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Overseas Research Report

Current Status on Science and Technology in ASEAN Countries

(Tentative edition)

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Center for Research and Development Strategy
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Contents

Introduction

Although the economic development in ASEAN countries has been discussed quite frequently in recent years, the development of science and technology (S&T) hasn't attracted so much attention except in Singapore. However, as labor costs rose and politics in foreign relations began to show problems in China, the "China Plus One" management strategy has developed widely in ASEAN countries on the initiative of Japanese companies. As a result, Japanese companies expanded its business not only in Thailand, Vietnam and Indonesia that have had a close relationship with Japan, but also in Myanmar, Laos and Cambodia. It is said that this has contributed to the economy growth in these countries. Just as many countries in the world have previously done in the past, when economic growth reaches a certain level, policies for S&T are promoted and strengthened in order to maintain and further develop the growth. This cross-country report summarizes the result of the research and analysis on the progress of S&T in ASEAN countries.

Speaking of the outline of the survey result, the progress of general S&T in ASEAN countries is not so rapid compared to the significant progress in economy.

Most of the countries except for Singapore, which shows high performance as developed as Western countries and Japan, focus on the development of S&T-related infrastructure and human resources with advanced skills. It is still too early for these countries to contribute to the world's S&T in the front lines. Malaysia and Thailand are thought to be at a relatively high level after Singapore. It is considered that these two countries and Singapore are able to build substantive relationships of cooperation with researchers in Japan, China and South Korea.

Vietnam, Indonesia and the Philippines follow next. These countries have a large population and are expected to gain great impacts when they see more economy growth in the future, but they have not yet reached that stage as of today.

Out of the other four ASEAN countries, Cambodia, Laos (Lao People's Democratic Republic) and Myanmar are busy dealing with nation-building and infrastructure development, and they have yet to implement any S&T activities on a full scale. As Brunei (Brunei Darussalam) has the largest resources, there is no need to proactively conduct S&T activities.

However, all these countries strive to promote S&T in their own way, recognizing its importance in underpinning national capability and economy. In particular, it is interesting to know that each country is conducting bio-related research activities based on the properties of geographical environment and biodiversity that are unique to Southeast Asia.

As for S&T cooperation between Japan and these ASEAN countries, Japan's research level has been much higher than that of these countries except for some including Singapore, and there are not so many direct advantages to Japan so far. However, it should be noted that ASEAN countries have their eyes not only on Japan. China, which is rapidly growing in the S&T field, has already strengthened economic ties with ASEAN countries. In South Korea, not only the government but also companies such as Samsung are proactive in developing human resources in ASEAN countries as a corporate strategy.

A preconceived image that ASEAN countries consider a relationship with Japan extremely important should be put aside. It is considered that Japan needs to fully understand the present situation of these countries and develop S&T relationships of cooperation with them in a strategic manner, depending on each country's situation. I would be much obliged if this report will be of some help.

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1. Introductory Chapter about ASEAN

1. ASEAN

(1) Outline

The Association of Southeast Asian Nations (ASEAN) was established on 8 August 1967 in Bangkok, Thailand during the Vietnam War, with the support of the US that feared the communization of Southeast Asian countries, which has been assumed by the domino theory. The original five members included Thailand, the Philippines, Malaysia, Indonesia and Singapore, which were all anti-communist nations.

Later, Brunei joined in 1984 after its independence from the UK, ASEAN's position of anti-communism was considerably changed by Vietnam's participation in ASEAN in 1995. It became a general regional cooperation organization for economy, society, politics, etc. Vietnam has been under the one-party rule of the Communist Party since 1976, when North and South Vietnam were unified. After the adoption of the *Doi Moi* (renovation) policy in 1986, followed by the signing of the Paris Peace Agreement in Cambodia in 1991 and the normalization of diplomatic relations with China, Vietnam normalized diplomatic ties with the US in 1995. This is the reason for agreement with Vietnam's membership by the original five members.

Myanmar and Laos became members in 1997 and Cambodia in 1999, making a total of 10 countries.

As a notable activity in the future, the ASEAN Economic Community will be established at the end of 2015, which aims to realize economic revitalization within the region and liberalization of people, goods and services.

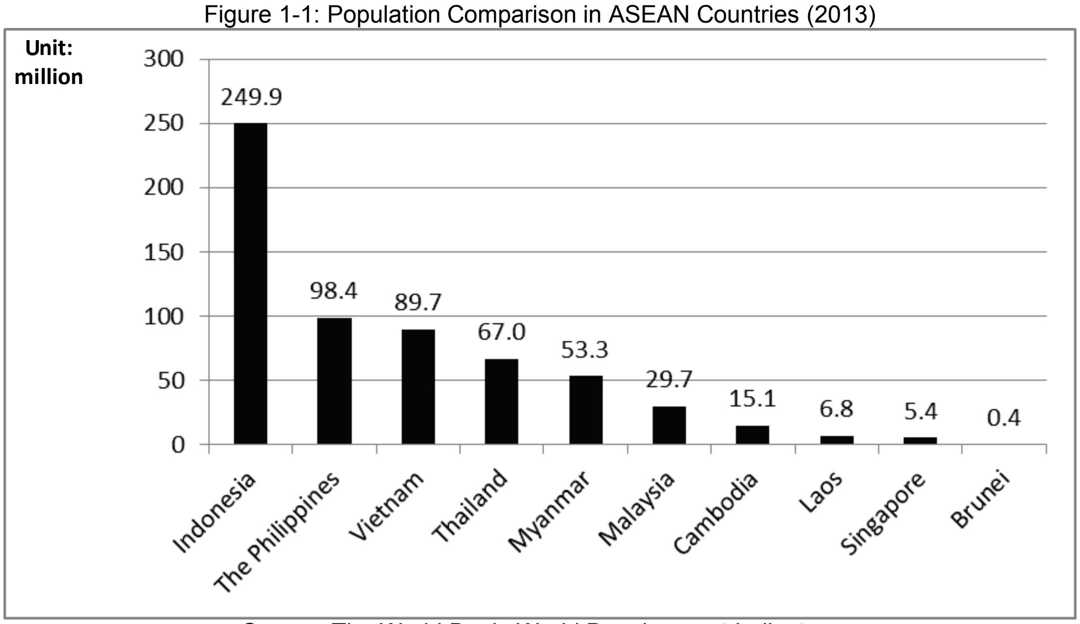
(2) Population

Many ASEAN countries have a large population. The figure 1-1 below shows populations of 10 ASEAN countries in order of size.

Indonesia has the fourth largest population in the world next to China, India and the US, and the population of the Philippines and Vietnam is around 100 million. As for population of EU countries, Germany has the largest population of about 80 million, and the UK, France and Italy have about 60 million. This shows how large the populations are in ASEAN countries.

On the contrary, Brunei, which has a population of only about 400,000, and Singapore, which has about 5.4 million population including expatriates, are also ASEAN members.

