STUDY ON THE STATE OF S&T DEVELOPMENT IN ASEAN

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	1
S&T R&D: HUMAN RESOURCES, EXPENDITURES, AND OUTPUTS	3
Human Resources Involved in S&T	3
Funding for S&T	4
S&T R&D Outputs: Scientific Publications	7
S&T R&D Outputs: Patents	8
Niches and Potentials of S&T in Socio-Economic Sectors	8
S&T UTILIZATION PROGRAM AND INDICATORS	9
OBSERVATIONS AND IDEAS FOR ASEAN MEMBER STATES	10
SUMMARY OF RECOMMENDATIONS TOWARD BUILDING ASEAN COMMUNITY 2015	11
ASEAN Vision and Key Strategies for S&T	11
R&D Cooperation	12
HRD Collaboration	12
Technology Transfer and Commercialization	12
Information/Knowledge Sharing	13
CHAPTER I	
PROJECT RATIONALE, BACKGROUND, AND OBJECTIVES	16
Characteristics and elements of the ASCC	16
Access to Science and Technology (S&T)	17
CHAPTER II	
METHODOLOGY	19
Guide for Situationers	20
CHAPTER III	
COUNTRY SITUATIONERS	23
BRUNEI DARUSSALAM	23
CAMBODIA	30
INDONESIA	34
LAO PEOPLE'S DEMOCRATIC REPUBLIC	45
MALAYSIA	53
MYANMAR	62
PHILIPPINES	69
SINGAPORE	82
THAILAND	96
VIETNAM	106
CHAPTER IV	
ANALYSIS OF FACTORS AND INDICATORS	111
S & T Strategies and Policies	111
Infrastructure for S&T	115
Synthesis	120
Human Resources Involved in S&T	122
Funding for S&T	122
S&T R&D Outputs: Scientific Publications	124

S&T R&D Outputs: Patents 125
S&T Utilization Program and Indicators 125
STRENGTHS/NICHES/POTENTIALS IN S&T 134
Capacity for S&T Human Resource Development in Higher Education Institutions 137
University-Based Research Institutes 142
Major Economic Indicators 143
CHAPTER V
OBSERVATIONS AND IDEAS FOR MEMBER STATES 145
CHAPTER VI
RECOMMENDATIONS TOWARD AN ASEAN COMMUNITY 2015 151
ASEAN Vision and Key Strategies for S&T 151
R&D Cooperation 151
HRD Collaboration 151
Information/Knowledge Sharing 152

TABLES

Page
Table 1 4
Number of Researchers (Headcount) Per Million Population
By Sector of Employment Among ASEAN Countries, Latest year Available
Table 2 5
Gross Expenditure on R&D (GERD), R&D Intensity, and Per Capita GERD among ASEAN Countries, Latest Available Data
Table 3 6
GERD by Sector of Performance in ASEAN Countries
Latest Year Available
Table 4 7
GERD by Source of Funds in ASEAN Countries
Latest Year Available
Table 5 8
Scientific Publications of ASEAN Member States
Table 6 8
Registered Patents in ASEAN Member States
Table 7 9
Niches/Potentials in Socio-Economic Sectors
Table 8 9
Focus of S&T Utilization Program among ASEAN MEMBER STATES
Table 9 43
Indonesia National Headcount of R&D Personnel 2009
Table 10 50
Lao PDR Composition of Agricultural Research Expenditure and Total Researchers 2003
Table 11 61
Malaysia's major exports
Table 12 73
Philippines
R&D Expenditures as % of GDP, 2007 and 2009

Table 13 74
Philippines
National R&D Expenditures by Sector 003, 2005, 2007, and 2009
Table 14 75
Philippines
R&D Expenditures in the Private Industry Sector by Type of Industry
Table 15 79
Philippines Sector of Performance in S&T03, 2005, 2006, 2008 (in thousand pesos)
Table 16 80
Philippines GERD Sector of Performance in S&T R&D Spending
Table 17 81
Number of Co-publications by Filipinos with Citizens from Other AMS
Table 18 92
Singapore's Gross Domestic Product by Industry (S$MIL)
Table 19 93
Singapore's Total Output of Manufacturing by Industry Cluster (S$ mil)
Table 20 94
Singapore's Exports by Major Commodity at Current Prices (S$ mil)
Table 21 95
Singapore's Total Trade by Selected Country at Current Prices (S$ mil)
Table 22 99
Thailand: Persons Involved in S&T R&D (Headcount)
Table 23 100
Thailand: Persons Involved in S&T R&D (FTE)
Table 24 101
Thailand: Human Resources in S&T
Table 25 101
Thailand: Expenditures for S&T R&D
Table 26 102
Thailand: Patent Applications and Patents Granted
Table 27 104
Top 10 Thai Exports 2011
Table 28 104
Top 5 Thai Imports 2011
Table 29 105
Thailand's Major Trading Partners in ASEAN
Table 30 109
Vietnam: Number of Scientific Publications (2000 – 2008)
Table 31 122
Number of Researchers (Headcount) Per Million Population by Sector of Employment among ASEAN Member States, Latest Available Data
Table 32 123
Gross Expenditure on R&D (GERD), R&D Intensity, and Per Capita GERD Among ASEAN Member States; Latest Available Data
Table 33 123
GERD By Sector of Performance in ASEAN Member States, Latest Available Data
Table 34 124
GERD By Source of Funds in ASEAN Member States, Latest Available Data

Table 35 125
Number of Scientific Publications among AMS
Table 36 125
Patents Granted among AMS
Table 37 126
Projects and Programs Related to S&T Utilization in the AMS
Table 38 128-133
Summary of Utilization Indicators among AMS
Table 39 134
Articulation of S&T Policies and Strategies, S&T and Innovation Infrastructure, and Utilization Programs
Table 40 135
S&T Human Resources, Investments, and Outputs
Table 41 135
HEI capacity for HRD in S&T and University-based Research Capability
Table 42 136
Areas of Strength in Major S&T Disciplines
Table 43 136
Strengths/Niches/Potentials in Socio Economic Sectors Where S&T Has Significant Role
Table 44 137
Niches in Products/ Commodities – Based on Major Exports
Table 45 144
Major Economic Indicators of ASEAN MEMBER STATES

FIGURES

Figure 1 14
Recommended schemes and funding mechanism for collaboration and cooperation among ASEAN member states for S&T utilization towards building ASEAN Community 2015
Figure 2 15
Conformity of the Study's Recommendations with the Krabi Initiative 2010

EXECUTIVE SUMMARY

STUDY ON THE STATE OF S&T DEVELOPMENT IN ASEAN

To reach the ASEAN Community's building goals of 2015, this STUDY ON THE STATE OF S&T DEVELOPMENT IN ASEAN was commissioned by the Advisory Body on ASEAN Plan of Action on Science and Technology (ABAPAST) in 2011.

The objectives of the study are to determine and assess S&T capacities (both human and infrastructure) of member states; to identify possible technology niches (strengths) in each ASEAN Member State (AMS); and to develop a set of strategies that can address two burning questions:

1. How could ASEAN synergize each other's strengths to ensure rapid, consistent, and harmonious S&T developments in each Member State without duplicating but complementing these developments, thus avoiding competition among the ASEAN Member States?
2. How could S&T development in ASEAN, both at national and regional levels, be relevant to the realization of the ASEAN Community by 2015?

This study thus covers a wide range of information from each ASEAN Member State (AMS). It covers S&T Policy and Development Strategies, Infrastructure for S&T, Funding for S&T, Human resources involved in S&T, S&T Outputs, S&T Utilization programs, Areas of Strength in S&T/R&D, Major Contributors to GDP, Major Exports, Major Trading/Economic Partners in ASEAN.

The strategies and policies on S&T in each AMS are influenced by political, historical, economic, and social conditions as well as the leadership's level of aspirations. Therefore, the focus of S&T development in ASEAN member countries though exhibiting many similarities, show varying emphases or priorities. All members have strategies involving development of information, strong linkages with relevant partners and involvement of various stakeholders to spur the development. The level of integration or cohesiveness of S&T policies in each AMS also differs from country to country. In addition, the role of the top leadership in the country varies in many ways. The common threads on S&T, which may be woven among ASEAN member states, are collaboration on sustainability, human capital development, and S&T fields like agriculture, aquaculture, biodiversity, energy, environment, health, and ICT.

In the area of human resources involved in S&T, the main information considered is the statistics on R&D personnel, measured in terms of number of researchers (headcount) per million population, obtained from UNESCO Institute of Statistics. The year when the latest statistics is available varies, ranging from 2002 to 2009. The statistics obtained are as follows: Brunei 673 (2009), Cambodia 56 (2002), Indonesia 179 (2009), Lao PDR 37 (2002), Malaysia 729 (2006)*, Myanmar 100 (2002), Philippines 130 (2007), Singapore 7,230 (2008), Thailand 582 (2007) and Vietnam 508 (2002).

* *Data from the National Survey of R&D by MOSTI Malaysia in 2008 gives a figure of 1,135 per million of Total Headcount of R&D Personnel.*

In terms of funding for S&T, the main indicator available is R&D intensity measured in terms of the Percentage of Gross Expenditure on R&D (GERD) to GDP, also obtained from the UNESCO Institute of Statistics. The figures show the following: Brunei 0.04% (2004), Cambodia 0.05% (2002), Indonesia 0.04% (2009), Lao PDR 0.04% (2002), Malaysia 0.63% (2006)*, Myanmar 0.16% (2002), Philippines 0.11% (2007), Singapore 2.26% (2009), Thailand 0.21% (2009), and Vietnam 0.19% (2002).

In 2000, the S&T R&D Scientific Publications produced per country were the following: Brunei – 31; Cambodia – 14; Indonesia – 429; Lao PDR – 9; Malaysia – 805; Myanmar – 19; Philippines – 353; Singapore – 3,465; Thailand – 1,182; and Vietnam – 315. In 2008, the figures increased: Brunei – 40; Cambodia – 75; Indonesia – 650; Lao PDR – 52; Malaysia – 2,712; Myanmar – 37; Philippines - 624; Singapore – 6,813; Thailand – 4,134; and Vietnam – 875.

The statistics on the number of registered patents showed Singapore having 274 patents in 2000 and 481 in 2007, followed by Malaysia, which had 63 patents in 2000 and 212 in 2007. The other AMS produced less than 50 patents per year in the years covered.

The S&T utilization programs in AMS are categorized into three: (1) those that support basic needs in agriculture and rural development (all AMS except Singapore); (2) those that support government functions for public services and national security (Indonesia and Malaysia); and (3) those that support the economic sector (Singapore, Malaysia, Thailand, Vietnam and Philippines).

Finally, recommendations are proposed in this study aimed at attaining the goal of building the S&T sector in the ASEAN Community. These recommendations cover the following:

- Setting an ASEAN Vision for S&T that will contribute positively to the building process for ASEAN Community 2015.

- Creating an active R&D Network that will be useful for ASEAN Member States. This collaboration will include ways to utilize knowhow and knowledge accumulated in universities and research institutions in every member state. Areas of collaboration will include socio-culture development and regional development. ASEAN Member States will come up with a security network in the areas of food and energy, water management, biodiversity, climate change, disaster management, and environmental preservation. This will evolve through a scheme called "Open Innovation" that will provide researchers and scientists access to shared R&D facilities and information across ASEAN. Other segments of the R&D Network will share models of research consortia among universities, public research institutions, and corporate business units. Public-private partnerships are recommended for S&T utilization projects that target regional development and public services across the region such as food and energy security, disaster management, and environmental preservation and rehabilitation.

* *Data from the National Survey of R&D by MOSTI Malaysia in 2008 gives an R&D intensity of .82% measured in terms of the Percentage of Gross Expenditure on R&D (GERD) to GDP.*

- Ensuring human resource development among ASEAN Member States through the AUN-SEED Program in collaboration with the Committee on Social Development. This means an Expanded AUN-SEED Program for advanced education in engineering and science. Included here is the adoption of a "sandwich" program and internship for researchers and technical personnel in R&D/S&T institutes ASEAN-wide.

- Strengthening regional competitiveness through the development of innovative and cooperative strategies that will support SMEs in technological upgrading. This will be accomplished by setting up SME technology helpdesk centers and networks across ASEAN and promoting high-tech firm start-ups through programs of cross-ASEAN technopreneurships that combine ideas, socio-cultural uniqueness, highly skilled human resources, and capital utilization across ASEAN.

- Establishment of the ASEAN Fund for Innovation organized under ABAPAST/ABASF and S&T utilization project funding organized under COST-Subcommittee as well as venture capital fund to support technology-based SMEs and tech-firms start-ups across ASEAN. ASEAN should take advantage of international cooperation and the scheme of public-private partnership to establish such funding.

S&T R&D: HUMAN RESOURCES, EXPENDITURES, AND OUTPUTS

Human Resources Involved in S&T

In terms of total R&D personnel per million population, Singapore has the highest headcount at 7,230 R&D personnel while Lao PDR has the lowest at 37 R&D personnel per million population. The distribution of R&D personnel among sectors of performance shows that more than half of Singapore's R&D personnel are employed in private business while in Brunei, Indonesia, Malaysia, Philippines, Thailand and Vietnam, the bulk of R&D personnel is employed in the higher education sector. More than half of the R&D personnel in Cambodia and Lao PDR are employed by the government sector. In this regard, it should be noted that Singapore has the least portion of R&D personnel working in the government sector (Table 1).

Table 1
Number of Researchers (Headcount) Per Million Population
By Sector of Employment among ASEAN Member States, Latest Available Data

Member Country (year available)	Total Headcount Per Million Population	Distribution by Sector of Employment (as % to total)				
		Business Enterprise	Government	Higher Education	Private Non-Profit	Not Specified
Brunei (2004)	673	11.0	21.2	67.8	-	-
Cambodia (2002)	56	15.2	53.0	11.8	20.0	-
Indonesia (2009)	179	1.9	31.3	66.8	-	-
Lao PDR (2002)	37	28.2	52.2	19.6	-	-
Malaysia (2006)*	729	21.9	14.2	63.9	-	-
Myanmar (2002)	100	n. a.	n. a.	n. a.	n. a.	-
Philippines (2007)	130	28.0	21.6	48.9	1.5	-
Singapore (2008)	7,230	54.4	7.2	38.4	-	-
Thailand (2007)	582	17.7	16.3	64.5	0.2	1.3
Vietnam (2002)	508	23.5	27.0	49.0	0.5	-

Source: UNESCO *Institute for Statistics*

** Data from the National Survey of R&D of MOSTI Malaysia in 2008 gives a figure of 1,135 per million for Total Headcount, 11.7% of which are employed in the Business Enterprise Sector, 11.6% in the government sector and 76.7% in the Higher Education Sector.*

Funding for S&T

As shown in Table 2, all ASEAN Member States except Singapore invest less in R&D relative to their GDP. They have R&D intensities of less than 1%, the level recommended by UNESCO for developing countries to achieve.

Table 2
Gross Expenditure on R&D (GERD), R&D Intensity, and Per Capita GERD among ASEAN Member States, Latest Available Data

Country (Year Available)	GERD (in '000 local currency)	R&D Intensity (GERD as % of GDP)	Per Capita GERD (in '000 PPP$)
Brunei (2004)	4,925	0.04	17.30
Cambodia (2002)	8,357,010	0.05	0.50
Indonesia (2009)	4,671,354,585	0.04	3.50
Lao PDR (2002)	6,560,000	0.04	0.50
Malaysia (2006)*	3,646,700	0.63	80.10
Myanmar (2002)	9,122,008	0.16	0.16
Philippines (2007)	7,566,360	0.11	3.90
Singapore (2009)	7,128,096	2.26	1,431.40
Thailand (2009)	18,225,253	0.21	16.70
Vietnam (2002)	1,032,560,900	0.19	3.10

Source: UNESCO *Institute for Statistics*

* *Data from the National Survey of R&D of MOSTI Malaysia in 2008 gives a GERD figure of 6,070,800,000 in local currency, giving an R&D Intensity of 0.82% as percentage of GDP, and a per capita GERD OF 114,100 in PPP$.*

A comparison of the distribution of national R&D expenditure by sector of performance shows the varying patterns of how R&D efforts are undertaken across ASEAN Member States. In Brunei Darussalam, Indonesia, Lao PDR, and Vietnam, R&D is predominantly performed in the government sector (Table 3). In comparison, the business enterprise sector performs a larger share in Malaysia, Philippines, Singapore, and Thailand. It should also be observed that the higher education sector performs a significant share of R&D in Thailand, Philippines, Singapore, and Vietnam.

Table 3
GERD by Sector of Performance in ASEAN Member States
Latest Available Data

Member Country (year available)	GERD (in '000 PPP$)	Sector of Performance (in % to total GERD)				
		Business Enterprise	Government	Higher Education	Private Non-Profit	Not Specified
Brunei (2004)	6,268	-	91.6	8.4	-	-
Cambodia (2002)	6,816	15.7	50.7	12.5	21.2	-
Indonesia (2009)	803,522	14.3	81.1	4.6	-	-
Lao PDR (2002)	2,637	36.9	50.9	12.2	-	-
Malaysia (2006)*	2,090,512	84.9	5.2	9.9	-	-
Myanmar (2002)	n. a.	n. a.	n. a.	n. a.	n. a.	-
Philippines (2007)	342,491	56.9	17.7	23.3	2.1	-
Singapore (2008)	6,605,896	71.8	7.6	20.5	-	-
Thailand (2007)	1,120,750	45.0	18.5	32.5	1.2	2.7
Vietnam (2002)	252,019	14.5	66.4	17.9	1.1	-

Source: UNESCO *Institute for Statistics*

* *Data from the National Survey of R&D of MOSTI Malaysia in 2008 gives a GERD figure of 3,161,875,000 in PPP$, with 70.5% share of performance by the Business Enterprise Sector, 9.9% share of performance by the Government Sector and 19.6% share of performance by the Higher Education Sector.*

The government sector serves as the predominant R&D funder in Brunei Darussalam, Indonesia, and Vietnam. By comparison, in Thailand, Singapore, Philippines, and Malaysia, the business sector is the biggest source of R&D funding. Table 4 shows that in all ASEAN Member States except Malaysia, the government sector plays an active role in R&D funding. It must also be pointed out that in Thailand, the higher education sector funds more than 10 per cent of the national R&D expenditure while the private non-profit sector and foreign sources play a significant role in R&D funding in Cambodia and Lao PDR.

Table 4
GERD by Source of Funds in ASEAN Member States
Latest Available Data

Member Country (year available)	GERD (in '000 PPP$)	Distribution by Source of Funds (in %)					
		Business Enterprise	Government	Higher Education	Private Non-Profit	Funds from Abroad	Not Specified
Brunei (2004)	6,268	1.6	91.0	7.4	-	-	-
Cambodia (2002)	6,816	-	17.9	-	43.0	28.4	10.6
Indonesia (2009)	803,522	14.7	84.5	0.2	-	-	0.7
Lao PDR (2002)	2,637	36.0	8.0	2.0	-	54.0	-
Malaysia (2006)*	2,090,512	84.5	2.4	6.5	-	0.2	6.3
Myanmar (2002)	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.
Philippines (2007)	342,491	62.0	26.1	6.4	0.9	4.1	0.5
Singapore (2008)	6,605,896	63.5	29.9	1.3	-	5.3	-
Thailand (2007)**	1,120,750	48.7	31.5	14.9	0.7	1.8	2.4
Vietnam (2002)	252,019	18.1	74.1	0.7	-	6.3	0.8

Source: UNESCO *Institute for Statistics*

* *Data from the National Survey of R&D of MOSTI Malaysia in 2008 gives a GERD figure of 3,161,875,000 GERD in PPP$, 66.45% of which comes from the Business Enterprise sector, 30.6% from the government sector, 0.74% from the Higher Education Sector, 0.11% Funds from Abroad, and 2.03% Not Specified.*

** *Funding source distribution is based on 2005 data.*

S&T R&D Outputs: Scientific Publications

Scientific publications in the ASEAN Member States are shown on Table 5. The figures indicate that Singapore leads all the 10 ASEAN Member States in terms of scientific publications with its number increasing from 3,465 in 2000 to 6,813 in 2008, or an increase of almost 100%. Second to Singapore is Thailand, showing a significant improvement in number of scientific publications; figures trebled from 1,182 in 2000 to 4,134 in 2008.

Malaysia also showed a high improvement increasing its number from 805 in 2000 to 2,712 in 2008. Philippines and Indonesia had a lower number with almost the same levels registered during the period. Vietnam caught up with an increase from 315 to 875 publications during the period. Other countries like Brunei Darussalam, Cambodia, Laos, and Myanmar had less than a hundred scientific publications per year in the period under study.

Table 5
Scientific Publications of ASEAN Member States

ASEAN	2002	2001	2002	2003	2004	2005	2006	2007	2008
Brunei	31	26	25	32	34	27	26	35	40
Cambodia	14	14	20	23	41	50	64	80	75
Indonesia	429	449	421	428	471	526	597	582	650
Lao PDR	9	12	16	24	27	34	49	44	52
Malaysia	805	906	961	1,123	1,308	1,520	1,757	2,151	2,712
Myanmar	19	21	12	21	30	38	42	40	37
Philippines	353	317	398	418	427	467	464	535	624
Singapore	3,465	3,781	4,135	4,621	5,434	5,971	6,300	6,249	6,813
Thailand	1,182	1,344	1,636	1,940	2,116	2,409	3,000	3,582	4,134
Vietnam	315	353	343	458	434	540	617	698	875

Source: UNESCO *Science Report 2010*

S&T R&D Outputs: Patents

As far as trend and ranking in terms of the number of registered patents are concerned, Singapore has stayed at the top with 274 in 2000 increasing to 481 in 2008. Malaysia is next with 63 in 2000 increasing to 212 in 2008. Philippines and other countries have registered patents numbering less than 50 per year.

Table 6
Registered Patents in ASEAN Member States

ASEAN*	2000	2001	2002	2003	2004	2005	2006	2007
Cambodia	-	-	-	-	1	-	1	-
Indonesia	11	13	9	13	11	12	7	9
Malaysia	63	65	94	77	111	117	162	212
Philippines	17	22	30	45	39	26	44	33
Singapore	274	373	505	523	540	429	519	481
Thailand	25	39	60	37	37	28	56	28
Vietnam	1	4		2	2	6	2	1

Source: UNESCO *Institute for Statistics*
** No data available from Brunei, Lao, and Myanmar*

Niches and Potentials of S&T in Socio-Economic Sectors

For niches or potentials in socio-economic sectors where S&T has a significant role to play, Table 7 shows the assessment based on productivity/export performance, range of services available, on infrastructure, and on human resources with advanced expertise in the area.

Table 7
Niches/Potentials in Socio-Economic Sectors

Socio-Economic Sectors	Performance/Productivity/Range of Services; Infrastructure; Human Resources
Agriculture	Very high for Malaysia and Thailand; high for all the AMS
Health	Very high for Philippines, Singapore, Thailand and Vietnam; high for Indonesia, Malaysia and Myanmar
Industrial and Manufacturing/Processing	Very high for Malaysia, Philippines, Singapore and Thailand; high for Brunei, Indonesia and Vietnam
Services (ICT, Finance, Engineering, etc)	Very high for Singapore; high for Malaysia, Philippines and Thailand
Disaster Management	Very high for Philippines; high for Brunei, Indonesia, Malaysia, Myanmar, Singapore, Thailand and Vietnam

S&T UTILIZATION PROGRAM AND INDICATORS

The objectives and targets of S&T utilization programs can be divided into three categories, namely: socio-cultural development, public services including defense and national security, and private sector to support the economy. The source of the knowledge on the other hand, is from three categories, namely universities, public research organizations (PROs) and private business R&D units. Based on the focus of S&T utilization program, Table 8 shows that the member states could be in one or more categories.

Table 8
Focus of S&T Utilization Program among ASEAN Member States

Focus of S&T Utilization Program	ASEAN Member States
Supporting basic needs in agriculture and rural development	All member states except Singapore
Supporting government functions for public services, defense, and national security	Indonesia and Malaysia
Supporting the economy	Philippines, Singapore, Malaysia, Thailand and Vietnam

The integration of S&T into the economic sector is most prominent in Singapore. Malaysia shows a balance of S&T utilization in the three sectors: socio-cultural development, national security and the economy. Thailand, Philippines, and to a lesser degree, Vietnam, are balancing the S&T utilization between supporting the economy and supporting socio-cultural development. The S&T utilization program in Indonesia is concentrated in its national security and defense program, giving less intensity to rural and socio-cultural development, while in the economic sector, S&T utilization is mainly coming from private initiatives with less involvement of the public research institutes and universities. The other member states including

Brunei, Cambodia, Myanmar, and Laos focus their utilization of S&T on agriculture and rural development.

OBSERVATIONS AND IDEAS FOR ASEAN MEMBER STATES

Brunei Darussalam:

- Focus on niche areas like biotechnology for agricultural diversity and energy development
- Partnerships with AMS for HRD capability building
- A national office devoted to S&T under the Prime Minister

Cambodia:

- Develop existing institutions doing R&D to attain world-class status (CARDI, ITC)
- An HRD Plan for S&T and long-term S&T Institution Building Program
- An S&T roadmap for mines and energy
- A national agency to coordinate S&T Program

Indonesia:

- Expand Technology Business Incubation Program
- Strong support for the research programs of university-based research institutes
- Full Government support to upgrade the S&T Programs in the public universities
- Accelerate implementation of roadmap for space technology

Lao PDR:

- Focus on R&D and HRD in agriculture particularly on the commodities most promising for export
- Strengthen S&T capability in water resources management both for industrial and energy use
- An HRD Development Plan for S&T including the area of techno-entrepreneurship
- Collaborative work among Provincial Departments for S&T, research institutes, national universities, and ministries to upgrade and to encourage the creation of small enterprises as a way of encouraging innovations and value creation

Malaysia:

- Gear the universities toward the commercialization of innovations and R&D outputs
- Orient the researchers toward the enterprise aspects of their innovations
- Each agency cluster in MOST to identify and venture on areas for global or regional leadership
- Collaboration of research institutes belonging to different ministries

Myanmar:

- The two graduate universities exclusively for MS and PhD in S&T, should be prepared to accommodate significantly bigger number of students
- Establishment of university-based research institutes to be supported by the Government
- R&D institutions should look how their outputs can be utilized for public good

Philippines:

- Higher investments in R&D and in capacity-building for R&D in S&T

- Invest in advanced technology platforms like biotechnology, nanotechnology, genomics and ICT
- Upgrade technological assistance to industries
- Expand technology business incubation program

Singapore:

- More technology-based enterprise creation among young and aspiring entrepreneurs
- Spilling-over investments by technopreneurs into neighboring countries particularly AMS
- Access to Singapore venture capital by technopreneurs from AMS

Thailand:

- Expand programs to empower local communities
- Expand the coverage of technology commercialization to include licensing of technologies to adaptors from other AMS
- Replicate success of some university technology licensing offices in the other universities

Vietnam:

- Assess the impact of S&T investment in the socio-economic development of the country
- Revive incentives for Spin-off Projects

SUMMARY OF RECOMMENDATIONS TOWARD BUILDING ASEAN COMMUNITY 2015

- How can ASEAN Member States (AMS) synergize in S&T?
- How can S&T developments in ASEAN collectively contribute to the building process of the ASEAN Community by 2015?

An initial set of suggestions is presented below for consideration by the AMS. The suggestions fall under the following headings: Vision and Key Strategies, R&D Cooperation, HRD Collaboration, Technology Transfer and Commercialization, and Information/ Knowledge Sharing.

ASEAN Vision and Key Strategies for S&T

Some AMS have adopted visions and strategies for S&T that are reflections of the aspirations and ideals for S&T of most AMS. Having an ASEAN Vision for S&T will surely contribute positively to the building processes for ASEAN Community 2015.

In relation to the articulation of the vision for S&T, it might also be worthwhile to consider having an S&T Development Act for each AMS. In general, a piece of national legislation for S&T highlights the importance of the sector for national development.

R&D Cooperation

It is high time that some form of institutionalization be made for R&D cooperation among AMS. The motivation to cooperate is usually to address issues that are urgent or critical in nature. There has to be a process of indentifying these critical R&D areas or programs or projects which are common among AMS, followed by a process of reaching a consensus as to whether a particular R&D concern or program or project will be done in a cooperative manner. To facilitate the institutionalization of these processes there has to be an R&D institution network within the ASEAN with its own set of rules as to who can be members and how it will operate as a network. If there is an ASEAN University Network for HRD Cooperation under the Committee on Social Development, why not an ASEAN RDI Network for R&D Cooperation under the Committee on Science and Technology? This concept will not be complete without the involvement and support of ASEAN Dialogue Partners.

HRD Collaboration

Three ideas are presented here, which are designed to enhance synergy in S&T among AMS.

Collaboration with the Committee on Social Development for an Expanded AUN-SEED Program. This program has been benefitting a good number of young researchers and academics in the different fields of engineering in being able to earn MS and PhD degrees in another AMS.

Adoption of the "SANDWICH" Program approach wherein the student/scientist can do the required coursework in his/her country and then do the required research/thesis/dissertation in another country where there will be a willing research collaborator.

Institution of a program of internship for researchers and technical personnel in R&D/S&T institutes ASEAN-wide. This can be another undertaking by the proposed ASEAN RDI Network. As an example, the internship program sponsored by the National Centre of Genetic Engineering and Biotechnology (BIOTECH) in Thailand benefits AMS Biotech researchers and scientists.

Technology Transfer and Commercialization

ASEAN as a market is big. There are technology transfer and commercialization projects or transactions that can be done in a better way if there are cooperating parties from different AMS. Examples of such mutually beneficial cooperation projects that could be commercialized are the following:

- Licensing of technologies for commercialization to enterprises coming from other AMS, in addition to licensees in the technology's country of origin
- Networking among venture capital companies in ASEAN for technology start ups
- Having an ASEAN Consortium for IP Related business development services

- Co-investments in large technology commercialization projects involving both private and public corporations in ASEAN

Information/Knowledge Sharing

It is worthwhile to consider sharing and linking research-based knowledge using an interoperability system. This idea was demonstrated at the Thailand Research Expo 2011 where 32 government and private sector agencies shared their research knowledge under the prototype of the National Research Indexing Hub Project (*The Nation*, September 5, 2011).

The summary of the recommendations is shown in Figure 1, which is in conformity with the Thematic Tracks and the Paradigm Shift identified in the Krabi Initiative 2010. The Thematic Tracks include ASEAN Innovation for Global Market; Digital Economy, New Media and Social Networking; Green Technology; Food Security; Energy Security; Water Management; Biodiversity for Health and Wealth; and Science Innovation for Life. The Paradigm Shift involves new approaches that are gaining acceptance worldwide; namely, STI Enculturation, Bottom-of-the-Pyramid Focus, Youth-focused Innovation, STI for Green Society, and Public-Private Partnership Platforms.

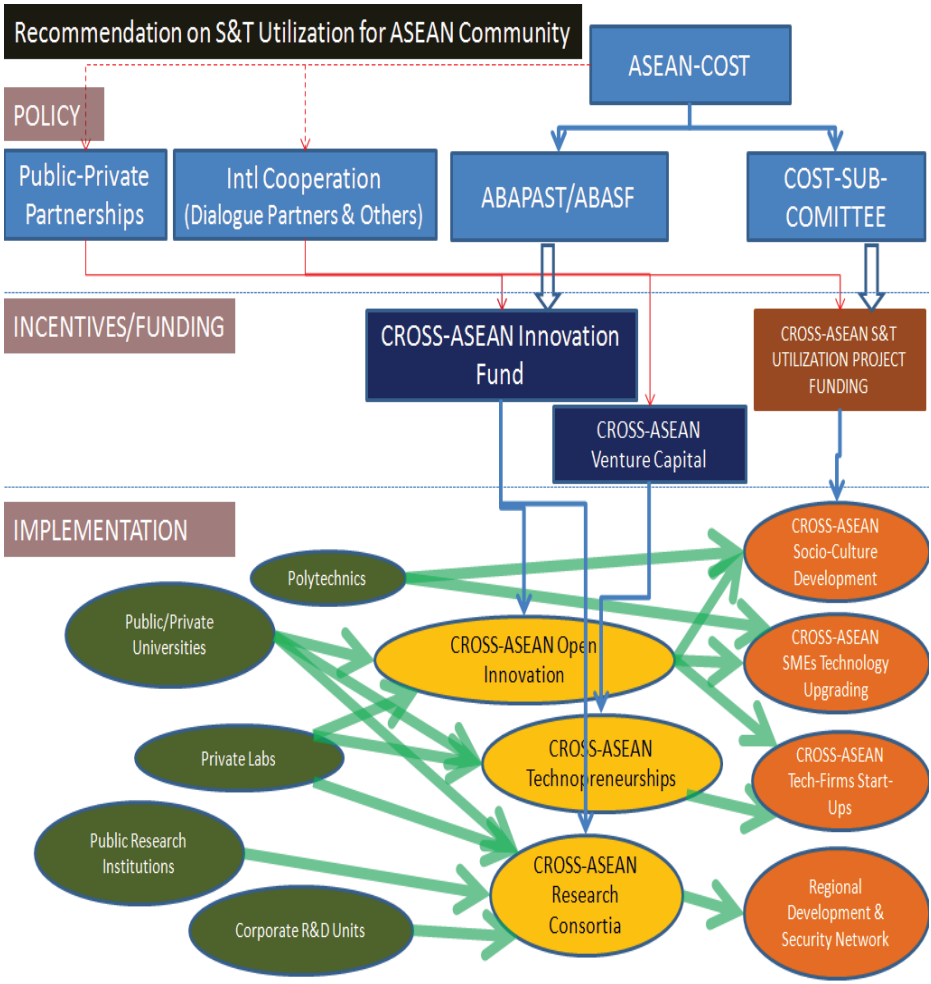

Figure 1
Recommended schemes and funding mechanism for collaboration and cooperation among ASEAN member states for S&T utilization towards building ASEAN Community 2015.

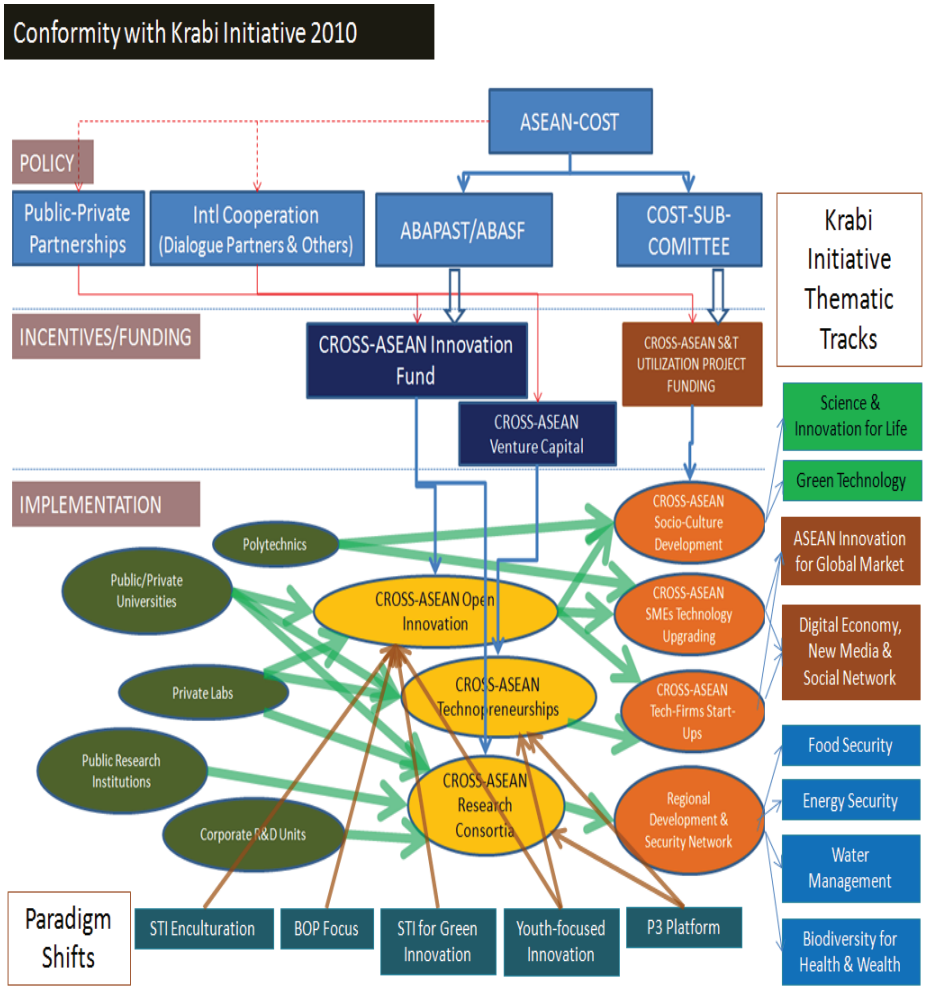

Figure 2
Conformity of the Study's Recommendations with the Krabi Initiative 2010

CHAPTER I

PROJECT RATIONALE, BACKGROUND, AND OBJECTIVES

ASEAN is one of the economically fastest growing regions in the world. This development was greatly felt in the industrial sector of many of its member states during the last two or three decades. However, member states have been found to still rely on natural resources exploitation and export in their bid to maintain their development at highly acceptable levels. To maintain their sustainable growth in the future, ASEAN member states (AMS) must gradually lessen their dependence on the exploitation of their natural resources and start to increase their economies' level of sophistication by adopting and espousing new technologies. It is also highly desirable that the gap in the levels of development and technological readiness among groups of AMS be reduced so that the ASEAN region as whole can enhance the socio-economic development and quality of life of its peoples.

On October 7, 2003, in Bali, Indonesia, ASEAN Leaders adopted the Declaration of ASEAN Concord II establishing an ASEAN Community by 2020. The ASEAN Community shall have three pillars: the political and security community, the economic community, and the socio-cultural community, all of which are closely intertwined and mutually reinforcing to ensure durable peace, stability, and shared prosperity in the region.

At the 12th ASEAN Summit on January 13, 2007, in Cebu, Philippines, the Leaders, affirming their strong commitment to accelerate the establishment of the ASEAN Community by 2015, signed the Cebu Declaration on the Acceleration of an ASEAN Community by 2015.

The Leaders at the 13th ASEAN Summit held in Singapore on November 20, 2007, agreed to develop a viable Blueprint to ensure that concrete actions are taken to promote the establishment of an ASEAN Socio-Cultural Community (ASCC).

Thus, 2015, which is barely three years away, is a milestone for which the whole ASEAN and its member states should prepare. It is the year when the Acceleration of the ASEAN Community and the establishment of an ASEAN Socio-Cultural Community (ASCC) will be realized.

Characteristics and elements of the ASCC

- The primary goal of the ASCC is to establish a people-centered and socially responsible ASEAN Community, whose final achievement will be enduring solidarity and unity among the nations and peoples of ASEAN. This will be accelerated by forging a common identity and building a caring and sharing society that is inclusive and harmonious and where the well-being, livelihood, and welfare of the peoples are enhanced.

- The ASCC will address the region's aspiration to lift the quality of life of its peoples through cooperative activities that are people-oriented and environmentally friendly geared towards the promotion of sustainable development. The ASCC shall contribute to building a strong foundation for greater understanding, good neighborliness, and a shared sense of responsibility among the nations of ASEAN.

- The ASCC is characterized by a culture of regional resilience, adherence to agreed principles, spirit of cooperation, and collective responsibility, which will promote human and social development, respect for fundamental freedoms, gender equality, protection of human rights, and social justice.

- The ASCC shall respect the different cultures, languages, and religions of the peoples of ASEAN, emphasizing their common values in the spirit of unity in diversity and adapt them to present realities, opportunities, and challenges.

