at the school level	Coherent and integrated approach to include the significance of biodiversity conservation in national curriculum	Develop an Education Strategy to mainstream environmental issues in the current school syllabus/curriculum and co-curriculum with the Ministry of Education.

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15. SUMMARY OF THE "ASM MULTI-STAKEHOLDER CONSULTATION WORKSHOP ON THE BIODIVERSITY SECTOR", HELD AT INSTITUT TADBIRAN NEGERA (INTAN) ON 5TH DECEMBER 2011

As part of the preparations of the ASM MSF Draft Final Report on the Biodiversity Sector on 5th December 2011 the ASM organized a multi-stakeholder workshop involving at INTAN with some 55 invited participants to solicit their own views and perspectives. The workshop commenced with opening remarks by the ASM MSF Study on the Biodiversity Sector Technical Committee Team and Project Team Director, Academician Tan Sri Datuk Dr Ahmad Mustaffa Babjee with regard to the purpose of the workshop. After an overview of the draft final report by the lead consultant, the participants were divided into four working groups (1. Science & Technology and Research Development and Innovation; 2. Institutional Aspects; 3. Issues and Initiatives, Policies, Practices and Priorities; 4. Human Capital) to address the following 6 topics:

1. Current Status
2. Issues and Challenges
3. Gaps in Knowledge
4. Future Needs
5. Proposed Recommendations/Action Plans
6. Strategies

The feedbacks of the four working groups have been summarized and are posted below:

1. **Current Status**

- Lack of data on species richness, habitat types and ecosystem services.
- Disturbance and destruction of ecosystems – need for restoration.
- Lack of ecosystem valuation in terms of environmental economics.
- Lack of tools and technologies for the conservation and sustainable utilization of biodiversity.
- Inadequate human capacity on Malaysia's biodiversity.
- Lack of institutional coordination for work on Malaysia's biodiversity.
- Absence of a centralized (and not a fragmentized or a compartmentalized) Bioinformatics and/or Biodiversity Council, along with a Natural History Institute, in Malaysia.
- Inadequate strengthening of basic and applied R&D and S,T&I in biodiversity.
- Funding for biodiversity is mainly available only for large scale projects.
- Lack of public awareness, including the role of NGO's, and outreach programmes on the conservation and sustainable use of biodiversity.
- Inadequate environmental education, information and action on Malaysia's biodiversity, especially with Malaysia being regarded as one of the 12 mega(bio)diverse countries in the world.
- No central depository for holotype specimens of Malaysia's rich flora and fauna.

- Dichotomy in the jurisdiction of biodiversity and natural resources at the Federal and State levels under Malaysia's constitution.

2. Issues and Challenges

- Provide adequate and continuous funding for R&D and S,T&I in biodiversity.
- Increase expertise and training in certain fields in biology related to biodiversity.
- Data on biodiversity is very much institutionalized and there is need for a National Biodiversity BioInformatics Centre.
- Strengthen coordination, cooperation and consolidation between agencies and institutions (stakeholders) involved in biodiversity related matters and this should be enhanced to minimize duplication and to optimize funding.
- Overcome conflicting policies between the priorities and practices of the different ministries overseeing biodiversity.
- Improve implementation on biodiversity within the education curriculum in Malaysia.
- Despite the existence of various policies and plans on biodiversity, their implementation and enforcement are often inadequate and ineffective.
- Inconsistent implementation of government policies, plans and practices for the conservation and management of biodiversity in Malaysia.
- Increase the awareness and understanding of the manifold dimensions of biodiversity among the political leaders in Malaysia.
- Initiate further exploration and exploitation of new, novel, and innovative S&T for the conservation and sustainable use of biodiversity in Malaysia.

3. Gaps in Knowledge

- Insufficient identification, documentation and inventorizing of biodiversity, natural resources and their ecosystems in Malaysia.
- Inadequacy of pursuing modern, cutting edge and frontier R&D and S,T&I technologies for the conservation, sustainable use and commercialization from biodiversity.
- Lack of proper ways and means of costing the benefits the loss of biodiversity and its natural resources in Peninsular Malaysia, Sabah and Sarawak.
- Insufficient human capital for the conservation and sustainable use of biodiversity in Malaysia, especially in certain critical disciplines like taxonomy

4. Future Needs

- The need for surveys and inventories on biodiversity in Malaysia along the lines of the landmark Mellinium Ecosystem Assessment.
- Instituting adequate safeguards against biopiracy, bioprospecting and the misuse of Malaysia's biodiversity.
- The need to undertake more ecosystem based management of biodiversity in Malaysia.

- Undertaking more conducive and mutually beneficial environmental, corporation and collaboration between Malaysian agencies, institutions and the private sector and their suitably qualified domestic and international counterparts.
- New and innovative sources of funding for R&D and S,T&I on biodiversity to be identified and built upon.
- Factors and forces related to climate change and their implications for biodiversity to be researched, documented and acted upon.

5. <u>Recommendations/Action Plans</u>

- The establishment of a biodiversity fund through which their deliverables should be better aligned towards addressing bio-prospecting, K-economy and the conservation, sustainable use and commercialization of biodiversity in Malaysia.
- Promoting more robust, inclusive and participatory community based management and conservation of biodiversity.
- Providing suitable career development plans and prospects for specific disciplines in biodiversity, including taxonomist and in other relevant disciplines.
- Facilitate the establishment and the operation of a high-level and influential National Biodiversity Centre, and its Natural History Institue, for the conservation and sustainable use of biodiversity for present and future generations.

6. <u>Strategies</u>

- Conduct proper economic evaluations of Malaysia's, including on the wealth and the loss of the country's biodiversity and natural resources, including goods and services.
- Enhance the role of nature and eco tourism as a source of contribution towards Malaysia's GDP in a manner that would conserve and sustainably utilize Malaysia's wealth of biodiversity and its ecosystems.
- Adapt, adopt and implement Malaysia's National Policy on Biodiversity (1998) as deemed appropriate.
- Conservation, sustainable use and commercialization of biodiversity in Malaysia is to be made a priority area for the country's R&D and S, T&I.