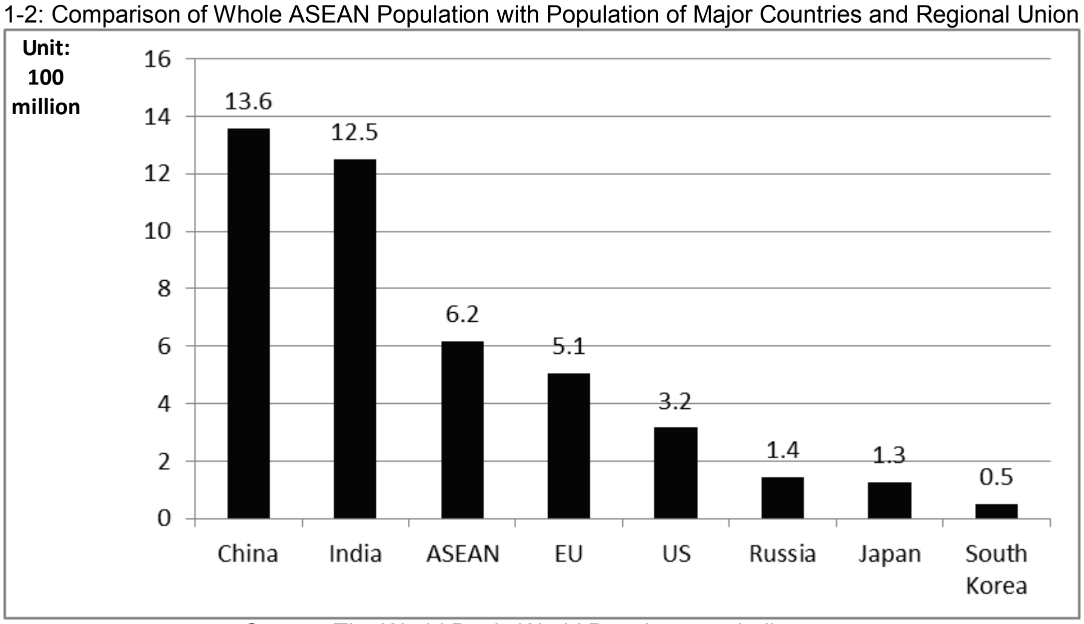
Figure 1-1: Population Comparison in ASEAN Countries (2013)



Source: The World Bank, World Development Indicators

The figure 1-2 shows the comparison of the whole ASEAN population with the population of other major countries and regional unions. It indicates that the ASEAN population is larger than that of the EU as a regional union but about half of China or India, which have the largest population in neighboring countries. However, the ASEAN population is double that of the US, about four times larger than that of Russia and Japan, and about 12 times larger than that of South Korea.

Figure 1-2: Comparison of Whole ASEAN Population with Population of Major Countries and Regional Union (2013)



Source: The World Bank, World Development Indicators

(3) Political form

Almost all ASEAN countries had been under the colonial rules of the West and they only obtained a political autonomous control at the time of their independence after the World War II. In order to move out of poverty and develop economic and social infrastructure, many countries have taken a dictatorial political form for development.

Indonesia (Suharto Administration) and the Philippines (Marcos Administration) experienced a typical dictatorial development. At present, these countries were freed from the constraints of the charismatic leaders and are gradually establishing democracy. Cambodia has also been democratized after the period of the dictatorship by Pol Pot.

Although not by a charismatic politician, dictatorship of a party or military forces has continued in Vietnam, Laos and Myanmar, and Brunei's politics is under the rule of hereditary sultans. In Thailand, although it has been considered that democracy was established, the military currently holds control.

A relatively stable political form has continued in Singapore and Malaysia after their independences from the UK.

In these ways, each country in ASEAN has a different political form, and its characteristics are different from the EU that mainly consists of Christian democracies.

(4) Religion

Most Indonesians, which are the largest population in ASEAN, Malaysians and Bruneians are Muslims. On the other hand, most Vietnamese, Thai, Cambodian, Myanmar, Laos, Singaporean people are Buddhists. Filipinos are mostly Christians, and most Indians who live around the Malay Peninsula are Hindus.

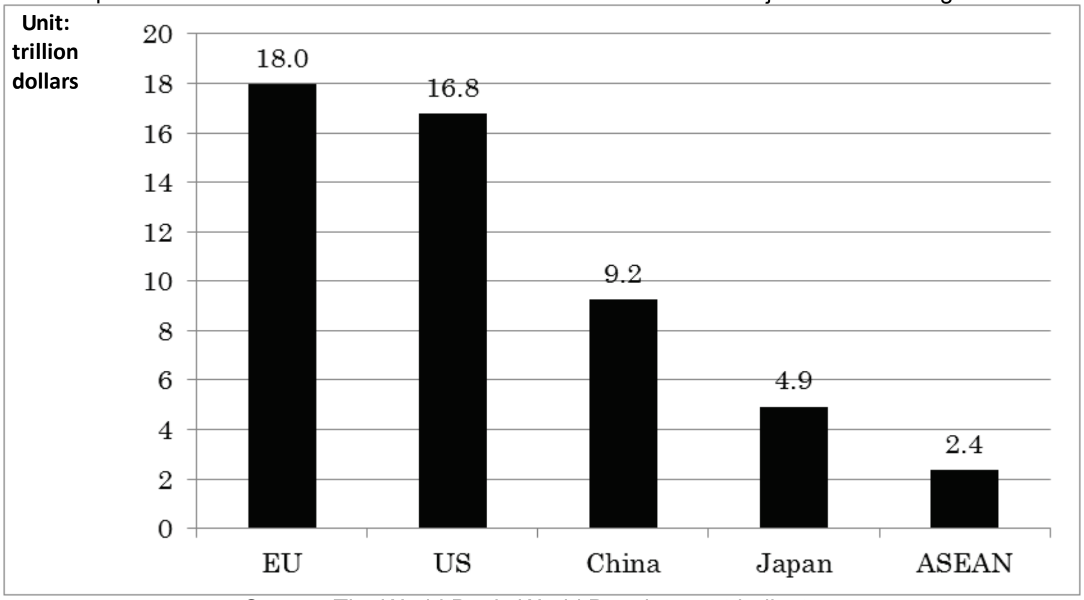
Religions are also different from those of the EU. A majority of people in the EU are Christians, which is relatively simple.

(5) Economy

1. Nominal GDP

If we compare all ASEAN countries with major countries and regional unions in the world, what position are they in? The following figure 1-3 is developed based on the 2013 statistics of the World Bank. It shows that the size of the ASEAN economy is about one seventh of that of the EU and the US about a quarter of that of China and about half of that in Japan so ASEAN economic scale is considered still small. Since there was no data of Myanmar in the World Bank statistics, data for ASEAN countries is a total of the other nine countries. According to the data in the International Monetary Fund (IMF) in 2013, the nominal GDP of Myanmar was only 56.4 billion US dollars ("US dollars" is hereinafter referred as to "dollars"). It is considered that, even if data of Myanmar was added, it would not affect the total value of 2.4 trillion dollars.

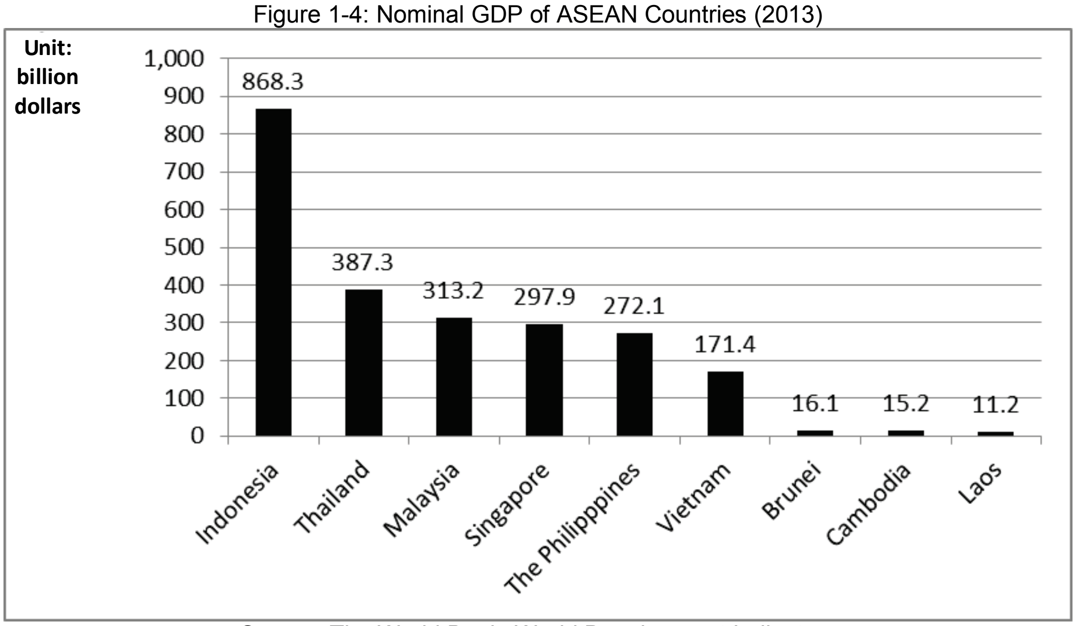
Figure 1-3: Comparison of Nominal GDP between all ASEAN Countries and Major Countries/Regional Unions (2013)



Source: The World Bank, World Development Indicators

The figure 1-4 shows the nominal GDP comparison among individual ASEAN countries using the same figures of the World Bank. It should be noted that the unit is different from that used in the figure 1-3. Indonesia's nominal GDP is the largest, which is still about one eleventh of that of China and about one sixth of that of Japan.