- The ASCC will also focus on the social dimension of Narrowing the Development Gap (NDG) by bridging the development gap among Member States.

- Based on the above, the ASCC envisages the following characteristics: (a) Continuing Human Development; (b) Increasing Social Welfare and Protection; (c) Implementation of Social Justice and Rights; (d) Ensuring Environmental Sustainability; (e) Building the ASEAN Identity; and (f) Narrowing the Development Gap among Member States.

Access to Science and Technology (S&T)

Facilitating Access to Science and Technology (S&T) is the ASEAN Socio-Cultural Community's (ASSC) special focus; thus, the ASCC has a whole section devoted to it. The strategic objective and recommended actions for S&T development are as follows:

Strategic objective: To develop policies and mechanisms that will support active cooperation in research, science and technology development, technology transfer and commercialization, and participation of private sector and other relevant organizations.

Actions:

- Establish a network of S&T centers of excellence to promote cooperation, sharing of research facilities, technology transfer and commercialization, and joint research and technology development by 2011;
- Strengthen collaborative research and development in applied S&T to enhance community well-being;
- Facilitate the exchange and mobility of scientists and researchers from public S&T institutions and private sector organizations according to the respective laws, rules, regulation and national policies of the ASEAN Nations;
- Establish strategic alliances with the private sector to promote R&D collaboration, technology transfer, and commercialization;
- Establish ASEAN scholarship and fellowship opportunities to support the ASEAN Virtual Institute of Science and Technology (AVIST) and other related science activities;
- Heighten the awareness on applied S&T for sustainable development;
- Develop a core set of S&T indicators that can serve as input in the development of human resource strategies by economic and industry planners;
- Enhance and sustain the utilization of the ASEAN Science and Technology Network (ASTNET) and other S&T networks; and
- Promote the development, use, and sharing of digital content among ASEAN Member States through a coordinated information and communication plan.

With this as background, the Advisory Body on ASEAN Plan of Action on Science and Technology (ABAPAST) commissioned the STUDY ON THE STATE OF S&T DEVELOPMENT IN ASEAN.

In the context of ASEAN Community building goals, the project's overall objectives are

1. To determine and assess S&T capacities (both human and infrastructure) of member states;
2. To identify possible technology niches (strengths) in each Member State; and
3. To develop a set of strategies addressing the following questions:
   (a) How can ASEAN create a synergy to combine each other's strengths and to ensure that S&T developments in each Member State would not be duplicated but instead be complementary to avoid competition among them?
   (b) How can S&T development in ASEAN, both at national and regional levels, be relevant to the realization of the ASEAN Community by 2015?

In addition, the Study addresses the following questions:

1. How can S&T be harnessed in the creation of wealth in ASEAN?
2. How can S&T help in ensuring equitable distribution of the fruits of development?
3. How can S&T development in ASEAN Member States be accelerated at a much faster rate?

CHAPTER II

METHODOLOGY

The study adopted the following methodology:

A. Selection and organization of the Project Team.
B. Identification of initial sets of information and data needed to hold a project inception meeting involving the members of the Project Team.
C. Holding of the Project Inception Meeting where the objectives and outputs of the project were classified, project activities firmed up, tasks and responsibilities of the Project Team members delineated; guidelines for information and data collection finalized, and a Project Timetable set and agreed upon.
D. Preparation of the Project Inception Report.
E. Preparation and submission of needed information and data by the ASEAN Focal Points.
F. Visits to the ASEAN Member States by ASEAN Experts and Consultants for face-to-face meetings, observations, discussions, and clarifications on the submitted sets of information and data.
G. Analysis of gathered information and data from among the Member States, synthesis of recommendations, and preparation of the Draft Project Report.
H. Submission of the Draft Project Report, dissemination, and distribution to ASEAN Focal Points.
I. Holding of the Summing-Up Meeting where the Draft Project Report will be discussed.
J. Printing and Dissemination of the Final Report.*

The timetable followed for the above activities is shown below:

PROJECT ACTIVITY	MONTH
A&B	June 2011
C&D	July 2011
E&F	August – September 2011
G, H and I	September 2011
J	October – November 2011

Activity I, the Summing-Up Meeting, was held in Makati City, Metro Manila, Philippines on September 28-29, 2011.

As agreed upon during the Project Inception Meeting held on July 4-5, 2011, in Manila, Philippines, each ASEAN National Focal Point of the project would submit the following information and data situationers:

1. S&T Policy and Development Strategy
2. Infrastructure for S&T

* The final Report shall be endorsed by the ASEAN Committee on Science and Technology (COST).

3. Funding for S&T
4. Human resources involved in S&T
5. S&T Outputs
6. S&T Utilization programs
7. Areas of Strength in S&T/R&D
8. Major Contributors to GDP
9. Major Exports
10. Major Trading/Economic Partners in ASEAN

In addition, the Head of the Science and Technology Division Cross-Sectoral Cooperation Directorate of the ASEAN Secretariat requested for the inclusion of the National Technology Innovation Framework.

Guide for Situationers

The guide that was followed for the above set of data/information is shown below:

1. **S&T Policy and Development Strategy**
   - National S&T Plans (latest)
     - Vision for S&T
     - Strategies
     - Policies
     - R&D Priority Areas (current)
   - S&T Laws and Other National Policy Pronouncements
   - Innovation System Framework, Policies, Strategies

2. **Infrastructure for S&T**
   - Institutional Arrangements for R&D
   - Government R&D institutes
   - Government R&D Funding Agencies
   - University-based RDIs
   - Private Business Firms (Research Centres)
     - Linkages
     - Research Consortia
     - Industry - Academe Linkages
     - Intermediaries (Bridging institutions) ex. TBIs, Science Parks, Technology Financing Companies

3. **Funding for S&T R&D**
   - Gross Domestic Expenditure on Research and Development (GERD)
   - GERD as a percentage of GDP
   - Contribution in % of government and private sector to GERD
     - Give latest figures available.
     - Show past year's figures, if available (maximum of 10 years)

4. **Human Resources Involved in S&T R&D**
   - Number of R&D Personnel
   - Number of Researchers

- Give latest figures available.
- Show past year's figures, if available (maximum of 10 years)
- Use Frascati Manual Definition below:

  R&D personnel include all persons employed directly on research and development activities as well as those providing direct services such as research and development managers, administrators and clerical staff. Those providing an indirect service, such as canteen and security staff, should be excluded, even though their wages and salaries are included as an overhead cost when measuring expenditure.

  Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods, and systems and in the management of the project concerned.
  - If the definition used is different from that in Frascati Manual, please indicate.
  - Report the figures in full-time equivalents (FTEs).

- Capability for S&T Human Resource Development in Higher Education Institutions
  - Number of Universities Offering Graduate Degree Programs in Science, Technology, Engineering, and Mathematics
  - List of Universities with Graduate Degree Programs in Science, Technology, Engineering, and Mathematics
  - Average Number of Graduates in Master and Doctoral Levels per Degree Program for Each University during the Last 5 Years

5. **S&T Outputs**
   - Number of Patent Applications in one year
     - Number of Applications from Residents
     - Number of Applications from Foreigners
   - Number of Patents Granted in one year
     - Number of Granted to Residents
     - Number of Granted to Foreigners
   - Number of Internationally Peer-Reviewed Publications
   - Number of Citations of S&T Publications in one year
     - Give the Source (Scopus, ISI, Science and Engineering Index (SEI), etc.)
     - Give latest figure available
     - Show past year's figures, if available (maximum of 10 years)

6. **S&T Utilization Programs Including Indicators of Utilization (In Government, In Industry, In Social Development)**
   - List and Describe National Programs Designed to Facilitate and Ensure
   - Utilization of Generated or Acquired Technologies, Results of R&D and Innovations
   - Mostly Descriptive; include figures, if available

7. **Areas of Strength in S&T (including medicine, health)**
   - On the basis of Technologies and Intellectual Properties Generated and Utilized

- On the basis of Available Expertise
- On the basis of Existing Centres of Excellence
- On the basis of internationally Peer-Reviewed Publications
- On the basis of Hadawi paper, OECD Review of Innovations in South East Asia (presented in Vientiane, Laos)
- On the basis of Research Areas with International Collaboration

8. **Major Contributors to GDP**
   - Indicate Top Contributors in Agriculture
   - Indicate Top Contributors in Mining and Primary Resources
   - Indicate Top Contributors in Manufacturing
   - Indicate Top Contributors in Services
   - Show Percentage Contributions during the Most Recent Year Available

9. **Major Exports**
   - Agriculture, Primary Industries, Manufacturing, Knowledge Industries
   - Rank in Order of Importance or Share
   - Maximum of 10

10. **Major Trading/Economic Partners in ASEAN**

Following the above Methodology, the study report is structured by chapter in the following manner:

CHAPTER I - PROJECT RATIONALE, BACKGROUND AND OBJECTIVES
CHAPTER II - METHODOLOGY FOR THE STUDY
CHAPTER III - COUNTRY SITUATIONERS
CHAPTER IV - ANALYSIS OF THE DIFFERENT FACTORS/INDICATORS
CHAPTER V - OBSERVATIONS/IDEAS FOR MEMBER STATES
CHAPTER VI - RECOMMENDATIONS IN SUPPORT OF AN ASEAN COMMUNITY BY 2015

CHAPTER III

COUNTRY SITUATIONERS

BRUNEI DARUSSALAM

1. **S&T Policy and Development Strategy**

The Brunei Darussalam Long-Term Development Plan contains the National vision (known as *Wawasan* Brunei 2035), the Outline of Strategies and Policies for Development (OSPD) and the National Development Plan (RKN) of Brunei Darussalam.

The Science and Technology, Research and International Division (previously known as Research and Development Unit) under the Ministry of Development is mandated to set up science and technology policy in Brunei. The Science and Technology policy in Brunei is documented in the Science and Technology Guidelines that outlines the priority agenda of researches. Halal foods, downstream oil and gas industries, ICT are among the priorities and research clusters promoted and funded by Brunei Government. The science and technology guidelines are used by the Brunei Research Council (BRC) in reviewing all proposals applying for funding from the government.

The first OSPD (2007-2012) elaborates the eight strategies underlined in the National Vision through 50 policy directions. It will be/was used as a guide to policy makers and implementers to prepare development programs and projects for a period of 10 years towards accomplishing the *Wawasan* goals.

In the areas of STI, focus is on (i) strengthening the STI institutional setup and arrangement, (ii) strengthening the existing STI infrastructure, (iii) financing STI research and promotion, and (iv) human capacity building from primary to tertiary level.

Toward the Knowledge-Base Economy, STI related activities focus on the promoted sectors such as financial services, development of halal products, and downstream oil industries.

Funding for all research and STI activities come from JPKE under the National Development Plan. STI/RDU, MOD monitors and coordinates the funding and is its custodian.

In addition to the science and technology policy, which regulates the research activities, science education and technology skill training is regulated by Brunei's Education Policy. Through the institution of systematic and structured reforms, with respect to education policy, structure, curriculum, assessment and qualifications, and professional development, Brunei aspires to transform its education landscape in support of the nation's drive to realize its Brunei Vision 2035 (*Wawasan* Brunei 2035).

In 1993, the 9-Year Education Policy was replaced by a 12-Year Education Policy, which mandates seven years of education in pre-school and primary, three years in lower secondary, and two years in upper secondary or vocational/technical education. In 2003, the new Education Order was inaugurated to achieve the status of an effective, efficient, and equitable system of education that would be both consonant with the national philosophy of Malay Islamic Monarchy as well as the needs of a modern, technological and ICT era. In 2007, the Compulsory Education Order 2007 was enacted, mandating that every Brunei residing in the country will have to receive compulsory education for at least nine years. The success of these educational policy changes through years was seen in Brunei's progressive improvements in its literacy rates from only 69% in 1971 to 80.3% in 1981, 89.2% in 1991 and 94.7% in 2001.

The high standard of mathematics and science education in Brunei Darussalam is revealed in the ranking of the quality of math and science education, which positioned Brunei at second place after Singapore among ASEAN Member States and 27th worldwide (with Singapore ranked at 1st place). However, the high standard imposed by BC GCE 'A' level' for university entrance has been found to cause relatively low tertiary education enrollment rates even by ASEAN standards, which is only 16% below Singapore (60%), Thailand (44.7%), Malaysia (32.1%), Philippines (28.7%) and Indonesia (21.3%).

2. Infrastructure for S&T

a. Science and Technology, Research and International Division (STI), Ministry of Development

The STI, under the Ministry of Development, is responsible for overseeing the nation's science and technology efforts. The Division is responsible for coordinating science activities locally, regionally, and internationally and for supporting R&D by funding research projects and science and technology activities (with funding coming from JPKE).

The National Committee on Science and Technology (NSTC) was formed in 1994, chaired by the Minister of Development. The mission of the committee is to promote and encourage the development of science and technology in the interest of national development. Its main objective is to ensure that S&T can effectively contribute to economy, environment, social and cultural development. Specifically, this committee is in charge of regulating the development of S&T in Brunei Darussalam, formulating policy towards expansion of S&T, and developing physical infrastructure for expansion of S&T in Brunei Darussalam.

To ensure the accomplishment of the abovementioned three main goals, eight strategies have been identified to ensure that all aspects of the development are implemented systematically and effectively. The eight strategies include the following: (i) education strategy, (ii) economic strategy (iii) security strategy, (iv) institutional development strategy, (v) local business development strategy, (vi)

infrastructure development strategy, (vii) social strategy, and (viii) environment strategy.

b. **Brunei Research Council**

In order to set the policy direction for research and development (R&D) and innovation, His Majesty's Government established the Brunei Research Council (BRC) under the Prime Minister's Office. The Council is presently located at the Department of Economic Planning and Development, which functions as its Secretariat. The Council is responsible for the formulation and determination of national policies on research and guidelines for promoting, facilitating, coordinating, and regulating the conduct of research activities in Brunei Darussalam. The Council has been active in identifying priority science and technology clusters to help Brunei Darussalam to develop its niche among the other already well-established players in the global arena.

c. **University-Based Research Institutes**

i. *Sultan Omar Ali Saifuddien (SOAS) Centre for Islamic Studies, University of Brunei Darussalam (UBD)*
The centre aims to generate Islamic experts and scholars capable of exploring contemporary issues in the context of Islam and appreciating and understanding Islam in the people's daily lives from the political, economic, and social perspectives.

ii. *Kuala Belalong Field Studies Centre*
Set up by UBD in 1991, it is located deep in the Temburong District's unspoiled jungle as an international focus for biodiversity research into the threatened rainforests of Borneo.

iii. *Institute of ASIAN Studies*
Administered under UBD, the institute focuses on research in historical, cultural, and social issues in Asia and has four subsidiary units namely—the East Asian Research Group, the ASEAN Research Group, the South Asian Research Group, and the Borneo Research Group.

iv. *UBD-IBM Centre*
Universiti Brunei Darussalam (UBD) has acquired an IBM Blue Gene supercomputer—the first of its kind in the ASEAN region.

v. *e-Government Innovation Centre (eG.InC)*
The eG.InC facilitates the collaboration (including the conduct of training programs and workshops) of Government agencies and industries to support the successful implementation of e-government. The key research areas in eG.Inc, in collaboration with experts from KAIST, include the following:
- Governance, Legislation, policy and standards
- Agile enterprise infrastructure
- National authentication and online security
- E-government roadmaps
- E-government portals and channels strategy and consultancy
- E-government evaluation and monitoring
- Business process reengineering for government services

d. **Institut Teknologi Brunei (ITB)**

ITB offers Higher National Diplomas and undergraduate degree programs in the fields of Engineering, Business, and Computing. Programs are offered in the areas of Business, Computing and Information Systems, Civil Engineering, Mechanical Engineering, Electrical & Electronics Engineering, Petroleum and Chemical Engineering. Since 1986, ITB has focused on meeting the national labor needs by enrolling a high percentage of local Bruneian students. However, a small percentage of international students have been and are currently enrolled in ITB programs. Through ITB's international outreach activities, Queens University Belfast (United Kingdom), the University of New South Wales (Australia), Shell International Exploration & Production (Singapore), Brunei Shell Petroleum and Brunei Liquefied Natural Gas are now among those universities and industries affiliated as partners of ITB currently collaborating in education and R&D activities.

Six research clusters within ITB have been identified. These include Electrical Power and Energy, Product and Manufacturing, Electronics and Communication, Computing and Information Systems, Business and Industrial Management and Civil, Environmental and Sustainability Engineering.

e. **Research Institutes under the Ministry of Industry and Primary Resources (MIPR)**

i. *Aquaculture Research And Development Division*
The Aquaculture Research and Development Division conducts research and development of aquaculture technology especially on fish/shrimp culture and fry production, verification of new culture technology as well as new species monitoring of aquaculture areas aiming to increase the productivity of aquaculture industry in Negara Brunei Darussalam.

ii. *Agro-Technology Research and Development Division*
Established in the Department of Agriculture and Agrifood under the Ministry of Industry and Primary Resources, this division is tasked to perform the following functions:

(1) To facilitate and assist agricultural entrepreneurs to deliver Halal, quality, safe, environmental friendly and market oriented agricultural and agri-food products;

(2) To generate strategic and innovative technologies in relevant areas of agro-technology to promote sustainable development of the agriculture and agri-food industries;

(3) To support the development of local agriculture and agri-food industries by providing advisory, consultancy, technical services and technology transfer in relevant areas of agro-technology to the industries;

(4) To upgrade expertise and capabilities in relevant sectors of agro-technology to support enhancement of further development of the agriculture and agri-food industries; and

(5) To assist in enforcement of regulations, guidelines and standards in the agricultural and agri-food industries.

The main units under the Agro-technology Development Division are Post Harvest & Food Technology, Farming Technology, Biotechnology, Soil and Plant Nutrient, Agrochemical Technology.

iii. *Science, Technology and Environment Partnership Centre (STEP)*
The centre facilitates and supports the implementation of the MoE's policies and strategy plan, and any other relevant national and international goals and objectives related to the fields of STE including mathematics and science education. The centre supports the MoE in achieving the goals and objectives of international organizations, including ASEAN, UNESCO, Islamic Educational Scientific and Cultural Organization (ISESCO) and the Commonwealth.

3. **Funding for R&D**

The R&D budget of Brunei is controlled by the Department of Economic Planning and Development (JPKE) under the Prime Minister's Office, and partly by the Science and Technology, Research and International Division under the Ministry of Development. The total R&D expenditure (GERD, budget base) is 63 Million Bruneian Dollars for Development Term 2007—2012, equivalent to 0.12% of GDP on a yearly basis. According to the Science and Technology Indicators survey by the Science and Technology, Research and International Division, in 2004, 91.1% of research funding came from the government and less than 0.1% from industries.

4. **Human Resources Involved in R&D**

a. **Human Resource Statistical Data**
R&D personnel in Brunei Darussalam number 244 (headcount, data 2004, including 99 women researchers, equivalent to 0.102 R&D personnel per 1000 population). No newer data is available and no specific definition on the R&D personnel exists. The R&D personnel are mostly affiliated with the University of Brunei Darussalam and Institute of Technology Brunei.

b. **Capability for S&T Human Resource Development in Higher Education Institutions**
The Brunei education system produces scientists and technologists in the oil and gas producing sector, the Ministry of Industry and Primary Resources (Agriculture, Fishery, and Forestry), health and education. Science has been introduced in lower secondary schools, and continues to be offered as National Diploma, Higher National Diploma, and both under- and postgraduate degree programs. By 2010, University Brunei Darussalam had 366 academic staff, including 229 (63%) local and 137 (37%) expatriate. For local staff, this number includes 9 Associate Professors, 49 Senior Lecturers, 140 Lecturers, and 31 Tutors. Contractual staff members include 12 Professors, 28 Associate Professors, 69 Senior Lecturers, 25 Lecturers, 2 Tutors and 1 Assistant Lecturer (UBD Statistics 2010).

5. **S&T Outputs**
Patents and publications are not well developed and documented in Brunei.

Based on 2004 S&T Indicators, there are 17 SCI journal articles and 2 applications to the US PTO. Most publications and patents are from the University of Brunei Darussalam and the Institute of Technology Brunei. First round S&T contribution per faculty include the Faculty of Science (FOS) $594.060,97; PAPRSB Institute of Health Sciences (IHS) $1.543.433,50; and Faculty of Arts and Social Sciences (FASS) $59.304,00. The second round includes Faculty of Science (FOS) $16.670.540,00; PAPRSB Institute of Health Sciences (IHS) $48.974,80; Faculty of Arts and Social Sciences (FASS) $607.671,12; Sultan Hassanal Bolkiah Institute of Education (SHBIE) $387.499,00; and Faculty of Business, Economics and Policies Studies (FBEPS) $180.583,20. No newer data is available.

6. **S&T Utilization Programs including Indicators of Utilization**

a. **Brunei Agro-Technology Park**
The park is a major 263-hectare site development close to the capital Bandar Seri Begawan. The Park attracts research and innovative technology applicants with a particular focus on life sciences-based activities in agriculture, fisheries, and forestry. The park is an industrial site for manufacturing, storage, transportation, research and development and other Halal related support services.

b. **Halal Science Centre**
The establishment of a Halal Science Centre is in line with Brunei Darussalam's aspiration to develop its ability to provide accreditation services for Brunei Halal Certification process and Brunei Halal brand project. This initiative streamlines Brunei's current capabilities in research and development and in analytical services supported by world-class technologies and expertise. At the initial stage, laboratory work will be concentrated on primary food ingredients for example, cooking oil, preservatives, and other basic food ingredients. On a later stage, the centre will be able to examine and analyze various food ingredients and will venture out to analyze non-food products.

c. **Innovation and Enterprise Office (IEO) in UBD**
Efforts for promoting innovation and entrepreneurship in UBD are supported by the Innovation and Enterprise Office. The office provides information, advice, and the commercialization of intellectual property rights. The office also helps researchers, entrepreneurs, and organizations obtain intellectual property rights, including patents, trademarks, copyrights, and trade secrets.

7. **Areas of Strength in S&T (including medicine, health)**

Biodiversity, energy, halal food, food security, agro-technology, climate change, Asian studies, and Islamic banking and finance are among areas of strength in science and technology in Brunei.

a. **Biodiversity**
The forests of Brunei Darussalam are among the most diverse in the world. The country is among the top 10 nations that have a very high percentage of forested land area (58%). UBD recently launched the "Global Earth Observatory

Project" with the Centre of Tropical Rainforest Science of Harvard University in partnership with the Smithsonian Tropical Research Institute of Panama.

b. **Energy**
Brunei Darussalam's oil and gas industry forms the heart of the country's economy currently, but the national economy policy continues to diversify its economy for long-term sustainable development. Brunei, especially UBD has an extensive research program on energy, particularly renewable and alternative energy.

c. **Food Security/Agrotechnology**
Food security is one of the foremost goals of the Ministry of Industry and Primary Resources (MIPR). The government aims to achieve 60% self-sufficiency in rice production by 2015. UBD helps to carry out research in this important area.

d. **Climate change modeling**
The collaboration between UBD and IBM provides UBD researchers the opportunity to work with world-class researchers from IBM's global research laboratories on projects that analyze and assess the current and future impact of climate change in the ASEAN region.

e. **Asian studies**
Strategically located in the hub of Asia, Brunei Darussalam has access to a wealth of resources and knowledge that enables UBD to set up research programs and research clusters focusing on historical, economic, cultural, and social issues in the region.

f. **Islamic Banking and Finance**
Islamic banking and finance has grown in global importance and is becoming an integral part of the banking and finance sector. The level of penetration of Islamic finance in Brunei Darussalam is the highest in the region, at approximately 40%.

8. **Major Contributions to GDP**

The major contributions to GDP are oil, natural gas, garments, and agriculture.

9. **Brunei Major Exports**

Exports commodities in Brunei included crude oil, natural gas, and Brunei's main exports and the country's economic mainstays include petroleum, liquefied gas, and its products. The government is attempting to promote economic diversification like clothing manufacture, banking, tourism, and construction industries.

10. **Major Trading/Economic Partners in ASEAN**

Brunei's exports partners are Indonesia (10.8%), Malaysia (1.6%), Singapore (2.6%) and Thailand (1.9) (JPKE – External Trade Statistics 2009). Oil and natural gas account for almost all exports. Since only a few products other than petroleum are produced locally, a wide variety of items must be imported. Brunei statistics show Singapore as the largest point of origin of imports, accounting for 25% in 1997. Japan and Malaysia were the second-largest suppliers.

CAMBODIA

1. S&T Policy and Development Strategy

As of today, Cambodia has not developed a comprehensive Science and Technology policy. Many elements for promoting S&T innovations are, however, implicitly present in the National Strategic Development Plan (2006-2010 and 2009-2013). The establishment of some institutions also reflects the areas where S&T can be used to improve productivity. Established in 1998, the Council for Agriculture and Rural Development cites the goal of improving agricultural productivity and diversification as well as the creation of non-agricultural rural private enterprises.

In addition, the National Information & Communication Technology Development Council was established in 2003 to formulate policies for Information Technology (IT) promotion and development. Another important government agency, the National Training Board, which was created in 2005, is tasked to prepare the national policy and the national training plan for technical and vocational education.

In 2006, the Law on Patents, Utility Model Certificates, and Industrial Designs was passed indicating a desire to harness innovations for economic development. The areas where S&T can be used for improved productivity are the key products that have been identified to have export potential. Meanwhile, the National Export strategy identifies products that could be developed into successful exports. This strategy also articulates the steps that could be taken to reinforce the competitiveness of garments, fruits and vegetables, organic rice, silk and silk products, and fresh water fish, all of which have high export potential. Aside from garments and agricultural products, tourism and construction are expected to play major roles in the economy in the coming years.

In terms of broad areas, the national development priorities for S&T are agriculture, engineering and technology, and the natural sciences.

Cambodia would also like to focus on technology development and application efforts to improve small and medium enterprises (SMEs). More than 31,000 SMEs are found in the manufacturing sector. In view of this, Cambodia has have identified four pillars for technology transfer to SMEs. These include upgrading of standards and product quality, linkages between industry and the research and development sectors, promotion of technologies to SMEs, and provision of skilled labor.

2. Infrastructure for S&T

Cambodia has a Council of Ministers, which prepares the National Strategy Development Plan (NSDP). The current plan is for the period 2009-2013. There is also a National Committee for Science and Technology. The ministries involved in S&T affairs or programs are the following:

- Ministry of Industry, Mines and Energy (MIME)
- Ministry of Education, Youth and Sport (MOEYS)
- Ministry of Agriculture, Forestry and Fisheries (MAFF)
- Ministry of Health (MOH)

- Ministry of Public Works and Transport (MPWT)
- Ministry of Post and Telecommunications (MPTC)
- Ministry of Land Management, Urban Planning and Construction
- Ministry of Environment (MOE)
- Ministry of Labour and Vocational Training (MOLVT) (Technical Education)
- Ministry of Commerce (MOC) and Cambodian Investment Board (CIB)
- Ministry of Economy and Finance (MEF)

Cambodia has 11 ministries that supervise 33 public universities. The biggest number is under the Ministry of Education. The Ministry of Agriculture supervises the Royal University of Agriculture. The Ministry of Health supervises the medical universities. The Ministry of Posts and Telecommunications supervises the Institute of Technology of Cambodia (ICT).

The Ministry of Commerce takes care of technology transfer and the Ministry of Industry, Mines and Energy (MIME) has under it the General Department of Industry where the Department of Industrial Techniques and S&T office and the Department of Intellectual Property, Creativity and Innovation Center can be found.

The Industrial Laboratory Center of Cambodia (ILCC), which takes care of standards and testing through its 4 divisions, Microbiology, Water Testing, Food Testing, and Non Food Testing, works under the Department of Industrial Techniques of MIME. The National Metrology Center is also under MIME's General Department of Industry.

The National Committee for Science and Technology, which was created in 1999, coordinates and facilitates the activities and tasks related to ASEAN initiatives in S&T.

3. Human Resources Involved in S&T R&D

In spite of the presence of the Institute of Technology of Cambodia (ITC), the Royal University of Agriculture, the medical universities, the universities under the Ministry of Education, and the rest of the 33 public universities, there is a general perception that the supply of highly trained scientist and engineers is limited. The capacity of the higher education institutions (HEIs) has not caught up with demand even though there is strong support from Government and international development partners.

- **Capability for S&T Human Resource Development in Higher Education Institutions**

While Cambodia can boast of some higher educational institutions with very good standards like ITC, RUA, University of Science for Health, Royal Academy of Cambodia, and Royal Pham Penh University, these universities need to beef up their capacity in terms of research capability and faculty development.

Some sample indicators show the following:

- RUA: 140 fulltime faculty

- 11 PhD holders
- Graduated 5 PhDs so far

- ITC : 157 fulltime faculty
  - 20% have PhD
  - in addition 150 young faculty and researchers are on training abroad

4. Expenditures for S&T R&D

Unofficial estimates of R&D expenditures as a percentage of GDP from the Ministry of Education is placed at .05%. The contributors to this R&D expenditure figures include the following:

Government Organization	-	25%
Universities	-	12%
Business Sector	-	12%
International/NGO donors	-	51%

The funds used by the different ministries for S&T activities particularly for human resource development and for the performance of various services are sourced from their respective budget allocations. R&D is funded mostly by international or foreign funding organizations. There is no clear funding program for R&D from Government. The private sector, on the other hand, is not yet in a good position to channel funds for R&D.

5. S&T Outputs

It is estimated that 396 scientific papers have been published with Cambodian authors/co-authors. About 94% of this involved co-authorship with researchers from other countries. This is an unofficial estimate from the Ministry of Education.

- **Number of Patent Applications in one year**
  Since the Law on Patents, Utility Model Certificates, and Industrial Designs was passed in 2006, 27 application for patents and 42 applications for industrial designs have been received by the Office of Patents. No applications for utility model certificates have been received so far. All 27 patent applications have been filed by foreigners. Almost all of the applications for industrial design (40 out of 42) were also filed by foreigners. To date no patent application has been approved yet while in the case of industrial designs, 40 have already been registered. The patent applications are mostly in the fields of Mechanical, Electronics, and Chemistry. Patent approvals are already expected before the year 2011 ends. Most Cambodian researchers are already aware of the patenting system in Cambodia.

- **Number of Internationally Peer-Reviewed Publications**
  While no complete statistics on researches completed in a year is available, the following sample indicators were obtained from three leading research institutions:
  - Royal university of Agriculture (RUA) – 10 projects ongoing
  - Cambodian Agricultural Research and Development Institute (CARDI) – 30 projects ongoing

- Institute of Technology of Cambodia (ICT) – 20 projects ongoing

The research outputs produced at RUA are in the area of post harvest processing, animal science, agronomy, soil science, plant pathology, fishery breeding, reforestation, and community development.

The research achievements of CARDI, on the other hand, are in terms of 3,217 crop accessions (2,595 for rice), 38 rice varieties released, 49% of rice fields covered by their rice varieties released, and 4 mung bean varieties developed. All of these were done within their first decade of existence.

Examples of R&D Projects in ITC are in biomass, biofuels, renewable energy, and environment.

6. S&T Utilization Programs Including Indicators of Utilization

In the absence of a centralized S&T office to monitor different S&T activities, particularly S&T utilization programs, there is no comprehensive report that can be given regarding this. The case of CARDI, however, looks like a best practice model for the utilization of outputs from R&D in S&T. CARDI, in addition to its Division for Agricultural Research and Increased Productivity, operates a Division on Agricultural Research on Diversification and Extension, as well as a Planning Collaboration and Business Office. Since CARDI's goal is to improve the living standards of all Cambodians, especially farmers, through agricultural research, its ultimate measure of performance is in terms of its research outputs, which are utilized by farmers whether these are accession samples, new crop varieties, new fertilizers, new pest control systems, new post harvest methods or new soil maps. CARDI monitors the percentage of fields or farms, which they are able to cover in their extension work.

7. Areas of Strength in S&T

Based on existing infrastructure, human resources, actual production performance, and potential, it appears that Cambodia's S&T niches, now or in the future, will include agriculture, mines and minerals, and possibly construction.

8. Major Contributors to GDP

Cambodia's major contributors to GDP are agriculture, garments, tourism, and construction.

9. Major Exports

Cambodia's major exports are garments, tourism, fruits and vegetables, fresh water fish, organic rice, and silk and silk products.

INDONESIA

1. S&T Policy and Development Strategy

The important role of science and technology for development is stipulated in the amendment of Indonesian Constitution of 1945. As the highest national consensus, the 1945 Constitution asserts that the mastery and application of science and technology is one of the Indonesian citizen's rights that must be fulfilled by the state. The assertion is contained in Article 28C Paragraph (1) of the 1945 Constitution, which reads, "Everyone has the right to develop themselves through the fulfillment of basic needs, is entitled to education and to benefit from science and technology, arts and culture, for improving the quality of life and for the welfare of the people."

To meet the demands of the rights of each citizen to science and technology, Chapter XIII of the 1945 Constitution on Education and Culture Article 31 Paragraph (5) determines that "the Government is to advance science and technology for the advancement of civilization and welfare of mankind while upholding religious values and national unity." Thus, it can be said that science is a human right and the government is obliged to advance science and technology in the country.

Vision and Mission of S&T Development

Science and technology development plans 2010-2014 are formulated in the S&T National Development Strategies (*Jakstranas* IPTEK) that was promulgated by the Minister of Research and Technology. National development of science and technology are planned and carried out in accordance with long- and medium-term of national development planning. The vision of national S&T development is "Science for the welfare and progress of civilization." The vision implies that science and technology development is essentially aimed at improving the economy and will ultimately improve the welfare and living standards of the nation, and aims to create a quality life of the nation economically, socially and culturally.

Indonesian S&T Development Strategic Framework

The National Mid-term Development Planning (NMDP 2010-2014) and the National Research Agenda (NRA) promulgated by the Minister of Research and Technology have identified the expected direction of S&T development in the context of Indonesia. In principle, S&T development efforts are directed towards two main goals: strengthening of national innovation system and improving the quality of R&D and S&T application.

The second area of development aims at improving the quality of Research and Development in seven focus areas: food security, energy security, ICT, transportation technology, defense technology, health and medicine, and advanced material technology. Research priorities in these seven foci have been determined and elaborated in the National Research Agenda 2010-2014, promulgated by the Minister of Research and Technology.

In May 2011, the Government of Indonesia launched a new policy direction aimed at accelerating the Indonesian economic development. The policy direction, which is called the Master Plan for Acceleration and Expansion of Indonesia Economic Development 2011 – 2025, has explicitly stated that ***S&T and Human Capital Development*** is one of the three pillars for the acceleration program. The two other pillars are ***Economic Potential Development through Economic Corridors*** and ***Strengthening the National Connectivity***.

The efforts to increase productivity towards the creation of competitive advantage can be achieved with the innovation-based human resource capacity development. The legacy of a natural resource-based economy, which is labor intensive, needs to be gradually improved towards being skilled labor intensive and eventually to human capital intensive. The improvement of human capital mastering science and technology is highly needed when Indonesia enters into the innovation-driven economies stage.

To realize the increase of productivity, it is recommended that Indonesia apply the Presidential Innovation Initiative 1-747 as a key driver in the transformation to an innovation-based economic system by strengthening the education system (human capital) and technological innovation capacity. Under the Presidential Innovation Initiative 1-747, one percent of the GDP will be earmarked towards this strategy. This proportion should be increased gradually to 3% of GDP by 2025. Research and development funding portion as mentioned above, comes from the Government and the business sector. The transformation will be carried out through the Seven Improvement Steps of Innovation Ecosystems, while the process will be carried out using Four Acceleration Economic Development Instruments as a model to strengthen key stakeholders in innovation, including tertiary institutions and community colleges. Therefore, it is expected that the Seven Innovation Targets in 2025 in the field of Human Resources and Science & Technology will be achieved in order to ensure sustainable economic growth. In line with the economic progress of the factor-driven economy towards innovation-driven economy, it is expected over time that the role of government in funding R&D will decrease and the role of the private sector in funding R&D will increase.

Innovation Implementation Initiatives in MP3EI

The following are some initiatives of innovation implementation that will support the success of MP3EI:

- Cluster Development in Support of Six Economic Corridors should be accompanied by innovation cluster strengthening as the center of excellence in order to improve the ability for innovation to enhance competitiveness. The development of the Center of Excellence is expected to integrate with industrial clusters.
- Revitalization of the PUSPIPTEK as Science & Technology (S&T) Park should deliver innovation-based SMI/SME in the various strategic areas, which are able to optimize interaction and utilization of university, research, and development institutions, and business resources so that it is able to produce innovative products. To maintain the continuity of the management of the S & T Park, it is necessary to carry out the following steps:

i. Make PUSPIPTEK a professionally managed Public Service Agency (Badan Layanan Umum/BLU) in order to create links between businesses and research.
ii. Make PUSPIPTEK a leading center of high-tech research.
iii. Establish Regional Innovation Cluster for Equitable Growth. MP3EI encourages and empowers efforts by the communities, business entities, and local governments that already have initiatives to develop innovation potentials on regional prime products and programs, such as the following:
    - Agro-industry Innovation Zone Development Model, in North Gresik, East Java Province;
    - Integrated Downstream Innovation Program Development Model, to develop palm oil, cocoa, and fisheries;
    - Non-Renewable and Renewable Energy Based Innovation Zone Development Model, in East Kalimantan Province; and
    - Strengthening of Innovation Stakeholders.

- A key factor for the successful implementation of MP3EI depends on smart and effective effort of innovation stakeholders consisting of academicians and researchers, business and industry, citizens, legislators, and government. Some of the following ideas have to be executed in the smart planning and utilization of the nation's potential in order to build a developed and dignified Indonesia:
    - Creation of human resources that have the competence, high level of integrity through a combined curriculum of science & technology, social value, and humanities education.
    - Optimization of the deployment of existing highly educated workforce, particularly those with master and doctoral degrees and overtime increase the number of PhD holders in science and technology to 7,000 – 10,000 by 2014.
    - Establishment of internationally accredited standard laboratories both in basic and applied science in universities, vocational and non-vocational R&D institutes, and in private research centers.
    - Encouragement of international cooperation to create better understanding and application of S&T and the utilization of best practices that have been developed in various countries.

Strengthening of Operation of the National Innovation System

The development of innovation products of an invention involves three main stakeholders in national innovation systems, namely: (a) the government as regulator, facilitator, and catalyst, (b) business/industry as the users of the invention, and (c) research institutions and universities as incubators of the invention. The collaboration of these three main stakeholders is very important and necessary for the development of innovative products.

In order to develop innovation, the Government will provide:

- Fiscal incentives will be offered to businesses (private and state-owned) that are developing innovation and to foreign companies that are using technology that was developed by Indonesia or transferring technology that was developed by foreign countries to Indonesia.

- Research funds will be granted to the innovation developer with the following conditions: (a) the innovative products have to meet the needs and interests of the industry; and (b) the innovative products have to be proven to have the ability to improve the productivity of the industries concerned. These requirements are important for the development of national innovation. The private sector is requested to become a major driver of innovation by providing information regarding state of the art technological invention needs, which have high market value.

Government Policy Framework for S&T Development

The implementation of national science and technology development is promulgated in Law No. 18 of 2002 on the National System of Research, Development, and Application of Science and Law No. 17 of 2007 on the National Long Term Development Plan (RPJPN) 2005-2025. Related regulations concerning with science and technology development in Indonesia are the following:

- Presidential Regulation No. 5 2010 concerning the National Mid-term Development Planning (NMDP) 2010-2014;
- Presidential Instruction No. 4 2003 on the Strategic Policy Formulation and Implementation of National Science and Technology Development;
- Government Regulation no. 20 2005 on Intellectual Property and Technology Transfer by Universities and Research and Development Institutes;
- Government Regulation no. 41 2006 on Research and Development permit for Foreign Institutions;
- Government Regulation no. 35 2007 on the Allocation of a portion of business revenues for Engineering Capability Improvement, Innovation and Diffusion of Technology; and
- Government Regulation no. 48 2009 regulating the Implementation of High Risk and Dangerous R&D and Application of S&T activities.