Figure 1-4: Nominal GDP of ASEAN Countries (2013)



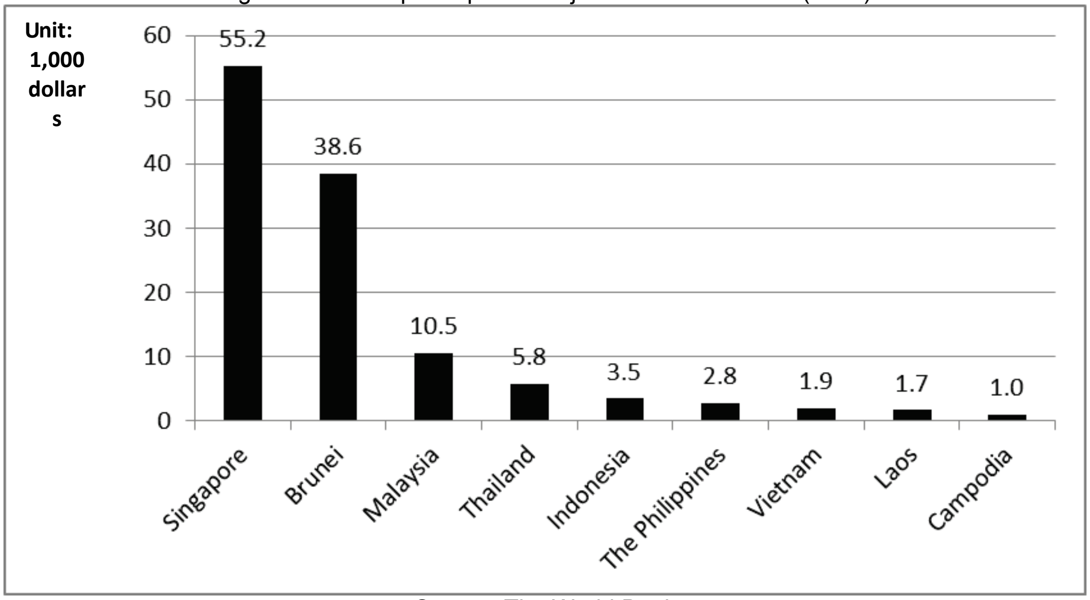
Source: The World Bank, World Development Indicators

2. Nominal GDP per capita

The comparison of GDP between the total ASEAN GDP and GDP per capita shows a different status.

The figure 1-5 shows GDP per capita in ASEAN countries in order of value, using the World Bank data in 2013. According to this, GDP value is extremely high in Singapore and Brunei, followed by Malaysia and Thailand. Indonesia has the highest GDP value in ASEAN but GDP per capita is the fifth highest, amounting to only one tenth of GDP of Singapore and Brunei. The Philippines, Vietnam, Laos, Cambodia and Myanmar come next after these two countries. There was no data of Myanmar in IMF statistics.

Figure 1-5: GDP per capita in major ASEAN Countries (2013)

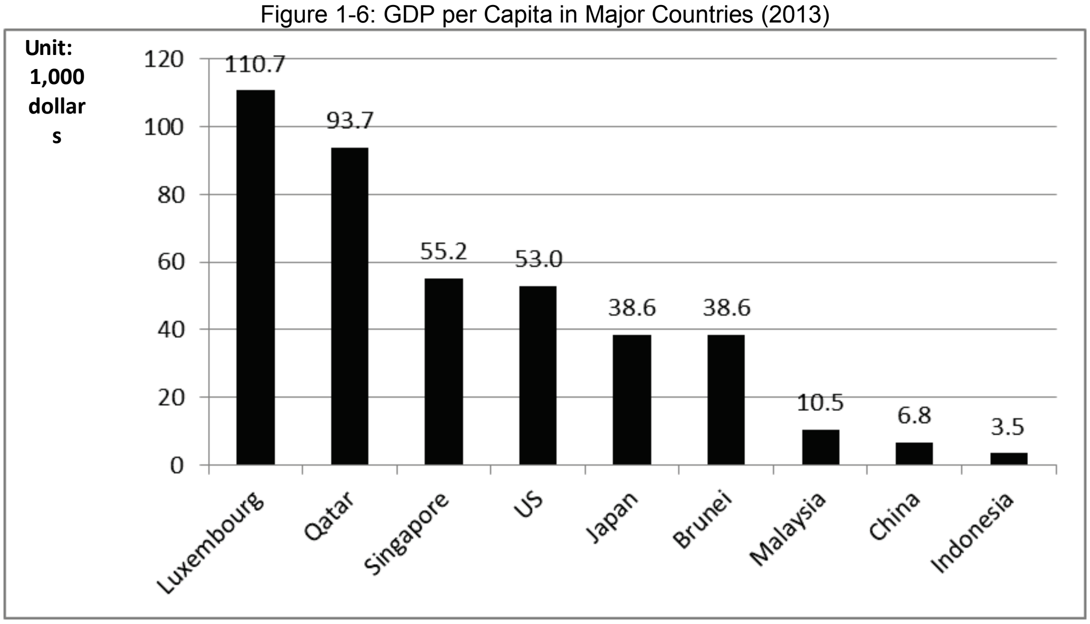


Source: The World Bank

The following figure 1-6 shows GDP per capita in the world and where these ASEAN countries are placed. Luxembourg of the EU has the world's highest GDP per capita. Norway is second (not shown in the figure). Qatar, which is known as the largest crude oil and natural gas producer in the world, comes in third. As for ASEAN top-ranked countries, Singapore is ninth, and Brunei is 25th. Amongst The US's GDP per capita is the tenth largest, and Japan is the 24th largest amongst major countries on the world. China is an economic power with the second highest GDP (national total) value in the world. However, its GDP per capita is a relatively small and is one eighth of that of Singapore because the country has a large population. China's GDP per capita is around half of that of Malaysia.

In ASEAN countries, the ratio of the highest GDP (Singapore) and the lowest (Myanmar) is 55:1. On the contrary, the ratio of the highest GDP per capita in the EU (Luxembourg) and the lowest (Bulgaria, 7,500 dollars) is 15:1, which shows the economic disparity in ASEAN countries is very large compared to that in EU countries.

Figure 1-6: GDP per Capita in Major Countries (2013)



Source: The World Bank

3. Industrial structure

Singapore is considered to have the most productive industrial structure in ASEAN countries and is active in intermediate trade and commerce, tourism and banking thanks to its geographical characteristics. In recent years, industries using S&T have been developing. Brunei is abundant in natural resources, and the national economy is supported by mining and service industries.

On the other hand, Thailand and Malaysia have started industrialization early by introducing foreign capital, and agriculture, forestry and fisheries as well as manufacturing are becoming the center of the national economy.

The main industry in Indonesia, the Philippines, Vietnam, Laos, Cambodia and Myanmar is the primary industry such as agriculture, forestry and fisheries. Although the industrial advancement through foreign capital, etc. in these countries was slow compared to aforementioned countries, the recent “China Plus One” policy, which was formulated in response to the increase in investment risk in China, is encouraging the advancement of industrialization in these countries.

(6) Summary

Having compared ASEAN countries from various aspects shows diversity in these countries. Compared to the EU, the diversity in ASEAN stands out such as the difference in population sizes, countries on the verge of democracy and those under a dictatorial regime, religious diversity, economic disparities, difference in industrial structure, etc.

2. ASEAN COST

Putting efforts on cooperation in S&T is encouraged in ASEAN. A typical challenge has been taken by the ASEAN Committee on Science and Technology (ASEAN COST). We will outline the ASEAN COST before explaining the comparison of scientific and technological capabilities in ASEAN countries.

(1) History

ASEAN COST is a committee that is specialized in the field of S&T.

The Bangkok Declaration for ASEAN's establishment in 1967 has already stated the promotion of mutual cooperation in the S&T field. ASEAN COST was established in 1977 with the aim of developing S&T and human resources as well as promoting technology transfers within and out of the region. The first meeting was held in the Philippines in 1978.

(2) AMMST and ASEAN COST

The ASEAN Ministerial Meeting on Science and Technology (AMMST) is set as a ruling body of ASEAN COST. After the first meeting held in Thailand in 1980, the organization alternately holds an official meeting and unofficial meeting every year. The most recent official meeting was the 15th meeting held in Kuala Lumpur in November 2013. The 8th unofficial meeting was held in Bogor (Indonesia) in August 2014.

ASEAN COST is positioned as a vice ministerial committee under ASEAN AMMST. The meetings are held about twice a year since the first meeting in 1978. The Headquarter of ASEAN COST is located in Jakarta.

(3) 9 subcommittees

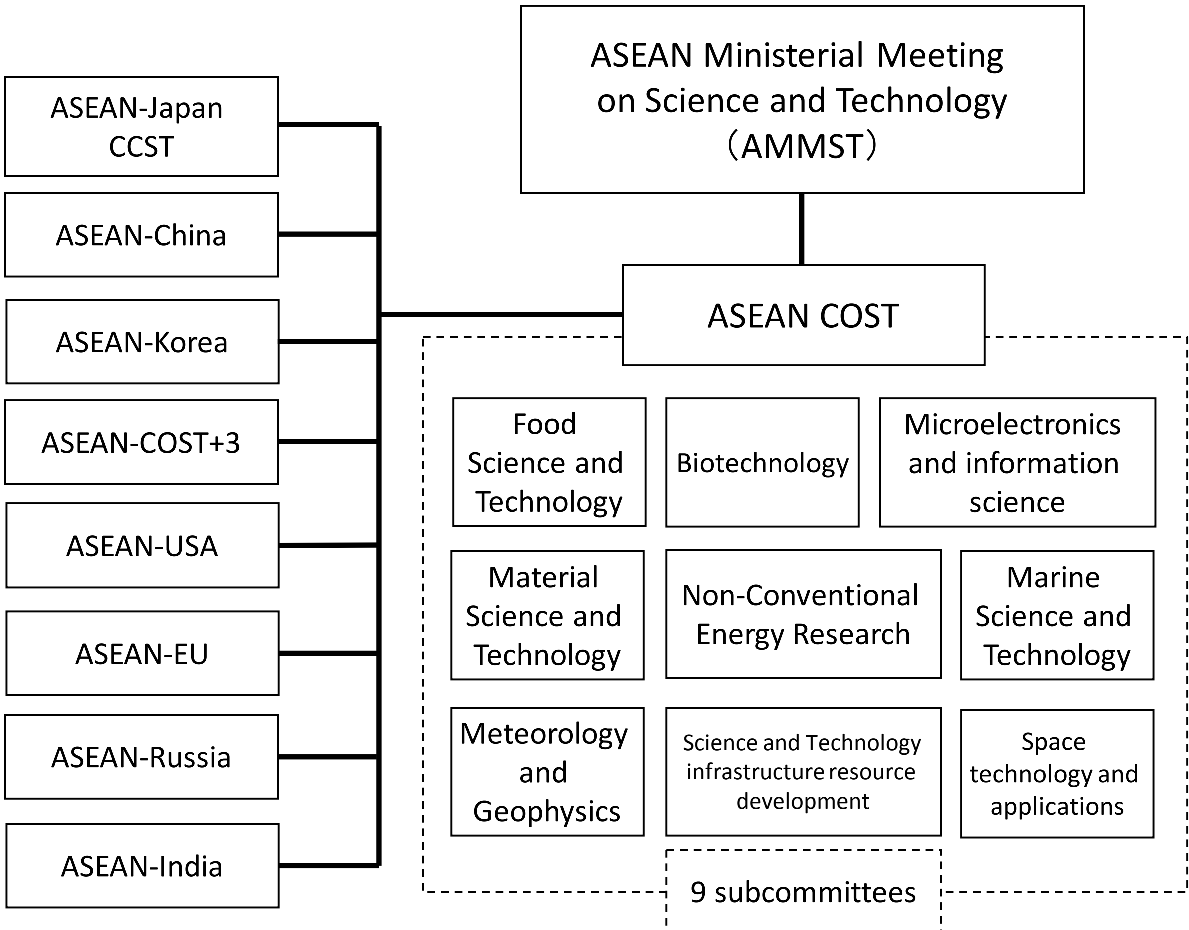
At the time of establishment, ASEAN COST had 8 subcommittees in the fields of Food Science and Technology, Biotechnology, Microelectronics and Information Science, Materials Science and Technology, Non-Conventional Energy Research, Marine Science and Technology, Meteorology and Geophysics, and S&T Infrastructure Resources Development. At present, the above eight fields plus Space Technology and Applications are operated in the subcommittees.

(4) Cooperation with countries outside ASEAN

ASEAN COST holds meetings with Japan, China, South Korea, Japan-China-South Korea, the US, the EU, Russia and India once every 1 to 2 years.

In the relationship with Japan, the frameworks of the ASEAN-Japan Cooperation Committee on Science and Technology (ASEAN-JAPAN CCST) and ASEAN COST+3 (Japan, China and South Korea) are important. ASEAN-Japan CCST previously held 4 meetings and ASEAN COST+3 held 8 meetings.

Figure 1-7: ASEAN S&T Related Organizations



3. Outline of S&T in ASEAN countries

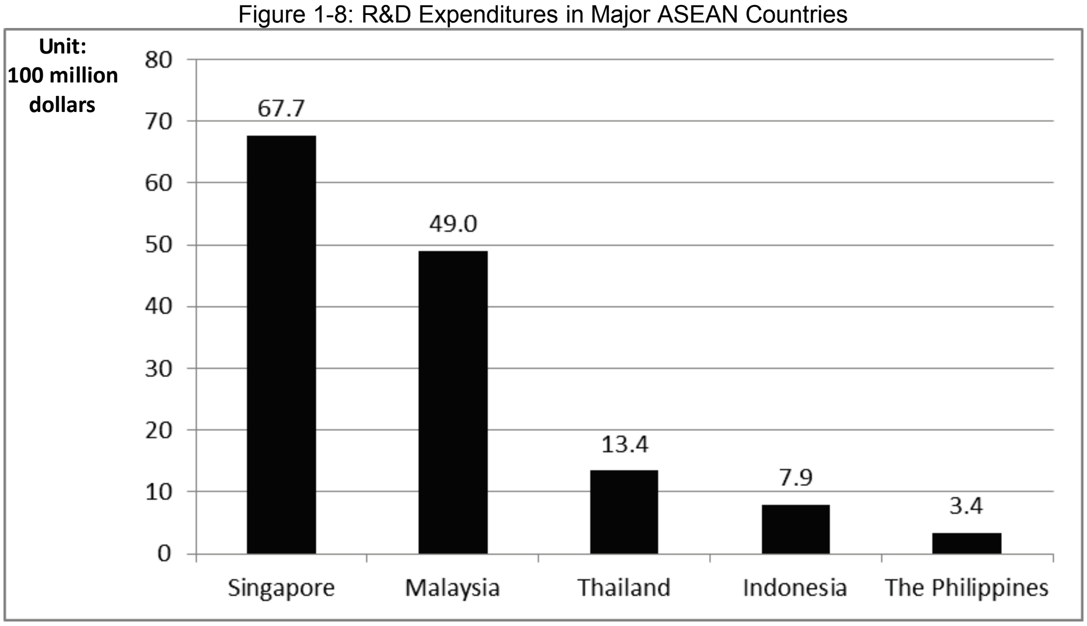
We will compare some S&T benchmarks to evaluate the level of S&T in each ASEAN country.