National science and technology development policies outlined in the Strategic Policy for National Development of science and technology (Jakstranas Science) year 2010-2014 are as follows:

- To increase capacity and capability of all science and technology resources in order to increase R&D productivity that is useful for the national production sector;
- To increase institutional capacity of R&D institutes and their supporting institutions to support the transfer R&D products to commercial products (the strengthening of national innovation systems);
- To develop and strengthen institutional and researcher networks at national and international level to support R&D productivity and utilization of national R&D results;
- To improve creativity and productivity of the national R&D to meet the needs of technology of the production sector and to improve competitiveness of national products and culture of innovation;
- To increase the utilization of national S&T for economic growth and creation of new jobs, and for the growing public awareness of the importance of S&T; and

- To give priority to the seven S&T priority development areas as listed in the National Long-term Development Plan 2005–2025 and National Medium-term Development Plan 2010-2014.

R&D Priority Agenda

Referring to the National Long Term Development Plan 2005-2025 and aiming to maintain continuity with what has been done in the previous five-year period, S&T development will support the following areas: Food Security, Energy, Transportation Technology and Management, Information and Communication Technology, Defense and Security Technology, Health and Medicine, and Advanced Materials.

2. Infrastructure for S&T

Institutional Arrangements for R&D

A number of institutions play important roles in S&T development in Indonesia. Most central is the Ministry of Research and Technology, whose role is essential in the formulation of research and technology policies, as well as in the coordination and synchronization of policy implementation of research and technology. Two other agencies are vital to R&D in Indonesia: The National Development Planning Agency, which formulated Indonesia's science and technology policy in the National Medium-Term Development Plan (RPJMN), and the Ministry of Finance, which is responsible for program and budget allocation for planning.

Other bodies related to S&T policy are the National Research Council of Indonesia whose duty is to assist the Ministry of Research and Technology in the formulation of research and technology policies and the Indonesian Academy of Science AIPI that reviews, monitors assesses, sets directions, and solves problems affecting the development and utilization of science and technology. The regulation of the Indonesian Academy of Science AIPI is stipulated in Act No. 8 of 1990.

Government R&D Institutes

Non-Ministerial R&D Institutes under the Ministry of Research and Technology

- Indonesian Institute of Science (LIPI)
- The Agency for The Assessment and Application of Technology (BPPT)
- National Institute of Aeronautics and Space (LAPAN)
- National Coordination Agency for Survey and Mapping (Bakosurtanal)
- The National Nuclear Energy of Indonesia (BATAN)
- National Standardization Agency of Indonesia (BSN)
- Nuclear energy Regulatory Agency of Indonesia (Bapeten)
- Eijkman Institute for molecular biology and biotechnology
- Center of Meteorology Climatology and Geophysics (BMKG)

Ministerial R&D Institutes

Ministerial R&D Institutes are responsible for research and development to support the program of ministry. There are 18 ministerial R&D institutes in Indonesia. These include the following:

- Ministry of Foreign Affairs

- Ministry of Internal Affairs
- Ministry of Defense
- Ministry of Law and Human Rights
- Ministry of Energy and Mineral Resources
- Ministry of Industry, Ministry of Trade
- Ministry of Agriculture
- Ministry of Forestry
- Ministry of Transportation
- Ministry of Marine Affairs and Fisheries
- Ministry of Manpower and Transmigration
- Ministry of Public Works
- Ministry of health
- Ministry of National Education
- Ministry of Social Affairs
- Ministry of Religious Affairs
- Ministry of Communication and Informatics

Regional Research and Development Agency

The Regional Research and Development Agency is a unit under the regional government and is responsible for research and development to support the program of regional governments. There are 69 Regional Research and Development Agencies all over the country.

University-based R&D Institutes

University-based research institutes are available in every state university and some private universities. Fifty university-based R&D institutes are owned by the state universities.

- The **University of Indonesia** conducts exceptional university-based researches in the fields of Nutrition, Dietetics, Public Health, Gastroenterology, Hepatology, Endocrinology, Metabolism, Nuclear Physics, Infectious Diseases, Electrical & Electronic Engineering, Multidisciplinary Materials Science, Obstetrics & Gynecology, Pharmacology & Pharmacy, and Applied Physics.
- The **Bandung Institute of Technology** is excellent in the research fields of Electrical & Electronic Engineering, Applied Physics, Computer Science, Artificial Intelligence, Computer Science Theory Methods, Multidisciplinary Materials Science, Physics, Condensed Matter, and Telecommunications.
- The **Gadjah Mada University** is dedicated to the research fields of Pharmacology & Pharmacy, Plant Sciences, Public Environmental Occupational Health, Anthropology, Evolutionary Biology Oncology, Food Science Technology, Biotechnology Applied Microbiology, Physics Applied Microbiology, Engineering Chemical, Immunology, and Multidisciplinary Materials Science.
- The **Bogor Agricultural University** is well known in the research fields of Zoology, Plant Sciences, Ecology, Food Science Technology, Biotechnology Applied Microbiology, Genetics & Heredity, Microbiology, and Agronomy.

Private Non-Profit Institutions that play a significant role in R&D

- **The Foundation of Telecommunication and Informatics Research-Jakarta**
- **Indonesian Society for Non-Destructive Testing-Jakarta** conducts policy-oriented studies on domestic and international issues.
- **The Institute for Social and Economic Research, Education and Information (LP3ES)-Jakarta** leads in policy research and academic publishing related to strategic issues.
- **The Laboratory of Development and Environment (Lablink)-Bandung** undertakes research activities and consultation in the field of environment and development.
- **The Indonesian Center for Biodiversity and Biotechnology (ICBB)-Bogor** is outstanding as it fulfills its mission to develop the people's awareness of biodiversity and biotechnology.
- **The Center for International Forestry Research (CIFOR)-Bogor** leads in research and management of forests in less-developed countries.
- **The Bremen Overseas Research and Development Association (BORDA)-Yogyakarta** runs researches in the fields of poverty alleviation, sustainable protection of natural resources, and the strengthening the social structure.
- **The Research Triangle Institute (RTI)-Jakarta** carries out research in the areas of health and pharmaceutical development, education and training, conducts surveys and statistics, and works in advanced technology, international development, economic and social policy, energy and the environment, and laboratory testing and chemical analysis.
- **The International Center for Research in Agroforesty (ICRAF)-Bogor** manages research activities to alleviate tropical deforestation, land depletion, and rural poverty through the development and promotion of improved agroforesty systems.
- **The International Rice Research Institute (IRRI)-Bogor** is a research and training organization that works to improve the well-being of poor rice farmers and consumers, as well as to enhance and protect the environment.

Research Consortia

- **The Indonesian Ganoderma Consortium** upholds the collective interest of practitioners in the palm industry to overcome the quick-spreading Ganoderma disease. The members of consortium consist of industry proprietors, research institutes, and officers from the Ministry of Agriculture.
- **The Indonesian Biotechnology Consortium** is prominent for its research activities in development and application of knowledge and technology in biotechnology. The members of the Indonesian Biotechnology Consortium are research institutes, universities, and industries.
- **The North Sulawesi Mitra Bahari Consortium** is a collaboration between government and non-government organizations to optimize the roles of various stakeholders in maritime activities

Science and Techno Parks

- The Centre of Science and Technology Research (Puspiptek-Serpong)
- The Cibinong Science Center (CSC-LIPI)
- The Bogor Botanical Garden (LIPI)
- The Agro Techno Park is a pilot area of cultivation and processing technology for agriculture. There are five agro-techno parks in Indonesia situated in Palembang, Bahorok, Minahasa Utara, Kota West Sumatera, and Jimbaran Bali.
- Solo Techno Park is a center for education and technology that promotes regional development
- Jababeka Education Park provides a vibrant and creative academic environment to children and the young residing in Kota Jababeka and surroundings.
- National Parks as conservation areas whose native ecosystems are managed with zone systems used for research, science, education, culture, and tourism.

3. Human Resources Involved in R&D

Table 9 presents the headcount of overall human resources in R&D in Indonesia, which includes researchers, technicians, and support staff. The R&D Personnel are dominated by R&D Researchers (65% of the total R&D Personnel), 53% of whom hold master's degrees. The government sector contributes the highest number of R&D Personnel with a headcount of 27,261 (comprising 43% of the total number of R&D Personnel). The total headcount of researchers comes from the university sector—7,335 persons (34.7%); the industrial sector—7,588 persons (35.9%); and the government sector—6,224 persons (29.4%).

Table 9
Indonesia: National Headcount of R&D Personnel
2009

Type of R&D Personnel	Manufacturing Industry Sector	Government Sector	Higher Education Sector*	Total
Researchers	7,588	11,114	22,228	40,930
PhD	19	1,353	5,458	6,830
Master's Degree	-	4,025	16,770	20,795
Bachelor's Degree	4,374	5,736	-	10,110
Non-Degree	3,195	-	-	3,195
Technicians	2,135	7,572	1,484	11,191
Other Support Staff	1,144	8,575	1,334	11,053
Total	**10,867**	**27,261**	**25,046**	**63,174**

**State Universities*
Source: R&D survey in University sector (2009), Industry sector (2010), and Government sector (2006)

Capability for S&T Human Resource Development in Higher Education Institutions

As many as 472 Universities, both private and state-owned, are offering graduate degree programs in Science, Technology, Engineering, and Mathematics. In 2010, there were 174,977 diploma graduates in science, technology, and engineering; 434,551 bachelor graduates; 43,729 masters' degree graduates; and 1,765 PhDs.

4. Expenditure for R&D

The total expenditure on R&D (GERD) based on a survey conducted by the Indonesian Institute of Science (University Sector Survey, 2009; Industry Sector Survey, 2010; Government Sector Survey, 2006) amounted to IDR 4.7 Trillion (USD 522 million) or about 0.08% of GDP and coming from the higher education sector (38%), the government sector (50%) and the private sector (18%).

5. S&T Outputs

The total number of patent applications in 2010 was 253 by residents and 4140 by foreigners, while the total patents granted in the same year were 115 to residents and 2,278 to foreigners. There was a 4.3% increase rate per year in the number of applications by residents during the past decade and 126% increase rate in the number of patents granted to residents, while there was a 5.7% increase rate in the number of applications by non-residents and 10.1% increase rate in the number of patents granted to non-residents.

The total number of publications by Indonesian authors in international peer-reviewed journals in 2010 was 1,000 articles, a sharp increase from 520 per year from 2001. There is a 7.8% increase rate per year in the number of journal publications during the last decade. High increase rates averaged at 14.4% per year as seem during the last three years. The total number of citations in 2010 was 11,150, averaged at 11.15 citations per paper (ESI, 2010).

6. S&T Utilization Programs Including Indicators of Utilization (In Government, In Industry, In Social Development)

Government Program to Private Sector

The program is coordinated by the Ministry of Research and Technology (KRT). The program includes 22 incentive schemes that cover strengthening linkages between R&D institutes, industries, and universities, incentives for science and technology diffusion to industry, incentives to promote science and technology based industry, design and creativity awards, and incentives for standardization and intellectual property rights promotion. Currently, research incentives provided by Ministry of Research and Technology are directed towards strengthening the R&D capacity of research institutes for basic and applied researches, incentives for centre of excellence promotion, incentives for industrial research consortia and incentives for building national innovation system to strengthen linkages between industry, government and universities. Programs for rural and regional development are intensively also promoted to enhance technology absorption by regional small and

medium enterprises and societal development such as installation of small-scale power plants to supply electricity in remote areas.

Other S&T utilization programs include the following:

a. **Early Disaster-Warning System**
   This system is an integrated information system for monitoring, forecasting, and modeling characteristics of the marine environment.
b. **Completion of the IGOS Program Indonesia**
   Go Open Source! (IGOS) has become a national movement to strengthen and improve the OSS-based information technology system in Indonesia. IGOS has been declared since 2004 and involves several ministries. After formed a roadmap 2005-2009, in 2009 a number of things have been achieved.
c. **Utilization of WIMAX**
   This is in line with the increasing needs of a fast, economical, and broad range IT. WIMAX (Worldwide Interoperability for Microwave Access) can be a solution for Indonesia as an archipelago. BPPT, in cooperation with the Ministry of Communications and Information is developing WIMAX in BWA telecommunications network that integrates 62 central government agencies and 472 districts throughout Indonesia.
d. **e-ID Card for Convenience and Safety**
   The use of electronic ID Cards (e-ID) is feasible for people. The number of distributed ID Cards is an accurate indication of population for persons aged 17 years and above. The Government has developed an e-ID card for the realization of single identity number. This breakthrough can prevent and minimize dual identity cards and the circulation of fake ID cards. Also in terms of security, the e-ID card is designed with authentication methods and maximum data security. The embedded chip in the card has authentication, encryption, and digital signatures.
e. **Digital Library Portal**
   This program was launched on November 11, 2010, by the Ministry of Science and Technology. This portal serves the needs of researchers in Indonesia to international journals. The Ministry of Research and Technology has made a breakthrough by taking subscriptions (subscription) collectively for international scientific journals and managing an online library network system (digital libraries) so that the international scientific journals can be accessed by researchers from their laboratories and other specific locations.
f. ***Nawala:*** **Clean and Safety Internet**
   Nawala Nusantara is a free service for Internet users who need a restrainer for negative sites.
g. **Information Village**
   The Information Village program is the government's commitment to ensure equal distribution of information, mainly in remote areas found outside the mainstream and are lagging behind in technology. The Information Village program will reach 500 locations by 2014.

7. Areas of Strength in S&T (including medicine, health)

Public health, plant sciences, environmental sciences, ecology, multidisciplinary geosciences, tropical medicine, microbiology, pharmacology & pharmacy, infectious diseases, zoology, immunology, biology, biochemistry, molecular biology, medicinal chemistry, and agronomy are among the research fields that are relatively strong in Indonesia based on the total number of publications in international journals. The publication in the fields of molecular biology and genetics, microbiology, immunology, space science, environment and ecology, and clinical medicine are mostly cited from Indonesian- authored publications, with average citation indexes of over 11 citations per paper. The area of agriculture, medical sciences, and technological sciences are the fields with the biggest number of researchers in Indonesia, accounting for 22% of the total Indonesian researchers.

8. Major Contributors to GDP

The major contributions to GDP in 2009 was Agriculture—IDR 858,25 trillion (17.13%); mining and primary resources—IDR 591,53 trillion (11.8%); Manufacturing—IDR 1.480,91 trillion (29.55%); and Services—IDR 2.080,95 trillion (41.52%).

9. Major Exports

The major export commodities of Indonesia are Food Products and Beverages, Textiles, Rubber and Plastic Products, Refined Petroleum Products, Wood and Product, Computer Office Machinery, Electronics and Communications and Motor Vehicles, Metal Products and Ship Building in the manufacturing sector; coal and copper ores in the mineral resource sector; and cocoa, coffee and shrimp in the agricultural sector.

10. Major Trading / Economic Partners in ASEAN

Indonesia's major trading partners are Japan, South Korea, Thailand, Singapore, Malaysia, India, the USA, and Germany.

LAO PEOPLE'S DEMOCRATIC REPUBLIC

Country Figures

Total Area	:	236,800 km2 (83rd), 2 % of Water
Population	:	2009 estimate 6,800,000 (104th in the world), Density 26.7/km2 (177th)
GDP (nominal)	:	2010 estimate $6.341 billion
GDP Per capita	:	$984
GDP (PPP)	:	2010 estimate $15.693 billion (130th)

Lao People's Democratic Republic is a landlocked country in Southeast Asia, bordered by Burma and the People's Republic of China to the northwest, Vietnam to the east, Cambodia to the south and Thailand to the west. The country's population was estimated to be 6.8 million in 2009.

Laos traces its history to the Kingdom, which existed from the 14th to the 18th century when it split into three separate kingdoms. In 1893, it became a French protectorate, with the three kingdoms, Kingdom of *Luang Phrabang*, Kingdom of Vientiane, and Kingdom of *Champasak*, uniting to form what is now known as Laos. It briefly gained independence in 1945 after Japanese occupation, but returned to French rule until it was granted autonomy in 1949. Laos became independent in 1954, with a constitutional monarchy under *Sisavang Vong*. Shortly after independence, a long civil war ended the monarchy, when the Communist Pathet Lao movement came to power in 1975.

Laos is a single-party socialist republic. The capital city is Vientiane. Other large cities include Luang Prabang, Savannakhet, and Pakse. The official language is Lao. Most people are Lao with a significant proportion of indigenous religion as well. It is a rising power in providing electricity to neighboring countries such as Thailand, China, and Vietnam and the economy is accelerating rapidly with the demands for its metals. It is a member of the Asia Pacific Trade Agreement (APTA), Association of Southeast Asian Nations (ASEAN), East Asia Summit, and La Francophonie. Laos applied for membership of the World Trade Organization (WTO) in 1997.

Overview on Science and Technology Development

Faced with the situation of economic competitiveness in the region, the government of Lao has made a great effort to build up its socio-economy, and to acquire modern technology and knowledge to support its national development to be equivalent with other countries. The government of Lao has integrated S&T activities into its national development plan and socio-economic development policy, and has increased investment in human resource development and the priority action program.

S&T investment is considered as one of the main factors for economic growth through technological changes in the production process. Considerable efforts for investment in S&T up to 2020 have been planned to reach the goal of economic

structural change in the direction of industrialization and modernization, including the setting up of the new Ministry of Science and Technology and allocating 1% of GDP for R&D in 2011.

1. S&T Policy and Development Strategy

The government of Lao is currently implementing the 7th Five Year National Socio-Development Plan for the period of 2011-2015. The plan is to determine the government's direction aimed at ensuring that the country achieves its key development goals, which include the following:

- To enhance and strengthen stability;
- To maintain an economic growth at least 8% each year; ensure stability and balance in macroeconomic system; build foundation for industrialized and modernized transformation and sustainable development;
- To achieve Millennium Development Goal of the United Nation in 2015 and lift the country from least developed country status by 2020; and
- To integrate the country's economy to the Greater Mekong Sub-region, ASEAN, and the international community in a dynamic manner.

The development plan for 2010-2011 targets GDP increases of 8-8.5% and hopes to achieve GDP per capita of 1,130 USD. In the economic sector, it targets the following:

- rice production of 3.38 million tons;
- electricity production of 9,087.75 million KWH; and
- exports to the level of US$1,229.73 million.

In the social sector, the development plan targets the following:

- to reduce poverty rate to 24% of total population and poor household rate to 19% of total households by the end of 2011;
- to ensure the rate of literacy for those aged 15 and above to reach 83%;
- to ensure the rate of literacy for those aged 15-40 to reach 90%;
- to ensure the rate of people using latrine facilities to reach 54%;
- to provide clean water to 80% of the people;
- to provide training and skilled labor development to 44,136 people;
- to create new jobs for 55,365 people; and
- to complete the number of culturally preserved villages to total 125.

To attain the target of at least 8% economic growth, the government of Lao will invest 32% of GDP, of which the state investment comprises 10.87% of GDP. Starting 2010, the government will allocate 30% of budget to the economic sector, 35% to the social sector, and 35% to roads and infrastructure development.

Science and Technology policy is yet to be established in Lao. The Ministry of Science and Technology was newly established in June 2011, and is still under re-organization from the original National Agency of Science and Technology before it becomes fully functioning as the institution to outline the country's science and

technology policy. Currently, the Agricultural Development Strategy 2011-2020 is the most relevant policy in Lao related to the science and technology policy as the agriculture and natural resource (ANR) sector is still the main thrust for science and technology development.

The strategic direction for the ANR is to ensure a successful and gradual transition from subsistence to commercial smallholder production. This can be achieved by applying innovative technologies for the systematic and continuous production of high-value agri-food products for local value-added agro-processing and for domestic, regional, and world markets.

The major themes of the ANR sector strategy include a strong focus on modernizing agricultural production and creating value-added food and agricultural products aimed at reducing rural poverty, maintaining food security, and applying results-based management to the natural resources that are the foundation for sustainable agricultural and rural development and resiliency to climate change. Lowland agriculture production will be focused with the application of technologies to improve and maintain the quality of soils and guide the use of agricultural chemicals; use appropriate technology and equipment for mechanized production; and apply climate change mitigation and adaptation measures.

2. Infrastructure of S&T

There are two main government institutions in charge of S&T development in Lao People's Democratic Republic: the Ministry of Science and Technology (MOST) for the whole nation and the Provincial Department for Science and Technology (PDST) for the provinces. The National Science Council (NSC), various ministries, universities, and research institutes also contribute to S&T development. All research institutes are available only at the MOST (originally the National Authority for Science and Technology, NAST) and under some of the ministries, especially the Ministry of Agriculture and Forestry (MAF).

- **Ministry of Science and Technology (MOST)**

  The Ministry of Science and Technology was formed and established in June 2011 from the National Authority for Science and Technology (NAST), under the Prime Minister's Office. MOST is a central organization under the government structure, whose role is to serve as secretary and assist the Government of Lao to organize and administer science and technology, intellectual property, standardization and metrology throughout the country. MOST is headed by the Minister of Science and Technology, and it consists of four administrative sections, five technical management sections, and three technical research and service sections. Before reorganized into MOST, NAST has accomplished some projects, which included the following:

  - Establishment of research institutes and information centres on S&T centrally and in some provinces;
  - Creation of some legislations relating to the management and promotion of science, technology and innovation (STI), which included the law on IP, the law on standardization and the policy on information and communication technology (ICT); and

- Completion of Phase I of the implementation of an "e-government project" , which included the setting up of national and local centres for e-governance, installation of linkage networks by using fibre optics and WiMax system, and installation of ICT equipment to train government staff on information technology.

- **Provincial Department for Science and Technology (PDST)**

  PDST, a governmental institution at the local level, acts as a secretary to the provincial governor and a leader of NAST and directly manages S&T, IP, standardization, and metrology in the provinces. It is a young institution, has low capacities, and a limited budget. PDST is yet to carry out its functions actively.

- **National Science Council (NSC)**

  NSC was established in 2002 as a technical institution under the Prime Minister's Office. NSC's main functions are to provide advice on social and natural research activities, and to consider and certify results of research carried out in the country. NSC is chaired by a Minister in the Prime Minister's Office, who is the Chairperson of NAST. Members of NSC are drawn from different public and private sector entities. The Council is yet to start its active functions.

- **Research Institutes under MOST and Line Ministries**

  MOST and different Line ministries have established institutes, centres, and councils relating to the research, development, application, and management of S&T for serving their own activities. Many activities, including pilot projects, have been undertaken by these ministries and some important results achieved. Under MOST, there are three research institutes: the Biotechnology and Ecology Research Institute, the Renewable Energy and New Material Research Institute, and the Technology Computer and Electronics Science Research Institute.

  The leading research institutes under the Line Ministries in Lao are the following:
  - the National Agriculture and Forestry Research Institute (NAFRI) under MAF with a total staff of around 300 persons;
  - the National Research Institute of Medicine Plant under the Ministry of Health (MOH) with total staff of less than 50 persons; and
  - the National Economic Research Institute under the Ministry of Planning and Investment (MOPI) with total staff of less than 30 persons.

- **National Universities**

  The country has five universities: National University of Laos in capital city of Vientiane, which is the leading university in the country; Suphanouvong University in Luangprabang; Champasack University; Savannakhet University; and the University of Public Health. The National University of Laos was founded in 1996 and has an important role in developing human resources in Lao as well as producing a number of scientists, technologists, and researchers. Other universities have been established very recently, and are still in the process of developing infrastructure and human resources.

- **Business Units**

  The industrial units in Lao People's Democratic Republic fall into four categories: state-run enterprises, private enterprises, joint enterprises, and collective enterprises. Most business units are involved in technology application, rather than S&T research. The computer is a basic technology that most business units are employing. Application of modern technologies, which are mostly imported, is very limited among business units that have low investment such as small and medium enterprises (SMEs).

3. Human Resources Involved in R&D

There is very limited resource on the statistical data on human resources involved in R&D in Lao PDR. The latest available data is based on a survey conducted by the Department of Science and Technology under the former NAST in 2002. The survey included 169 institutions comprising of business enterprises, government institutions, higher education institutions, and private non-profit organizations. According to the 2002 survey, there were 1,946 persons (headcount) human resources devoted to R&D distributed among higher education (58%), government research institutions (31%), and business enterprises (11%). The human resources devoted to R&D (FTE) totaled 550 persons, comprising of 55% of higher education, 31% of government research institutions, and 14% of business enterprises. The number of researchers among the human resources devoted to R&D included 490 persons based on headcount, distributed to higher education (55%), government research institutions (31%), and business enterprises (14%); and 120 persons based on FTE, distributed to higher education (42%), government research institutions (33%), and business enterprises (25%).

- **Capability for S&T Human Resource Development in Higher Education**

The National University of Laos is the only higher education institution offering post-graduate programs. The university has an important role in developing human resources in Lao, producing a number of scientists, technologists, and researchers in the fields of Agriculture & Food, Applied Science & Technologies, Biology & Nature, Computers & Communication, Earth & Ocean Science, Energy & Energy Conservation, Environment, Health & Medicine, Mathematics, Physics & Chemistry, and Science Education.

Other universities have been established very recently and are still in the process of developing infrastructure and human resources.

4. Expenditure for R&D

The total R&D expenditure based on National R&D Survey (2002) is 6,560 million KIP (US$ 649,800), shared by government research institutions (51%), higher education sector (12%), and business enterprises (37%).

Different survey data by the Agricultural Science and Technology Indicators (ASTI) on agricultural research expenditure and number of researchers in 2003 is presented in Table 10.

Table 10
Composition of Agricultural Research Expenditure and Total Researchers
Lao PDR, 2003

Public Agencies/ Government	Spending KIP (millions)	Spending Intl dollars (millions)	Researchers (FTEs)	Spending (%)	Researchers (%)	Number of Agencies in sample
NAFRI	16,501.50	10.1	105	89.9	83.7	1
NUoL	1,723.30	1.1	18.4	9.4	14.7	2
Subtotal	18,224.80	11.1	123.4	99.2	98.4	3
Private enterprises	140.2	0.1	2	0.8	1.6	1
Total	**18,365.00**	**11.1**	**125.4**	**100**	**100**	**4**

5. S&T Outputs

Laos is yet to establish record on science and technology outputs, including international publications as well as patent granted.

6. S&T Utilization Programs including Indicators of Utilization

There were some activities of S&T utilization programs conducted by the NAST including the following:

- Research activities and dissemination of results of research and information to the public;
- Technical training and workshops to upgrade knowledge of governmental officials at both local and national level
- Implementation of an "e-government project" in national and local centers for e-governance, installation of linkage networks by using fiber optics and WiMAX system, and purchase of ICT equipment to train government staff on information technology.
- Implementation of the Lao National Biosafety Framework, coordinated by MOST and involving seven ministerial institutions including NAFRI and Department of Agriculture (MAF), Department of Food and Drugs (MOPH), Cabinet Office of Lao Woman Union, Department of Law (MOJ), Department of Environment (MOENR). The project will last for four years, funded by TEF, costing USD 1 million in cash and USD 0.5 million in kind with support from Lao Government.

7. Areas of Strength in S&T

Given the importance of the agricultural sector to the Lao economy, agricultural R&D plays an important development role for the country. Four agencies are involved in agricultural R&D. In 2003, these agencies employed a combined number of 125 full-time equivalent (FTE) researchers and spent close to 18 billion Lao kip in 2000 constant prices, the equivalent of 11 million international dollars in 2000 constant prices. The National Agriculture and Forestry Research Institute (NAFRI) is

the only government agency involved in agricultural R&D in Laos. In 2003, this institute accounted for roughly 84% of the country's total agricultural researchers and 90 percent of expenditures. NAFRI was established in 1999 through the amalgamation of existing agriculture, livestock, fisheries, and forestry research centers, with the tasks of designing, implementing, and coordinating all agriculture and forestry research in Laos. The institute is mandated to play a major role in the National Growth and Poverty Eradication Strategy (NGPES) through the provision of improved technologies and information for crop, livestock, forestry, and aquatic resource production with the aim of improving productivity. The institute has an additional eight research centers: the Agriculture Research Centre (ARC), the Coffee Research Centre (CRC), the Forestry Research Centre (FRC), the Horticulture Research Centre (HRC), the Livestock Research Centre (LRC), the Living Aquatic Resources Research Centre (LARReC), the Northern Agriculture and Forestry Research Centre (NAFReC), and the Soil Survey and Land Classification Centre (SSLC).

During 1998-2003, total agricultural researcher numbers in Laos rose steadily, while agricultural R&D expenditures contracted by half in constant prices during 1999–2003. The principal agricultural research agency, the National Agriculture and Forestry Research Institute (NAFRI), accounted for 90% of Laos' agricultural R&D spending in 2003. NAFRI employed only a few scientists holding PhD degrees. However, researcher qualification levels are expected to rise because a large number of NAFRI researchers are currently undertaking PhD and MSc training abroad. Since its establishment in 1999, NAFRI has depended almost exclusively on donor support, with the result that its donor-driven research does not always contribute to Laos' overall agricultural R&D needs. Private sector involvement in agricultural R&D is limited.

The higher-education sector plays a limited role in the Lao agricultural research system, accounting for just 15% of the country's total FTE research staff and an estimated 9% of agricultural R&D spending. Two faculties are involved in agricultural R&D under the Vientiane-based National University of Laos (NUoL). The Faculty of Forestry (FoF) is the larger of the two, employing 12 FTE researchers in 2003. FoF's research activities concentrate mainly on silvicultural issues and to a limited extent agroforestry and community forest issues. Most research activities are performed by individual staff members as part of collaborative programs initiated by other agencies. The faculty is currently setting up a formal research program for the next five years. NUoL's Faculty of Agriculture (FoA) employed seven FTE researchers in 2003. These researchers were spread across three formal research programs: cropping systems and crop management, livestock and fisheries, and agroeconomics and agroprocessing.

8. Major Contributors to GDP

The estimated GPD in 2010 is $6.341 billion, with agriculture sector accounted 29%, industry sector 26.5% and services 39%.

Subsistence agriculture still accounts for half of the GDP and provides 80% of employment. Only 4.01% of the country is arable land, and 0.34% used as permanent cropland, the lowest percentage in the Greater Mekong Sub-region. Rice

dominates agriculture, with about 80% of the arable land area used for growing rice. Approximately 77% of Lao farm households are self-sufficient in rice.

The economy receives development aid from the IMF, ADB and other international sources, and foreign direct investment for development of the society, industry, hydropower and mining, most notably copper and gold. Tourism is the fastest-growing industry in the country. Economic development in Laos has been hampered by brain drain, with a skilled emigration rate of 37.4% in 2000.

Laos is rich in mineral resources but imports petroleum and gas. Metallurgy is an important industry, and the government hopes to attract foreign investment to develop the substantial deposits of coal, gold, bauxite, tin, copper, and other valuable metals. In addition, the country's plentiful water resources and mountainous terrain enable it to produce and export large quantities of hydroelectric energy. Of the potential capacity of approximately 18,000 megawatts, around 8,000 megawatts have been committed for exporting to Thailand and Vietnam.

The country's most widely recognized product might well be Beerlao, which is exported to a number of countries including neighbors Cambodia and Vietnam. It is produced by the Lao Brewery Company.

9. Lao Major Exports

Lao’s major export commodities are mining products (copper and gold), which account for more than 50% of total Lao exports, hydropower electricity that makes up 26% of the total export, industrial products such as beer and processed coffee and agricultural products such rice and coffee beans as well as tourism goods.

10. Major Trading/Economic Partners in ASEAN

Thailand, Vietnam, and Cambodia are the major economic partners of Lao in ASEAN.

MALAYSIA

1. S&T Policy and Development Strategy

Malaysia has come a long way in the development of S&T. Since the introduction of the first National Science and Technology Policy (NSTP) in 1986, the country has successfully developed S&T into a coherent system. While many of the recommendations of the first NSTP remain valid, there is a need to align it to the changing environment and the pervasive role of knowledge in the globalised economy to meet the challenges of the new millennium. Because of the review, the second NSTP and Plan of Action were produced in 2003. The second NSTP has seven key strategic thrusts as follows:

a. Strengthening research and technological capacity and capability;
b. Promoting commercialization of research outputs;
c. Developing human resource capacity and capability;
d. Promoting a culture of science, innovation and techno-entrepreneurship;
e. Strengthening institutional framework and management for S&T and monitoring of S&T policy implementation;
f. Ensuring widespread diffusion and application of technology leading to enhanced market driven R&D to adapt and improve technologies; and
g. Building competence for specialization in key emerging technologies.

The new science and technology policy, which incorporates innovation components and the science act, is being drafted. This National Science, Technology and Innovation Policy (NSTIP) will contribute toward will contribute toward achieving a sustainable high-income Knowledge-based economy (K-economy) by 2020. Malaysia is aiming to move toward a high-income economy by 2020 by building a progressive scientific and innovative society. Vision 2020 has STI as one of its strategic priorities: "to establish a scientific and progressive society, a society that is forward looking, one that is not only a consumer of technology but also a contributor to the scientific and technological civilization of the future".

Malaysia is at a crucial phase of development to transform the nation into an advanced and high-income economy. The Government has embarked on a national transformation program premised on four pillars, namely *One Malaysia*: *People First, Performance Now*, the Government Transformation Programme (GTP), the Economic Transformation Programme (ETP), and the Tenth Malaysia Plan.

As part of the ETP, the New Economic Model (NEM) was introduced and it constitutes aspirations of a united and advanced nation. The goals to be achieved are high income, inclusiveness, and sustainability. The targeted income per capita is USD15,000-20,000 by 2020. Inclusiveness is aimed to enable all communities to benefit fully from the wealth of the country, while sustainability is to meet present needs without compromising future generations. The ultimate goal of NEM is to improve the people's quality of life.

The ETP identified 12 National Key Economic Areas (NKEAs) and NEM 8 Strategic Reform Initiatives (SRIs). The 12 NKEAs are Tourism; Business Services; Oil, Gas and Energy; Electrical and Electronics; Education; Healthcare; Communications Content

and Infrastructure; Palm Oil; Agriculture; Greater Kuala Lumpur/Klang Valley; Financial Services; and Wholesale and Retail. The 8 NEM SRIs are re-energizing the private sector; developing a quality workforce and reducing dependency on foreign labor; creating a competitive domestic economy; strengthening of the public sector; transparent and market friendly affirmative action; building the knowledge-based infrastructure; enhancing the sources of growth; and, ensuring sustainability of growth.

S&T Laws and Other National Policy Pronouncements

Every five years the Government renews the development plan of the country (Five Year Development Plan). The first National S&T Policy was initiated during the 4th Malaysia Plan. In 1990, the Government launched Vision 2020 and this was followed by the Privatisation Master Plan, the National Multimedia Plan (1995), the establishment of National Innovation Council (NIC) (2004), and the National Innovation Model (2007). Other related policies that enhance vision 2020 include the following:

a. The National Biotechnology Policy (NBP)
b. Outline Perspective Plans (OPP)
c. The Tenth Malaysia Plan (2011-2015)
d. Industrial Master Plan (IMP)
e. National Cyber Security Policy
f. Intellectual Property Commercialisation Policy for R&D Projects Funded by the Government
g. National Green Technology Policy
h. The National Strategic ICT Roadmap
i. National Science and Research Council (NSRC)

Innovation System Framework

The Ministry of Science, Technology, and Environment (MOSTE) was renamed Ministry of Science, Technology, and Innovation (MOSTI) in 2004. NIC was established in 2004 to propel the national agenda forward and enhance the country's National Innovation System. The Council is chaired by the Prime Minister and MOSTI is its secretariat. In 2007, the National Innovation Model was introduced and this model had dual approaches namely, market- driven and technology-driven innovations.

Agensi Inovasi Malaysia (AIM), a statutory body under the Prime Minister's Department, was established in 2011 to be the driving force behind Malaysia's push towards establishing an innovation economy. It has two clear objectives, to bring about societal well-being through the cultivation of the innovation eco-system and to drive the national innovation agenda to generate a new wave of wealth. A reform in institutional structure is being undertaken to improve innovation outcomes.

2. Infrastructure for S&T

a. S&T Institutions

The key actors in Malaysia's STI system are government and government- linked organisations.

MOSTI spearheads the development of STI and oversees more than 20 departments, agencies, and companies clustered into 7 focus areas: biotechnology, ICT, industrial technology, sea to space, science and technology core services, nanotechnology, and oceanography.

Ministry of Higher Education (MOHE) aims to turn Malaysia into a hub of excellence for higher education and also to develop at least 20 Centres of Excellence (CoE) internationally recognised in terms of research output, copyrights, publications and research collaborations and to commercialise at least 10% of the research output.

Other Ministries include the Ministry of Natural Resources and Environment, Ministry of Energy, Green Technology and Water, Ministry of Agriculture, Ministry of Health, and Ministry of Plantation Industries and Commodities and the Ministry of Defence.

b. Government Research Institutes

Following are the public research institutes under the various ministries:

i. MOSTI
   a) Malaysian Institute of Microelectronic System (MIMOS Berhad)
   b) SIRIM Berhad
   c) Malaysia Remote Sensing Agency (ARSM)
   d) Malaysia Nuclear Agency
   e) Malaysia Genome Institute (GENOMalaysia)
   f) Malaysian Institute of Pharmaceuticals and Nutraceuticals (IPHARM)
   g) Agro-Biotechnology Institute Malaysia (ABI)
   h) Technology Park Malaysia Corporation (TPM)
   i) National Space Agency (AAN)

ii. Ministry of Natural Resources and Environment
   a) National Hydraulic Research Institute of Malaysia (NAHRIM)
   b) Forest Research Institute of Malaysia (FRIM)
   c) Mineral Research Centre (MRC)

iii. Ministry of Energy, Green Technology and Water
   a) Malaysia Green Technology Corporation

iv. Ministry of Agriculture
   a) Veterinary Research Institute (VRI)
   b) Fisheries Research Institute (FRI)
   c) Malaysian Agricultural Research and Development Institute (MARDI)

v. Ministry of Health
   a) Institute of Medical Research (IMR)

vi. Ministry of Plantation Industries and Commodities
   a) Malaysian Rubber Board (MRB)
   b) Malaysian Palm Oil Board (MPOB)
   c) Malaysian Cocoa Board (MCB)
   d) The Fibre and Biocomposite Development Centre (FIDEC)

vii. Ministry of Defence
   a) Science and Technology Research Institute for Defence (STRIDE)

c. Government R&D Funding Agencies

Under the 10th Malaysia Plan (2011-2015), the Government will support R&D and commercialization across the value chain under a number of initiatives as shown in Figure 7. A number of RD&C funds/grants are made available including Cradle Fund, Science Fund, Pre-commercialization Fund, Fundamental Research Grant Scheme, Commercialization of R&D Fund, Biotechnology Commercialization Grant, Business Growth Fund, Technology Acquisition Fund, and Venture Capital Fund. Under this arrangement, funding will come from the Ministry of Finance (MOF), MOSTI, MOHE, and the Venture Capitals (Malaysian Technology Development Corporation (MTDC), Malaysia Debt Ventures Berhad (MDV), Malaysia Venture Capital Management Berhad (MAVCAP), and Kumpulan Modal Perdana (KMP).