(1) R&D expenditures

R&D expenditures in ASEAN countries are still low. In many of these countries, the statistical system for S&T is not adequate, and no accurate data has been obtained. The figure 1-8 shows the comparison of R&D expenditures in countries where data since 2007 is available. Although recent figures of Vietnam, Myanmar, Cambodia, Brunei and Laos are unclear, they are considered to be lower than that of the Philippines.

Singapore's R&D expenditures were the largest at around 6.8 billion dollars, which is only 1/22nd of Japan's expenditures - about 150 billion dollars.

Figure 1-8: R&D Expenditures in Major ASEAN Countries



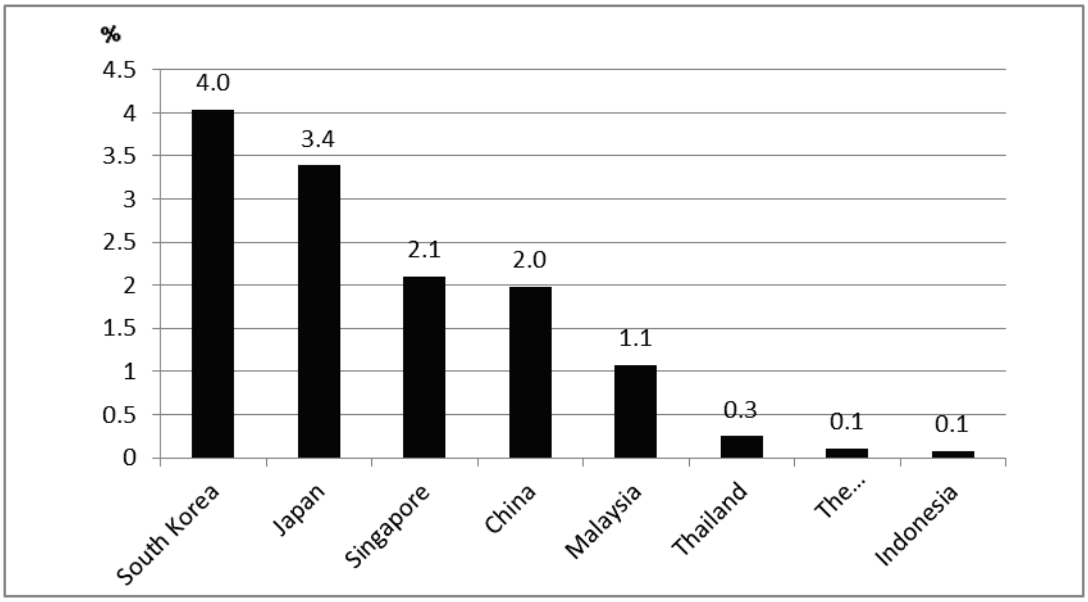
Source: UNESCO Institute for Statistics

(Note) Figure of Singapore is taken from 2012, Malaysia from 2011, Thailand from 2009, Indonesia from 2009 and the Philippines from 2007 (Purchasing power parity (PPP) conversion).

The following figure 1-9 shows R&D expenditures as a percentage of GDP.

The percentage of Singapore (2.1%) is lower than that of South Korea (4.0%) and Japan (3.4%) but higher than that of China (2.0%), which indicates that the figure of Singapore is on the level of major developed countries and stands out from other ASEAN countries. Malaysia comes next to Singapore in ASEAN, although the figure is only half of that of China. Figures of other ASEAN countries are even lower.

Figure 1-9: R&D Expenditures as a Percentage of GDP



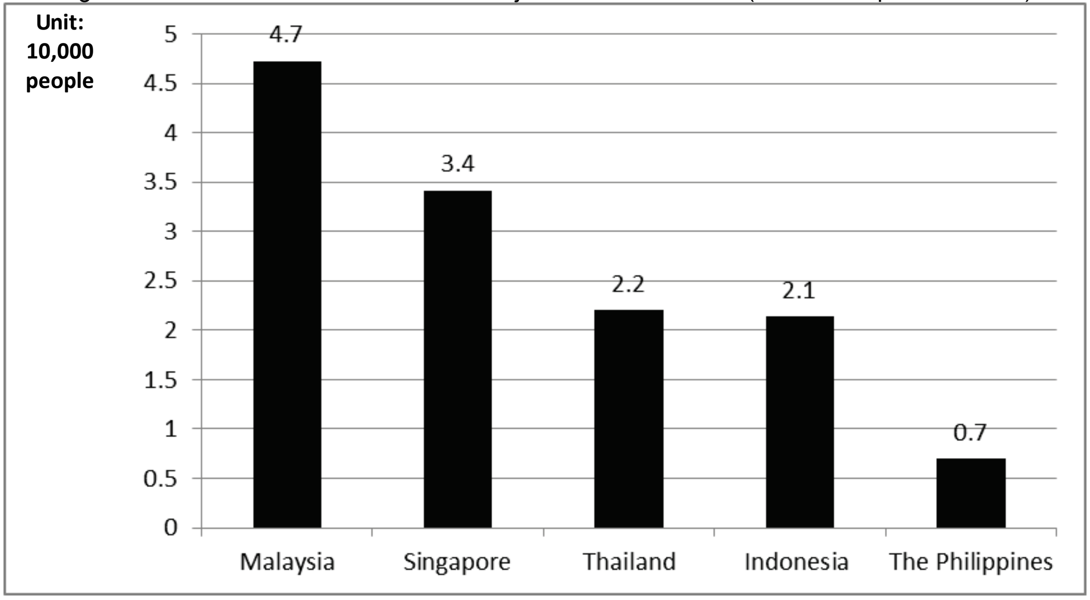
Source: UNESCO Institute for Statistics

(Note) Figures of Singapore and China are taken from 2012, South Korea, Japan and Malaysia from 2011, Thailand and Indonesia from 2009, the Philippines from 2007.

(2) Number of researchers

The figure 1-10 shows the number of researchers in major ASEAN countries. It also has the comparison between countries with data after 2007 only.

Figure 1-10: Number of Researchers in Major ASEAN Countries (Full-time Equivalent: FTE)

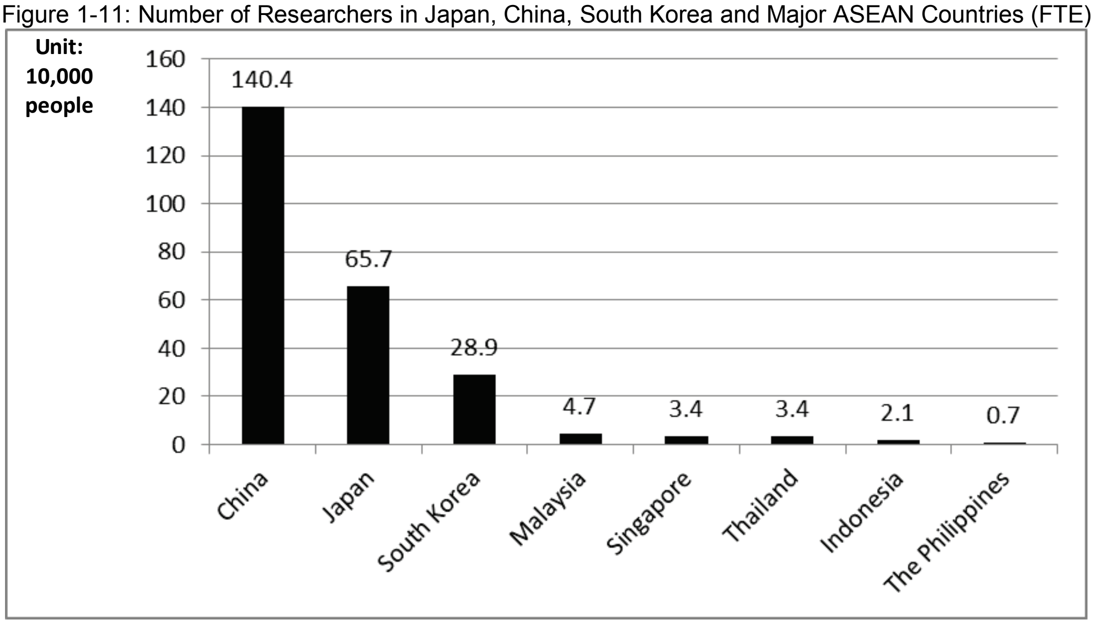


Source: UNESCO Institute for Statistics

(Note) Figure of Singapore is taken from 2012, Malaysia from 2011, Thailand from 2009, Indonesia from 2009 and the Philippines from 2007.

The figure 1-11 compares the above data with that of Japan, China and South Korea - major R&D countries in Asia. Even through Malaysia has the largest number of researchers in ASEAN countries, it is only around 1/30th of that in China and around 1/15th of that in Japan. This shows that there is a significant difference in quantity, apart from quality.

Figure 1-11: Number of Researchers in Japan, China, South Korea and Major ASEAN Countries (FTE)



Source: UNESCO Institute for Statistics

(Note) Figures of China and Singapore are taken from 2012, Japan, South Korea, Malaysia and Thailand from 2011, Indonesia from 2009 and the Philippines from 2007.

(3) Overseas education

Education in countries with developed S&T is important in training researchers. For countries that accept students, the number of candidates from developing countries matters in order to know the level of their own S&T.

The following two figures 1-12/1-13 show a ranking of countries that accept students from ASEAN. The former includes statistics of China and the latter does not.

The former figure 1-12 mainly shows ASEAN countries with higher levels of S&T. These countries focus more on China as well as Western countries and Australia, and not so much on Japan. Many people in Singapore and Malaysia are of Chinese origin and most of them would like to study in Western countries that have a different culture. However, the number of people who are studying in China is larger than that of Japan. In the past, it was considered that the most common country for overseas study was Japan for people from Thailand, Indonesia and Vietnam. It should be noted that the number of students from these countries who study in China is currently around 5 times more than that in Japan.

Figure 1-12: Destinations for Overseas Education from ASEAN Countries
(with statistics of China) (2012)

Origin \ Destination in number order	1	2	3	4	5
Singapore	Australia 9,379	UK 5,253	US 4,363	China 4,250	Malaysia 796
Malaysia	Australia 17,001	UK 12,822	US 6,531	China 6,045	Japan 2,400
Thailand	China 16,675	US 7,386	UK 6,098	Australia 3,282	Japan 2,476
Indonesia	China 13,144	Australia 9,431	US 6,907	Malaysia 6,222	Japan 2,213
Vietnam	China 13,038	US 15,083	Australia 11,081	France 5,642	Japan 4,047

Source: UNESCO, Education Statistics
(Note) Data of China developed by the Chinese Service Center for Scholarly Exchange.

The figure 1-13 summarizes the status of 5 countries without statistics on students studying in China. For these countries except for Myanmar, the major destination for overseas education is not Japan.

Figure 1-13: Destinations for Overseas Education from ASEAN Countries
(without statistics of China) (2012)

Origin \ Destination in number order	1	2	3	4	5
Cambodia	France 602	Vietnam* 530	Australia 462	Japan 333	UK 323
The Philippines	US 3,094	Australia 2,374	UK 1,306	Japan 632	New Zealand 429
Brunei	UK 2,257	Australia 579	Malaysia 309	New Zealand 76	US 67
Myanmar	Japan 1,139	US 782	Australia 641	Malaysia 346	UK 295
Laos	Vietnam** 2,153	Thailand 1,344	Japan 246	Australia 180	France 106

Source: UNESCO, Education Statistics
(Note) *The latest figure is 422 in 2013, ** The latest figure is 1,832 in 2013.

(4) Scientific papers

1. Comparison of total number of papers

According to a survey analyzed by the National Institute of Science and Technology Policy (NISTEP) under the direct jurisdiction of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) based on data of Thomson Reuters, the numbers of papers and ranking of ASEAN countries from 2009 to 2011 are as follows. The number of "top 10% papers" is counted for each field with consideration of citation levels.

Figure 1-14: Number of research papers in ASEAN countries

Country	Total number of research papers	Ranking	Number of top 10% papers ranking
Singapore	25,763	31	24
Malaysia	16,971	39	39
Thailand	16,054	40	40
Vietnam	3,486	59	67
Indonesia	2,921	62	63
The Philippines	2,318	67	59
Cambodia	406	115	100
Laos	258	128	131
Brunei	174	140	138
Myanmar	148	146	159

Source: Benchmarking of Scientific Research 2012

According to the above figure 1-14, Singapore is making an impressive showing in the world. However, Singapore's total number of papers (25,763) is only 2.7% of the worlds' top the US (926,235), 6.2% of China (415,371) and 11.3% of Japan (228,446). Therefore, Singapore's impact in the international arena is not so large.

Malaysia and Thailand follow Singapore, and it is considered that these three countries are gaining the chance to become cooperative and competitive with Western countries, Japan, China and South Korea.

Vietnam, Indonesia, and the Philippines are on the next ranking, followed by lower-ranking Cambodia, Laos, Brunei and Myanmar.

The status of S&T by country in the following chapters is explained based on this paper number ranking.

2. Partners of joint papers

The figure 1-15 shows countries of researchers who coauthored papers with researchers in ASEAN countries, based on data by NISTEP.

Figure 1-15: Partners of Joint Papers in ASEAN Countries

Country	No. 1	No. 2	No. 3	No. 4	No. 5
Singapore	US	China	UK	Australia	Japan
Malaysia	UK	China	US	Japan	India
Thailand	US	Japan	UK	Australia	China
Vietnam	France	Japan	US	Germany	UK
Indonesia	Japan	US	Australia	Netherland	UK
The Philippines	US	Japan	Germany	Australia	India
Cambodia	US	Japan	Vietnam	France	The Philippines
Laos	Thailand	UK	Japan	US	France
Brunei	US	Australia	UK	China	France
Myanmar	Japan	Thailand	US	France	Germany

Source: Benchmarking of Scientific Research 2012

This figure shows that collaborative relationships between ASEAN countries are not so active except for a few cases. Having a higher level, Singapore mainly has equal collaborative relations as developed countries in the West. Other countries also collaborate more with Western countries with relatively good relationships with Japan and Australia. China has a strong cooperative relationship with Singapore and Malaysia, where many Chinese people live, but the relationships with other countries are weak.

3. Comparison by institution

The figure 1-16 shows the analysis conducted by the Center for Research and Development Strategy (CRDS) under the Japan Science and Technology Agency (JST) using data of Thomson Reuters. It analyzes the rankings of top universities and research institutions in ASEAN countries based on the number of scientific papers published in the 10 years between 2005 and 2014. Top institutions in Japan, China and South Korea are also shown for a comparison. All organizations of ASEAN countries in the top 1,000 in the number of papers are listed, and for countries that have institutions outside the top 1,000, those with the highest ranking are listed.

Figure 1-16: Ranking for the Number of Papers Written by Major Universities and Research Institutions

Institutions	Country	Total paper number ranking	Citation ranking
Chinese Academy of Sciences	China	3	9
University of Tokyo	Japan	18	38
Seoul National University	South Korea	40	112
National University of Singapore	Singapore	76	108
Nanyang Technological University	Singapore	162	257
University of Malaya	Malaysia	428	940
Malaysia University of S&T	Malaysia	545	999
Mahidol University	Thailand	561	611
Chulalongkorn University	Thailand	582	779
Universiti Putra Malaysia	Malaysia	658	1314
A*STAR	Singapore	738	735
University Kebangsaan Malaysia	Malaysia	805	1527
Chiang Mai University	Thailand	963	1149
University of the Philippines Diliman	The Philippines	1968	2120
University of Indonesia	Indonesia	2438	2944
Pasteur Institute	Cambodia	3534	3343

Source: Thomson Reuters

The above figure shows that top-level research institutions and universities in Japan, China and South Korea are doing as good as major research institutions and universities in the world, although they are slightly receding in citation ranking. In ASEAN countries, research institutions and universities that are considered to be on the same level as these research institutions and universities in Japan, etc. are the National University of Singapore and the Nanyang Technological University. Although there are universities with a relatively high level in Thailand and Malaysia, they are not as good as top-level universities in developed countries.