The funds being managed by MOSTI under the plan are the Science Fund for Research; the TechnoFund for cutting edge technologies towards the creation of new businesses, which are technology-based; the InnoFund to support the commercialization of technological innovations in new or existing products; and the Community Innovation Fund to assist community groups in translating knowledge and ideas into products, processes, or services that improve quality of life.

d. **University-based R&D – Public University**

Malaysia has 20 public universities that contribute university-based research R&D. Five universities have been given the status as "Research University" and they are the Universiti Kebangsaan Malaysia (UKM); University Malaya (UM), Universiti Putra Malaysia (UPM), Universiti Sains Malaysia (USM), and Universiti Teknologi MARA (UTM). A Research University is the public university that has been accredited by the Cabinet in 2006 to become a hub of excellence for education and research. Characteristics of a research university include research-focused field of study, competitive entry, quality lecturers, and ratio of graduates and post-graduates to be 50:50.

Malaysia also has 476 private higher education institutions (PHEI).

e. Private Non-Profit Institutions that play a significant role in R&D

Private non-profit institutions play a significant role in R&D. They give awards, support research through grants, and provide international fellowships. The more active ones are the Malaysia Toray Science Foundation (MTSF), National Cancer Council (MAKNA), Cancer Research Initiatives Foundation (CARIF), Dr. Ranjeet Bhagwan Singh Medical Research Trust Fund, and Sime Darby Foundation.

f. Linkages (Academia-Industry Linkages)

An Academia – Industry Consultative Council (AICC) was established under MOHE to foster better ties between the world of academia and industry with the shared view of formulating mutually beneficial understanding and cooperation between the participating stakeholders.

g. Technology Financing Companies

Malaysia has technology financing companies, such as the Malaysia Technology Development Corporation (MTDC), the Malaysia Venture Capital Corporation (MAVCAP), the Malaysia Development Ventures (MDV), and the KMP, which focuses on research commercialization, ICT investments, early stage company financing, and technology transfer in support of the National Innovation Model of 2007.

3. Human Resources Involved in R&D

The headcount of overall human resource in R&D, which includes researchers, technicians, and support staff for the period 1998 to 2008 indicates a rising trend from 1998 to 2004, but with a slight decrease in 2006 to 24,588, almost equivalent to the number recorded in 2002. However, in 2008, the number increased to 40,840. The same trend is also recorded for the total number of researchers for the same period.

Capability for S&T Human Resource Development in Higher Education

Both public and private universities offer graduate degree programs in Science, Technology, Engineering, and Mathematics (STEM). There are 20 public universities and all of them offer graduate degree programs in STEM. Out of the 20 private universities, that have the highest student enrolment, only 16 offer graduate degree programs in STEM. The total number of students in 2010 at the public universities with Graduate Degree Programs in STEM was 23,309 for Masters and 8,338 for PhD level.

4. Expenditure for R&D

Gross Domestic Expenditure on Research and Development (GERD) in 2008 was RM 5,405.8 million compared to RM 3,646.7million in 2006. GERD as a percentage of GDP in 2008 was 0.73 compared to 0.64 in 2006. In 2006, private sector contribution to GERD constituted 85% percent while the Government only contributed 15% percent. The national GERD increased consistently from 1992 to 2008. However, the ratio of GERD per GDP only increased consistently from 1996 to 2002. The ratio decreased slightly in 2004 and increased again in 2008.

5. S&T Outputs

a. Patents Granted

Total number of patent applications in 2010 was 6,464 compared to 5,737 applications in 2009, of which 5,189 applications were from residents and 1,275 from non-residents. The total number of patents granted in 2010 for residents were 204 compared to 1,973 for non-residents. Patents applied from 2001 to 2010 were 52,437 and 31,014 patents were granted during the same period. It is of correct usage, only 4% were granted to Malaysians, while the remaining 96% were granted to non-residents. The total number of applications from 2001 to 2005 was 27,661, a reduction of 10% to 24,776 for the year 2006-2010. For the period of 2001-2010, there were more applications from non-residents compared to Malaysians. Only 12.6% of the applications were from Malaysians.

b. Malaysian-authored Publications

The total number of Malaysian-authored S&T publications as indexed in Scopus from the earliest date of 1909 to February 2009 was 54,124, about half of which or totally 22,276 were published between 2001 to February 2009. Malaysian-authored publications received 127,914 citations for the same period. This indicates that on average, Malaysian authors have received 2.4 citations per publication throughout the publishing period. The pattern of Malaysian-authored publications in Malaysia from 2001 to 2008 showed a significant increase of 43% in 2004, while from 2005-2008 the rate of growth decreased.

6. S&T Utilization Program including Indicators of Utilization

a. Incubators

The National Incubator Network Association (NINA) was formally established in 2004 to serve as a common platform for knowledge sharing on incubation/business acceleration among all the incubators in Malaysia and for forging collaborative efforts among incubators.

b. **UPM-MTDC Technology Centre**: It is a joint-venture project between UPM and MTDC. The centre is strategically located within the vicinity of the Multimedia Super Corridor.

c. **UKM-MTDC Technology Centre**: This is a joint venture between UKM and MTDC. The centre was planned to attract companies mainly involved in biotechnology.

d. **UTM-MTDC Technology Centre**: It is a joint venture project between UTM and MTDC and is located on a 4.24-acre property within the Technovation Park. The centre was planned to attract companies mainly involved in advanced engineering and life sciences. The Centre has a total built up area of 31,200 sq ft.

e. **SIRIM Berhad**: SIRIM offers technology incubation facilities in spin casting, investment casting, ceramics, cosmetics, and natural products.

f. **MSC Technology Commercialisation Centre**: The centre, formerly known as MSC Central Incubator and Accelerator (MCIA), is located within the Multimedia University compound in Cyberjaya. It focuses on ICT and multimedia.

g. **Incubation Centers** are also available at Technology Park Malaysia, Kulim Hi Tech Park, and USM (Kompleks EUREKA).

h. Science/Technology Parks:

(i) **TPM**: TPM provides a unique comprehensive balance of technology support and R&D capabilities including rental of incubator premises; technology and business incubation programs; and, technology commercialization assistance and support.

(ii) **Kulim Hi-Tech Park**: It is envisioned to be the 'Science City of the Future', which will integrate a science park targeting technology-related industries primarily in the fields of advanced electronics, mechanical electronics, telecommunications, semiconductors, optoelectronics, biotechnology, advanced materials, R&D, and emerging technologies. KHTP incorporates the functions of industrial, R&D facilities, amenities, medical and educational institutions, and recreational facilities.

(iii) **Senai Hi-Tech Park – Iskandar Malaysia (SHTP)**: This Park was launched in May 2010 with three focus areas: the high-tech manufacturing activities, R&D activities, professional services, and human capital development. SHTP

targets companies in hi-tech manufacturing activities – hi-end electrical and electronics, semiconductor, photonics, optoelectronics, nanotechnology, alternative energy sources and green technology

(iv) **Cyberjaya**: it is situated about 50 km south of Kuala Lumpur. It is the ICT-focused cluster located within the Multimedia Super Corridor (MSC).

7. Areas of Strength in S&T

Malaysia's areas of strength in S&T is evident based on patents granted in the field of technology classified according to the International Patent Classification (IPC), number of researchers in the field of research, and on scientific publications. Based on the Intellectual Property Corporation of Malaysia (MyIPO) data from 2005 to 2008, Chemistry and Metallurgy recorded the highest number of patents granted (451 or 20.1%), followed by human necessities (423 or 18.9%), transporting operations performance (421 or 18.8%) and electricity (364 or 16.2%).

The Malaysian Science and Technology Indicators Report (2008) showed that the field of Engineering Science contributed the largest number of researchers (more than 3500 persons), followed by Applied S&T (about 2000), Medical and Health Science (1500), Agriculture Science (1500), ICT (about 1900), and Social Science (about 1500).

The same report also showed that five highly ranked scientific publications in Malaysia by subject areas for a period from 1909 to February 2009 were medicine (18%), followed by Engineering (14%), Biochemistry, Genetics and Molecular Biology (9%), Agriculture and Biological Sciences (9%), and Physics and Astronomy (8%).

In line with the strategy to generate new sources of growth, the Government has stress significantly on targeted R&D to build competence and specialization in emerging technologies. Focus is directed into areas including biotechnology, ICT, and nanotechnology.

a. Biotechnology

Biotechnology is being positioned as a new engine of growth to enhance economic prosperity and social well-being of the nation. Three focus areas, namely agriculture, healthcare, and industrial biotechnologies have been developed by leveraging on the nation's strength and competitive advantage.

As an indicator, the National Biotechnology and Bioinformatics Network (NBBnet) has reported that there are 112 companies registered with NBBnet under 10 different categories of biotechnology companies as of 2008.

b. Information and Communication Technology

The Government is taking significant efforts to leverage on ICT as an enabler to enhance productivity and competitiveness as well as to drive and harness new sources of growth. The National Strategic ICT Roadmap has identified three focus areas of technology that could advance Malaysia economically and technologically over the next ten years and beyond, and could help fulfill the

tenets of Vision 2020, and these are: (i) Wireless Sensors Networks; (ii) Predictive Analytics; and (iii) 3-Dimensional Internet.

Malaysian ICT Report (2007) shows that as an indicator, the Malaysian ICT industry has continued to grow positively from year to year over the past decade. For example, the ICT industry's contribution to the nation's GDP was 9.0% and 9.8% in 2008 and 2009, respectively.

c. Nanotechnology

The Government through MOSTI has been actively supporting R&D in nanotechnology and in promoting transfer of technology to the relevant industries. A major milestone from the Government's initiative was the establishment of the National Nanotechnology Directorate (NND) in 2010 under MOSTI, while the National Nanotechnology Statement was launched in July 2010.

d. Oceanography

The commitment to bring R&D in oceanography to a higher level has lead to the establishment of National Oceanography Directorate (NOD) in November 2000 to serve as the National Focal Point for the coordination of research, development, and commercialisation (R&D&C) and all related activities of oceanography and marine science in Malaysia.

8. Major Contributors to Gross Domestic Product (GDP)

Major contributors to GDP (2010) include agriculture (RM 81,400 million or 10.4%), mining and quarrying (RM 96,131 million or 12.3%), manufacturing (RM 200,028 million or 25.6%), construction (RM 24,773 million or 3.2%) and services (RM 377,715 million or 48.4%).

9. Malaysia's Major Exports

The total export in 2010 was RM639,428 million (Table 11). The major categories of exports were electrical and electronic products; palm oil and palm oil-based products; timber and timber-based products; liquefied natural gas; crude petroleum; petroleum products; articles of apparel and clothing accessories; natural rubber and other manufactured goods and articles. The highest value comes from electrical and electronic products contributing RM249,797 million, which constitutes almost 40% of the total export.

Table 11
Malaysia's Major Exports*

Group	2010 (RM million)
Electrical and Electronic Products	249,797
Palm Oil & Palm Oil Based Products	62,853
Timber & Timber Based Products	20,346
Liquefied Natural Gas	38,099
Crude Petroleum	30,765
Petroleum Products	25,542
Articles of Apparel & Clothing Accessories	12,480
Natural Rubber	9,210
Other Manufactured Goods & Articles	89,706
Other Exports	100,629
Total	**639,428**

** Except for selected commodities, single transactions with a value below RM5,000 have been included under "other exports"*

Source: Department of Statistics Malaysia

10. Major Trading/Economic Partners in ASEAN

Malaysia's trade with ASEAN (excluding Singapore) continues to expand strongly, accounting for 13.8% of Malaysia's total trade. Singapore was Malaysia's second largest trade partner, accounting for 12.4% of the total trade. Malaysia's top five export destinations in ASEAN for 2010 were Singapore, Thailand, Indonesia, Vietnam, and the Philippines. The top five import sources of Malaysia within ASEAN in 2010 were Singapore, Thailand, Indonesia, the Philippines, and Vietnam.

Malaysia's exports to ASEAN Member States for January-July 2010 amounted to RM94,975 million compared to the total imports of RM 81,285 million, registering a trade surplus of RM13,690 million.

MYANMAR

1. S&T Policy and Development Strategy

The Government of Myanmar enacted the Science and Technology Development Law of Myanmar on June 7, 1994. It has the following objectives:

a. to carry out development of Science and Technology for promotion of industrial production contributory towards the National Economic Development Plans;
b. to carry out Research and Development for the increased extraction and utilization of domestic raw materials and the promotion of industrial production enterprises based on modern Science and Technology;
c. to effect Technology Transfer for the promotion of production processes and the improvement of the quality of goods;
d. to nurture luminaries required for the development of Science and Technology and for Research and Development and to improve their qualifications;
e. to communicate and co-operate with domestic and foreign research institutes and organizations for the development of Science and Technology and Research and Development; and
f. to honor and grant appropriate benefits to outstanding luminaries and inventors in the field of Science and Technology.

The Ministry of Science and Technology was established in 1996 with the following objectives:

a. to carry out research and development programmes for national economic development;
b. to strengthen the national economy utilizing the national resources;
c. to enhance production in the agricultural and industrial sectors through technology transfer and distribution of knowledge gained from research and development work;
d. to produce and nurture human resources for advanced science and technology;
e. to carry out tasks such as laboratory analysis, quality control and standardization of industrial raw materials and finished products; and
f. to conduct applied research on the utilization of atomic energy.

The current National Science and Technology Plan envisions the following role and objectives for Science and Technology:

a. Import Substitution
b. Defense Support
c. Development of New and Renewable Energy Source
d. Rural Development Support particularly Poverty Alleviation
e. Health Service Support
f. National Industrial Sector Upgrading
g. Development of Value Adding Materials/Technologies
h. National Development

The major strategies are Human Resource Development (HRD) for S&T and Research and Development (R&D).

For the Human Resources Development Strategy the strategic action programs are the following:

a. extending and upgrading Technological Universities and Colleges, Computer Universities, Government Technical Institutes and Government Technological High Schools;
b. offering PhD courses to nurture qualified researchers and teachers;
c. offering special courses and new S&T subjects developed in line with the modern age;
d. encouraging the production of research works that will directly support the establishment of an industrialized nation and that will bring about the development of society, the economy, and the security of the nation;
e. providing advanced teaching aids and laboratory equipment;
f. providing up-to-date reference materials; and
g. providing up-to-date machines and other facilities to be used in practical workshops that will help support the application of theoretical knowledge.

For the Research and Development (R&D) Strategy, the current priority areas are Biotechnology, Materials Science, Nanotechnology, Renewable Energy, Engine Production, Hydropower Turbine Production, Nuclear Technology, CNC Machines, and Unmanned Aerial Vehicle. R&D is to be focused on supporting national development particularly industrial development and rural development.

The Department of Advanced Science and Technology supervises five technological universities. The Department of Technical & Vocational Education (DTVE) supervises 27 technological universities, 25 computer universities, 1 aerospace and aeronautical engineering university, 4 government technical colleges, 14 government technical institutes, 43 government technical high schools, and 4 technical training schools. The Department of Advanced Science and Technology (DAST) supervises 5 technological universities, which include two that offer only MS and PhD programs. These are Yangon Technological University (YTU) and Mandalay Technological University (MTU). All higher education institutions (HEIs) are government-owned.

2. Infrastructure for S&T

The agency mainly responsible for S&T is the Ministry of Science and Technology (MOST), which was created in 1996. There are five original departments in MOST, namely:

a. Department of Technical & Vocational Education (DTVE)
b. Department of Advanced Science and Technology (DAST)
c. Myanmar Scientific & Technological Research Department (MSTRD)
d. Atomic Energy Department
e. Department of Science Promotion and Cooperation

There are other Ministries involved in R&D for S&T. These are the following:

a. The Ministry of Education for the natural and physical sciences, which supervises the universities not under MOST, Ministry of Agriculture, Ministry of Health, and Ministry of Transportation
b. The Ministry of Agriculture for R&D and HRD in agriculture, which supervises one Agricultural University
f. The Ministry of Health for R&D and HRD in health, which supervises four medical universities that offer MBBS (their equivalent of MD), MS & PhD in health sciences
g. The Ministry of Transportation for HRD, which supervises marine engineering through the Maritime University

The Materials Science and Materials Engineering Research Department (MSMERD), the Biotechnological Research Department (BRD), the Technological Research Department and the National Analytical Laboratory have been added to enhance R&D capability.

Each of the abovementioned ministries has allocations for HRD and R&D in S&T in their respective budgets. All of these institutions and agencies are state-owned organizations. Involvement of the private sector in S&T R&D is minimal.

3. Human Resources Involved in S&T R&D.

Only the organizations cited in #2 (Infrastructure for S&T) have human resources doing S&T R&D.

Among these, the largest R&D organizations are the MSTRD, Atomic Energy Department, Technological Research Department, Department of Biotechnological Research and Department of Technology Promotion and Coordination that belong to MOST. MSTRD is the largest with 300 personnel of which 50 are researchers.

The universities provide the other group of researchers. These researchers come from the faculty of the universities the numbers of which are shown below:

MOST-DAST:	4 Technological Universities 1 Myanmar Aerospace and Aeronautical Engineering University 25 Computer Universities
MOST-DTVE:	27 Technological Universities
Ministry of Education:	44 Universities, which include those offering academic programs in the natural and physical sciences.
Ministry of Agriculture:	1 Agricultural University
Ministry of Health:	15 Medical Universities
Ministry of Transportation:	1 Maritime University

The largest pool of university researchers come from Yangon Technological University (YTU) and Mandalay Technological University (MTU). These two universities offer MSc and PhD degrees in the different Engineering and Technology fields.

According to UNESCO statistics, the number of researchers (headcount) per million people in Myanmar in 2002 was at 100 researchers per million population.

S&T HRD Capability/Capacity

Myanmar has a very well structured system for developing advanced human resources in Science and Technology. In engineering for instance, there are 32 technological universities all over the country. Four (4) technological universities, 1 Aerospace and Aeronautical Engineering University and 25 Computer Universities, are under the supervision of the Department of Advanced Science and Technology in MOST. Two technological universities and two computer universities are designed to offer MSc and PhD Programs.

The four technological universities and the Aerospace Engineering University under MOST-DAST are the following

- Yangon Technological University (YTU)
- Mandalay Technological University (MTU)
- Pyay Technological University (PTU)
- West Yangon Technological University (WYTU)
- Myanmar Aerospace and Aeronautical Engineering University (MAEU)

YTU and MTU are the only ones offering MSc & PhD in engineering. The other universities offering MS and PhD in the sciences are 13 Medical Universities, 1 Agricultural University, and 38 Universities under the Ministry of Education

The degrees and diplomas given at the YTU, MTU, MAEU, and Computer Universities are the following:

- PhD Degree in Engineering (Aero, Chemistry, Civil, EC, EP, IT, MC, Tech, Met, Min, NT, Pet, Tex)
- PhD Degree in Architecture
- PhD Degree in Engineering/Applied Science (Bio-Tech, Chemistry, Mathematics, NT, Physics, RS)
- MSc Degree in Engineering and Architecture (Aero, Arch, ChE, Civil, EC, EP, IT, MC, Mech, Met, Min, NT, Pet, Tex)
- MSc Degree in Applied Science (NT, Bio-tech)
- Bachelor's Degree in Engineering, Architecture and Applied Science (Aero, Arch, Bio-tech, ChE, EC, EP, IT, MC, Mech, Met, Min, NT, Pet, Tex)

The Computer Universities grant the following degrees and diplomas:

- PhD Degree (IT, CHT)
- Master's Degree (M.C.Sc/ M.C. Tech/ M.I.Sc/ M.A.Sc)
- Bachelor's Degree in Computer Science (B.C.Sc (Hons.), B.C.Sc)
- Bachelor's Degree in Computer Technology (B.C. Tech (Hons), B.C. Tech)
- Diploma (D.C.Sc)

During the last five years, YTU graduated an average of 37 PhDs per year and MTU an average of 99 PhDs a year. During this period, YTU graduated an average of 98

MSc while MTU graduated an average of 140 MSc per year. Starting 2011-2012, YTU will be increasing its target admission to raise enrolment to 1,200 by 2016. Their current enrolment is only 157 for both MSc and PhD. MTU has more students and graduates because its MSc and PhD offerings are in two categories. One category is for regular students in government service. These are the scholars of MOST and other government agencies and they comprise about 90% of the student population of MTU. Most of them are the faculty members in the technological universities under MOST.

Research output from the technological universities is still low because of the offering of the undergraduate courses. However, the two research based Universities (YTU & MTU) implement about 400-500 new research projects a year. These include the researchers carried out by MSc and PhD students. The laboratory facilities in the graduate technological universities need significant upgrading.

To complement its capability building efforts, several international cooperative agreements have been entered into by the Government of Myanmar. Countries with which Myanmar S&T institutions have cooperating agreements with include Japan, China, India, Pakistan, Republic of Korea, and Germany.

4. Expenditures for S&T R&D

The budget and expenditures for R&D in S&T are accounted for by each of the government institutions mentioned above (#2 Infrastructure for S&T).

There is no single office yet compiling all statistics on human resources and expenditures for R&D although MOST has a Database Division that compiles statistics only for MOST.

According to UNESCO statistics, the R&D Expenditure of Myanmar as a percentage of GDP in 2002 is at 0.16%.

In 2010, R&D Expenditure of Myanmar as a percentage of GDP is 1.5%.

5. S&T Outputs

While there are some products and technologies developed in the government research departments, commercialization is limited since there is no Patent Right Protection System yet in Myanmar. It is hoped that the Intellectual Property Law of Myanmar will be adopted soon. Examples of products and technologies developed by the Myanmar Scientific and Technological Research Department (MSTRD) are anti-malaria herbal medicine that will now go through clinical trials, composite material using waste plastics for housing construction, ceramic insulators for electric transformers, and jars made from clay used for purifying water. The Biotechnological Research Department under the MOST has come out recently with biofertilizers and these are now produced in three factories owned by MOST. Whatever commercial production is generated from government R&D from its technologies is commercialized by the government itself through its agencies and universities.

Since there are no Myanmar patents issued yet, some professors or researchers have applied for patents abroad.

The publications coming out from R&D are those that were presented in two international conferences sponsored by Myanmar between 1997 and 2008. These are the International Conference on Computer Application (ICCA) and the International Conference on Science and Engineering (ICSE). These two conferences generated 803 scientific papers, which were then published as proceedings. During the same period, 997 scientific papers were presented abroad by Myanmar researchers bringing the total to 1,800 papers since 1997. The average number of citations of S&T publications per year is 229.

No real technology commercialization through industry adaptors or through start-up enterprises can be cited. Fund constraints for scaling up from laboratory scale to pilot plant scale has been cited also as a deterrent to commercialization or utilization of technologies and products generated from R&D in addition to the absence of an Patent Protection system.

6. S&T Utilization Programs Including Indicators of Utilization

There are yet no national programs designed to facilitate and ensure the utilization of generated or required technologies or results of R&D and innovations. Perhaps the closest to this is the setting up of biofertilizer factories that can supply products to farmers and end-users. Biopesticides and biofungicides developed through research have also been utilized. Ministry of Science and Technology officials have indicated that different government ministries are responsible for ensuring the adoption or utilization of technologies generated through R&D. Examples of these include technologies in plant tissue culture, natural bio-fertilizers, natural plant growth stimulants, natural liquid bio-pesticides, bio-fungicide, rooting hormone, anti-malaria medicine, biogas, and in cattle breed upgrading, which are supervised by the Ministry of Science and Technology and Rural Development.

The researches on industrial technologies such as those on Computer Numerically Controlled (CNC) Machines, engine production, hydropower turbine production, and renewable energy have already produced results, which the country has started to utilize.

7. Areas of Strength, S&T Niches

Engineering can be considered an area of high potential because of the number of higher educational institutions (HEIs) or universities that are dedicated to engineering disciplines.

There are 32 technological universities in Myanmar, all under MOST, which offer a wide range of engineering disciplines to include petroleum engineering, textile engineering, and mining engineering. Two of these technological universities offer MSc and PhD programs in 13 engineering field or disciplines. The biggest number of PhD students goes to Civil Engineering and Electrical Power Engineering. There are also 25 computer universities, also all under MOST, with two universities – the

University of Computer Studies Yangon and the University of Computer Studies Mandalay offering MSc and PhD in Computer Studies. Computer Science or Information Technology can be considered an area of high potential.

If exports can be considered as basis for areas of strength, Myanmar is an exporter of rice, forest products particularly teakwood and other hardwood, fish, prawn, livestock and meat, bean, natural gas, rubber and gemstones (jade) and garments. These are mostly in the agriculture-forestry-natural resources sectors.

The other areas where Myanmar is trying to build S&T capability are in biotechnology, nanotechnology, nuclear technology, renewable energy, and materials science.

8. Major Contributors to GDP

The major contributors to GDP are Agriculture, Livestock and Fishery, Processing and Manufacturing, Construction, Mining, Forestry, Transportation and Trade.

9. Major Export

The major exports are Natural Gas, Jade, Bean, Garment, Fish, Teak, Rubber, Hard Wood, and Rice.

10. Major Trading Partners in ASEAN

The major trading partners of Myanmar in ASEAN are Thailand, Singapore, Malaysia, and Indonesia.

PHILIPPINES

1. S&T Development Policy and Strategy

Like other countries in the ASEAN region, the Philippines has increasingly recognized that scientific knowledge and technological innovation are key drivers of long-term economic growth, primarily through its impact on labor productivity. R&D produces knowledge and technology, which can be used to enhance the productivity of factors of production, and R&D benefits spill over to individuals other than the researchers, to other firms and sectors of the economy.

In fact, the 1987 Philippine Constitution has enshrined science, technology, and innovation (STI) as essential for national development and progress. With this recognition, the government has been directed to:

1. give priority to research and development, invention, innovation, and their utilization; and to science and technology education, training and services (Sec 10);
2. support indigenous, appropriate and self-reliant scientific and technological capabilities and their application to the country's productive systems and national life (Sec. 10);
3. regulate the transfer and promote the adaptation of technology from all sources for the national benefit (Sec. 12);
4. encourage the widest participation of private groups, local governments, and community-based organizations in the generation and utilization of science and technology (Sec. 12);
5. protect and secure the exclusive rights of scientists, inventors, artists and other gifted citizens to their intellectual property and creations, particularly when beneficial to the people, for such period as may be provided by law. (Sec. 13).

Also, the Constitution affirms the authority of the Congress to provide incentives, including tax deductions, to encourage private participation in programs of basic and applied scientific research; and to provide scholarships, grants-in-aid or other forms of incentives to deserving science students, scientists, researchers, inventors, technologists and specially-gifted citizens (Sec. 11).

The Constitution outlines the role that government has to play in harnessing the potentials offered by modern science and technology to the country's social and economic needs. However, the definition of government's role in STI has been conditioned by the changing economic, socio-cultural, and political environment in the country.

The Aquino Administration has set new national directions for the Philippines. President Benigno Simeon Aquino III envisions the Philippines to be a country with a re- awakened sense of right and wrong through the living examples of the country's highest leaders; an organized and widely-shared rapid expansion of the national economy through a government dedicated to honing and mobilizing the people's skills and energies as well as the responsible harnessing of natural resources; a

collective belief that doing the right thing does not only make sense morally but translates into economic value as well; and public institutions rebuilt on the strong solidarity of the society and its communities.

Guided by this vision, all government departments and agencies have been directed to orient their programs, projects and activities towards the following five (5) identified key result areas, namely:

1. **Transparent, accountable, and participatory governance** – to institutionalize open, transparent, accountable and inclusive governance;

2. **Poverty reduction and empowerment of the poor and vulnerable** – to translate the gains from good governance into direct, immediate and sustainable benefit for the poor;

3. **Rapid, inclusive, and sustained economic growth** – to achieve rapid economic expansion that generates jobs and livelihood for and increase the income of the poor while moving away from the boom-and-bust cycle of the economic performance of the past;

4. **Just and lasting peace and the rule of the law** – to attain a just, comprehensive, and lasting peace within the bounds of law; and

5. **Integrity of the environment and climate change adaptation and mitigation** – to promote sustainable natural resource utilization and climate change adaptation and mitigation strategies and measures among national government agencies, the local government units (LGUs) and their respective communities, the general public, and other stakeholders.

These five key result areas embody the Aquino Administration's Social Contract with the Filipino People. To pursue them, the Cabinet, the highest policy-making body of the executive branch of government, has been organized thematically into five Cabinet Clusters, one for each cited key result area.

- **Philippine Development Plan (PDP) 2011-2016**

Chapter 3 of PDP entitled, "Competitive Industry and Services Sectors", enunciates that science, technology, and innovation are "crucial factors for productivity, competitiveness, job creation, sustainable development, and poverty alleviation"." To increase productivity and efficiency, the government shall give priority to the development of areas that have the highest growth potentials and generate the most jobs. These include: tourism; business process outsourcing (BPO); mining; agri-business and forest-based industries; logistics; shipbuilding; housing; electronics; infrastructure; and other industries with high growth potential."

PDP also states, "The government shall continue to implement the national innovation strategy called Filipinovation. This will enable the country to achieve (a) a competitive and multidisciplinary work force competent in producing value-added knowledge-based services of global standards; (b) competitive local firms driven by

or borne out of constant innovations brought about by increased R&D; and (c) a public policy environment that ensures continuous innovation not only through executive, legislative and judicial initiatives but through local government programs. It will promote the usage of Information and Communications Technology (ICT) in enterprises. Filipinnovation focuses on: (a) strengthening human capital investments for STI; (b) stimulating STI; (c) enhancing management of the STI system; and (d) upgrading the Filipino mindset in S&T. Since the strategy/policy imperatives are interconnected, it shall be coordinated and harmonized to create necessary conditions to deepen and consolidate STI capacity."

- **Cabinet Cluster System and STI**

To enhance horizontal governance, the Cabinet, the highest policy-making body of the Executive branch of government, has been organized thematically into Cabinet Clusters corresponding to the five (5) key result areas adopted by the Aquino Administration. These are: 1) Transparent, accountable, and participatory governance; 2) Poverty reduction and empowerment of the poor and vulnerable; 3) Rapid, inclusive, and sustained economic growth; 4) Just and lasting peace and the rule of the law; and 5) Integrity of the environment and climate change adaptation and mitigation. The Department of Science and Technology (DOST) has been designated as regular member of the Economic Development Cluster and the Climate Change Cluster.

- **DOST Five-Point Action Agenda**

To focus its STI interventions, the DOST has adopted a 5-Point Action Agenda. These include: 1) Using S&T to address pressing national concerns and problems; 2) Developing appropriate technologies to create growth in the countryside and alleviate poverty; 3) Harnessing technology to improve industry competitiveness; 4) Using S&T to enhance the delivery of government and social services; and 5) Developing emerging technologies to boost national competitiveness. As a strategy, DOST will adopt the program management approach to address said identified priority areas.

- **Congressional Commission on Science, Technology and Engineering (COMSTE)**

The COMSTE, a body created jointly by the Senate and the House of Representatives, undertakes a national review and assessment of the science, engineering, and technology research and development system of the country with a view to: (a) enhancing the system's internal capability to satisfactorily implement the constitutional provisions on science and technology; (b) providing the system with the necessary funding requirement and other infrastructure support; (c) strengthening the linkages will all sectors concerned with science, and technology and engineering R&D; and (d) assisting the science and technology and engineering sector in achieving its goals and targets through policies and approaches that are consistent with the nation's development perspectives.

Its recent initiatives focus on the creation of innovation clusters in the country to be spearheaded by the DOST. Among its proposed innovation clusters are on Algae

Research and Commercialization; Cloud Computing in Cebu, Disaster Science and Management; Non-Adversarial Mining in Mindanao; Remote Sensing and Decision Support for Agriculture; and High Value Added Electronic Products.

In the Philippines, empirical evidences show that R&D and innovation yield high rates of return even higher than those for public infrastructure capital; and that they offer higher social than private gains, clearly indicating that R&D and innovation can indeed be rewarding to the Filipino society.[1] The disparity in rates of return indicates failures in the operation of markets as well as to the weaknesses of technological, economic, and political institutions in facilitating the creation, diffusion, and application of knowledge and technologies.

It is an accepted fact that the difficulties faced in establishing effective national systems of innovation are not the same for all countries, even in the ASEAN region. Also, the operation of the market and the development of the private sector are considered as necessary condition for the emergence of an effective system of innovation but empirical evidences have shown that these are not sufficient. Government action is also required. It is from 'governance' perspective that this paper attempts to outline the challenges faced by the Philippines in coming up and implementing public policies on science, technology and innovation.

Need to Define the Role of R&D in National Development

Many studies have shown that research and development (R&D) is a key driver of long-term economic growth, primarily through its impact on productivity. R&D produces knowledge and technology, which can enhance the productivity of factors of production, and R&D benefits spill over to individuals other than the researchers, to other firms and sectors of the economy.

The 1987 Constitution (Article IV) directs the government to give priority to research and development, invention, innovation, and their utilization; and to science and technology education, training and services (Sec 10). Also, the Constitution affirms the authority of the Congress to provide incentives, including tax deductions, to encourage private participation in programs of basic and applied scientific research; and to provide scholarships, grants-in-aid or other forms of incentives to deserving science students, scientists, researchers, inventors, technologists and specially-gifted citizens (Sec. 11).

R&D Investment Pattern

There are theoretical and empirical evidences showing that R&D is prone to market failures. Economists say that a market failure occurs when the price mechanism does not work and fails to give the right signal to private investors in their investment decisions for profitable ventures. Cororaton (1998) showed that in the Philippines, R&D yields high rates of return, higher than the rates for public infrastructure capital and that it has higher social rate of return than private rate of return, clearly indicating that R&D can indeed be highly socially profitable. While it

[1] Cororaton (1998) estimated the rates of return to R&D investment in the Philippines.

can be potentially rewarding, R&D in the country does not attract adequate level of investments.

UNESCO recommends that developing countries invest 1% of their GDP to R&D. However, the country's national R&D expenditure level has been estimated to reach only 0.14% of GDP in 2009. Of this total R&D investment, 72% came from private sector and 28% from public institutions (Table 12).

Table 12
Philippines: R&D Expenditures as Percentage of GDP, 2007 and 2009

Indicator	2007	2009
GDP (current prices/ in million pesos)	6,648,619	8,026,143
Total R&D Expenditures (current prices/ in million pesos)	7,556	11,127
R&D Expenditures as % of GDP	0.11	0.14
Public R&D Expenditures (current prices/ in million pesos)	2,660	3,155
% of total*	35%	28%
Private R&D Expenditures (current prices/ in million pesos)	4896	7,972
% of total**	65%	72%

** includes expenditures of government agencies and state universities and colleges*
*** includes expenditures of private industries, private universities and private non-profit institutions*

R&D underinvestment in the country could be attributed to many factors. All investment is uncertain, but investment in R&D is particularly risky because its outcomes cannot be assured. While inherently risky, its uncertainties are even magnified by market imperfections such as externalities, public good-related problem and information asymmetry.

Private investors normally do not factor externalities, whether positive or negative, into their investment decisions and thus, will most likely regard an R&D endeavor as unprofitable even if it can possibly generate significant technological and knowledge spillovers (positive externalities) to the economy and society.

Once knowledge or a technology is created, it would be difficult to exclude others from using it or to make others pay for its benefits. Knowledge and technology spill over and eventually become freely appropriable like a "public good", giving private investors difficulties in recouping their investments.

Information gaps exist between R&D performer/innovator and investor, limiting R&D financing. The success of R&D necessitates secrecy but investors require information disclosure. As a result, many R&D endeavors often lapse lacking funding.

Moreover, the emerging concept of a national innovation system (NIS) suggests that the primary role of government is to correct systemic failures, which may include market failures, but can also include the "disconnectedness" between actors or institutions. Many studies have shown that R&D efforts flourish and often succeed when actors in the national innovation system collaborate to share knowledge, risks, and costs. Comparatively, R&D and innovative performance is stunted when players

are "disconnected" and do not collaborate. Thus, the NIS approach suggests that governments should correct systemic failures by focusing on overcoming "barriers" to and strengthening "drivers" of collaboration among NIS players, particularly in terms of how incentives in one policy domain affect the incentives in other policy domains.

Based on survey results, the private business sector remains to be the biggest R&D investors in the country contributing an average of 62% of the total national R&D expenditures (Table 13). The government sector accounts for 17% while the higher education sector for 19% (with publicly funded HEIs accounting for more than private HEIs).

Table 13
Philippines: National R&D Expenditures by Sector
2003, 2005, 2007, and 2009

Sector of Performance	R&D Expenditures (in million pesos, at current prices)			
	2003	2005	2007	2009
All Sectors	5,910	6,327	7,556	11,127
Government	1,130	1,175	1,334	1,393
Higher Education	657	1,350	1,757	2,130
Public HEIs	455	1,093	1,326	1,762
Private HEIs	202	257	431	367
Private Non-Profit	105	96	162	228
Private Business	4,018	3,705	4,303	7,376

Source: DOST R&D Surveys (Government, HEIs & PNP); NSO-ASPBI for Private Industry (2009 data from 2008 ASPBI)

In terms of private sector R&D investments, the manufacturing sector accounts for the highest share (78% of the total), followed by the real estate renting and business activities (which includes the emerging IT-Business Process Outsourcing sector) and financial intermediation sectors (Table 14). R&D underinvestment can be observed in most sectors, particularly in agriculture, fishing, and health and social work sectors where productivity enhancement could be the most socially profitable.

Table 14
Philippines: R&D Expenditures in the Private Industry Sector by Type of Industry
2003, 2005, 2006, 2008 (in thousand pesos)

Private Industry Major Sector	R&D Expenditure			
	2003	2005	2006	2008
Total All Industry Sectors	4,018,085	3,705,095	4,034,104	7,376,075
Agriculture, hunting and forestry	34,382	58,849	18,519	44,689
Fishing	43	2,841	1,034	1,272
Mining and quarrying	8,274	4,959	212,979	8,941
Manufacturing	3,279,598	2,314,377	2,756,726	5,766,530
Electricity, gas and water	174,373	33,545	102,467	98,500
Construction	10,220		102,467	61,355
Wholesale & retail trade; repair of motor vehicles, motorcycles and personal & household goods	159,075		91,126	109,360
Hotels and restaurant	26,795	29,589	38,907	34,902
Transport, storage and communication	6,131	704,062	46,093	36,287
Financial intermediation	28,284	89,425	82,159	408,196
Real estate renting and business activities	178,540	359,295	433,443	482,995
Health and social work	37,996	52,977	84,113	33,063
Other community, social and personal service activities	74,374	55,176	64,071	289,985

Sources: NSO-Annual Survey of Philippine Business and Industry (ASPBI), 2003, 2005 & 2008; NSO-Census of Philippine Business and Industry (CPBI), 2006; Note: Data do not include R&D expenditures in education sector as this was already included in the Higher Education Institutions (HEIs) covered by DOST R&D survey.

R&D Policy and Issues

From a policy perspective, the economic rationale for government support to R&D is that its benefits spill over to individuals other than the researchers, to other firms and sectors of the economy and that its social rates of return can be significantly higher than private rates of return, confirming the non-excludability of technological progress. It is also premised on the thinking that the value of R&D benefits could not be fully captured by the R&D performer, and because of this, private individuals and firms would most likely perform less R&D than is desirable from the economy's point of view. Markets cannot be expected to allocate an efficient or socially optimal amount of R&D investments justifying government intervention on R&D.

In this context, the Philippine government supports R&D through a combination of fiscal and regulatory policies. These policy instruments are designed to encourage investment in R&D or increase private rates of return to R&D investments to levels closer to social rates of return, and to respond to the problems of market imperfections and their impacts on R&D investment and economic growth.

These include the following: 1) maintenance of government-funded R&D institutions; 2) provision of R&D grants; 3) provision of R&D tax incentives; and 4) granting of patents.

Government-funded R&D Institutions

The government maintains a network of government R&D institutions. A number of them are with the departments with seven under the Department of Science and Technology (DOST) but the most of these are with the state colleges and universities. They perform mission-oriented R&D related to their specific legal mandates. Government R&D institutions account for about 18 % of the total government R&D funding while SUC-based R&D institutions about 9 %.

Government R&D Grant Schemes

A number of government institutions provide R&D grants and the DOST is one of them. DOST has estimated that about 73 % of total government funding for R&D is being provided as R&D grants by different government R&D grant-giving institutions.

In response to the need to synchronize government-funded R&D efforts with the overall national development agenda, the Presidential Coordinating Council for R&D (PCCRD) has been created under Executive Order No. 604. It has been tasked to coordinate R&D activities of various sectors, recommend allocation of R&D budgets, establish priority R&D areas for public funding, establish a monitoring and evaluation system for government-funded R&D institutions, and encourage private as well as international R&D funding. Among the issues raised in the PCCRD are the following:

- the need to harmonize or unify publicly-funded R&D efforts;
- the need to enhance the monitoring and evaluation of all publicly-funded R&D programs and projects;
- the need to overcome barriers to importation of R&D equipment and materials;
- the need to maximize the country's potentials as R&D location, and;
- the need to sustain R&D efforts over long-term.

The challenge is to direct the scarce public funds to highly socially profitable R&D programs whose socio-economic outcomes immediately spill over to the economy particularly to the poor in the countryside. Likewise, it is recognized that government institutions are generally less good than the market in "choosing winners"; that political pressures often push in uneconomic directions; and that it is often politically hard to terminate the subsidy or protection. Governance capability of government R&D institutions has to be enhanced towards greater transparency and accountability.

Also, the Congressional Commission on Science and Technology and Engineering (COMSTE) has been created through a joint resolution of the 13th Congress. It has reviewed the S&T and R&D sector focusing on the following six priority areas: 1) Agriculture and Food; 2) Electronics and Semiconductor industry; 3) Energy and

Environment; 4) Health Sciences; 5) Information and Communications Technology (ICT), and; 6) Science, Mathematics and Engineering Education. It presently advocates the adoption of innovation clustering approach in R&D implementation through joint research grants that can better promote collaboration among universities, government research institutes, and firms. The DOST together with the Department of Agriculture and the Commission on Higher Education are pilot testing the creation of innovation clusters for algae research, smart and precision farming, cloud computing, mining technologies, and disaster science.

R&D Tax Incentives

The government provides R&D tax incentives under the Tax Reform Act of 1997, also known as the National Internal Revenue Code (Republic Act No. 8424). Private firms are allowed to deduct from their taxable income any R&D expenditures that they have incurred during the taxable year including the amortization of R&D capital equipment over a period of not less than sixty (60) months excluding land acquisition or improvement and any expenditure for ascertaining the existence, location, extent, or quality of any deposit of ore or other mineral, including oil or gas.

Also, under Executive Order No. 226 or the Omnibus Investments Law, private firms that perform R&D are entitled to incentives such income tax holiday; duty free importation of capital equipment, incentives for the necessary and major infrastructure and facilities in less developed areas; access to bonded manufacturing/trading warehouse system; and employment of foreign nationals.

While R&D tax incentives enable markets to determine freely which R&D investments to undertake, Congress might need to review them. The R&D tax incentive scheme under RA 8424 or the Internal Revenue Code has been implemented since 1998 as deductions from the gross income. Comparatively, in other countries, the normal pattern of government R&D tax support is through a tax credit, under which a portion of the amount of research investment is directly deducted from taxes and not from the gross income. Tax credit has been found to be more effective in promoting high-tech business start-ups, which may not have profits until sometime after they have invested in research. Obviously, there may be considerations in whether the tax credit should be given to encourage local research as opposed to building local technological capability through the acquisition of research or technology from abroad. Tax credits may also have to be given to those who undertake “innovations at the bottom of the pyramid” or “below-the-radar innovations” particularly in the countryside.

Granting Patents

In terms of regulation, patents are granted by the government specifically through the Intellectual Property Office (IPO) to protect intellectual property rights as a partial remedy to the free rider problem caused by the inappropriability of technology, particularly for technologies that are specific to the production of a particular good or substitutes. Providing monopoly power to R&D performers reduces the effects of inappropriability and increases the costs of imitation. Thus,

intellectual property protection facilitates the diffusion of technology while preserving the incentive to invest in R&D. However, technologies that are of general use are more difficult to appropriate by the use of patents and other measures.

In this connection, the Technology Transfer Act of 2009 (R.A. 10055) has been enacted with the aim of promoting and facilitating the transfer, dissemination, and effective use, management, and commercialization of intellectual property, technology and knowledge resulting from research and development funded by the government for the benefit of national economy and taxpayers. This law makes the R&D performing institution the default owner of intellectual properties resulting from publicly funded R&D.

Growing a Venture Capital Industry

The government may have to consider growing a venture capital industry in the country particularly to promote high-tech businesses. As shown by experiences of other countries, an effective venture capital process would have to be complemented by a network of marketing, technological, financial, and legal skills. Most of all, venture capitalists should be legally enabled to recoup their investment through varied "exit" strategies from selling the start-up to the public on a major stock market to selling it to a major firm already in the business.

The DOST has initiated the establishment of a number of technology business incubators TBIs) in the country. TBIs are designed to offer a package of skills and infrastructures, such as conveniently available business and legal expertise and assured pure water, electricity, communications, and transportation capabilities. Studies show that TBIs located near a university or research institution have higher success rates as in the cases of Silicon Valley and Hsinchu Park. This initiative is meant to prepare the ground for a vibrant local venture capital industry. Congress may need to enact a law giving incentives to local venture capitalists.

***Government Procurement as a Means to Build Local Technological* Capability**

Government may have to harness its procurement or purchasing power as a strategy to strengthen local technological capacity. It may impose a higher level of standards on those seeking to supply or invest in technology to the country. Moreover, with the WTO Agreement on Government Procurement, the government may have to exploit Article V that provides an exception for the benefit of developing nations.

Building a Critical Mass of R&D Workers

It is fully recognized that one of the most significant challenges facing R&D in the country is to develop a critical mass of R&D workers and to keep them in the country. To address this need, the DOST has supported the Engineering Research and Development for Technology (ERDT) Program that offers graduate scholarships in engineering, thesis and dissertation grants, research grants, visiting professor grants, and post-doctoral grants to qualified candidates. Its objective is to produce a critical mass of engineers with advanced degrees who are equipped to do research and development that can address the needs of local industries, R&D institutions,

and academe. The ERDT Program is collaboratively implemented by a consortium of universities led by the UP College of Engineering and UP Los Baños, Ateneo de Manila University, Central Luzon State University, De La Salle University, Mapua Institute of Technology, Mindanao State University – Iligan Institute of Technology and University of San Carlos. The program will help make the Philippines globally competitive by increasing the quantity and quality of local engineering research efforts.

2. Human Resources Involved in S&T

- The country's R&D workers in terms of headcount numbered some 9,325 (116 per million population) in 2002 and increased to 14,649 (165 per million population) in 2007. However, scientists and engineers engaged in R&D increased from 7,203 (90 per million population) in 2002 to 11,490 (130 per million population) in 2007.
- By sector of performance, the distribution of R&D personnel has been changing. While the bulk (42 %) of R&D workers is with the higher education sector, the share of the business enterprise has grown from 20% in 2002 to 35% in 2007 (Table 15).

Table 15
Philippines: Sector of Performance in S&T

Sector of Performance	2002	2007
All Sectors	9,325 (100%)	14,649 (100%)
Government	32.8 %	21.8%
Higher Education	43.9%	41.7%
Public HEIs	33.6%	28.1%
Private HEIs	10.3%	13.4%
Private Non-Profit	2.6%	1.4%
Business Enterprise	20.8%	35.1%

3. Infrastructure for S&T

- There are a plethora of institutions engaged in R&D. While the DOST has been mandated under the law to coordinate R&D efforts in the country, there are actually 52 government R&D institutions in 9 Departments. Only eleven of these are under the direct supervision of the DOST.
- In the higher education sector, the University of the Philippines (UP) System has 95 R&D institutes in 6 campuses all over the country. Also, there are 131 R&D institutes under the 117 state universities and colleges.
- The University of the Philippines Diliman Campus has built the Science Complex that has been envisioned to support other universities.
- Also, under the leadership of the UP College of Engineering, a consortium of 8 universities nationwide has been organized under the Engineering R&D for Technology (ERDT), a program that is being funded by the DOST.
- Multi-disciplinary approach to R&D has yet to take root in the country.

4. Funding for S&T

- GERD in 2002 amounted to 5.77 billion pesos, which was 0.15 % of GDP. In 2007, GERD was pegged at 7.56 billion pesos or 0.11 % of GDP. National R&D spending has not been keeping up with economic growth.
- In 2002, the private sector accounted for the bulk (72%) of GERD and the government, 28%. In 2007, the private sector contributed 65% while the government, 35%.
- By sector of performance, the Higher Education Sector has increased its share in R&D spending from 13 % in 2002 to 23 % in 2007 (Table 16).

Table 16
Philippines: GERD Sector of Performance in S&T R&D Spending

Sector of Performance	2002	2007
All Sectors	5.77 B (100%)	7.56 B (100%)
Government	16.9%	17.7%
Higher Education	13.2%	23.3%
Public HEIs	11.1%	17.6%
Private HEIs	2.1%	5.7%
Private Non-Profit	2.1%	2.1%
Business Enterprise	67.8%	56.9%

5. S&T Utilization Program

- The concept of Technology Business Incubators has been gaining ground. In the last three years, three four additional TBI facilities have been established through different partnership arrangements, DOST-ASTI-PEZA Open TBI in UP Diliman (government-led); Entrepreneurship Center at NEC of UP College of Engineering (academe-led); Tacloban IT center (Local Government-led) and the UPLB-based TBI (academe-led). TBIs are also being established in Cebu and Davao.
- The Philippine Technology Transfer Law has been enacted giving the R&D institutes the default ownership of the intellectual property arising from publicly funded R&D.
- The proposed Innovation Clusters are calculated to enhance S&T utilization all over the country.

6. **S&T Outputs**

- In 2000, there were 574 patents granted and these increased to 1,679 in 2009.
- In terms of patents applications filed in 2000, 1,082 were from foreigners and eight (8) from nationals. By comparison, in 2009, there were 1,082 applications from foreigners and 22 from nationals.
- As cited in the draft OECD Study, “OECD Review of Innovation in Southeast Asia: Innovation Performance and Linkages”, the Philippines in 2000 had 17 PCT applications which grew to 32 in 2008.

- The number of co-publications by Filipinos with counterparts in other ASEAN Member States has increased, as cited in the draft OECD Study, "OECD Review of Innovation in Southeast Asia: Innovation Performance and Linkages" (Table 17).

Table 17
Number of Co-publications by Filipinos with Citizens from Other AMS

Country	2000-2004	2005-2009
Indonesia	51	110
Malaysia	50	142
Singapore	50	144
Thailand	91	176
Vietnam	35	89

7. Areas of Strength in S&T/R&D

- Disaster Science and Management
- Climate Change
- Aquaculture
- Biodiversity

8. Major Contributions to GDP

These sectors identified in PDP would contribute significantly to inclusive growth and employment generation:

- Business Process Outsourcing (including knowledge process outsourcing)
- Tourism
- Electronics
- Mining
- Housing
- Agribusiness/Forest-based Industries (banana, pineapple, mango, papaya, and okra; preserved fruits; beverages; and processed marine products)
- Logistics
- Shipbuilding
- Infrastructure

9. Major Exports

- Electronic Products
- IT-enabled Services
- Automotive parts (Ignition Wiring Set & Other Wiring Sets Used in Vehicles, Aircrafts and Ships)
- Articles of Apparel & Clothing Accessories
- Coconut Oil
- Tuna
- Banana

10. Major Trading/Economic Partners in ASEAN

Singapore, Thailand, and Malaysia

SINGAPORE

1. S&T Policy and Development Strategy

Singapore has enjoyed robust economic growth since independence in 1965. In 2009, per capita GNI reached $52,251 – 32 times the level in 1965. Economic development in Singapore has gone through several phases, characterized by the strategies in response to challenges and opportunities at the time.

In the 1990s, Singapore embarked on a major technology drive to transform itself into a knowledge-driven economy, intent on joining the ranks of industrialized and high technology countries. Singapore initiated its first National Technology Plan in 1991. It was formulated to steer the development of science and technology in Singapore, with the aim of enhancing economic competitiveness. It meant moving to an economic phase in development and promoting activities with more innovative and design content. This followed with the second 5-year plan for the years 1996 – 2000. This National Science and Technology Plan helped to bring Singapore closer to having world-class science and technology capability, with significant resources set aside to strengthen the workforce, to support R&D in industry, and to develop indigenous R&D capability. The third national 5-year plan, the Science and Technology (S&T) Plan 2005, focused on strengthening R&D capabilities in niche areas, nurturing local talent and recruiting global talent, and working with industry through technology transfer and other mechanisms.

R&D has become a cornerstone of Singapore's economic development. Testament to its importance is the high-level attention it receives. The Research, Innovation, and Enterprise Council (RIEC), a public and private sector council chaired by Prime Minister (PM) Lee Hsien Loong leads Singapore's national drive to promote research and enterprise. RIEC advises the Singapore Cabinet on national research and innovation policies.

Most recently, Singapore brought to a close S&T2010. The S$13.9 billion plan saw Singapore build a significant base of R&D capabilities. There is a spectrum of industry oriented research institutes across engineering and biomedical sciences and Universities with research excellence in areas such as energy, water, and biomedical sciences. It has helped attract talent and private R&D investments. Between 2005 and 2009, the number of research scientists and engineers in Singapore increased markedly from about 21,000 to more than 26,000. Private sector expenditure on R&D increased from about S$3 billion to about S$3.7 billion. R&D also yielded products and processes that generated an average of S$18 billion in sales revenue each year.

Over the 20 years of evolving national S&T plans, Singapore's Gross Expenditure on R&D (GERD) as a percentage of GDP has increased from 0.81% in 1990 to 2.28% in 2009. The number of research scientists and engineers also grew significantly from 4,329 in 1990 to 26,608 in 2009.

The most recent national S&T plan, which covers the period 2011-2015, is called Research Innovation Enterprise (RIE) 2015. The six key strategies for RIE 2015 are:

- Focus a greater proportion of R&D on economic outcomes. This means greater support for private sector R&D, closer collaborations between public and private sector R&D, and added emphasis on commercialization of intellectual properties, leading to new and better products and services. Support for private R&D will be increased from S$2.1 billion to S$2.5 billion. Within public R&D, a new S$1.35 billion Industry Alignment Fund will encourage public researchers to work more closely with industry.

- Place greater emphasis on competitive funding, to spur innovation and bring out the best ideas for further support and development. A greater proportion of R&D funding will be available on a competitive basis, while maintaining an appropriate level of assured funding for core capabilities. Competitive funding will help us refresh and renew our R&D portfolio, whilst ensuring that the best capabilities are retained. The National Research Foundation's Competitive Research Programme will be expanded significantly from S$350 million to close to S$1 billion.

- Strengthen synergies across our various R&D performers in the Agency for Science, Technology and Research (A*STAR) research institutes, universities, hospitals, CREATE (Campus for Research Excellence and Technological Enterprise) centres, and industry. Greater funding priority will be given to such multi-disciplinary and collaborative efforts, including corporate R&D laboratories. A*STAR's Joint Council Office, which supports multidisciplinary research across the physical and biomedical sciences, will receive an expanded budget of S$250 million.

- Invest ahead of industry, to seed the intellectual capital that forms the basis for future innovations. Scientists will receive the support and autonomy to pursue the questions that emerge from their research, and to create new knowledge in areas their selected areas. The Ministry of Education (MOE) has enhanced its Academic Research Fund to provide more support for basic, investigator-led research. A new Tier 3 programme has been introduced, to fund programme-level research projects ranging from S$15 million to $25 million over 5 years. MOE also intends to increase the amount awarded for its Tier 2 grants to S$25 million by 2014.

- Provide stronger support for our scientists to take their ideas from basic research through to commercialization. This will strengthen the work of our technology transfer offices, translational and innovation centers, and enterprise incubators and accelerators. The Innovation and Enterprise budget will be approximately doubled to S$1.08 billion.

- Continue to emphasize the attraction and development of scientific talent to meet the needs of our industry and public sector research institutions. $735 million will be allocated to scholarships and fellowships for talent training at renowned institutions both locally and overseas.

Examples of research priorities for 2011-2015 include the following:

- **Electronics** – Data Storage and Semiconductors system integration
- **Biomedical Sciences** – Translational and Clinical Research to convert laboratory discoveries into new drugs, devices and diagnostics, and Nutrition and Medical Technology
- **Infocomms and Media** – Data Analytics and Interactive and Digital Media
- **Engineering** – Precision Engineering and Transport Engineering
- **CleanTech** – Intelligent Energy Systems and Energy Efficiency

2. Infrastructure for S&T

Starting with pockets of R&D capabilities residing in research institutes and the universities, Singapore has now established an emerging and vibrant R&D ecosystem comprising public sector research institutions, Institutions of Higher Learning including the universities, polytechnics, Research Centers of Excellence and international institutions, hospitals and academic medical centers, and corporate R&D laboratories. At the same time, Singapore's autonomous universities were also transformed to become more research-intensive. To manage the research performers and to ensure the long-term relevance of Singapore's R&D investments, a holistic R&D framework was put in place.

- The **Research, Innovation and Enterprise Council (RIEC)** and the **National Research Foundation (NRF)** were set up in 2006 under the Prime Minister's Office to lead and coordinate the research of different agencies, within a larger national framework, in order to provide a coherent and comprehensive strategic overview and to help advance Singapore's National R&D Agenda. NRF aims to develop policies and plans to implement the six strategic thrusts for the national R&D agenda and implement these policies by allocating funding to the programmes that meet the strategic objectives.

  NRF provides grants at various stages of the Innovation and Enterprise Continuum. There are Proof-of-Concept Grants, Technology Incubation Scheme Grants, and Early Stage Venture Funding Scheme. It also operates the University Innovation Fund for Entrepreneurial Education, and the Innovation and Enterprise Institute.

- The **Ministry of Education (MOE)** oversees and funds academic research at tertiary institutions as well as investigator-led research through the expanded Academic Research Fund (AcRF). MOE focuses on research that is foundational in nature, with longer timeframes and driven by knowledge creation.

- The **Ministry of Health (MOH)**, through the National Medical Research Council (NMRC), focuses on scientific and health research with the aim of driving the translational of basic research to advance human healthcare, and to increase the translational and clinical research capabilities of public hospitals, research institutions, and medical researchers.

- The **Ministry of Trade and Industry (MTI)** drives mission oriented research, through the close integration of the efforts of its economic agencies, A*STAR, SPRING and EDB.

  - **A*STAR** nurtures public sector R&D in biomedical sciences, physical sciences and engineering, and supports Singapore's key economic clusters by providing intellectual, human and industrial capital to partners in industry and the healthcare sector. A*STAR's R&D strategies are closely integrated with Singapore's economic development strategies, and these enable Singapore to attract R&D projects with multi-national companies (MNCs), widen industry reach and help local enterprises upgrade. Apart from supporting research at its own research institutes, A*STAR plays a key role as a source of funds of R&D in the extramural community in Singapore.

  - Together with EDB, A*STAR helps to anchor various flagship R&D projects and attract more MNCs to locate corporate R&D activities in Singapore.

  - A*STAR also partners SPRING, the enterprise development agency for growing innovative companies and fostering a competitive small and medium enterprise (SME) sector, to upgrade the technology capabilities of local enterprises by providing support such as financing, capability and management development, technology and innovation, and access to markets.

  - In all, the various grants provided by MOE, MOH, MTI, and NRF would help to stimulate and support research and innovation in the larger scientific community in Singapore, and contribute to knowledge creation and attraction of industry projects.

- **Research Performers in Singapore Include the following:**

  - A*STAR Research Institutes
    The Science and Engineering Research Council (SERC) promotes public sector R&D in a wide range of fields including communications, data storage, materials, chemicals, computational sciences, microelectronics, process manufacturing and metrology. Research institutes include:
    - Data Storage Institute (DSI)
    - Institute of Chemical and Engineering Sciences (ICES)
    - Institute of High Performance Computing (IHPC)
    - Institute for Infocomm Research (I^2R)
    - Institute of Materials Research and Engineering (IMRE)
    - Institute of Microelectronics (IME)
    - National Metrology Centre (NMC)
    - Singapore Institute of Manufacturing Technology (SIMTech)

  - The Biomedical Research Council (BMRC) oversees seven research institutes (RIs) and other research units that serve to support key industry clusters in

Biomedical Sciences such as pharmaceuticals, medical technology, biotechnology and healthcare services. Research performers include:

- Biooinformatics Institute (BII)
- Bioprocessing Technology Institute (BTI)
- Genome Institute of Singapore (GIS)
- Institute of Bioengineering and Nanotechnology (IBN)
- Institute for Medical Biology (IMB)
- Institute of Molecular and Cell Biology (IMCB)
- A*STAR-Duke-NUS Graduate Medical School Neuroscience Research Partnership (NRP)
- Singapore Bioimaging Consortium (SBIC)
- Singapore Consortium of Cohort Studies (SCCS)
- Singapore Institute for Clinical Sciences (SICS)
- Singapore Immunology Network (SIgN)
- Singapore Stem Cell Consortium (SSCC)
- Experimental Therapeutics Centre (ETC)

- Institutions of Higher Learning include:
  - National University of Singapore
  - Nanyang Technological University
  - Singapore University of Technology and Design
  - Duke-NUS Graduate Medical School
  - Singapore Management University
  - Nanyang Polytechnic
  - Ngee Ann Polytechnic
  - Republic Polytechnic
  - Temasek Polytechnic

- Research Centres of Excellence (RCE) conducts world-class investigator-led research with a global impact, focusing on areas aligned with the long-term strategic interests of Singapore. These Centres will build upon the existing academic strengths and research competencies of the local universities and complement the principally mission-oriented programmes of A*STAR. It will serve to attract top academic research talent and retain them in Singapore. At the same time, RCEs will engender interest in research among local students, and encourage more to pursue research careers. RCEs include the following:
  - Centre for Quantum Technologies
  - Cancer Science Institute Singapore
  - Earth Observatory of Singapore
  - Mechanobiology Institute
  - Singapore Center on Environmental Life Sciences Engineering

- Hospitals and academic medical centres include the following:
  - Singapore General Hospital
  - National University Hospital
  - National Skin Centre
  - Singapore National Eye Centre
  - Changi General Hospital
  - KK Women's and Children's Hospital

- Tan Tock Seng Hospital
- National Dental Centre of Singapore
- Singapore Eye Research Institute
- National Heart Centre Of Singapore
- National Cancer Centre Of Singapore
- National Healthcare Group
- Singapore Health Services
- Woodbridge Hospital
- National Healthcare Group Polyclinics
- Alexandra Hospital
- National Neuroscience Institute Of Singapore

- Some examples of corporate labs that have been set up in Singapore include the following:
  - Applied Biosystems
  - Becton Dickinson
  - Edwards Life Sciences
  - Siemens
  - *Novartis* Institute for Tropical Diseases (NITD)
  - *Abbott Laboratories*
  - *GSK Centre* for Cognitive and Neurodegenerative Disorders *Takeda Pharmaceutical Company Limited*
  - *Fujitsu*
  - *Vestas Wind Systems A/S*

3. Human Resources Involved in S&T R&D

Total R&D Manpower (including researchers, postgraduate students, technicians, and support staff) grew by 2.2% from 40,504 employees in 2008 to 41,388 employees in 2009. This represents a CAGR (Compound Annual Growth Rate) of 6.3% from a base of 23,971 employees in 2000.

The number of researchers grew by 1.2% from 28,760 researchers in 2008 to 29,092 researchers in 2009. This represents a CAGR of 6.2% from a base of 16,981 researchers in 2000.

Research Scientists and Engineers (RSEs) are a subset of the total number of researchers and comprise the researchers, who hold formal qualifications at the university degree level. RSEs exclude fulltime postgraduate research students. In 2009, the number of RSEs grew by 3.4% from 25,745 in 2008 to 26,608 in 2009. This represents a CAGR of 7.0% from a base of 14,483 in 2000.

In the private sector, the number of PhD RSEs grew at a rate of 2.3% from 1,246 in 2008 to 1,275 in 2009. This represents a CAGR of 12.4% from 446 PhD RSEs in 2000. RSEs with a Masters degree grew at a rate of 0.2% from 3,741 in 2008 to 3,750 in 2009. This represents a CAGR of 8.6% from 1791 Masters RSEs in 2000. RSEs with a Bachelors degree declined by 3.1% from 10,362 in 2008 to 10,043 in 2009. The CAGR however, was 6.4% from 5,760 Bachelor RSEs in 2000.

In the public sector, the number of PhD RSEs grew by 11.7% from 4,901 in 2008 to 5,476 in 2009. This represents a CAGR of 8.3% from 2,665 PhD RSEs in 2000. RSEs with a Masters degree grew at a rate of 5.2% from 2,502 in 2008 to 2,631 in 2009. This represents a CAGR of 3.9% from 1791 Masters RSEs in 2000. RSEs with a Bachelors degree grew by 14.7% from 2,993 in 2008 to 3,433 in 2009. The CAGR was 6.5% from a base of 1,954 Bachelor RSEs in 2000.

S&T HRD Capability/Capacity

- **National University of Singapore**

  As at 2010, NUS had 26,418 undergraduates and 10,548 graduates. Some examples of NUS research institutes and centres include the following:
  - Centre for Maritime Studies (CMS)
  - Centre for Remote Imaging, Sensing and Processing (CRISP)
  - Institute for Mathematical Sciences (IMS)
  - Interactive & Digital Media Institute (IDMI)
  - Life Sciences Institute (LSI)
  - NUS Environmental Research Institute (NERI)
  - NUS Nanoscience and Nanotechnology Initiative (NUSNNI)
  - Singapore Synchrotron Light Source (SSLS)
  - Solar Energy Research Institute of Singapore (SERIS)
  - Temasek Laboratories (TL@NUS)
  - The Logistics Institute - Asia Pacific (TLI - Asia Pacific)
  - Tropical Marine Science Institute (TMSI)

- **Nanyang Technological Institute**

  As at 2010, NTU had 23,043 undergraduates and 10,044 graduates. Some examples of NTU research institutes and centres include:
  - Institute of Environmental Science and Engineering (IESE)
  - Nanyang Environment & Water Research Institute (NEWRI)
  - Electromagnetic Effects Research Laboratory (EMERL)
  - Energetics Research Institute (E*n*RI)
  - Intelligent Systems Centre (IntelliSys)
  - Satellite Engineering Centre (SEC)
  - Thales@NTU
  - Temasek Laboratories@NTU

- **Campus for Research Excellence And Technological Enterprise (CREATE)**

  CREATE is a multi-national, multi-disciplinary research enterprise housing some 1,000 research talent. Current centres in CREATE include the following:

  - The Singapore-Massachusetts Institute of Technology Alliance for Research and Technology (SMART) Centre;

- The Singapore-Swiss Federal Institute of Technology Centre for Global Sustainability (SEC)
- Research on Regenerative Medicine Initiative in Cardiac Restoration Therapy between Technion-Israel Institute of Technology, NTU and NUS;
- Technical University Munich-CREATE Centre on Electromobility in Megacities;
- Research on Cellular and Molecular Mechanism of Inflammation between Hebrew University of Jerusalem and NUS;
- Berkeley Education Alliance for Research in Singapore (BEARS) between University of California at Berkeley, NTU and NUS and;
- Research on Nanomaterials for Energy and Water Management between Ben-Gurion University, Hebrew University of Jerusalem and NTU.

- **Duke-NUS Medical School**

  Duke-NUS Medical School was established to produce highly trained medical leaders needed to support the Biomedical Sciences Initiative. This will help to increase the supply of doctors practicing in Singapore, give the country the flexibility to produce more physicians to meet future needs, and train doctors who are exposed to clinically related research, thus increasing the nation's capacity to develop a vibrant biomedical hub.

  Duke-NUS focuses on five Research Programmes. These include the following:
  - Cancer and Stem Cell Biology
  - Cardiovascular & Metabolic Disorders
  - Emerging Infectious Diseases
  - Health Services & Systems Research
  - Neuroscience and Behavioral Disorders

- **Singapore University of Technology and Design (SUTD)**

  The Singapore University of Technology and Design (SUTD) aims to become the centre and stronghold of global research and breakthroughs through creative technical research and education anchored in design within a multi-disciplinary approach. SUTD will produce engineering, architectural and systems graduates who are well versed in technical functionality and form to design the innovations of tomorrow. The first batch of students will matriculate in April 2012.

4. Expenditures/Funding for S&T R&D

Singapore's pattern of expenditures for S&T/R&D is shown below:

- GERD in 2000 : S$3.0Billion
- GDP in 2000 : S$162.6Billion
- GERD / GDP in 2000 : 1.84%
- GERD in 2009 : S$6.0Billion
- GDP in 2009 : S$265.1Billion
- GERD / GDP in 2009 : 2.26%

Public expenditure on R&D grew from S$ 2 billion in 2008 to S$ 2.3 billion in 2009.

To further boost research, innovation and enterprise (RIE), the Singapore Government will invest S$16.1 billion over 2011-2015 as part of its RIE 2015 plan. This is a 20% increase over 2006-2010. At 1% of the national GDP, it is on par with advanced countries. This demonstrates Singapore's continued commitment to both basic and mission-oriented research in our public sector research institutions.

The share of Government in R&D expenditures is about 61.6% while that of the private sector is about 38.4%.

The types of R&D conducted by companies in the private sector are classified into three categories:

- Basic research (experimental or theoretical work undertaken without any particular application or use in view);
- Applied research (original investigation directed primarily towards a specific practical aim or objective); and
- Experimental Development (systematic work that is directed to producing or improving substantially materials, products and devices; or installing new processes, systems, and services).

5. S&T Outputs

In 2009, Singapore published 10,237 papers in total. A*STAR published 3,200 papers while the autonomous universities in Singapore published the rest. The number of patents awarded has increased significantly from 20 in 1992 to 747 in 2008. The sales revenue from products of R&D performed in Singapore has doubled from about S$ 6.4 billion in 1996 to about S$ 12.3 billion in 2009. R&D has helped to sustain the competitiveness of established sectors such as Marine and Offshore Engineering and Electronics, and seeded new growth sector such as Biomedical Sciences and CleanTech.

6. S&T Utilization Programs Including Indicators of Utilization

To promote the utilization of technologies Singapore's A*STAR provides direct support for industrial innovation either by partnering firms to undertake research, development and design activities, or by assisting companies in bringing prototypes to production or adopting new technology. It also provides or shares R&D/technical facilities and services to industry. Through the cohabitation of public and industry R&D, the inter-mingling of R&D personnel encourages the flow of R&D talent from the research institute to industry. A*STAR also identifies cutting-edge technologies from its research institutes and undertake development risks to bring them to a stage that is easily commercialized by industry. Several initiatives are designed to strengthen technology innovation in small and medium enterprises (SMEs).

A multi-pronged approach has been adopted to nurture and develop technology enterprises. Singapore continues to provide broad-based support for early-stage

companies, especially in nascent sectors. Initiatives include investing and incubating early stage technology start-ups through NRF's Technology Incubation Scheme and Early Stage Venture Funding.

7. Areas of Strength, S&T Niches

Singapore's areas of strength or S&T niches can be gleaned from its research priorities as earlier mentioned under the S&T development strategy. Some key highlights of capabilities include the following:

- *Electronics*
  Singapore has strong capabilities in data storage and semiconductors, which have contributed to the growth and development of the electronics sector.

  In Data Storage, Singapore has built up expertise in areas such as spintronics, media and interfaces, mechatronics and recording channels, optical materials and systems, and network storage technologies.

  In Semiconductors, Singapore has built up strong capabilities in areas such as integrated circuit design and sub-systems, packaging, CMOS (complementary metal-oxide semiconductor) and MEMS (microelectromechanical systems).

- *Biomedical Sciences*
  Singapore has strengths across the entire biomedical sciences spectrum, in areas such as bioprocessing technology, human immunology, eye diseases, stem cell, and cancer biology.

- *Infocomms & Media*
  Singapore has built capabilities in interactive and digital media, IT, computational science, communications and multimedia technologies, cloud computing and security.

- *Engineering*
  In Precision Engineering, Singapore research institutes will advance their strong manufacturing capabilities through research in advanced materials, microfluids, printed electronics, nano-manufacturing of multi-functional products and sustainable manufacturing.

  In Transport Engineering, R&D is a key driver for growth in the Aerospace and Marine and Offshore sectors. The A*STAR Aerospace Consortium engages companies across the entire value chain in pre-competitive research in maintenance repair and overhaul (MRO), engine-related technologies, avionics and composite materials.

- *CleanTech*
  Singapore leads in its expertise in Water and Solar research, and will develop capabilities in intelligent energy systems and energy efficiency.

8. Major Contributors to GDP

Singapore's major contributors to GDP are electronics and chemicals manufacturing as well as finance and business services (Table 18).

Table 18
Singapore's Gross Domestic Product by Industry (S$MIL)

GROSS DOMESTIC PRODUCT BY INDUSTRY (S$ mil)		
	2009	2010*
GDP AT CURRENT MARKET PRICES	266,659.2	303,652.2
Goods Producing Industries	**71,724.2**	**80,922.2**
Manufacturing	54,128.8	63,463.9
Construction	**13,675.2**	**12,961.5**
Utilities	3,812.9	4,392.7
Other Goods Industries[1]	**107.3**	**104.1**
Services Producing Industries	169,796.7	193,215.0
Wholesale & Retail Trade	**41,496.7**	**47,160.2**
Transport & Storage	21,343.1	24,448.7
Hotels & Restaurants	**5,534.6**	**6,320.7**
Information & Communications	9,885.6	10,380.7
Financial Services	**31,078.8**	**34,155.0**
Business Services	35,089.5	40,033.4
Other Services Industries	**25,368.4**	**30,716.3**
Ownership of Dwellings	11,231.6	11,781.1
Gross Value Added At Basic Prices	**252,752.5**	**285,918.3**
Add: Taxes on Products	13,906.7	17,733.9

[1] Comprise Agriculture, Fishing and Quarrying.

* Estimated value

Note: The industries are classified according to SSIC 2005.

Source: Singapore Department of Statistics

Table 19
Singapore's Total Output of Manufacturing by Industry Cluster (S$ mil)

TOTAL OUTPUT OF MANUFACTURING BY INDUSTRY CLUSTER (S$ mil)		
	2009	2010*
Electronics	73,837.8	94,193.6
Semiconductors	**38,370.1**	**57,029.4**
Computer Peripherals	9,492.2	8,966.9
Data Storage	**14,032.6**	**14,487.2**
Infocomms & Consumer Electronics	9,907.6	11,375.6
Other Electronic Modules & Components	**2,035.5**	**2,334.6**
Chemicals	63,791.2	80,506.5
Petroleum	**35,382.8**	**41,627.9**
Petrochemicals	20,635.2	29,991.0
Specialty Chemicals	**5,875.2**	**6,794.5**
Others	1,898.0	2,093.0
Biomedical Manufacturing	**21,151.6**	**23,253.5**
Pharmaceuticals	17,821.5	19,668.0
Medical Technology	**3,330.1**	**3,585.5**
Precision Engineering	20,313.2	26,546.2
Machinery & Systems	**9,476.5**	**14,073.9**
Precision Modules & Components	10,836.7	12,472.3
Transport Engineering	**28,432.2**	**25,058.7**
Marine & Offshore Engineering	19,943.5	16,030.6
Aerospace	**6,895.0**	**7,207.7**
Land	1,593.7	1,820.4
General Manufacturing Industries	**19,257.6**	**20,936.2**
Printing	2,584.8	2,656.7
Food, Beverages & Tobacco	**6,793.3**	**7,283.3**
Miscellaneous industries	9,879.6	10,996.2
TOTAL MANUFACTURING	**226,783.7**	**270,494.7**

*** Estimated value**

Notes: Refers to all manufacturing establishments.

The industries are classified according to SSIC 2010.

Figures may not add up due to rounding.

Source: Economic Development Board

9. Major Exports

Singapore's major exports are in the mineral fuels and petroleum products as well as machinery and equipment, electronic components and chemicals (Table 20).

Table 20
Singapore's Exports by Major Commodity at Current Prices (S$ mil)

EXPORTS BY MAJOR COMMODITY AT CURRENT PRICES (S$ mil)		
	2009	2010
TOTAL	391,118.2	478,840.7
Mineral Fuels	**78,398.0**	**103,511.0**
Petroleum Products	59,191.7	76,886.8
Non-oil	**312,720.2**	**375,329.8**
Food	4,718.2	5,455.4
Meat, Fish & Dairy Produce	**808.7**	**965.8**
Cereals, Fruits & Vegetables	533.5	597.2
Coffee & Spices	**1,183.6**	**1,322.5**
Beverages & Tobacco	2,824.6	3,256.5
Crude Materials	**2,265.6**	**2,820.0**
Rubber	293.5	658.7
Wood	**82.1**	**81.6**
Animal & Vegetable Oils	593.0	610.6
Palm Oil	**282.8**	**275.0**
Chemicals	46,597.9	56,644.3
Medicinal Products	**8,377.3**	**8,332.1**
Manufactured Goods	16,835.5	18,904.7
Veneer & Plywood	**41.2**	**37.2**
Textile Yarn & Fabrics	614.1	638.8
Iron & Steel	**4,197.9**	**4,200.2**
Machinery & Equipment	203,294.9	244,933.1
Power Generating Machines	**5,758.0**	**5,540.9**
Industrial Machines	10,215.6	8,812.4
Radio & Television Receivers & Parts	**2,748.3**	**2,894.1**
Electronic Components & Parts	91,138.5	119,327.1
Road Motor Vehicles	**4,849.7**	**5,450.2**
Ships, Boats & Oil Rigs	3,435.7	3,161.7
Miscellaneous Manufactures	**27,501.7**	**33,410.0**
Clothing	1,516.1	1,455.7
Miscellaneous	**8,088.9**	**9,295.2**

Source: International Enterprise Singapore

10. Major Trading Partners in ASEAN

Singapore's major trading partners in ASEAN are Malaysia, Thailand, Indonesia, the Philippines, and Vietnam (Table 21).