As for the Philippines, Indonesia and Cambodia, the current research level of even top universities and research institutions in each country is quite low. Moreover, universities and research institutions in Vietnam, Laos, Brunei and Myanmar are outside the ranking.

4. Number of “Nature”-related papers

Next, we will look at the ranking related to “Nature” that is famous in international weekly journal of science. Based on the number of papers published in “Nature” itself and related science journals, “Nature” is releasing a ranking every year - “Nature Publishing Index – 2013 Global Top 200”. The following figure 1-17 shows the ranking of the research institutions and universities in ASEAN countries and top list institutions in China, Japan and South Korea, which were posted on this “Nature Publishing Index”.

Again, the high level of two universities in Singapore is shown by the fact that those universities are ranked higher than the Korea Advanced Institute of Science and Technology (KAIST) in South Korea, although lower than the Chinese Academy of Sciences and University of Tokyo, Japan.

It is only Singapore that has research institutions ranked within the “Top 200” in ASEAN, and its level is definitely high in comparison with other ASEAN countries.

Figure 1-17: Ranking of number of “Nature”-related papers

Research institutions	Country	Ranking
Chinese Academy of Sciences	China	6
University of Tokyo	Japan	8
National University of Singapore	Singapore	46
Nanyang Technological University	Singapore	73
KAIST	South Korea	77
A*STAR	Singapore	123

Source: Nature Publishing Index - 2013 Global Top 200

(5) University rankings

The figure 1-18 is drawn up on the basis of the world’s university ranking data developed by British Quacquarelli Symonds Limited (QS). Top universities in Japan, China and South Korea are listed for a comparison. The level of the National University of Singapore and the Nanyang Technological University is equal to or higher than Japan’s level, and the level of universities in other countries is generally low.

Figure 1-18: Universities in ASEAN Countries in QS World University Ranking

Ranking	University	Country
22	National University of Singapore	Singapore
31	University of Tokyo	Japan
31	Seoul National University	South Korea
39	Nanyang Technological University	Singapore
57	Peking University	China
151	University of Malaya	Malaysia
243	Chulalongkorn University	Thailand
257	Mahidol University	Thailand
259	University Kebangsaan Malaysia	Malaysia
294	Universiti Teknologi Malaysia	Malaysia
309	Universiti Sains Malaysia	Malaysia
310	University of Indonesia	Indonesia
367	University of the Philippines	The Philippines
376	Universiti Putra Malaysia	Malaysia
461－470	Bandung Institute of Technology	Indonesia
461－470	Ateneo de Manila University	The Philippines
501－550	Chiang Mai University	Thailand

Source: QS World University Rankings（2014/15）

(6) Summary

Singapore has a special status and is the only ASEAN country that shows performance as developed as Western countries and Japan. Although the impact of its S&T in the world level is not so large because its small territory, Singapore's venturous policy of inviting overseas researchers and the prioritizing policy should be noted.

It is considered that Malaysia and Thailand are on a relatively high level next to Singapore. These two countries and Singapore have a level sufficient to develop substantive cooperative relationships with researchers in Japan, China and South Korea.

Vietnam, Indonesia and the Philippines follow next. Having large populations, these countries would have a considerable potential as their economy grows in the future, although there is not so much impact so far.

Out of the four other ASEAN countries, Cambodia, Laos and Myanmar are hustling on nation-building and infrastructure development, and have yet to implement any S&T activities on a full scale. As Brunei has the largest resources, there is no need to proactively conduct S&T activities.

In summary, there is an urgent need for ASEAN countries other than Singapore to develop infrastructure and human resources for S&T. By achieving them, they are aiming to contribute in the front line of S&T in the world.

2. Singapore

2.1 Outline

In 1991, Singapore established the first science and technology five-year plan that defines the direction of science and technology of the country. Since then, infrastructures (including human resources) that contribute to research and development have been improved. Industry-oriented research has been carried out by industry-academia-government collaboration as the center of the policy. Also, in view of the circumstances and environment of the time, substantial and intensive fund-injections have been made into the specific research projects such as biomedical and water-related technologies, which are regarded as drivers having a huge impact on Singapore's industry. As a result, the world's top-level science and technology activities have been carried out in Southeast Asia.

2.2 Current Socioeconomic Trends and Background

2.2.1 Basic Information

Singapore (official country name "Republic of Singapore") is a city-state located at the eastern end of the Strait of Malacca at the tip of the Malay Peninsula and lies between latitudes 1° 22' north, and longitudes 103° 88' east, almost on the equator. Nearly 5.18 million people live in Singapore (2011) in an area of 710 km^2, which slightly exceeds the 23 wards of Tokyo. This 5.18 million includes 3.79 million Singapore citizens and permanent residents and 1.39 million expatriates, migrant workers and others. It is a distinctive demographic structure that over a quarter of the population is mobile.

2.2.2 History

After the arrival of Sir Thomas Stamford Raffles to Singapore Island in 1819, who was then the secretary of the British East India Company, Singapore first appeared in world history. Immediately after, convinced that Dutch power, in the power struggle in the region at that time, did not extend to Singapore Island, Raffles signed a treaty with Sultan Hussein Shah of Johor, who ruled the island, to develop a British trading post.

Later, having gained a sphere of influence over the northern part of the Strait of Malacca under the Anglo-Dutch Treaty of 1824, the British signed a new treaty with the Sultan realizing full and permanent sovereignty over Singapore, and started to accelerate development and colonization of Singapore (In 1867, Singapore became a crown colony under direct British control) .

Singapore continued to progress, with a central focus on trade as an intermediate port for East-West trade and had moved into simple, low-skilled processing industries such as natural rubber and tinning by the early 20th century. After the United Kingdom placed its naval base for the British Eastern Fleet in Singapore at the end of the World War I, military-base-related industry, which involves ship repairing and maintenance, grew in addition to trade and simple processing fields.

After experiencing the Shonanto era under the Japanese military occupation of 1942-45, re-colonization by post-war Britain, autonomy in 1959, and complete independence from the UK in 1963 as a member of the Federation of Malaya, Singapore was separated from the Federation of Malaya due to the differences in policy and racial issues in August 1965.

2.2.3 Politics

Singapore is a parliamentary republic with a president as the head of state. It has a Cabinet as the executive branch (one cabinet office and 14 ministries) and unicameral parliamentary as a legislative organ. The People's Action Party (PAP), which was established in 1954 during the British colonial period, has held control of Parliament with large majorities in every election since self-governance was secured in 1959. After independence in 1965, the PAP has been Singapore's ruling party and central to implementing every one of the city-state's policies without many difficulties. Also, the Cabinet, with its strong support, is rock-solid. As of 2012, the PAP holds 81 of the 87 parliamentary constituencies.

2.2.4 Ethnic Groups, Languages and Religion

Singapore is a multiracial country of citizens and permanent residents with a majority population of Chinese (74.1%), Malay (13.4%), Indian (9.2%) and others (3.3%). The constitution says Malay is the national language. The other three official languages are English, Mandarin and Tamil. English is the main working language and is the mandatory first language along with other official languages in all schools in Singapore. Most Singaporeans understand both English and their native language.

In terms of religion, the most followed religion in Singapore is Buddhism, with 42.5% reflecting the ethnic make-up mentioned above, followed by Islam 14.9%, no religion 14.8%, Christianity 14.6% Hinduism 4.0% and others 0.6% (population aged 15 and over in Census 2000 of the Singapore Department of Statistics 2000).

2.2.5 Education System

Singapore has a 6-4-2 system of education (6 years of primary, 4 years of secondary, followed by 2 years of junior college; respectively equivalent to 6 years of elementary, 3 years of junior high and 1 year of senior high school and 2 years of senior high school in the Japanese education system), and the 6 years of primary is its compulsory schooling.