Table 21
Singapore's Total Trade by Selected Country at Current Prices (S$ mil)

TOTAL TRADE BY SELECTED COUNTRY AT CURRENT PRICES (S$ mil)		
	2009	2010
TOTAL	747,417.4	902,062.6
Asia	**514,720.9**	**634,426.5**
Bahrain	557.1	424.2
Bangladesh	**2,147.3**	**2,396.0**
Brunei Darussalam	1,392.8	1,464.2
Cambodia	**1,652.5**	**3,217.7**
China, People's Republic of	75,710.5	95,312.2
Hong Kong, China	**49,168.2**	**60,084.7**
India	21,585.7	30,667.5
Indonesia	**58,517.0**	**67,920.9**
Iran (Islamic Republic of)	2,871.6	3,479.0
Japan	**44,951.8**	**55,593.6**
Korea, Republic of	38,558.1	44,062.1
Kuwait	**4,260.9**	**3,852.3**
Laos, People's Democratic Republic	53.2	35.1
Malaysia	**86,144.8**	**106,603.8**
Pakistan	1,237.4	1,715.5
Philippines	**14,787.5**	**22,298.1**
Saudi Arabia	12,832.7	16,406.6
Sri Lanka	**1,207.5**	**1,749.1**
Taiwan	31,177.5	42,680.6
Thailand	**26,519.9**	**31,284.2**
United Arab Emirates	11,594.8	13,875.3
Vietnam, Socialist Republic of	**13,413.0**	**12,254.1**
America	96,114.4	109,672.3
Brazil	**3,506.2**	**3,748.2**
Canada	4,964.6	3,415.2
United States	**66,920.6**	**78,386.6**
Europe	99,836.4	116,169.8
EU, of which	**86,815.7**	**99,409.0**
France	17,340.2	17,649.5
Germany, Federal Republic of	**17,436.7**	**20,494.2**
Italy	4,597.5	4,762.3
Netherlands	**11,811.5**	**15,667.6**
Sweden	1,619.5	2,067.8
United Kingdom	**13,712.6**	**15,936.7**
Switzerland	5,048.8	7,754.3
Oceania	**27,688.9**	**29,780.5**
Australia	21,120.4	21,821.3
New Zealand	**2,808.0**	**3,106.3**
Africa	9,056.7	12,013.4

Source: International Enterprise Singapore

THAILAND

1. S&T Policy and Development Strategy

Thailand's S&T Policy and Development Strategy is articulated in the country's National Science Technology and Innovation Master Plan 2012-2021. It recognizes the strong influence of demographic and social changes, energy and environment situation, regionalization (ASEAN +) and green innovation in attaining a sustainable economy and quality society. Green innovation is Thailand's goal for attaining a quality society and a sustainable economic growth. The strategies involved are: (1) Empowering Society and Local Communities, (2) Enhancing Economic Competitiveness and Flexibility, and (3) Ensuring Energy, Resource, and Environment Security. These will be supported by (4) a strategy of developing and enhancing human capital and (5) a strategy of promoting and supporting the development of Science, Technology and Innovation (STI) infrastructure and enabling factors. The three "Pillar" Strategies and two "Foundation" strategies are translated into required key actions as follows:

- **Strategy I : Empowering Society and Local communities**
  - Promote STI development to empower local communities to be more eco-efficient and self-resilient
  - Support R&D in social/community/enterprises and promote the use of local indigenous wisdom and clean technology to create value added to local products
  - Support R&D to improve the quality of health service and reduce dependency on imported medicines

- **Strategy II : Enhancing Economic Competitiveness and Flexibility**
  - Promote STI development to increase productivity of agricultural, manufacturing and service factors
  - Promote the development of green products and services for value creation
  - Support R&D and STI development to alleviate the impact of non-tariff barriers and increase opportunities for exports

- **Strategy III : Ensuring Energy, Resources and Environmental Security**
  - Promote the development of natural resources and environmental forecasting models
  - Promote the development and utilization of STI for adaptation and mitigation (GHG emission reduction)
  - Support R&D and utilization
  - STI to increase the use of renewable and alternative energy
  - Promote the development of STI for natural resource and environmental management

- **Strategy IV: Developing and Enhancing STI Human Capital**
  - Support HRD to increase the ratio of students graduated with bachelor degrees in science and technology to 60%

- Support HRD and provide incentives to increase R&D personal to 25 persons (FTE) per 10,000 of total production, of which 60% are in the private sector
- Promote science awareness, STI capacity building programs and society of life-long learning

- **Strategy V: Promoting and Supporting the development of STI infrastructures and enabling factors:**
  - Improve STI infrastructure and enabling factors to improve the country ranking in S&T infrastructure by IMD
  - Increase total R&D investment to 1% of GDP by 2016 and 2% by 2021
  - Develop STI infrastructure, policy incentives, and legal measures such as regional science parks, national labs, tax incentives, matching grants, VC, and IP management system. The goal is to stimulate R&D in the private sector to account for at least 70% of total national R&D investment by 2016.

- The twelve (12) strategic economic factors that Thailand has targeted for green and greener products and services are the following:
  - Rice and Rice Products
  - Renewable Energy
  - Rubber and Rubber Products
  - Processed Food
  - Electrical and Electronics
  - Automotive and Parts
  - Plastics and Petrochemicals
  - Fashion (Textiles, Jewelry, leather)
  - Tourism
  - Logistics
  - Construction and Related Services
  - Creative and Digital Contents

- The strategic social issues to be addressed include the following:
  - Labor Mobility
  - Social/Inclusive Innovation
  - Science Awareness
  - Science Education
  - R&D for Society
  - S&T for Health
  - S&T for Poverty Reduction and Social Equity

- The three (3) goals to improve Thailand's competitiveness in STI:
  - From the current R&D/GDP ratio of 0.23% to greater than or equal 1% by 2016
  - From the current 670 fulltime Equivalent (FTE) R&D personnel per Million Population to 1500 per Million Population
  - From a 45% - 55% mix of private sector and government sector expenditure for R&D to a 70% - 30% mix

For the first time, the target figures above are reflected not only in the National STI Master Plan but also in the National Development Plan.

2. S&T Infrastructure

Thailand's S&T Infrastructure consists of a National Science, Technology, and Innovation Policy Committee chaired by the Prime Minister. The research and development organizations and programs under the Ministry of Science and Technology and under the other ministries include Agriculture and Cooperatives, Education, Public Health, Defense, Transport, Natural Resources and Environment, Industry, and Energy. In addition, there is the office of the Prime Minister, the National Research Council of Thailand, the State Enterprises, and the private non-profit organizations.

The infrastructure also includes the Intellectual Property (IP) Infrastructure, the science parks, the centers of excellence, the national laboratories, the linkage (research consortia, industry-academe linkages) programs, and the technology financing companies. The higher education institutions (HEI) with science, technology, engineering, and mathematics program can be considered part of the infrastructure.

Special mention can be made about Thailand's science parks, centers of excellence as well as the system of incentives and assistance programs to stimulate science, technology, and innovation development.

There are four (4) science parks in Thailand located in four (4) regions of the country. The main science park is located in Khlong Leang district in Pathum Thani Province and it is composed of four (4) national research centers; namely, the National Centre of Genetic Engineering and Biotechnology (BIOTECH), the National Metal and Material Technology Centre (MTEC), the National Nanotechnology Centre (NANOTEC) and the National Electronics and Computer Technology Centre (NECTEC). Its first phase consists of more than 140,000 sq m of built-up space and the second phase now under construction provides over 124,000 sq m of total floor area. The other three regional science parks are the Northern Science Park in Chiangmai University in Chiangmai Province, the North Eastern Science Park in Suranaree University of Technology in Nakoruratchasima Province, and the Southern Science Park in Prince of Songkla University in Songkla Province.

There are also centers of excellence in nine research universities as follows:

- Chulalongkorn University
- Thammasat University
- Mahidol University
- Kasetsart University
- Chiang Mai University
- Khon Kaen University
- Prince of Songkla University
- King Mongkut's University of Technology Thonburi
- King Mongkut's Institute of Technology Ladkrabang

In addition, there are several other focused centres in universities and National Science and Technology Development Agency (NSTDA) across the country, which can be separated into seven main sectors namely Electronics and Computers, Material Science, Biotechnology and Agriculture, Medical Technology and Public Health, Energy and Environment, Nanotechnology, and Industrial STI Development.

The incentive systems and assistance programs cover the following:

- Industrial Technology Support Program for SMEs
- Company Directed Technology Development Program for private sector R&D
- Good-Innovation-Interest Free Loan for Product Development – from the National Innovation Agency (NIA)
- Innovation Coupon for SMEs which are innovation project grants managed by NIA and the Federation of Thai Industries (FTI)
- BOI-STI Programme which grants tax incentives to locators at the Thailand Science Park
- 200% Tax Deduction for R&D Spending by private enterprises

3. Human Resources Involved in S&T R&D

For purposes of uniformity, the Frascati definition has been adopted for the term "R&D personnel" and researchers. Tables 22 and 23 show the 2003-2007 statistics gathered from the National Research Council of Thailand and the National Science and Technology Development Agency.

Table 22
Thailand Persons Involved in S&T R&D (Headcount)

	Headcount (Persons)		
	2003	**2005**	**2007**
R&D Personnel	76,184	67,876	73,498
Public	64,085	56,125	60,596
Private	12,099	11,751	12,902
R&D Personnel per Million Population	1,208	1,087	1,166
Researchers	29,850	34,084	38,982
Public	23,459	27,682	32,096
Private	6,391	6,402	6,886
Researchers per Million Population	473	546	618

Table 23
Thailand Persons Involved in S&T R&D (FTE)

	Full Time Equivalent (FTE)		
	2003	**2005**	**2007**
R&D Personnel	42,379	36,967	42,624
Public	35,369	29,217	33,979
Private	7,010	7,750	8,645
R&D Personnel per Million Population	672	592	676
Researchers	18,114	20,506	21,392
Public	14,466	15,676	16,406
Private	3,648	4,830	4,986
Researchers per Million Population	287	329	339

UNESCO statistics on total headcount of R&D personnel per million population for Thailand in 2007 gives a figure of 582.

Capability for S&T Human Resource Development in Higher Education

Nine designated national research universities and two leading S&T-intensive universities make up the higher education institutions (HEIs) of Thailand with comprehensive S&T programs.

The nine designated national research universities are the following:

- Chulalongkorn University
- Thammasat University
- Mahidol University
- Kasetsart University
- Chiang Mai University
- Khon Kaen University
- Prince of Songkla University
- King Mongkut's University of Technology Thonburi
- King Mongkut's Institute of Technology Ladkrabang

The two leading S&T-intensive universities are the following:

- King Mongkut's University of Technology North Bangkok
- Suranaree University of Technology

Table 24 gives a glimpse of Thailand's growing capability to produce advanced human resources in science and technology.

Table 24
Thailand Human Resources in S&T

Level/Year	2004	2005	2006	2007
Master's Degree Graduates in S&T	6,417	7,623	7,473	9,657
Doctoral Degree Graduates in S&T	870	1,093	1,135	1,059

The S&T fields are Science, Health & Welfare, Agriculture, and Engineering.

4. Expenditures for S&T R&D

Table 25 presents the figures for R&D expenditures in Thailand for the years 2001 to 2007 were sourced from the National Research Council of Thailand and the National Science and Technology Development Agency. The GDP figures used were sourced from Thailand's Economic and Social Development Board.

Table 25
Thailand Expenditures for S&T R&D

Year	2001	2002	2003	2004	2005	2006	2007
Total Expenditures for R&D in Million Baht	13,486	13,302	15,499	16,571	16,667	19,549	18,225
Expenditures by Business Sector	5,284	5,164	5,928	6,023	6,679	7,999	8,210
Expenditures by Other Sector	8,202	8,138	9,571	10,548	9,988	11,550	10,015
R&D Expenditures as % of GDP	0.26%	0.24%	0.26%	0.26%	0.24%	0.25%	0.21%

UNESCO statistics for Gross Expenditures for R&D for Thailand in 2007 gives a figure of 1,120.75 Million PPP $ or 18,225 Million Baht.

5. S&T Outputs

S&T Outputs include patents, publications, and citations; bibliometric data on international co-publications are also used.

The statistics on patent applications and patents granted in Thailand for the period 2003 to 2006 are shown in Table 26.

Table 26
Thailand Patent Applications and Patents Granted

Year	2003	2004	2005	2006	2007	2008
Total Patent Applications	8,574	8,942	10,885	9,821	10,339	10,561
Inventions	3,631	3,569	4,545	3,560	3,521	3,820
Designs	4,943	5,373	6,340	6,261	6,818	6,741
Total Patents Granted	2,326	2,044	1,322	1,878	1,824	2,185
Inventions	1,006	716	553	1,121	948	988
Designs	1,320	1,328	769	757	876	1,197

6. S&T Utilization Programs

These include indicators of utilization of S&T outputs in government, industry, and social development.

Thailand has a clear STI policy to promote scientific research and focuses on creative and sustainable economic growth in sectors that will increase the value chain. In the 2012-2021 National Science, Technology, and Innovation Policy statement, the 12 sectors that are targeted have been identified.

Two examples of S&T investments, which are now operational and being utilized, are the Thailand Earth Observation Satellite (THEOS) and the Synchrotron facility at the Synchrotron Light Research Institute (SLRI) at the Technopolis of Suranaree University of Technology. THEOS is used in the measurement of air temperature and pressure, wind direction and speed, sea surface temperature, location tracking, marine, meteorology, and multi legend monitoring. The Synchrotron facility, on the other hand, is used for different types of spectroscopy, microscopy, X-ray diffraction, X-ray lithography, and crystallography.

In addition to investment in S&T facilities, Thailand has also set up specialized estates and zones to accommodate industrial clusters with enhanced synergies. Science and technology villages were also set up starting in 1987 to assist villagers to integrate modern science and technology with Thai local know-how to enhance productivity and improve quality of life. Technology clinics and inclusive innovation projects are also being supported by government.

Thailand has also embarked on a number of technology-based programs to transfer Green Innovation. These include their Renewable Energy Development Program, Energy Efficiency Improvement Program, Water Resources Management Program, and Eco-Industrial Towns Programs.

7. Areas of Strength in S&T

Thailand's scientific infrastructure ranking rose from 49th in 2007 to 37th out of 44 in 2008 according to the World Competitiveness Yearbook of the International

Institute for Management Development (IMD). According to the same yearbook, Thailand's technological infrastructure ranking improved from 48th in 2007 to 43rd in 2008. In the same year, 2008, the World Economic Forum's (WEF) Global Competitiveness Report ranked Thailand as 34th out of 134 countries in terms of innovation and sophistication.

On the basis of human resources available, institutional capabilities and actual industry experience Thailand's S&T strengths are in the food-biotechnology-life sciences-agricultural sciences chain, in energy technologies and in manufacturing technologies particularly in the automobile and electronics industry. In the medical field, Thailand is strong in the medical hub concept and in system based public health, of the total number of papers published in the Science Citation Index (SCI) by Thais in 2007, the biggest number (1,439 out 4,214) came from the medical sciences. On the basis of the top 10 Thai exports, one can have a glimpse of Thai's areas of strength, which would logically include the science and technology components. The top 10 Thai exports in 2011 are the following:

- Computers and parts
- Automobiles and parts
- Jewelry
- Rubber
- Plastic
- Electrical Circuits
- Chemicals
- Rubber Products
- Cooking Oil
- Rice

8. Major Contributors to GDP

Recently, Thailand experienced GDP growth by 8.0% in 2010 making it one of the fastest growing economies in Asia and the fastest growing economy in South East Asia. The country has a GDP net worth of 9.5 trillion Baht (on a purchasing power parity (PPP) basis), or US$584 billion (PPP) making it the 24th largest economy in the world. This classifies Thailand as the 2nd largest economy in Southeast Asia after Indonesia. Despite this, Thailand ranks midway in the wealth spread in Southeast Asia, as it is the 4th richest nation according to GDP per capita, after Singapore, Brunei, and Malaysia.

Thailand has a strong automobile industry which grew by 63% in 2010 with 1.6 million cars produced ranking it as 13th in the motor vehicle producing countries in the world.

Thailand's economy functions as an anchor economy for the neighboring developing economies of Laos, Burma, and Cambodia. Thailand's recovery from the 1997-1998 Asian financial crisis depended mainly on exports, among various other factors. Thailand ranks high among the world's automotive export industries along with manufacturing of electronics goods.

Tourism revenues are on the rise and contributing to about 6% of GDP. The GDP growth of Thailand was 8.0% in 2010, higher than previous highs of 5-7% under the previous civilian administration. Thailand enjoys high foreign investment and consumer confidence.

9. Major Exports

The top 10 exports and the top 5 imports of Thailand are shown in Tables 27 and 28.

Table 27
Top 10 Thai Exports 2011

1. Computers and parts
2. Automobiles and parts
3. Jewelry
4. Rubber
5. Plastic
6. Electrical Circuits
7. Chemicals
8. Rubber Products
9. Cooking Oil
10. Rice

Table 28
Top 5 Thai Imports 2011

1. Crude Oil
2. Machinery
3. Chemical
4. Minerals
5. Electronics and Parts

Source : http://www.ops3.moc.go.th/infor/db_sql/gp_main_trade.asp

At a glance, Thailand's export and imports for 2010 can be described as follows:

- Total value of export: US$191.3 billion
- Primary exports – commodities: textiles and footwear, fishery products, rice, rubber, jewelry, automobiles, computers and electrical appliances
- Primary export partners: US (10.9% of total exports), China (10.6%), Japan (10.3%)
- Total value of imports: US$156.9 billion
- Primary imports – commodities: capital goods, intermediate goods and raw materials, consumer goods, fuels
- Primary imports partners: Japan (18.7% of total imports), China (12.7%), and Malaysia (6.4%)

The main destinations of Thailand's exports are the rest of Asia and the US. The country also ranks high among the world's automotive export industries and

electronic goods manufacturers. Thailand is also among the world's largest exporter of several agricultural products, such as rice, shrimps, tapioca, rubber and sugar.

The US is Thailand's largest export partner and the third-largest supplier after Japan and China. Although traditionally Thailand's major markets have been North America, Japan, and Europe, economic recovery witnessed by Thailand's regional trading partners also helped boost growth in Thai export. The country has also increased its exports in some of its non-traditional export markets, including India, China, and the Middle East.

10. Major Trading/Economic Partners in ASEAN

The percentage shares of Thailand's trade with the nine other ASEAN Member States in 2010 are shown in Table 29.

Table 29
Thailand Major Trading Partners in ASEAN

		% share	
	Export	**Import**	**Total Trade**
Thailand-Brunei	0.07	0.05	0.06
Thailand-Cambodia	1.20	0.12	0.68
Thailand-Indonesia	3.76	3.11	3.45
Thailand-Laos	1.09	0.41	0.76
Thailand-Malaysia	5.41	5.87	5.63
Thailand-Myanmar	1.06	1.54	1.29
Thailand-Philippines	2.50	1.30	1.92
Thailand-Singapore	4.61	3.45	4.05
Thailand-Vietnam	2.99	0.77	1.92
Thailand-ASEAN	**22.70**	**16.63**	**19.77**

In terms of exports, Thailand's top destinations in ASEAN are Malaysia, Singapore, Indonesia, Vietnam, and the Philippines.

In terms of imports, Thailand's leading partners are Malaysia, Singapore, Indonesia, Myanmar, and the Philippines.

VIETNAM

1. S&T Policy and Development Strategy

Vietnam's strategies for Science and Technology are the following:

- To ensure a scientific base for Vietnam's socioeconomic development with the orientation of sustainability and international integration;
- To contribute to the raising of quality of economic growth and the competitiveness of the national economy; and
- To build and develop S&T capacity.

Key development tasks have been identified until 2020 in support of these strategies.

A set of R&D priorities has also been identified and these are in the following areas:

- ICT
- Biotech on Community Health Care
- Nano and New Materials
- Automation
- Environmental Protection and Natural Disaster Prevention
- Space Technology

These priorities are handled and managed by a Directorate of National Target Program. In addition, there is now a National Target Program on Climate Change chaired by the Prime Minister. All target programs are cross-sectoral. They are separate from the sectoral ministries and separate from the Ministry of Science and Technology (MOST). Each directorate has to deal with the Ministry of Finance.

2. S&T Infrastructure

The National System of S&T or the national infrastructure for S&T in Vietnam is composed of the following:

- The Ministry of Science and Technology (MOST)
- R&D institutions in ministries
- Higher Educational Institutions (HEI's)/universities
- R&D institutions affiliated to localities, associations and business entities
- Science and Technology departments in ministries and provinces

In the process of formulating S&T strategies, the following are involved:

- National Council for S&T Policy
- Vietnam Academy of S&T (VAST)
- National Assembly
- Vietnam Communist Party

There are three groups of research institutions in Vietnam: the Vietnam Academy of Science and Technology (VAST) based in Hanoi; the sectoral public R&D institutes found in line ministries and MOST; and the university based research institutes.

VAST has 32 research institutes employing nearly 4,000 researchers. The largest institute in VAST is the Institute of Materials Science (IMS). Starting 2009 VAST has also started awarding MS and PhD degrees.

The sectoral public R&D institutes, on the other hand, are found in the ministries of:

- Industries and Trade
- Transportation
- Agriculture and Rural Development
- Construction
- Health
- Natural Resources & Environment
- Science and Technology

The Ministry of Trade and Industry has the biggest number of R&D institutes. These are on Petroleum, Oil, Gas, Electronic, Automobile, Chemicals, Energy, Textile, Manufacturing, and Shipping. The Ministry of Agriculture and Rural Development (MARD) has R&D institutes for Water, Forestry, Agriculture, and Fisheries. MOST has an Applied Technology Institute and a Nuclear Research Institute. Other research institutions are mostly for social science research.

3. Human Resources Involved in S&T/R&D

UNESCO statistics indicate that in 2002 the number of researchers (headcount) per million population in Vietnam is at 508. The distribution of these researchers by the sector of employment (as a percentage to total) is as follows:

- Higher Education - 49.0%
- Government - 27.0%
- Business Enterprise - 23.5%
- Private Non-Profit - 0.5%

A more current figure, but limited to the Vietnam Academy of Science and Technology (VAST) is the nearly 4,000 researchers working in its 32 research institutes.

Capability to Develop Advanced Human Resources for S&T

There are 380 universities in Vietnam; 276 are public while 104 are private. They can be categorized into national, regional, and specialized universities. The national universities are the Vietnam National University (VNU) Hanoi and the Vietnam National University (VNU) Ho Chi Minh. The specialized universities are the Hanoi University of Science and Technology and the Hanoi Civil Engineering University.

The national universities, the specialized universities and some regional universities offer MSc and PhD degrees in the various fields of science, technology, and engineering. It is noteworthy to mention that the research institutes in VAST take in graduate students coming from different universities in the different regions for

their dissertation work. The Institute of Material Science (IMS), for example, is currently hosting the dissertation research of 75 PhD students coming from different regions of Vietnam.

Information has been given that Vietnam will open a new university for Science and Technology. This is in a new campus 30 kilometers from Hanoi. It already opened but it limited its students to MS and PhD students only. In the future, it will have BS programs. This is collaboration between the Vietnam Government and the French Government. Initial investment was Euro 200 Million.

4. Expenditures for S&T/R&D

UNESCO statistics indicate that in 2002 the Gross Expenditure on R&D (GERD) in Vietnam was PPP $252.019 Million. As a percentage of GDP, this translates to 0.19%. The distribution of these expenditures by sector of performance (as a percentage to total) is as follows:

- Government - 66.4%
- Higher Education - 17.9%
- Business Enterprise - 14.5%
- Private Non-Profit - 1.1%

Vietnam's investment in R&D was reported to have grown from US$ 60 Million in 1997 to US$ 270 in 2005. Close to 80% of investments in R&D comes from the State Budget.

UNESCO statistics has also shown that in 2002 the distribution of GERD by source of funds (as a percentage to total) is as follows:

- Government - 74.1%
- Business Enterprise - 18.1%
- Funds from Abroad - 6.3%
- Higher Education - 0.7%
- Not Specified - 0.8%

5. S&T Outputs

The 2010 UNESCO Science Report has shown that the number of scientific publications in Vietnam rose from 315 in year 2000 to 875 in the year 2008. The increasing trend is shown in Table 30.

Table 30
Vietnam: Number of Scientific Publications (2000 – 2008)

Year	Number of Scientific Publications
2000	315
2001	353
2002	343
2003	458
2004	434
2005	540
2006	617
2007	698
2008	875

The number of registered patents from Year 2000 to Year 2007 totaled 18 only considering that the Patent Law of Vietnam has just been recently passed.

6. Utilization of S&T Outputs

The best example of technology utilization from R&D outputs is in the case of vaccines. Vietnam has invested much for several decades in human resource development and in R&D for vaccines. The results have been commercialized through a government spin off enterprise. Today, Vietnam is 100% self sufficient in basic vaccines for immunization.

The Government has embarked on a support program for technology spin off companies. This is called the Incentive for Spin off Project. The incentive translates to US$ 35,000/Project. During the first year that it was implemented in 2005-2006, 16 spin off companies benefited from the program. In the second year of the program, there were only two beneficiaries of the program.

There are also national programs to utilize technologies or technological knowhow for the benefit of the people. These examples can be cited: the Vietnam National Energy Efficiency Program, the Vietnam Food Processing Program for Communities and the Vietnam National Program in Response to Climate Change.

In addition incubation centers are operated within universities to assist spin offs from generated technologies.

7. Areas of Strength in S&T/R&D

The areas of strength in S&T/R&D in Vietnam can be based on what are considered the best institutes in the VAST. These are the institutes of Material Science, Biotechnology, Information Technology, Mathematics, and Chemistry. International publications are the key indicator for this.

In terms of technologies that created self-sufficiency, vaccines, and rice technology can be cited.

8. Major Contributors to GDP

The major contributors to Vietnam's GDP are agriculture, garments, tourism, and construction.

9. Major Exports

Vietnam's major exports are crude oil, marine products, rice, coffee, rubber, tea, garments, and shoes.

10. Major Trading/Economic Partners in ASEAN

Vietnam's major trading/economic partners in ASEAN are Malaysia, Singapore, and Thailand.

CHAPTER IV

ANALYSIS OF FACTORS AND INDICATORS

The analysis performed in the following paragraphs has been based by the researcher on the preceding data as submitted by the ASEAN Member States as far as their S&T R&D status would be situated at the writing of the report. The expert or research analyst used various criteria to determine the levels of development of each AMS in the selected categories. These criteria include quantitative and qualitative indicators. This analysis was carried out in Chapters IV, V, and VI of this study.

S & T Strategies and Policies

Most ASEAN member countries invoke their Constitution as the fundamental source of the rights of their peoples to enjoy the fruits of S&T and R&D in their daily lives. Majority incorporate their S&T Strategies and Policies in their National Economic and Development Plans or Environment Plans. Other countries incorporate them in the plans of ministries on the basis of mandated functions or areas of responsibilities. Laws on S&T including incentives and intellectual property protection have been enacted in a number of countries.

Brunei Darussalam

Brunei Darussalam's policies are embodied in the country's Science and Technology Guidelines, which include the priority agenda for research. The government has identified preferred areas, which include production of Halal foods, distribution of downstream oil and gas industries, and development of ICTs. Brunei's Education Policy envisions the institution of systematic and structured reforms with respect to education policy, structure, curriculum, assessment and qualifications, and professional development.

Cambodia

Cambodia has no comprehensive policy on S&T. The policies are embedded in the policies of the ministries or agencies, which are mandated to fulfill functions relating to education, youth and sport, health, mines industry and energy, public works, environment, land use management and construction, telecommunication, agriculture, forestry, and fishery, and water resources. Similarly, many elements that promote S&T or innovation are implicit in the following (1) National Poverty Reduction Strategy (2006-2010); (2) Rectangular Strategy in NSDP (2006-2010); and (3) National Strategic Development Plan (NSDP 2009-2013)

Despite its limitations, Cambodia has adopted a law on patents, utility models, and certificates on industrial design in 2006.

Indonesia

Indonesia's National Medium Term Development Plan (2010-2015) and National Research Agenda promulgated by the Minister of Research and Technology aims to strengthen the innovation system, support the R&D system and improve S&T applications. Its S&T are intertwined with the Master Plan for Acceleration and Expansion of Indonesia's Economic Development. The latter has three pillars, which include Human Development, Economic Development through Economic Corridors, and Strengthening the National Connectivity.

The President's Initiative 1-747 aims to achieve the following: introduce incentives, develop innovation centers to support SMEs, enhance researcher remuneration system, and develop R&D infrastructure through a research funding system and management of support innovations.

The outcomes resulting from the implementation of the goals are clearly defined and the roles of the public institutions, the private sector, and universities are expressed in its framework for development. Notable is the inclusion of defense industry and transportation as strategic industry.

Laos

Lao's S&T strategy is defined in the 7th Five Year National Socio – Development Plan for the period 2011-2015. Its key development goals are (a) enhance and strengthen stability; (b) maintain an economic growth of at least 8% each year, ensure stability and balance in the macroeconomic system, build foundation for industrialized and modernized transformation and sustainable development; (c) achieve the Millennium Development Goals of the United Nations in 2014 and lift the country from least developed country status by 2020; and (d) integrate the nation's economy to Greater Mekong Sub-region, ASEAN and international in a dynamic manner.

National policies on S&T are evolving. At present, the Agricultural Development Policy 2010-2020 is the most relevant S&T policy since the agriculture and natural resources (ANR) sector is still the main thrust for S&T development. The ANR aims to ensure a successful gradual transition from subsistence into smallholder production. Innovative technologies such as those that aim to improve and maintain the quality of soil provide guidance in the use of chemical fertilizer, and adopt measures that will be applied for the systematic and continuous production of high value agri-food products for local value-added agro-processing and for domestic, regional, and world markets. Modern agricultural production aims to reduce poverty and apply climate change mitigation and adaptation measures in the agricultural activities.

Malaysia

Malaysia's 1st National Science and Technology Policy was adopted in 1986. The most recent draft plan refers to a vision 2020, which will propel the nation towards achieving a sustainable high-income knowledge-based economy by

2020. The attainment of the goal of high income is anchored on the principles of inclusiveness and sustainability. Specifically, S&T aspirations are embedded in the Economic Transformation Programs, which have 12 National Key Reform Areas and Eight Strategic Reform Initiatives. The 8 SRIs are (1) re-energizing the private sector; (2) developing quality work force and reducing dependence on foreign labor; (3) creating a complete domestic economy; (4) strengthening the public sector; (5) transparent and market friendly affirmative action; (6) building the knowledge infrastructure; (7) enhancing the source of growth; and (8) ensuring the sustainability of growth.

Myanmar

Myanmar's National S&T Plan (NSTP) defines the role and objectives of S&T as follows: import substitution, defense support, development of new and renewable energy source, rural development support particularly poverty alleviation, health service support, national industrial sector upgrading, and development of value adding materials/technologies. The major strategies are human resource development for S & T and Research and Development.

The R&D priority areas are biotechnology, materials science, nanotechnology, renewable energy, engine production, hydropower turbine production, nuclear energy, CNC machines, and unmanned aerial vehicle.

Philippines

The Philippine Development Plan for 2010-2016 aims to strengthen government programs that contribute to socio-economic development through the advancement of science, technology, and innovation particularly those which support the national innovation strategy called Filipinnovation, a public-private initiative launched in late 2007.

The Filipinovation strategy articulates the collaboration among and between the private sector, academic institutions, and other sectors of society to enable the country to strengthen its capability to meet the challenges brought about by globalization. It calls for human capital development, expansion of technology and innovation-based business incubation and acceleration efforts, adoption of innovation-friendly policies and improvement of the people's mindset towards innovation. In concrete ways, the Philippine STI policy addresses inclusive growth issues through more focused STI interventions.

Singapore

Singapore's Research, Innovation and Enterprise (RIEs) Thrusts for 2011-15 encompass the following objectives: (1) to focus a greater proportion of R&D on economic outcomes to reap the returns on investments; (2) to enhance support for private sector R&D to raise business expenditure on R&D towards 2.5% of GDP by 2015; (3) to put greater emphasis on competitive funding as a means to select the best ideas; (4) to foster greater synergies between researchers across the public and private sectors, including multidisciplinary and breakthrough

science; (4) to emphasize continually on basic science and knowledge as the basis for future innovations; and (5) to extend stronger support for commercialization to spur the development of new products and services. RIEs will support Singapore's long-term vision to make it a research intensive, innovative, and entrepreneurial economy.

Agencies and institutions in Singapore have extensive collaboration with the private sector.

Thailand

Thailand's Conceptual Framework for STI Policy (2011-2021) is aptly called Green and Inclusive Innovation. STI is envisioned to bring about a quality society, which takes into consideration the vital factors of demographic social change, energy and environment and regionalization (ASEAN). Some key aspects in which STI will address are (1) social changes: aging society, digital society and low carbon society; (2) climate change: technology adaptation, technological need assessment; (3) geopolitics: ASEAN +6, education standardization, trade and science; (4) Health care: emerging diseases preventive medicine, genomic therapy; (5) agriculture and food: STI and major crops and animals, national agricultural systems; (6) decentralization: role of local government, STI and community and regional innovation system; (7) energy crisis: renewable energy, environmentally related industry; (8) economy and trade: resource based high value added sectors, Free Trade Agreements and development of domestic market; and (9) technological change: nuclear technology policy, GMO policy, road map for nanotechnology, biotechnology, material technology, and ICT.

The National Science and Technology Act of 2008 envisions science and technology and innovation as the driving force to attain sustainable economic and social development.

Vietnam

As early as 2004, the government **of Vietnam** approved the Strategic Orientation for Sustainable Development described as VN Agenda 21 – a framework strategy to ensure the SD in the 21st century. It subsequently adopted Vietnam's National Strategy for Environment Protection (NSEP) in 2010 in its vision toward 2020. NSEP is considered part of the country's socio economic development strategy towards Sustainable Development.

The strategy until 2020 embodies the following goals: (1) ensure a scientific base for Vietnam's socio-economic development with the orientation of sustainability and international integration; (2) contribute raising quality of economic growth and competitiveness of national economy; (3) build and develop the S&T capacity to reach the high level of the region. Until 2020, its development tasks aim to develop an S&T foundation integrated with the international scientific and technological community, increasing popular awareness, and training a basic and long-term resource for Vietnam. These tasks include the building of a system of S&T support funds; the formation of a network of diverse S&T

consulting and transfer organizations to meet the demands of enterprises, particularly SMEs, and those located in rural areas; and the prioritization of research on social development doctrines and socio-economic development models.

Vietnam approved a number of laws relating to S&T, Intellectual Property, and High Technology. In 2009, it initiated the formulation of the Vietnam S&T Development Strategy of 2011-2020.

Infrastructure for S&T

Brunei Darussalam

While Brunei does not have a Ministry for S&T, nevertheless, it has agencies and a Council that assume important functions for the development of science and technology for the country. The Department of Economic Planning and Development under the Prime Minister's Office is advised by the Brunei Research Council on matters pertaining to research proposals funded by BRC. The University of Brunei Darussalam is the leading academic institution. It has the Sultan Omar Ali Saiffudien for Islamic Studies, the Institute of Asian Studies, and the UBD – IBM Centers, which offer studies pertaining to their fields of expertise. Meanwhile, the Institute of Technology Brunei (ITB) offers undergraduate and graduate courses on science, technology, and engineering. It also coordinates and initiates research and creative work across a targeted spectrum of disciplines and fields and maintains a strong link between the University and industry.

Cambodia

As a young member of ASEAN, Cambodia will need support from member countries. It has no mechanism for coordinating STI development. A few R&D programs are undertaken by relevant ministries. What may be considered as a collegial mode of policy formulation is the National Committee on Science and Technology, which is chaired by the Ministry of Industry, Mines, and Energy. It has eight members represented by line agencies. A number of S&T policies emanate from the Supreme Economic Council of the Ministry of Economy and Finance, Ministry of Agriculture and Ministry of Labour and Vocational Training.

Indonesia

Indonesia has a Ministry of Research and Technology (MRT), which formulates policies and coordinates their implementation. The National Research Council provides advice to the MRT. The Indonesian Academy of Science (AIPI) reviews, assesses, and monitors the development and utilization of technology needed for research projects and activities. The Research Institutes under the MRT are Indonesia Institute of Science (LIPI), Agency for the Assessment and Application of Technology (BPPT), National Aeronautics and Space (LAPAN), National Coordination Agency for Survey and Mapping (Bakosurtanal), Nuclear Energy of Indonesia (BATAN), National Standardization Agency of Indonesia (BSN), Nuclear

Regulatory Agency of Indonesia (Bapeten), Eijkman Institute of Biology and Biotechnology, and Center of Meteorology, Climatology and Geophysics (BMKG).

Other Ministries have their own Research Institutes. Among these are the Ministry of Agriculture, Ministry of Health, and Ministry of Communications and Informatics. Indonesia has 50 university-based research institutes such as the Bogor Agricultural University, Bandung Institute of Technology, and Gadjah Mada University. The University of Indonesia is recognized for health researches while the Bandung Institute of Technology is identified with research in physics, computer science, and engineering. Gadjah Mada University is known for its strength in life sciences, pharmacy, and chemistry.

Laos

The Ministry of Science and Technology of Lao is the central agency for S&T, which is under the Office of the Prime Minister. It was established in June 2011. The functions of S &T development at the provincial levels are vested in the Provincial Department of Science and Technology Departments. They are responsible for providing assistance on intellectual property matters, standardization, and metrology. The National Science Council (NSC) provides advice on social and natural science programs. It is chaired by a Minister and is under the Office of the Prime Minister.

Three Research Institutes operate directly under the MOST: Biotechnology and Ecology Research Institute (BERI), Renewable Energy and New Material Research Institute (RENMRI), and the Technology Computer and Electronics Research Institute (TCESRI). The leading research institutes under the line ministries are the National Agriculture and Forestry Research Institute (NAFRI) under the Ministry of Agriculture and Forestry (MAFRI) and the National Research Institute of Medicine Plant (NRIMP), under the Ministry of Health.

The five universities in Lao are the University of Lao, Suphanouvong University, Champasak, Savannakhet University, and the University of Public Health.

Malaysia

MOSTI is the lead Ministry responsible for formulating policies in the area of science, technology, and innovation and spearheads the development of STI in the country. The Ministry oversees more than 20 departments and agencies clustered into seven focus areas: biotechnology, ICT, industrial technology, sea to space, science and technology core services, nanotechnology, and oceanography. The National Innovation Council (NIC) chaired by the Prime Minister, was established in 2004 to propel the national agenda forward and enhance the country's National Innovation System. The Tenth Malaysia Plan (2011-2015) unveiled a new governmental structure that aims to reform and to streamline the governance of STI including the establishment of Malaysia Innovation Agency (AIM) to be the vanguard for innovation in Malaysia. AIM will be the driving force behind Malaysia's push toward establishing an "innovation

economy" that will be instrumental in delivering a new wave of wealth for the Nation and sowing the seeds of sustainability for future generations.

The National Council for Scientific Research and Development (NSCRD), which was established in 1975, has been replaced with the National Science and Research Council (NSRC), established in 2011. The Council is chaired by the Science Advisor to the Prime Minister, and the members are the Secretary Generals of ministries actively involved in R&D and experts from the academia and the private sector. The Council's role is to strategize and prioritize R&D focus areas to meet the challenges of becoming a knowledge-based economy by 2020, as well as encouraging interdisciplinary research.

As of 2011, Malaysia has 20 public universities. The older and more established that have been given the status as "Research University" include the University of Malaya, Universiti Kebangsaan Malaysia, Universiti Putra Malaysia, Universiti Sains Malaysia and Universiti Teknologi Malaysia. Private universities are growing in importance and are catering to the growing needs of industry and the institutional sector. Malaysia has 476 private higher education institutes (HEI) categorised under five different groups. Among them are the Multimedia University, which focuses on multimedia and ICT-based courses and the University of Tenaga National, a private university, which focuses on engineering, information technology, business management, and related courses. University Teknologi Petronas focuses on engineering science and technology. The University of Science and Technology has been established to focus on S&T courses. Various private colleges in Malaysia offer degree programs on a twinning basis with overseas institutions of higher learning, while foreign universities have set up branch campuses in the country. The government research institutes are dominated by agriculture. To advance commodity-based crops specific GRIs are in place such as the Malaysian Rubber Board, Malaysian Palm Oil Board, Malaysian Cocoa Board and Malaysian Agriculture Research and Development Institute. In the area of biotechnology, the Government has also set up research institutes i.e. Malaysia Genome Institute, Malaysia Institute of Pharmaceuticals and Nutraceuticals, and Agro-Biotechnology Institute Malaysia, which have been integrated into a National Institute of Biotechnology for greater efficiency.

Myanmar

Myanmar has a Ministry of Science and Technology (MOST). The Departments that MOST oversees are the Department of Technical and Vocational Education (DTVE), Department of Advance Science and Technology (DAST), Myanmar Scientific and Technological Research Development (MSTRD), Atomic Energy Department (MSTRD), Department of Science Promotion and Coordination (DSPC), Materials Science and Materials Engineering Department (MSMED), and the Department of Biotechnological Research (BTR). The other Ministries that have research and development programs on S&T are the Ministry of Education, Ministry of Agriculture, Ministry of Health, and Ministry of Transportation.

The Universities provide the researchers to the Ministries that have R&D programs. The largest pool of researchers comes from the Yangon Technological University (YTU) and Mandalay Technological University (MTU)

Philippines

The Philippines has its Department of Science and Technology (DOST) as the central policy making body that coordinates STI programs and provide grants in aid for priority areas. It has three sector-based councils, specifically, the Philippine Council for Agriculture, Aquatic Resources and Forestry Research and Development (PCAARD), the Philippine Council for Health Research and Development (PCHRD), and the Philippine Council for Energy and Emerging Technology Research and Development (PCIEERD).

The Councils have governing boards whose members represent the academia, the private sector and other relevant civil society or associations. The DOST Secretary chairs the Boards. The Councils are mandated to formulate strategies, plans and programs, and support projects for S&T development, to allocate grants and funds to their respective sector-based clients; and to monitor R &D projects.

DOST supervises seven research institutes specifically the Industrial Technology Development Institute (ITDI), the Food Nutrition Research Institute(FNRI), the Forest Products Research and Development Institute (FPRDI), the Philippine Nuclear Research Institute (PNRI), the Advance Science and Technology Institute (ASTI), the Metals Industry and Research Development Center (MIRDC), and the Philippine Textile Research Institute (PTRI). Recently, the Technology Research Center (TRC) was transferred to DOST and the functions of the Commission on Information Communications Technology (CITC) were given to DOST.

Four service institutes are also supervised by DOST: the Science Education Institute, the Science and Technology Information Institute, the Technology Application and Promotion Institute, the Philippine Atmospheric, Geophysical and Astronomical Services, and the Philippine Institute of Volcanology.

The Congressional Commission on Science and Technology and Engineering (COMSTE) undertakes a national review and assessment of the science and technology and engineering research and development systems of the country. It aims to enhance the system's internal capability to satisfactorily implement the constitutional provisions on science and technology; to provide the system with the necessary funding requirement and other infrastructure support in strengthening the linkages with all sectors concerned with S&T and engineering R&D; and to assist the science and technology and engineering sectors in achieving their goals and targets through policies and approaches that are consistent with the nation's development perspective.

The scope of DOST's responsibility for STI is quite broad. Other research offices under line agencies such as the Department of Agriculture and Department of Environment and Natural Resources are also being supervised by DOST.

Likewise, crop-based state-owned enterprises are attached to line agencies including the Philippine Coconut Authority and the Philippine Tobacco Administration.

Singapore

Singapore is unique since it does not have a Ministry of Science and Technology. However, the Prime Minister chairs the Research, Innovation, and Enterprise Council (RIEC), which advises the Cabinet on national research and innovation policies to drive the transformation of Singapore into a knowledge-based economy with strong capabilities in R &D. It is composed of cabinet members and distinguished local and foreign members from the business, science and technology communities. The National Research Foundation (NRF), which is under the Prime Minister serves as the secretariat of RIES. The Agency for Science, Technology, and Research (A*STAR) under the Ministry of Trade and Industry is composed of two entities: the Biomedical Research Council and the Science and Engineering Council. The universities have strong linkages with well-known universities of other countries. The Campus for Research and Technological Enterprise (CREATE) collaborates with well-known academic institutions in Europe and the United States and develops bright science and technology students to become scientists in specific fields.

Programs that encourage entrepreneurships are well established in Singapore. For instance, the National University of Singapore established a University level cluster to provide an enterprise dimension to NUS teaching and research involving the University's students, staff, and alumni.

Singapore is focused on economic outcomes of STI policies. The leadership of the Prime Minister and extensive collaboration with industry, academe both at the national and international level contribute to its excellent performance in the global market.

Thailand

Thailand's Ministry of Science & Technology (MOST) is the lead organization for S&T. Nevertheless, it does not supervise all Government Research Institutes (GIRs). Other line agencies and state-owned corporations and authorities also undertake research and technology functions. A vital policy mechanism for S&T policy formulation is the National Science, Technology, and Innovation Policy Committee (NSTIC), which is chaired by the Prime Minister. The Minister of MOST serves as the Vice Chairperson of NSTIC. Its Members are the Ministers of Agriculture and Cooperatives, Information and Communications Technology, Commerce, Taxation, Education, Public Health, Industry, the Chairman of the National Research Council Executive Board, 11 independent experts, the Permanent Secretary of the Ministry of Science and Technology as the Secretary, and the Secretary General of the National Science Technology and Innovation Policy Office (STI Office) as the Assistant Secretary.

It is noteworthy that Thailand's mechanism for STI involves the Cabinet and other stakeholders such as Public Organizations, the Board of Trade of Thailand, Financial Institutions, State Enterprises, Academic Institutions, Federation of Thai Industries, the Civil Society, and Regional and Local Governments. Considered as demand stakeholders, they provide inputs on STI.

The following take part in the regional hearings called to discuss STI Towards Societal Well-Being: in the Upper North – Chiang Mai University; Lower North – Naresuan University; Central and West – Kesetsart University; South – Prince of Songkla University; Upper Northeast – Khon Kaen University; Lower Northeast – Suranaree University of Technology; and East – Burapha University.

Vietnam

Vietnam has a Ministry of Science and Technology (MOST). Research and Development Institutes are under the supervision of the appropriate ministries. Specifically these are the ministries of trade and industry, transportation, agriculture and rural development, construction, health, natural resources and environment and science and technology. The Ministry of Trade and Industry has the biggest number of Research and Development Institutes (RDIs), particularly petroleum, oil number of RDIs to supervise, which include gas, automobiles, chemicals, energy, textile, manufacturing, and shipping. The RDIs under the Ministry of Agriculture and Rural Development include water, forestry, agriculture, and fisheries RDIs. MOST has supervision over the Applied Technology Institute and the Nuclear Research Institute. The Vietnam Academy of Science and Technology has 32 RDIs. Its Institute of Materials Science has the largest number of personnel.

SYNTHESIS

From the reports and review of some literature on ASEAN STI, the following insights emerge:

Strategies and policies are influenced by many factors: political history, economic and social conditions, and level of aspirations of the leadership of the countries. Thus, one may note that the focus of ASEAN Member States, though exhibiting many similarities, show varying emphases or priorities.

Practically all members have strategies involving development of human capital, infrastructure, communication, or dissemination of Information, strong linkages with relevant partners and involvement of various stakeholders to spur development. The level of integration or cohesiveness of STI policies differ from member to member. Likewise, the role of the top leadership, such as the Prime Minister or President varies from country to country.

One good example of the prominence of the role of the national leader is the case of Singapore. The Prime Minister chairs the RIEC. The clear focus on economic outcomes by mobilizing industry, government, and the academe, and strong linkages with international

institutions enhance and preserve the high performance of Singapore in the global market. One may note that the GRIs of Singapore are not coordinated by a single department but are dispersed among various departments.

Indonesia's S&T Plan is clearly intertwined with its industry or economic development plan. Notable is the President's 1-747, aptly called Innovation Implementation Initiatives, which highlights the roles of S&T human capital and infrastructure contributions in attaining well-defined national goals.

It will be noted that Malaysia and Thailand wove their S & T plans into their economic and social plans and clearly articulated the relevance of strengthening the human capital to achieve the goals of development and sustainability. What is most explicit in Thailand's plan is the concern for changes in demography and STI's role in addressing these changes. Thailand also recognizes the ASEAN's role in STI. Thailand and the Philippines have notably given priority to marginalized stakeholders or constituents that have needs for STI interventions. Significant in the strategies and the policies of Thailand are the focus on demographic developments and needs of the rural community. Also notable are the processes of consultations in formulating programs for the aforementioned sectors, involving as it does academic institutions, and regional and local governments. Similarly, the Philippines has programs in remote and far-flung areas and island provinces. These include transfer of technologies appropriate for the circumstances of those in rural areas. These are implemented by the Provincial Science and Technology Centers in collaboration with other agencies of government.

While Thailand, Malaysia, Philippines, and Vietnam incorporate in their plans and strategies sectors that need special focus such as rural communities, countryside, and local and regional areas, Singapore puts emphasis on creating an environment for entrepreneurs, companies, and firms that can provide innovative products and services.

Thailand directly addresses societal issues related to the changes in demography and focuses on decentralization and regional and local government participation in STI. These ensure delivery of S&T services or implementation of programs at the local level. Likewise, the Philippines mobilizes regional units to implement programs designed to encourage micro-, medium-, and small-scale enterprises to adopt appropriate technologies and to help communities and remote areas in their S&T needs. Perhaps one may state that both Thailand and the Philippines have designed their S&T interventions to bring S&T to all economic levels in their respective societies.

Like Malaysia and Thailand, Vietnam asserts the importance of sustainable development. In addition, Vietnam stresses that integration with the international scientific and technological community is a major task, thereby highlighting the value of linkages and collaboration on a global basis. Like Thailand and the Philippines, Vietnam emphasizes S&T's vital role in addressing concerns found in the rural areas. Vietnam incorporates tasks relating to researches on socio-economic development models.

The common threads on STI, which may be woven among ASEAN Member States, are collaboration on sustainability, biotechnology, information and communication technology, and human capital development. The latter may include consideration of mutual recognition agreements for specific fields or disciplines in the S&T professions. Undoubtedly, the latter

will entail consultation and collaboration with Labor and Education Ministries and the appropriate ASEAN Committees.

Human Resources Involved in S&T

In terms of total R&D personnel, Singapore has the highest number at 7,230 R&D personnel while Lao PDR has the lowest at 37 R&D personnel per million population. The distribution of R&D personnel among sectors of performance shows that more than half of Singapore's R&D personnel are employed in private business while in Brunei, Indonesia, Malaysia, Philippines, Thailand, and Vietnam, the bulk of R&D personnel is employed in the higher education sector. It is only in Cambodia and Lao PDR where more than half of their R&D human resources are employed by the government sector. Moreover, it should be noted that Singapore had the least portion of R&D personnel working in the government sector (Table 31).

Table 31
Number of Researchers (Headcount) Per Million Population
By Sector of Employment among ASEAN Member States, Latest Available Data

Member Country (year available)	Total Headcount Per Million Population	Distribution by Sector of Employment (as % to total)				
		Business Enterprise	Government	Higher Education	Private Non-Profit	Not Specified
Brunei (2004)	673	11.0	21.2	67.8	-	-
Cambodia (2002)	56	15.2	53.0	11.8	20.0	-
Indonesia (2009)	179	1.9	31.3	66.8	-	-
Lao PDR (2002)	37	28.2	52.2	19.6	-	-
Malaysia (2006)*	930*	9.3*	14.2*	76.5*	-	-
Myanmar (2002)	100	n. a.	n. a.	n. a.	n. a.	-
Philippines (2007)	130	28.0	21.6	48.9	1.5	-
Singapore (2008)	7,230	54.4	7.2	38.4	-	-
Thailand (2007)	582	17.7	16.3	64.5	0.2	1.3
Vietnam (2002)	508	23.5	27.0	49.0	0.5	-

Source: UNESCO *Institute for Statistics*

** National Survey of R&D by MOSTI Malaysia in 2008 yields the following: 1,135,000 Total Headcount per Million Population, 11.7% of which are in Business Enterprises, 11.6% in Government, and 76.7% in Higher Education.*

Funding for S&T

All ASEAN Member States except Singapore invest less in R&D relative to their GDP (Table 32). They have R&D intensities of less than 1%, the level that the UNESCO has recommended for developing countries to achieve.

Table 32
Gross Expenditure on R&D (GERD), R&D Intensity, and Per Capita GERD Among ASEAN Member States, Latest Available Data

Country (Year Available)	GERD (in '000 local currency)	R&D Intensity (GERD as % of GDP)	Per Capita GERD (in '000 PPP$)
Brunei (2004)	4,925	0.04	17.3
Cambodia (2002)	8,357,010	0.05	0.5
Indonesia (2009)	4,671,354,585	0.04	3.5
Lao PDR (2002)	6,560,000	0.04	0.5
Malaysia (2006) *	5,405,800*	0.73*	101.54*
Myanmar (2002)	9,122,008	0.16	0.16
Philippines (2007)	7,566,360	0.11	3.9
Singapore (2009)	7,128,096	2.26	1,431.4
Thailand (2009)	18,225,253	0.21	16.7
Vietnam (2002)	1,032,560,900	0.19	3.1

Source: UNESCO *Institute for Statistics; Recommend converting GERD to USD for better comparison*

** National Survey of R&D by MOSTI Malaysia in 2008 yields the following: Gross Expenditure of 6,070,800,000 GERD in local currency, 0.82% R&D Intensity (GERD as percentage of GDP), and 114.1% Per Capita GERD (in '000 PPP$).*

A comparison of the distribution of national R&D expenditure by sector of performance shows the varying patterns of how R&D efforts are undertaken across ASEAN Member States. In Brunei Darussalam, Indonesia, Lao PDR, and Vietnam, R&D is predominantly performed in the government sector. Comparatively, the business enterprise sector contributes a larger share in Malaysia, Philippines, Singapore, and Thailand. It should also be observed that the higher education sector performs a significant share of R&D in Thailand, Philippines, Singapore, and Vietnam (Table 33).

Table 33
GERD by Sector of Performance in ASEAN Member States, Latest Available Data

Member Country (year available)	GERD (in '000 PPP$)	Sector of Performance (in % to total GERD)				
		Business Enterprise	Government	Higher Education	Private Non-Profit	Not Specified
Brunei (2004)	6,268	-	91.6	8.4	-	-
Cambodia (2002)	6,816	15.7	50.7	12.5	21.2	-
Indonesia (2009)	803,522	14.3	81.1	4.6	-	-
Lao PDR (2002)	2,637	36.9	50.9	12.2	-	-
Malaysia (2006)*	2,815,521*	72.4*	11.2*	16.5*	-	-
Myanmar (2002)	n. a.	n. a.	n. a.	n. a.	n. a.	-
Philippines (2007)	342,491	56.9	17.7	23.3	2.1	-
Singapore (2008)	6,605,896	71.8	7.6	20.5	-	-
Thailand (2007)	1,120,750	45.0	18.5	32.5	1.2	2.7
Vietnam (2002)	252,019	14.5	66.4	17.9	1.1	-

Source: UNESCO *Institute for Statistics*

** Data from the National Survey of R&D of MOSTI Malaysia in 2008 gives a GERD figure of 3,161,875,000 in PPP$, with 70.5% performance by the Business Enterprise Sector, 9.9% performance by the Government Sector and 19.6% performance by the Higher Education Sector.*

Among ASEAN Member States, the government sector serves as the predominant R&D funder in Brunei Darussalam, Indonesia, and Viet Nam. Comparatively, in Thailand, Singapore, the Philippines, and Malaysia, the business sector is the biggest source of R&D funding. In all ASEAN Member States except Malaysia, the government sector plays a very active role in R&D funding. It must also be pointed out that in Thailand, the higher education sector funds more than 10 per cent of the national R&D expenditures while the private non-profit sector and foreign sources play a significant role in R&D funding in Cambodia and Lao PDR (Table 34).

Table 34
GERD by Source of Funds in ASEAN Member States, Latest Available Data

Member Country (year available)	GERD (in '000 PPP$)	Distribution by Source of Funds (in %)					
		Business Enterprise	Government	Higher Education	Private Non-Profit	Funds from Abroad	Not Specified
Brunei (2004)	6,268	1.6	91.0	7.4	-	-	-
Cambodia (2002)	6,816	-	17.9	-	43.0	28.4	10.6
Indonesia (2009)	803,522	14.7	84.5	0.2	-	-	0.7
Lao PDR (2002)	2,637	36.0	8.0	2.0	-	54.0	-
Malaysia (2006)*	2,090,512	84.5	2.4	6.5	-	0.2	6.3
Myanmar (2002)	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.
Philippines (2007)	342,491	62.0	26.1	6.4	0.9	4.1	0.5
Singapore (2008)	6,605,896	63.5	29.9	1.3	-	5.3	-
Thailand (2007)**	1,120,750	48.7	31.5	14.9	0.7	1.8	2.4
Vietnam (2002)	252,019	18.1	74.1	0.7	-	6.3	0.8

Source: UNESCO *Institute for Statistics*

* *Data from the National Survey of R&D by MOSTI Malaysia in 2008 shows that Malaysia had 3,161,875,000 GERD PPP$, of which 66.45% was sourced from Business Enterprises, 30.67% from Government, 0.74% from Higher Education, 0.11% from Funds from Abroad, and 2.03% from unspecified sources.*

** *Funding source distribution is based on 2005 data.*

S&T R&D Outputs: Scientific Publications

Scientific publications in the ASEAN Member States are shown in Table 35. Figures show that Singapore leads all the 10 ASEAN Member States in terms of scientific publications with its number increasing from 3,465 in 2000 to 6,813 in 2008 or an increase of almost of 100%. Second to Singapore is Thailand, which showed significant improvement in number of scientific publications as it almost trebled its number from 1,182 in 2000 to 4,134 in 2008. In terms of percentage increase, Malaysia even showed highest improvement as it increased its number to more than three folds from 805 in 2000 to 2,712 in 2008. Philippines and Indonesia had lower number at almost the same levels registered during the period. Vietnam caught up with an increase from 315 to 875 during the period. Other countries like Brunei Darussalam, Cambodia, Lao, and Myanmar had less than a hundred.

Table 35
Number of Scientific Publications among AMS

ASEAN	2000	2001	2002	2003	2004	2005	2006	2007	2008
Brunei Darussalam	31	26	25	32	34	27	26	35	40
Cambodia	14	14	20	23	41	50	64	80	75
Indonesia	429	449	421	428	471	526	597	582	650
Lao PDR	9	12	16	24	27	34	49	44	52
Malaysia	805	906	961	1,123	1,308	1,520	1,757	2,151	2,712
Myanmar	19	21	12	21	30	38	42	40	37
Philippines	353	317	398	418	427	467	464	535	624
Singapore	3,465	3,781	4,135	4,621	5,434	5,971	6,300	6,249	6,813
Thailand	1,182	1,344	1,636	1,940	2,116	2,409	3,000	3,582	4,134
Vietnam	315	353	343	458	434	540	617	698	875

Source: UNESCO *Science Report 2010*

S&T R&D Outputs: Patents

Trend and ranking in terms of the number of registered patents (Table 36) shows Singapore staying at the top of the ASEAN Member States with 274 in 2000 increasing to 481 in 2008. Malaysia is next with 63 in 2000 increasing to 212 in 2008. The Philippines and other countries have registered patents numbering less than 50.

Table 36
Patents Granted

ASEAN*	2000	2001	2002	2003	2004	2005	2006	2007
Cambodia	-	-	-	-	1	-	1	-
Indonesia	11	13	9	13	11	12	7	9
Malaysia	63	65	94	77	111	117	162	212
Philippines	17	22	30	45	39	26	44	33
Singapore	274	373	505	523	540	429	519	481
Thailand	25	39	60	37	37	28	56	28
Vietnam	1	4		2	2	6	2	1

Source: UNESCO *Institute for Statistics*
** No data available from Brunei, Lao, and Myanmar*

S&T Utilization Program and Indicators

The objectives/targets of S&T utilization programs can be divided into three categories, namely: socio-cultural development, public services including defense and national security, and private sector to support the economy. The source of the knowledge on the other hand, is from three categories, namely universities, public research organizations (PROs) and private business R&D units. Table 37 shows the complete outline of all the projects and programs related to S&T utilization in the AMS.

Table 37
Projects and Programs Related to S&T Utilization in the AMS

S&T Innovation and Utilization Programs

	Users / Source of Knowledge	Socio-Cultural Sector	Public Sector		Business Sector		
		Socio-culture and rural development	Government Public Services	National Security/ Defence Program	Technology SMEs Business Start-Ups	Technological upgrading for SMEs	Commercial-ization by Established Industries
Brunei Darussalam	Univs	Δ	Δ	X	X	X	X
	PRIs	Δ	Δ	X	X	X	X
	Business R&Ds	X	X	X	X	X	X
Cambodia	Univs	Δ	X	X	X	X	X
	PRIs	Δ	X	X	X	X	X
	Business R&Ds	X	X	X	X	X	X
Indonesia	Univs	Δ	Δ	X	X	X	X
	PRIs	O	Δ	O	X	X	X
	Business R&Ds	X	Δ	Δ	Δ	Δ	Δ
Laos	Univs	Δ	X	X	X	X	X
	PROs	Δ	Δ	X	X	X	X
	Business R&Ds	X	X	X	X	X	X
Malaysia	Univs	Δ	X	X	Δ	X	Δ
	PROs	Δ	O	Δ	Δ	Δ	Δ
	Business R&Ds	X	X	X	X	X	O
Myanmar	Univs	X	X	X	X	X	X
	PRIs	X	Δ	X	X	X	Δ
	Business R&Ds	X	X	X	X	X	X
Philippines	Univs	O	Δ	X	Δ	X	X
	PRIs	X	O	X	X	X	X
	Business R&Ds	X	X	X	X	X	X
Singapore	Univs	X	X	X	Δ	Δ	Δ
	PROs	X	X	X	Δ	Δ	Δ
	Business R&Ds	X	X	X	Δ	O	O
Thailand	Univs	O	Δ	X	Δ	Δ	Δ
	PRIs	O	O	X	X	O	Δ
	Business R&Ds	X	X	X	X	X	O
Vietnam	Univs	Δ	X	X	Δ	X	X
	PRIs	O	Δ	X	X	Δ	Δ
	Business R&Ds	X	Δ	X	X	X	Δ

Notation description

O Fairly good Δ Fair X Minimal/Not identified/Non-existence

The summary of the utilization indicators is illustrated in Table 38. The integration of S&T into the economic sector is most prominent in Singapore. Malaysia shows a balance of S&T utilization in the three sectors (socio-cultural development, national security and the economy). Thailand, the Philippines, and to a lesser degree Vietnam are balancing the S&T utilization between to support the economy and for socio-cultural development. The S&T utilization program in Indonesia is concentrated in national security and defense and with less intensity to rural and socio-cultural development, while in the economic sector, the S&T utilization is mainly coming from private initiatives, with less involvement from the public research institutes and universities.

Table 38
Summary of Utilization Indicators
(Please refer to next page)

	S&T Innovation and Utilization Programs						
	Users	**Socio-Cultural Sector**	**Public Sector**		**Business Sector**		
	Source of Knowledge	**Socio-culture and rural development**	**Government Public Services**	**National Security/ Defence Program**	**Technology SMEs Business Start-Ups**	**Technological upgrading for SMEs**	**Commercial-ization by Established Industries**
Brunei Darussalam	Univs	UBD is involved in many S&T projects related to biodiversity, aquaculture and forest reserve.	UBD is linked strongly with almost every government S&T project.	Not identified	Some initial efforts for promoting innovation and entrepreneurship in UBD through innovation and enterprise providing information, advice, and the commercialization of intellectual property rights.	Not identified	Not identified
	PRIs	Aquaculture Research and Development Division under the Ministry of Industry and Primary Resources serves aquaculture technology especially on fish/shrimp culture and fry production to increase the productivity of aquaculture industry in Negara Brunei Darussalam.	Halal Science Centre providing accreditation services for Brunei Halal Certification process and Brunei Halal brand project; e-Government Innovation Centre (eG.InC) facilitates the collaboration (including trainings and workshops) of the Government agencies and industries to supports the successful implementation of e-government.	Not-identified	Non-existence.	Not identified	Not identified
	Business R&Ds	Non-existence	Non-existence	Not-identified	Non-existence	Non-existence	Activities of R&Ds initiated by private sectors are still very limited.
Cambodia	Univs	The research outputs produced at Royal University of Agriculture are in the area of post harvest processing, animal science, agronomy, soil science, plant pathology, fishery breeding, reforestation which contribute to community development in the country. R&D Projects by Institute of Technology of Cambodia are in biomass, biofuels, renewable energy and environment.	Not identified	Not identified	Non-existence.	Non existence	Non -existence
	PRIs	The Cambodian Agricultural Research and Development Institute (CARDI) are contributing 3,217 crop accessions (2,595 for rice), 38 rice varieties released, 49% of rice fields covered by their rice varieties released, 4 mungbean varieties and other outputs.	Not identified	Not identified	Non-existence.	Non existence	Non -existence
	Business R&Ds	Non-existence	Non-existence	Non-existence	Non-existence.	Non existence	Non -existence

Indonesia	Univs	University community development program in rural area focusing on agro-technology	Some government projects involving universities but in very limited roles. Universities are main source of knowlegde transfer for regional government in applying S&T.	Not identifed	University based business incubators are yet to be developed. Some initiatives in leading universities are indentified.	Non existence	Most leading universities offering technology consultancies to private sectors
	PRIs	Small scale electricity, clean water, organic fertilizer, high yield crop seeds, food processing and post-harvest technology, etc.	ICT (Open source program, e-ID program, WIMAX); transportation (train transportation management system, bus design and manufacturing); disater management (Tsunami early warning system, disasters (vulcanic erruption, flood, landslide) management). The government is also planning to boast the	The biggest dissemination projects of research outputs from PROs are to Defence industries, including IDR 150Trillion (USD 17B) 5 year (2010-2014) project for revitalization of defence industries involving rocket technology, armor vehicles and industry, aircrafts industry, ship building, UAV); national security (genetic forensics).	Some start-ups companies from personnels of PROs are identified, but mostly informal and focused on services and technological consultancies.	Government initiated institution such as Business Technology Center and Business Incubation Center are nurturing SMEs and become intermediators between PROs and SMEs for technology absorption.	Contribution of PROs to business sector very limited; linkages are through technology consultation to industries.
	Business R&Ds	Big firms are contributing to rural development through CSR (community social responsibility) but not necessary technical.	Firms frequently involved in government funded projects for public services that require technological input from private sectors.	Despite the large scale, involvement of private R&D unit in big projects of S&T utilization for national security is very limited.	Several high-tech business start-ups initiated by private sector oriented for export have been identified such as Terafulk (ship design and building), Xirca (chipset design), Edwar Technology (tomography imaging system manufacturing), Tesena (medical equipments), Solusi247 (Radar design).	Big firms are contributing to nurturing SMEs through CSR (community social responsibility) but not necessary technical.	Vaccine technology; system engineering, tobacco companies, electronics industries
Laos	Univs	Vientiane-based National University of Laos (NUoL) has but very limited activities on dissemination of research outputs, working with NAFRI, in the fields of agriculture, silvicultural issues, agroforestry and community forest, crop management, livestock and fisheries, and agroeconomics and agroprocessing.	Non-existence	Non-existence	Not identified	Non-existence	Non -existence
	PROs	Given the importance of the agricultural sector to the Lao economy, the largest S&T utilization activities are conducted by NAFRI with the tasks of designing, implementing, and coordinating all agriculture and forestry research in Laos. Some activities of S&T utilization programs conducted by the NAST including: • Research activities, and dissemination of results of research and information to the public. • Technical training and workshops to upgrade knowledge of governmental officials at both local and national level.	Implementation of an "e-government project" in national and local centres for e-governance, installing linkage networks by using fibre optics and WiMax system, and ICT equipment to train government staff on information technology; Implementation of Lao National Biosafety Framework, coordinated by MOST and involving 7 ministerial institutions including NAFRI and Department of Agriculture (MAF), Department of Food and Drugs (MOPH), Cabinet Office of Lao Woman Union, Department of Law (MOJ), Department of Environment (MOENR); the project is lasting for 4 years, funded by TEF, costing for 1 million US$ and 0.5 million US$ of in-kind support from Lao Government.	Non-existence	Non-existence.	Not identified	Non -existence
	Business R&Ds	Not identified	Not identified	Non-existence	Non-existence.	Non existence	Not identified

Malaysia	Univs	Involvement of universities in projects for rural development are identified.			The government vigorously promotes university-based technology business incubations coordinated by MTDC, such as UTM-MTDC, UPM-MTDC and UKM-MTDC Technology Centers. However, the effort is yet to show success stories.	Transfer of industrial technology from university to industry particularly SMEs is poorly developed. University links with high-tech clusters across the country are relatively weak.	Commercialization rate of universities funded under the grants for "Intensification of Research in Priority Areas" is only 5% of research results. Natural products, molecular biomdecine, industrial biotechnology, marine science and aquaculture and cancer research are among research activities linked with business sector associated with univrsities (Universiti Sains Malaysia, Universiti Putra Malaysia).
	PROs	PROs are quite involved in a number of S&T projects for rural development especially in Sabah/Serawak regions.	Several PROs established to provide research and services related to industry and engineering including MIMOS, SIRIM, MPC, Nuclear Malaysia, Malaysian Remote Sensing Agency and Malaysian Institute of Economic Research (MIER). PROs assigned to safeguard the quality of health care include IMR, IJN dan CARIF with a growing reputation in cell and molecular biology, gene expression and drug discovery techniques, and Agro-Biotechnology Institute, Malaysia Genome Institute and Institute of Nutraceutical and Pharmaceuticals for pharmaceutical breakthroughs.	A number government projects for national securities including cybercity/cyberspace security, forensic and STRIDE defense system and sea-to-space agenda.	SIRIM facilities to offer technology incubation facilities in spin casting, investment casting, ceramics and cosmetics and natural products; MSC Malaysia Technology Commercialisation Centre focusing on ICT and multimedia; Incubation Centres are also available at Technology Park Malaysia, Kulim Hi Tech Park and USM (Kompleks EUREKA).	Stated onwed companies like Petronas have had more success in nurturing smaller enterprises.	Public sector participation in industry-linked research is lacking.Exception are commodity research organizations such as Malaysian Palm Oil Board (MPOB), Malaysian Rubber Board (MRB), Malaysian Cocoa Board (MCB) and Forest Research Institutions Malaysia (FRIM) focusing on agriculture and forestry have close link with firms in the relevant sectors.
	Business R&Ds	Not identified	Not identified	Not identified	Not identified	Linkages between domestic SMEs (95% of total number of firms) and large companies that own R&D units is very limited. Technological learning by local firms via interaction with foreign subsidiaries is limited.	Research activities in business sector are mostly conducted by MNEs involving electrical and electronics (E&E) (46% of total foreign R&Ds), chemicals, food and beverages, rubber and plastics, and automotives sectors. Most R&D by domestic firms is conducted by large state-owned enterprises including automobile manufacturer Proton, oil dan gas company Petronas, and large palm oil firms.
Myanmar	Univs	Not identified	Not identified	Not identified	Non-existence.	Not identified	Non -existence
	PRIs	Not identified	Examples of products/technologies developed by the Myanmar Standards and Industrial Research Department (MSIRD) are anti-malaria herbal medicine which will now go through clinical trials, composite material using waste plastics for housing construction, ceramic insulators for electric transformers and jars made from clay which can be used to purify water.	Defence support becomes one of science and technology plan envisions, however programs related to S&T utilization of R&D outputs from public research institutions is yet to identified.	Non-existence.	Not identified	The Biotechnological Research Department under the MOST has come out recently with biofertilizers and these are now produced in 3 factories owned by MOST.
	Business R&Ds	Non-existence	Non-existence	Non-existence	Non-existence.	Not identified	Not identified

Philippines	Univs	Universities are actively involved in community development utilizing S&T for rural development projects sponsored by the government, including agro-technology, biodiversity, aquaculture, disaster management and renewable energy.			Several activities for technology business incubation are under going in universities, e.g. Incubation center of University of Philippines, Innovation Cluster at University Ateneo Manila.	Not identified	Not identified
	PRIs	Not identified	Public Research Institutes are strongly involved in government programs related to disaster management, ICT and aquaculture.	Not identified	Non-existence.	Not identified	Not identified
	Business R&Ds	Not identified				Not identified	Not identified
Singapore	Univs	Non-existence	Not identified	Not identified	Technopreneurships from universities becoming popular as part of third wave of high tech start-up in Singapore since early 2000s, including companies founded by university professors (e.g. Semicaps, an IC failure analysis equipment maker founded by a professor from NUS), and companies founded by university students (e.g. tenCube, a mobile security company founded by NUS students, recently acquired by McAfee).	Singapore has a well-developed tertiary education system, incorporating universities and polytechnichs which are set up with mission to train middle-level professionals to support technological and economic development.	Technology commercialization from universities is increasing since early 2000s supported by government program to stimulate economic growth through industrially-relevant research, technology commercialization, high tech spin-offs, attraction of foreign talent and injecting an entrepreneurial mindset among graduates. However, the success is very limited, as only 2.9% of total revenue from technology licensing in Singapore are coming from universities.
	PROs	Non-existence	Not identified	Not identified	Start-up companies coming from public research institutions and tertiary institutions are becoming popular and funded by venture capital firms and emerging angel invesment community including Muvee, a video editing software technology spin-off from I2R. However, high-tech start up program funded by the government generally faile as eventhough the government has spent USD1 billion with Technopreneurship 21 program for 5 years between 1998-2003, but with little success.	PROs have significant role to strengthen the technological capabilities of SMEs through SPRING program.	The mission of PROs are to develop applied technological capabilities deemed critical to support Singapores's major industrial clusters already existence in Singapore, and new core competencies in new generic technologies (e.g. molecular and cell biology and wireless communication technologies). However, the share of revenue from products/processes commercialization of R&D results attributed to PROs is minor, only 0.06% of the total. Contribution of revenue from R&D product/process commercialization is mostly coming from private sector.
	Business R&Ds	Non-existence	Not identified	Not identified	High-tech independent start-up firms seeking to pioneer innovative products through their own R&D and brand development include PC firms (IPC, GES), audio-card firms (Creative, Aztech), industrial electronics (Powermatics, Teledata), machine tools makers and industrial machinery makers (Excel Machine Tools) in late 1980s to 1990s and firms related to internet//e-commerce in 1990s to 2000s. However, most of these either failed, exited or acquired by larger firms.	Technically advanced SMEs are operating in various supporting industries supplying to MNCs, particularly precision engineering, such as Amtek (metal stamping), Spindex (precision engineering), Meiban (precision plastic moulding), Gul technology (printed/flexible circuit board), and Venture Manufacturing and JIT (contract manufacturing).	Manufacturing firms constitute the largest performer for R&Ds in Singapore, concentrated in electronic and engineering sectors. There are growing share of private sector R&D going to services sector, in particular IT and communications services. In high-tech manufacturing sector, foreign firms dominate the R&D activities. Government linked companies (GLCs) have significant role in high-tech industries that are engaged in aerospace repair/maintenance engineering (ST Aerospace), semiconductor frabrication (Chartered Semiconductor Manufacturing), electronic system integration (ST electronics) and computer software systems (SCS), shipyards and rigbuilding (Sembawang Group and Keppel).

Thailand	Univs	Universities are intensely involved in community development utilizing S&T for rural development projects sponsored by the government.	Universities become important source of knowledge for public institutions in providing services in the country.	Involvement of universities in government projects of S&T utilization for defense and security program is not identifed.	Quite active business incubation in Chulalonkorn University; some initiatives on business incubation started at Tamasat University. However, success stories are yet to be developed.	SMEs in traditional sectors carry out joint activites with universities. Universities provide consulting and technical services to SMEs.	Linkages between universities an industry in Thailand are mostly limited to consulting and technical services, commercialization of research results by industries is very limited. Firms performing R&D in science-based sectors have intense collaboration with local universities, particularly petroleum, petrochemical, electrical machinery, telecommunications and computer sectors. Successful cases of university involvement in industry is Centex Center of Excellence for Shrimp Molecular Biology and Biotechnology at Mahidol University with support from the Thai National Center for Genetic Engineering and Biotechnology (BIOTEC) and Petroleum and Petrochemical College at Chulalongkorn University which supplies skilled workers to petroleum industry and providing testing and analysis services.
	PRIs	Ministry of Science and Technology has initiated several projects to promote the use of science and technology for social and local community development including "Science and Technology Villages", a program covering 160 villages around the country to assist villagers to integrate modern science and technology with their local know-how to enhance productivity and improve quality of life; "One Tambon, One Product" program by the National Science and Technology Development Agency to develop at least 10 model science communities, 12 concepts from local wisdom and create at least 60 prototype technologies or services to assist elderly and disabled	A number of big projects involving S&T utilization include 12 Mass Transit Lines (2010-2029) in Bangkok and Metropolitan Regions, Thailand Earth Observation Satellite, Synchrotron Light Research institute (SLRI) under the supervision of the Ministry of Science and Technology to operate and develop the Siam Photon Source and the Siam Photon Laboratory; other key activities to foster green innovation including renewable energy development program, climate change technology needs assessments energy, conservation program energy efficiency improvement program and promotion of green industry and eco-industrial towns.	Food and energy security has become one of development strategies that involving S&T utilization, direction of S&T development to support national defense and other national security is not prominent.	University spin-off of business start-ups from PROs are non-existent.	Government utilisation programmes in the 12 economic sectors supported by PROs to mainly target SMEs, namely Rice and rice products, Cassava, sugarcane and oil palm for energy, Rubber and rubber products, Food processing, Electrical appliances and electronics, Automotive industry, Petrochemical industry, Fashion industry – textile, leather and jewellery, Tourism and related industry, Logistics and related industry, Construction and related industry, Creative and digital economy	Activites by PROs, especially under the National Science and Technology Development Agency (NSTDA) are focused on R&Ds or providing technical serc\vices for public and private entities such as testing and callibrating, and generally do not assist companies in building capabilities such as technology assimilation, adaptation, design and engineering. Exception is the Hard Drive Institute (DHHI) which was created by IDEMA, an industrial association for hard drive disk drive firms, with local research institutes and representatives of Board of Investment, that is engaging research projects to upgrade the capabilities of the entire hard drive industry in Thailand.
	Business R&Ds	Not-identified.	Not-identified	Non-existence	Non-existence.	Multinationals have not been active in developing subcontractors or giving technical assistance to local suppliers.	Most R&Ds by multinationals is performed by electrical machinery sector including electronics, food, motor vehicles and chemicals.

Vietnam	Univs	Most agricultural research by universities has focused on lowland farming systems, particularly the development and dissemination of new rice varieties. Can Tho University conducts research to support the development of the Mekong River delta region through enhanced agricultural and aquaculture techniques, seed development, and improvements in farming methods. The hanoi University of Agriculture is prominent in farm-related investigations.	Not identified	Not identified	The Hanoi University of Technology is the largest university in Vietnam, has significant role to supply quality graduates to meet the needs of Vietnamese economy. HUT has seven companies that help to market and commercialize university technologies ans has set up incubation centers in nearby science park. Students are encouraged to initiate start-up companies with the help of the incubation centers.	Not identified	Not identified
	PRIs	Significant number of agro-scientists are working al the local level for rural development in agricultural sector. Over 30 state agricultural research institutes under the Ministry of Agriculture and Rural Development are engaged in research on breeding and screening plants varieties and animal breeds, technical aspects of crop and livestock production and the improvement of existing farming systems. However, the quality of researches are generally low, and relevant agricultural research results are often not shred with farmers and rural workers.	The public sectr plays the major role in the innovation system in Vietnam including public services projects.	Not identifed	Not identified	Center for S&T Transfer Services has newly established under the new Technology Transfer Fund to help local enterprises adopt foreign technology and to transfer know how and technologies from public research institutes and universities. The Hoa Lac High-Technology Park which are formed with financial support from Japan, hosts 10 companies primarily Japanese aims to promote research and development, produce high technology products, incubate technology enterprises and develop human resources. The government subsidize heavily the development of the information technology sector; currently around 600 software development firms located in Ho Chi	The majority of public research institutes does not have the requisite technical and financial resources, are delinked from market and the priate sector, do not engage in technology transfer. Exception is biotechnology sector where sufficient funding has led to high quality researches. VABIOTECH is an example of state-owned research institute under Ministry of Health which has successfully become world class in manufacturing vaccine.
	Business R&Ds		Non-public institutes generally act as sub-contractors of public research institutes in conducting state-funded projects	Not identified	Not identified	Not identified	R&D conducted by multinational enterprises operates mainly according to the parent firm innovation policy, and tend to operate independently from domestic companies, and do not form networks of production, supply and distribution with them. State owned enterprises have not been proactive in research activities except R&D projects funded by the government based on the national science and technology plan. Most R&D by state-owned firms has been in the shipbuilding and telecommunications industries.

STRENGTHS/NICHES/POTENTIALS IN S&T

Tables 39 to 44 indicate strengths, niches, and potentials in S&T among the ASEAN Member States. These approximations are based on the limited information that were gathered during the period of this study and based on impressions/perceptions that have been expressed by authors in this report. The authors used these data to offer a qualitative summary of the strengths, niches, and potentials of the AMS as a guide to understanding the possible directions a country might take henceforth.

The matrices are categorized as follows:

1. Articulation of S&T Policies and Strategies, S&T and Innovation Infrastructure, and Utilization Programs (Table 39)
2. S&T Human Resources, Investments, and Outputs (Table 40)
3. HEI capacity for HRD in S&T and University-based Research Capability (Table 41)
4. Areas of Strength in Major S&T Disciplines (Table 42)
5. Strengths/Niches/Potentials in Socio Economic Sectors Where S&T Has Significant Role (Table 43)
6. Niches in Products/ Commodities Based on Major Exports (Table 44)

Table 39
Articulation of S&T Policies and Strategies, S&T and Innovation Infrastructure, and S&T Utilization Programs among AMS

ASEAN Member States	Indicators		
	Policies/ Strategies	Infrastructure	Utilization Programs
Brunei	x	xx	x
Cambodia	x	x	x
Indonesia	xxx	xxx	xx
Laos	x	x	x
Malaysia	xxx	xxx	xxx
Myanmar	xx	xx	x
Philippines	xx	xxx	xx
Singapore	xxx	xxx	xxx
Thailand	xxx	xxx	xx
Vietnam	xx	xx	xx

Legend: xxx – Advanced; xx – Developed; x – Evolving

Table 40
S&T Human Resources, Investments & Outputs among AMS

ASEAN Member States	Indicators		
	S&T Human Resources	S&T Investments	S&T Outputs
Brunei	xxx	x	x
Cambodia	x	x	x
Indonesia	xx	x	xx
Laos	x	x	x
Malaysia	xxx	xxx	xxx
Myanmar	xx	xx	x
Philippines	xx	xx	xx
Singapore	xxx	xxx	xxx
Thailand	xxx	xx	xxx
Vietnam	xxx	xx	xx

Legend: xxx – High; xx – Low; x – Very Low

Table 41
HEI Capacity for HRD in S&T and University-based Research Capability of AMS

ASEAN Member States	Indicators	
	HEI Capacity for HRD in S&T	University-based Research Capability
Brunei	xx	xx
Cambodia	x	x
Indonesia	xx	xx
Laos	x	x
Malaysia	xxx	xx
Myanmar	x	x
Philippines	xx	xx
Singapore	xxx	xxx
Thailand	xxx	xx
Vietnam	xx	xx

Legend: xxx – Very High; xx – High; x – Low

Table 42
Areas of Strength in Disciplines of AMS

ASEAN Member States	Indicators				
	Basic Sciences (Math, Chemistry, Physics, Biology)	Agriculture and Related Sciences	Medical Sciences	Engineering & Technology	Emerging Technologies (ICT, Biotech, Nanotech, Automation)
Brunei	x	xx	x	x	x
Cambodia	x	x	x	x	x
Indonesia	xx	xx	xx	xx	xx
Laos	x	x	x	x	x
Malaysia	xx	xxx	xx	xx	xxx
Myanmar	xx	xx	xx	x	x
Philippines	xx	xxx	xxx	xx	xx
Singapore	xxx	xx	xxx	xxx	xxx
Thailand	xx	xxx	xxx	xx	xxx
Vietnam	xx	xxx	xxx	xx	xx

Legend: xxx – Very Strong; xx – Strong; x – Developing

Table 43
Strengths/Niches/Potentials in Socio Economic Sectors
Where S&T has a Significant Role among AMS

ASEAN Member States	Indicators				
	Agriculture	Health	Industrial Manufacturing / Processing	Services (ICT, Finance, Engineering)	Disaster Management
Brunei	xx	x	xx	x	xx
Cambodia	xx	x	x	x	x
Indonesia	xx	xx	xx	x	xx
Laos	xx	x	x	x	x
Malaysia	xxx	xx	xxx	xx	xx
Myanmar	xx	xx	x	x	xx
Philippines	xx	xxx	xxx	xx	xxx
Singapore	xx	xxx	xxx	xxx	xx
Thailand	xxx	xxx	xxx	xx	xx
Vietnam	xx	xxx	xx	x	xx

Legend: xxx – Very Strong/Very High; xx – Strong/High; x – Developing/Has Potential

Table 44
Niches in Products/Commodities (Based on Major Exports) of AMS

ASEAN Member States	Niches in Products and Commodities (based on major exports)
Brunei	Crude oil, natural gas, garments
Cambodia	Garments, timber, rice, fish, tobacco, footwear, fruits and vegetables, silk and silk products
Indonesia	Petroleum and liquefied natural gas, electrical appliances, computers, motor vehicles, wood and wood products, textiles, rubber, food products, coal, copper, metal products
Laos	Wood products, garments, electricity, beer, rice, coffee, tin, copper, gold
Malaysia	Electronic equipment, petroleum and liquefied natural gas, wood and wood products, palm oil, rubber, garments, textiles, chemicals
Myanmar	Natural gas, wood products, teak, pulses, beans, fish, rice, garments, jade and gems, rubber
Philippines	Semiconductors and electronic products IT-enabled services, transport equipment, garments and accessories, copper products, petroleum products, coconut oil, fruits, tuna
Singapore	Machinery and equipment (including electronics), consumer goods, pharmaceuticals and other chemicals, mineral fuels, petroleum products
Thailand	Computers and parts, automobiles and parts, jewelry, rubber, plastic, electrical circuits, chemicals, rubber products, cooking oil, rice
Vietnam	Crude oil, marine products, rice, coffee, rubber tea, garments and shoes

CAPACITY FOR S&T HUMAN RESOURCE DEVELOPMENT IN HIGHER EDUCATION INSTITUTIONS

Higher Education Institutions Noted for or Offering Advanced Education in Science and Technology

Brunei Darussalam

University Brunei Darussalam produces graduates for S&T fields particularly in the areas of science and engineering servicing the oil and gas-producing sector, in the agricultural, fishery and forestry sciences, and in the health science. It has an academic staff totaling 366, 63% of whom are Brunei nationals and 37% are expatriates.

Cambodia

While Cambodia has 33 public universities and a number of private universities offering programs in science, technology, engineering, agriculture, education, and

medicine, there is a general perception that there is limited supply of highly trained scientists and engineers. Most of the scientists and engineers who opt to work for advanced degrees have to go to other countries to earn these (MS and PhD).

The Institute of Technology of Cambodia (ITC) offers engineer and master's degrees in different fields like civil, electrical, chemical, mechanical, electronics, energy, and environmental engineering. It has a full-time faculty numbering 157, 20% of which have PhD degrees. In addition, about 150 young faculty and researchers are currently studying or on training abroad. The Royal University of Agriculture, on the other hand offers different specializations including aquaculture and forestry. It offers MS degrees in these different fields. However, its doctoral programs are limited to two (2) fields of specialization now. The other universities offering advanced degrees in the sciences are the Royal Academy of Cambodia, the Royal Phnom Penh University, and the University of Science for Health. The Royal Academy of Cambodia offers PhD degrees in the basic sciences.

Indonesia

Indonesia has 472 universities, both public and private, which offers graduate degree programs in science, technology, engineering, and mathematics. In 2010, those universities produced 434,551 baccalaureate, 43,729 masters' degree holders, and 1,765 PhD graduates in science, technology, and engineering.

Fifty of the state or public universities have university-based R&D institutes (RDIs). The most prominent among these state universities and their corresponding strengths are the following:

University of Indonesia	:	Medicine, Pharmacy, Nutrition, Electrical & Electronics Engineering, Materials Science, Applied Physics, Nuclear Physics
Bandung Institute of Technology	:	Electrical and Electronics Engineering, Computer Science & Artificial Intelligence, Materials Science, Telecommunications, Applied Physics and Condensed Matter Physics
Bogor Agricultural University	:	Plant Sciences, Zoology, Food Science, Ecology, Agronomy, Biotechnology, Microbiology, Heredity, and Genetics
Gadjah Mada University	:	Plant Sciences, Pharmacology Pharmacy, Evolutionary Biology, Applied Microbiology, Biotechnology, Materials Science, Applied Physics, Chemical Engineering, Food Science, Public Health, Immunology, Oncology and Anthropology

Laos

The National University of Laos is the only higher education institution offering graduate programs to provide the scientists, technologists, and researchers, in the fields of Agriculture and Food, Applied Science and Technologies, Biology and

Nature, Computers and Communications, Earth and Ocean Science, Energy and Energy Conservation, Environment, Health & Medicine, Mathematics, Physics, Chemistry and Science Education.

Other universities have just been established recently and they are still in the process of developing infrastructure and human resources.

Malaysia

Malaysia has 20 public universities and 476 private higher education institutions (HEIs) categorized under five groups. All of the public universities offer graduate degree programs in Science, Technology, Engineering, and Mathematics (STEM). Among the private universities, 16 are offering graduate degree programs in STEM. In 2010, the total number of graduate students working for their masters degrees at the public universities with graduate programs in STEM was 23,309 while the total number of PhD students was 8,338.

Five (5) out of the 20 public universities have been given the status of "Research University" by the Government in 2006. They are now hubs of excellence in education and research. These are the Universiti Kebangsaan Malaysia (UKM); Universiti Malaya (UM); Universiti Putra Malaysia (UPM); Universiti Sains Malaysia (USM); and Universiti Teknologi Malaysia (UTM).

These research universities are characterized by research-focused fields of study, competitive entry, top-caliber faculty, and 50:50 ratios of undergraduate and graduate students.

Among the private universities, some are owned by business conglomerates like the University Teknologi Petronas and a good number are partnerships with foreign universities like the Curtin University of Technology Sarawak, the Monash University Malaysia, the University of Nottingham Malaysia Campus, the Swinburne University of Technology Sarawak Campus, the Sunway University College, and Taylor's University.

Myanmar

Myanmar has a well-structured system for developing advanced human resources in Science and Technology. There are 32 technological universities, 25 computer universities, 1 aerospace and aeronautical engineering university, 2 agricultural universities, and a number of universities that are under the Ministry of Education (about 50). All the technological universities and institutes are under the Ministry of Science and Technology. Five of the technological universities are supervised by the Department of Advanced Science and Technology of these five technological universities, there are two that offer only MS and PhD programs. These are the Yangon Technological University (YTU) and the Mandalay Technological University (MTU). All higher education institutions (HEIs) are government owned.

It has been observed that research output from the technological universities is still low. These are attributed to low level of funding for research in the universities,

limitations in facilities and graduate faculty, as well as low levels of graduate enrollment in science, technology and engineering.

Philippines

The Philippines has 117 state universities and colleges. In addition, there are more than a hundred private universities nationwide. In the field of engineering, eight (8) universities offer MS and PhD programs:

1. University of the Philippines Diliman
2. Ateneo de Manila University
3. De La Salle University
4. Mapua Institute of Technology
5. University of the Philippines Los Baños
6. Central Luzon State University
7. University of San Carlos
8. Mindanao State University-Iligan Institute of Technology

These eight universities now make up the Engineering R&D for Technology (ERDT) Consortium, which the Government supports through MS and PhD scholarships and research grants.

There is also a consortium for Advanced Human Resource Development in the Sciences. Most of the Universities in the Engineering Consortium are also in the Science Consortium. Others are in the Science Consortium only.

Some unique features characterize the operation of the above-mentioned consortia in science and engineering. One is the use of the 'Sandwich' Program approach particularly for PhD students. They take the coursework in the Philippine universities but they can do their thesis or dissertation abroad in collaboration with foreign researchers/institutions. Another one is the sharing of visiting professors from abroad among the consortium members. The Returning Scientists Program, which involves the services for teaching and research by Filipino expatriates abroad, also helps in keeping the curricular offerings up to date. And there is also the sharing of research facilities such as the Science Complex and Engineering Complex at the University of the Philippines for the benefit of other graduate students and researchers.

Foreign students are now coming to the Philippines mostly for their baccalaureate degrees. This is partly attributed to the use of English as a medium of instruction in all Philippine universities.

Singapore

Two top-ranked universities worldwide are found in Singapore. These are the National University of Singapore, which had 26,418 undergraduates and 10,548 graduates in 2010, and Nanyang Technological University with 23,043 undergraduates and 10,044 graduates in 2010. Recently, a new university was established – the Singapore University of Technology and Design (SUTD) which will produce engineering, architectural and systems graduates who are well-versed in

technical functionality and form to design the new innovations of tomorrow. The first batch of students will matriculate in April 2012.

Thailand

Among the many universities of Thailand, the following have been designated as national research universities:

1. Chulalongkorn University
2. Thammasat University
3. Mahidol University
4. Kasetsart University
5. Chiang Mai University
6. Khon Kaen University
7. Prince of Songkla University
8. King Mongkut's University of Technology Thonburi
9. King Mongkut's Institute of Technology Ladkrabang

There are also two leading S&T-intensive universities, namely, King Mongkut's University of Technology North Bangkok and Suranaree University of Technology

It should also be mentioned that the Asian Institute of Technology is located in Thailand. Thailand produces around 10,000 MS graduates and 1,000 PhD graduates in S&T a year.

Vietnam

There are 380 universities in Vietnam, 276 are public while 104 are private. They can be categorized into national, regional, and specialized universities. The national universities are the Vietnam National University (VNU) Hanoi and the Vietnam National University (VNU) Ho Chi Minh. The specialized universities are the Hanoi University of Science and Technology and the Hanoi Civil Engineering University.

The national universities, the specialized universities, and some regional universities offer MS and PhD degrees in the various fields of science, technology, and engineering.

Observation:

It can be seen from the foregoing that the capability to develop advanced human resources in S&T is there, but in general, it is constrained by the availability of faculty with advanced degrees and research experience, by the availability of resources for research and by the availability of infrastructure for training and research. Capacity wise and output wise it appears that member states like Malaysia, Singapore, and Thailand are able to produce the needed human resource in S&T for their own needs. Others like the Philippines, Indonesia, and Vietnam can produce more if there will be more who will be drawn and can have access to graduate education in S&T. The other member states would need to invest a lot more in infrastructure and faculty development.

University-Based Research Institutes

It can be seen from the situationers of the ASEAN Member States that the capability to develop advanced human resources in S&T is also manifested in the existence and productivity of the research institutes in the universities.

It can be observed that Brunei has a Field Studies Centre for biodiversity research and an IBM Blue Gene Supercomputer Center, which are under the wings of the University Brunei Darussalam.

Indonesia has university-based research institutes in every state university and some private universities, with those located at the University of Indonesia, the Bandung Institute of Technology, Bogor Agricultural University, and Gadjah Mada University as the most prominent.

Malaysia has university-based research institutes also, but in addition, it has technology centers, which are joint venture projects of leading universities like the Universiti Putra Malaysia, Universiti Kebangsaan Malaysia, and Universiti Technologi Malaysia with the Malaysia Technology Development Corporation (MTDC). These technology centers serve as incubation areas for technology-based start-up enterprises.

The Philippines has R&D institutes in its larger state universities. The University of the Philippines alone has 95 R&D institutes in six of its campuses, while 131 other R&D institutes are based in the other state universities.

Singapore, through NUS and NTU operates several university based research institutes and centers. The National University of Singapore, for example, has the following:
Centre for Maritime Studies (CMS)
Centre for Remote Imaging, Sensing and Processing (CRISP)
Institute for Mathematical Sciences (IMS)
Interactive & Digital Media Institute (IDMI)
Life Sciences Institute (LSI)
NUS Nanoscience and Nanotechnology Initiative (NUSNNI)
Singapore Synchrotron Light Source (SSLS)
Solar Energy Research Institute of Singapore (SERIS)
Temasek Laboratories (TL@NUS)
The Logistics Institute - Asia Pacific (TLI – Asia Pacific)
Tropical Marine Science Institute (TMSI)

NTU, for its part, operates the following research institutes:
Institute of Environmental Science and Engineering (IESE)
Nanyang Environment & Water Research Institute (NEWRI)
Electromagnetic Effects Research Laboratory (EMERL)
Energetics Research Institute (EnRI)
Intelligent Systems Centre (IntelliSys)
Satellite Engineering Centre (SEC)

Thales@NTU
Temasek Laboratories@NTU

Thailand's university-based research institutes can be found mostly in its nine research universities and leading S&T focused universities.

In Vietnam, the university-based research institutes accounts for a significant portion of the total number of researchers in the country.

Major Economic Indicators

The major economic indicators including GDP, sectoral GDP, major export commodities and partners and major import commodities and partners are listed in Table 45.

Table 45
Major Economic Indicators of ASEAN MEMBER STATES

	ECONOMIC INDICATORS OF ASEAN							
	GDP (billion USD)	Major Contributors to GDP [%]	Total Exports [billion	Major Export Commodities	Major Export Partners	Total Import [billion	Major Import Commodities	Major Trading Partners
Brunei Darussalam	20.38 (2010)	Agriculture (0.7%), industry (73.3%), services (26%) (2010)	10.67 (2008)	Crude oil, Natural Gas, Garments	Japan 32.8%, Indonesia 24.4%, Australia 13.4%, South Africa 12.2%, US 5.5% (2007)	12.055 (2007)	Machinery, Petroleum Products, Liquefied Natural Gas	Singapore 37.1%, Malaysia 19%, Japan 7%, China 6%, Thailand 5%, US 4.3%, UK 4.1% (2009)
Cambodia	30.181 (2010)	Agriculture: 33.4%, industry: 21.4%, services: 45.2% (2011 est.)	6.491 (2010)	Clothing, timber, rubber, rice, fish, tobacco, footwear	US 54.5%, Germany 7.7%, Canada 5.9%, UK 5.5%, Vietnam: 4.5% (2010)	6.005 (2010)	Petroleum products, cigarettes, gold, construction materials, machinery, motor vehicles, pharmaceutical products	China 22.6%, Vietnam 12.7%, Hong Kong 12.4%, Thailand 11.9%, South Korea 5.4%, Singapore 5.4% (2010)
Indonesia	706.56 (2010)	Agriculture (16.5%), industry (46.4%), services (37.1%) (2010)	158 (f.o.b. , 2010)	Oil and gas, electrical appliances, plywood, textiles, rubber	Japan 15.9%, China 9.9%, US 9.3%, Singapore 8.8%, South Korea 7.0%, India 6.4%, Malaysia 5.8%, Australia 2,8% (2009)	132 billion (2010)	Machinery and equipment, chemicals, fuels, foodstuffs	Singapore 16.1%, China 14.5%, Japan 10.2%, US 7.3%, Malaysia 5.9%, South Korea 4.9%, Thailand 4.8%, Australia 3.5%, Saudi Arabia 3.2%, (2009)
Laos	7.49 (2010)	Agriculture sector 29%, industry sector 26.5% and services 39% (2010)	1.104 (2009 est)	Wood products, garments, electricity, coffee, tin, copper, gold	Thailand 29.18%, China 15.04%, Vietnam 14.96%, UK 4.29% (2009)	1.308 (2009 est.)	Machinery and equipment, vehicles, fuels	Thailand 66.2%, China 11.45%, Vietnam 5.3% (2009)
Malaysia	414.4 (2010 est.)	Agriculture: 10.5% industry: 41.4% services: 48.2% (2010 est.)	210.3 (2010 est.)	Electronic equipment, petroleum and liquefied natural gas, wood and wood products, palm oil, rubber, textiles, chemicals	Singapore 13.4%, China 12.6%, Japan 10.4%, United States 9.5%, Thailand 5.3%, Hong Kong 5.1% (2010 est.)	156.6 (2010 est)	Electronics, machinery, petroleum products, plastics, vehicles, iron and steel products, chemicals	China 12.6%, Japan 12.6%, Singapore 11.4%, United States 10.7%, Thailand 6.2%, Indonesia 5.6% (2010 est.)
Myammar	71.772 (PPP; IMF 2010 est.)	Agriculture: 42.9%, industry: 19.8%, services: 37.3% (2009 est.)	6.504 (2009 est.)	Natural gas, wood products, pulses, beans, fish, rice, clothing, jade and gems	Thailand 52%, India 12.3%, China 8.8%, Japan 4.3% (2008)	3.555 (2009 est.)	Fabric, petroleum products, plastics, fertilizer, machinery, transport equipment, cement, construction materials, crude oil; food products, edible oil	China 31.3%, Thailand 20.8%, Singapore 20.4%, Malaysia 5% (2008)
Philippines	199.59 (2010)	Agriculture (13.9%), industry (31.3%), services (54.8%) (2010 est.)	51.4 (2010)	Semiconductors and electronic products, transport equipment, garments, copper products, petroleum products, coconut oil, fruits	Japan 12.5%, Netherlands 9.8%, Hong Kong 8.6%, China 7.7%, Germany 6.5%, Singapore 6.2%, South Korea 4.8% (2009 est.)	54.7 (2010)	Electronic products, mineral fuels, machinery and transport equipment, iron and steel, textile fabrics, grains, chemicals, plastic	Japan 12.5%, United States 12%, China 8.8%, Singapore 8.7%, South Korea 7.9%, Republic of China 5.7% (2009 est.)
Singapore	251.5 (2010 est.)	Agriculture: 0%; industry: 26.8%; services: 73.2% (2009 est.)	358.4 (2010 est.)	Machinery and equipment (including electronics), consumer goods, pharmaceuticals and other chemicals, mineral fuels	Malaysia 11.9%, Hong Kong 11.7%, China 10.4%, Indonesia 9.4%, United States 6.5%, Japan 4.7%, South Korea 4.1% (2010 est.)	310.4 (2010 est.)	Machinery and equipment, mineral fuels, chemicals, foodstuffs, consumer goods	Malaysia 11.7%, United States 11.5%, China 10.8%, Japan 7.9%, South Korea 5.8%, Indonesia 5.4% (2010 est)
Thailand	318.85 (2010)	Agriculture (11.4%), industry (44.5%), services (44.1%)	195.7 (2010 est.)	Textile, Footwear, Fishery Products	Asean 20.1%, U.S. 12.6%, Japan 11.6%, the People's Republic of China 9.7%, Singapore 6.3%, Hong Kong 5.7%, Malaysia 5.1% (2007)	181.1 (2010 est.)	Capital Goods, Intermediate Goods, Raw Materials	Japan 20.3%, the People's Republic of China 11.6%, U.S. 6.8%, Malaysia 6.2%, UAE 4.9%, Singapore 4.5%, Taiwan 4.1%, (2007)
Vietnam	276.6 (2010 est.)	Agriculture: 20.6%, industry: 41.1%, services: 38.3% (2010 est.)	72.03 (2010 est.)	Clothes, shoes, marine products, crude oil, electronics, wooden products, rice, machinery	US 20%, Japan 10.7%, China 9.8%, South Korea 4.3% (2010 est.)	84.3 (2010 est.)	Machinery and equipment, petroleum products, steel products, raw materials for the clothing and shoe industries, electronics, plastics, automobiles	China 23.8%, South Korea 11.6%, Japan 10.8%, Taiwan 8.4%, Thailand 6.7%, Singapore 4.9% (2010 est.)

Source: CIA World Fact Book

CHAPTER V

OBSERVATIONS AND IDEAS FOR MEMBER STATES

Brunei Darussalam

As a small country well endowed with oil and natural resources and with the highest per capita income in the region, Brunei needs to identify some niche areas where it can focus its S&T development with a view to making itself a regional center in those areas. For example, it can consider areas like biotechnology for agriculture biodiversity and energy development. This would need, however, a strong human resource back up, and therefore the country has to give priority emphasis to this particular requirement. It can also enhance partnerships particularly with neighboring ASEAN member states in order to hasten the human resource capability building process.

On the infrastructure side, it may be very well to consider having a national office devoted to S&T directly under the Office of the Prime Minister.

Considering also the resources of Brunei, it should rate Very High instead of Low in investment on S&T.

Cambodia

Leading and potentially leading R&D players in Cambodia such as the CARDI and RUA for agriculture and ITC for engineering and technology have to be fully developed to attain world-class status. Their research programs have to be expanded although they should maintain the kind of focus that they now have. CARDI's international collaboration has to be sustained but there should be a way of making its long-term operations more sustainable. Its practice of mentoring students in agriculture even if it is not a degree granting institution should be continued and supported. In the case of RUA, the research and academic programs should be strongly linked with the end-user sector and as much as possible they should lend support to the major export commodities in agriculture. In the case of ITC, some research refocusing is recommended particularly considering that it is under the umbrella of the Ministry of Posts and Communications. The human resource development particularly for faculty members of ITC should continue and they should adopt a goal of attaining a faculty mix with at least 50% PhDs from the present 20%. Its capacity to service MSc and PhD students should be increased to be able to meet the country's needs in a rapidly growing world economy.

A good Human Resource Development (HRD) Plan for the S&T Sector as well as a long-term S&T Institution Building Program should be formulated and adopted. Cambodia's fast economic growth should be coupled with long term investments in S&T, which will in turn help assure long-term sustainable growth and development.

Cambodia's plan to utilize its mines and energy potential towards maximizing the sustainable economic benefits can be pursued and in this regard, an accompanying S&T development plan for the sector should be put in place and implemented.

Likewise, the priority or importance being given by the country to small and medium enterprises (SMEs) is very laudable. The pillars it has identified in transferring technology to SMEs have to be translated into concrete action. The first among the four pillars, which is upgrading of standards and product quality, has to be addressed fully by way of providing easy access to SMEs for S&T services. The Industrial Laboratory Center of Cambodia should be able to extend its reach through satellite units that can be set up where SMEs are concentrated.

Cambodia's Intellectual Property Office should engage in a campaign among researchers particularly in the leading research institution. It is also imperative that the evaluation of patent applications be speeded up to be able to gain credibility and a wider patronage from potential client beneficiaries.

Lastly, it may be high time for Cambodia to set up a national S&T agency to coordinate S&T programs particularly HRD, R&D, Technology Transfer, and S&T services. There should also be a system of ensuring government funding for R&D to address public good.

Indonesia

Indonesia has a very comprehensive plan for S&T development. While its S&T indicators like R&D expenditures and number of researchers per million population are still very low, Indonesia has a well-defined S&T policy and development strategy and it has the S&T institutions in place. The system of higher education is also well in place. It can also be observed that the S&T system, particularly the R&D organizations, are linked to the industrial sector. In addition, Indonesia puts high priority in ensuring the utilization of S&T/R&D outputs to benefit the public.

One of the areas where some attention may be given is the program for technology business incubation. This is important in creating a new breed of entrepreneurs who are driven by innovation and R&D. It is also very relevant since there are strong linkages between the R&D institutions and the various industry sectors. The geographic location should be studied carefully depending on the sectors that are targeted and considering the location of the S&T parks.

The presence of state universities with strong S&T programs in the different regions of the country and the existence of university-based research institutes is a strength that should be put to advantage. The potentials of these institutes should be harnessed by supporting research programs that respond to socio-economic development priorities.

The upgrading of the capability and quality of higher education institutions (HEIs) involved in S&T Programs should be given full support by the Government. Like the research programs in the Government R&D institutions, the programs in the academe should also be strongly linked to the industry or socio-economic sectors where their research outputs can be useful. The area of space technology has already been given attention by Indonesia. Perhaps it can accelerate the implementation of their road map for this. It should consider collaboration with

other ASEAN members (ASM) as well as external partners to fast track the development in this area.

Laos

Laos, being one of the smallest AMS in terms of population, needs to focus on a few areas directly contributing to economic and social development effectively.

The first area suggested is agriculture, particularly the most promising commodities for export. The second area is water resources both for industrial and energy use. The third area is information and communication technology (ICT) for development. There are already areas of strength in the sectors and the opportunities are there.

The country needs a very good plan for human resource development not only towards work in S&T areas but also in the aspect of technopreneurship. It will benefit from collaboration and cooperative programs along this line.

Towards creating a strong entrepreneurial class, the Provincial Departments for Science and Technology (PSTD), the research institutes, and the national universities, together with the appropriate line ministries, should work together to upgrade and to encourage the creation of small and medium enterprises (SMEs). This will help create an environment that will encourage innovations and value creation.

Malaysia

Malaysia adopted an S&T development strategy that supports the Industrial Technology Development Plan prepared by the Ministry of International Trade and Industry (MITI) and the National Development Plan, which is prepared every 5 years. Its S&T infrastructure is tailored to support the following focus areas through their agencies and clusters: Biotechnology, ICT, Industrial Technology, Sea-to-Space, S&T Core Services, Nanotechnology, and Oceanography. All of these are geared towards their goal of creating a sustainable high-income knowledge-based economy by 2020 (Vision 2020).

It is suggested that Malaysia further concentrate on three areas: higher education, technopreneurship, and global leadership. The universities are now big players in the Malaysian R&D system. They now produce more IPs and S&T publications. They should now be geared or oriented towards commercialization of innovation and output of R&D. The second area, technopreneurship, is very much tied up to the first suggestion. Researchers, particularly those in the academia should be oriented to look at the enterprise aspects of their innovations. They should be supported in their attempts to translate innovations into economic activities. The last suggestion is global leadership. This should augur well with Malaysia's goal of a knowledge-based sustainable economy. For example, each agency cluster in MOSTI identifies an area that can be nurtured to become of global or regional significance and investments of material and intellectual resources can be made to attain global competitiveness.

The government research institutes are now clustered under the umbrella of different ministries; they would perform better if there were collaboration between

ministries to maximize potentials for generating innovations. For example, the Institute of Microelectronic Systems can collaborate with the Institute of Medical Research or the Fisheries Research Institute; the Malaysian Remote Sensing Agency can collaborate with the Forest Research Institute; or the Genome Institute can collaborate with the Veterinary Research Institute, etc. There are countless possibilities in marrying one discipline to another.

Myanmar

Myanmar has streamlined its higher education institution (HEI) network and has placed a major part of it under the Ministry of Science and Technology. It provides a very good opportunity to integrate the activities of the universities focused on S&T to the rest of the S&T infrastructure. Five of the technological universities out of 32 have been placed under the Department of Advanced Science and Technology (DAST) of MOST. It is recommended that these universities be fully equipped and supported to carry out R&D. The two universities that are tasked to produce MSc and PhD graduates in engineering and technology, in particular, need substantial upgrading in many aspects. One recommendation is to gear these universities to accommodate more MSc and PhD students. A major graduate scholarship program for Science, Technology, and Engineering could be launched by the Government, in addition to the graduate study support program that they have for government workers in ST&E (mostly engineering teachers). Finally, a system of competitive research project funding could be instituted nationwide to include researchers in universities as possible recipients.

It is also suggested that the Government consider the possibility of having specialized R&D institutes based in the leading universities. This will ensure the continuity of research work in the universities' S&T faculties. The current R&D priority areas like Materials Science, Nanotechnology, Renewable Energy, Hydropower Turbine Production, and Unmanned Aerial Vehicle need not be carried out in Government R&D institutes under ministries. These can be done in the universities and this is where the idea of setting up university-based institutes might be worth considering.

Myanmar should also now look into how the investments in science and technology could benefit the people. Many of the objectives found in the current National Science and Technology Plan are targeted at serving society, namely, new and renewable energy source, rural development support particularly poverty alleviation and health service support. It is therefore imperative that R&D institutions pay attention to the utilization of science and technology for public good. The constraints that have been cited in preceding paragraphs should be overcome.

Philippines

The institutional infrastructure in the country is currently in place. However, many export-oriented industries still need technology-capable support enterprises, for example, electronics, shipbuilding, and automotive parts.

Although technopreneurship has been gaining ground, S&T contributions from the small and medium industry sector still needs encouragement. Innovations in some aspects of S&T in the SME sector can contribute to the overall S&T environment in the country. Still, some sectors urgently need S&T to improve their performance and services. Under-investment in R&D is apparent and this has to be addressed through motivation and encouragement. There is also a need for more research engineers and scientists in the Philippines.

Based on the above observations, priority implementation should focus on much-needed financial resources for R&D, particularly in the food and energy security, health, and transportation sectors.

Another area for investment is the development of advanced human resources in Science, Technology, and Engineering, and in the upgrading of facilities. One way to accomplish this is to encourage public universities to produce more MSc and PhD graduates in science, technology, and engineering. In the area of basic education, the country needs to invest more in the areas of science and mathematics.

The Philippines can already invest in advanced technology platforms like biotechnology, nanotechnology, genomics, and ICT. There should also be continuous and consistent upgrading of the technological capabilities of the supporting industries sector. This means the expansion of the technology business incubation program to spur the creation of more technology spin off enterprises.

Singapore

Almost all indicators point to the fact that Singapore is at the top of the class as far as S&T initiatives, investments and outputs are concerned. Perhaps the ideas that can be put forward are in the areas of entrepreneurship creation, R&D collaboration, and offshore investments.

The creation of more technology-based spin-off enterprises and their eventual success is one of the ultimate measures of success of innovation and R&D initiatives. While the Singapore Government has been quite successful in linking with existing enterprises for technology upgrading and diversification, there is need for more enterprise creation from among young and aspiring entrepreneurs who would like to go into technology-based business. Related to this is the possibility of spilling over investments by technopreneurs into neighboring countries such as ASEAN member states and likewise the possibility of making Singapore venture capital to be accessed by technopreneurs from country neighbors.

R&D collaboration with other ASEAN member states is very much needed. For example, the practice of having sandwich programs in MSc and PhD degrees is gaining popularity and it is hoped that Singapore will find this mutually beneficial together with countries that are willing to collaborate in these areas.

Thailand

Thailand's overarching goal of attaining a quality society and a sustainable economic growth through green innovation is a very good model for the rest of the ASEAN member states. The strategy of empowering society and local communities in support of this overarching goal is also very noteworthy. It might be worthwhile to consider that for some of the component projects designed to empower local communities some twinning arrangements can be done. This means that as Thailand implements a community project, this is replicated in another AMS at its own expense; in fact, this will allow countries to analyze the success and failure factors of such S&T related projects.

It may also be worth considering if an AMS like Thailand can expand the coverage for the commercialization of technologies developed. For example, if the licensing of a particular technology is not exclusive, can the country that developed the technology market its innovation to businesses from other AMS for more widespread commercialization?

It is hoped also that the success of some universities in Thailand in operating technology-licensing offices will be replicated in their other universities, whether public or private.

Thailand's three "Pillar" and two "Foundation" Strategies can very well be adopted throughout ASEAN. Achievement indicators must be developed and made measurable for the different strategies. These indicators can be models for the other ASEAN member states to follow. It is also worth mentioning that the critical areas of concern in the CRABI initiative of Thailand have been well thought of and very relevant in the ASEAN region.

Vietnam

Considering the investments Vietnam has made in S&T development in terms of human resource development, infrastructure, and R&D, the government can now assess the impact of these investments on the socio economic development of the country. This will ensure optimum use of resources in various S&T Programs. For example, it should answer the question of whether the utilization or commercialization of technologies can be done in a more cost effective or economically beneficial manner.

It has been noted that the program on Incentive for Spin-off Projects was not continued after a 2-year implementation period in 2005 – 2007. It has also been observed that some spin-off enterprises have never been weaned from the institutes from which they originated. Considering the number of advanced human resources (MSc and PhD graduates) that are being produced in the academic institutions of Vietnam and the number of research institutes in operation, a higher level of technology utilization or commercialization may be expected in the near future.

CHAPTER VI

RECOMMENDATIONS TOWARD AN ASEAN COMMUNITY 2015

The initial questions posed in this study are twofold:

1. How can ASEAN Member States (AMS) synergize in S&T?
2. How can S&T developments in ASEAN collectively contribute to the building process of the ASEAN Community by 2015?

To answer these questions, the study presents a set of suggestions. These suggestions are grouped under the following headings: Vision and Key Strategies; R&D Cooperation; HRD Collaboration, Technology Transfer, and Commercialization; and Information/Knowledge Sharing.

ASEAN Vision and Key Strategies for S&T

Some AMS have adopted visions and strategies for S&T that are reflections of the aspirations and ideals for S&T of most AMS. Having an ASEAN Vision for S&T will surely contribute positively to the building processes for ASEAN Community 2015.

In relation to the articulation of the vision for S&T, it might also be worthwhile to consider having an S&T Development Act for each AMS. In general, a piece of national legislation for S&T highlights the importance of the sector for national development.

R&D Cooperation

It is high time that some form of institutionalization be made for R&D cooperation among AMS. The motivation to cooperate is usually to address issues that are urgent or critical in nature. There has to be a process of identifying these critical R&D areas or programs or projects that are common among AMS, followed by a process of reaching a consensus on how AMS will cooperate in a particular R&D concern or program or project.

To facilitate the institutionalization of these processes, there has to be an R&D institution network within the ASEAN with its own set of rules on who can be members and how it will operate as a network. If there is an ASEAN University Network for HRD Cooperation under the Committee on Social Development, why not an ASEAN RDI Network for R&D Cooperation under the Committee on Science and Technology? This concept will not be complete without the involvement and support of ASEAN Dialogue Partners.

HRD Collaboration

These ideas are designed to enhance synergy in S&T among AMS.

Collaboration with the Committee on Social Development for an Expanded AUN-SEED Program. This program has been benefiting a good number of young researchers and academics in the different fields of engineering in being able to earn MS and PhD degrees in another AMS.

Adoption of the "Sandwich" Program approach wherein the student, the researcher, or the scientist can do the required coursework in his or her country and then do the required research, thesis, or dissertation in another country where there will be a willing research collaborator.

Institution of a program of internship for researchers and technical personnel in R&D/S&T institutes ASEAN-wide. This can be another undertaking by the proposed ASEAN RDI Network. For example, Thailand's National Centre of Genetic Engineering & Biotechnology (BIOTECH) currently sponsors an internship program that benefits AMS Biotech researchers and scientists.

Technology Transfer and Commercialization can be encouraged. ASEAN as a market is big. There are technology transfer and commercialization projects or transactions that can be done in a better way if there are cooperating parties from different AMS.

Here are examples of mutually beneficial cooperative activities in commercialization projects:

- Licensing of technologies for commercialization to enterprises coming from other AMS, in addition to licensees in the technology's country of origin
- Networking among venture capital companies in ASEAN for technology start ups
- Having an ASEAN Consortium for IP Related business development services
- Co-investments in large technology commercialization projects involving both private and public corporations in ASEAN

Information/Knowledge Sharing

It is worthwhile to consider sharing and linking research-based knowledge using an interoperability system. This idea was demonstrated at the Thailand Research Expo 2011 wherein 32 agencies in both government and private sectors have shared their research knowledge under the prototype of the National Research Indexing Hub Project. (*The Nation*, September 5, 2011).

In addition to the abovementioned suggestions, the AMS should seriously consider the Thematic Tracks and the Paradigm Shift identified in the Krabi Initiative 2010. The Thematic Tracks include the following: ASEAN Innovation for Global Market; Digital Economy, New Media and Social Networking; Green Technology; Food Security; Energy Security; Water Management; Biodiversity for Health and Wealth; and Science Innovation for Life are common concerns among the ASEAN Member Countries. The Paradigm Shift, which includes STI Enculturation, Bottom-of-the-Pyramid Focus, Youth-focused Innovation, STI for Green Society, and the Public-Private Partnership Platform, contains new approaches that are gaining acceptance worldwide.