Singapore is known for its extreme competition in education. It has been said that a student's subsequent academic course will be greatly affected by the Primary School Leaving Examination (PSLE) taken at the time of graduating from primary school. Singapore's school enrolment rate for the year 2010 was as follows: 98.1% for secondary, 27.7% for Junior Colleges and 43.4% for Polytechnics (equivalent to National Institute of Technology, Japan), 26.0% for University (in Singapore) and 21.0% for other vocational schools.

2.2.6 Economy

Upon separation from the Federation of Malaya due to policy differences in 1965, Singapore lost the Malaysia market as a relay destination and also lost its British-related economic activity, which corresponded to 15% at the time of GDP, through the sudden withdrawal of the Royal Navy Far East base in 1968, where led to an increase in the unemployment rate and creating widespread social unrest. Subsequently, restoring social stability through job creation became an urgent task.

In response, the Singapore government, disregarding unpredictable primary industry from the beginning, targeted second and tertiary industry, namely 1) transit trade 2) tourism, 3) the finance industry, and 4) industry to promote in its economic policy development toward a stable society. Among the four, the industry sector has been regarded as the key driver in creating a large number of jobs.

Dr. Alert Winsemius, who led the UN Survey Mission to Singapore in 1961, pointed out in his report that because Singapore was lacking the basic skills to promote industrialization on its own at that time, it should first implement industrialization by attracting foreign investment. With this advice, the Economic Development Board (EDB) was formed in 1961 to draw foreign investors to Singapore. Later, in 1968, JTC (Jurong Town Corporation, now renamed JTC Corporation) was set up independently from EDB as an industrial park developer. Under these two implementing entities, Singapore's industrialization has been promoted. This mechanism is being continued today in its policy-driven development scheme for biomedical, water and aerospace industries etc.

Incidentally, the state of "missing the basic skills to promote industrialization on its own" has not changed even today, 50 years after independence. According to statistics, out of the 2011 fixed-asset investments of SGD13,734 million in the manufacturing industry, foreign capital is SGD11,858 million, accounting for 86% of the investments (US 5,047, Japan 995, Europe 2,131, Asia Pacific and other regions 3,684 (SGD million).

Furthermore, understanding that it may not be competitive with any other Asian countries in unskilled and labor-intensive industries dependent on a low-wage labor force, Singapore has made a structural shift to high-value-added and knowledge-based industries, contributing to its sustainable development. As a result, its awareness of science technology improvement has increased.

As of 2011, GDP was SDG326.832 billion (about 21.038 trillion yen; 1S$ = 64.7 yen), and GDP per capita is SDG61,692 (about 3.971 million yen). It is one of the richest countries in Asia. Its major industrial makeup of GDP is as follows: manufacturing 20%, retail wholesale industry 16%, financial services industry 11%, and transportation and storage service industry 8%.

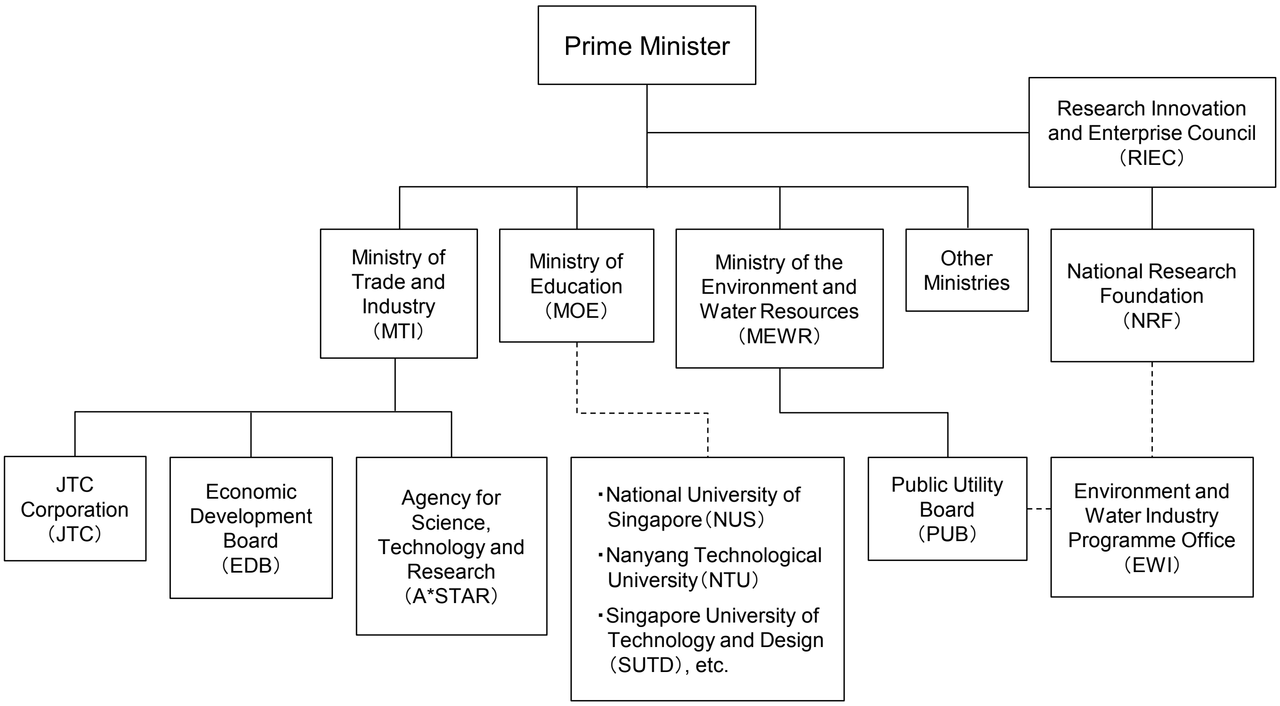
2.3 Science and Technology Policy

2.3.1 S&T Related Organizations

Singapore's major science and technology-related organizations are shown below. The roles of the organizations will be described in the following section.

With "Research Innovation and Enterprise Council (RIEC)" at the top, which is a science and technology-related policy council institution, there are the Ministry of Health (MOH), the Ministry of Education (MOE), and the Ministry of Trade and Industry. This is the executive branch, respectively responsible for medical and public health, education and basic industrial and applied research. As independent or as funding agencies for each jurisdiction ministry, there are the National Research Foundation (NRF) and the Agency for Science, Technology and Research (A*STAR). Furthermore, as a research and development body, there are universities and national research institutes from A*STAR.

Figure 2-1: Governmental Organization Chart Related to S&T in Singapore



2.3.2 Policy and Trends in S&T

In 1991, seeking a transition from capital-intensive industries, such as petrochemicals, to technology-intensive industries including electronics, the Singapore government established a science and technology body called the National Science and Technology Board (NSTB, later reorganized as A*STAR), promoting the integration of industry and research and development (science and technology). In that year, a national technology plan was introduced as the guideline for the direction of the nation's science and technology administration over five years. Thereafter, it is sequentially developed every five years. As of 2013, measures have been carried out in line with the 5th science and technology plan.

Since 1991, the promotion of industry-oriented research and development through industry-academia-government collaboration and the development of human resources with advanced knowledge and skills to support that research and development are the essentials of the plan. Another unique aspect of this plan is that intensive and heavy investment is committed, considering the circumstances of the moment, to some specific research and development areas (biomedical, water science, etc.) that are expected to have a significant impact on the future industry of the nation.

This trend seems to be carried on in the 6th plan, whose design is in progress. At the end of 2014, the government announced a "Smart Nation" policy. In this policy, ICT that contributes to social life, environment-friendly buildings, and sensor technologies contributing to them were mentioned, suggesting there can be distinct research areas in the next plan.

As for reference, the outlines of the plans, from 1st to 5th, are given below.

1) The 1st National Technology Plan (1991-1995)

- Budget: SGD2 billon

- Promotion of output-oriented (industry-oriented) research through cooperation between government research institutes and industry
- As prioritized fields, manufacturing technology, IT, electronics, materials, energy, water, environment, biotechnology and medical

2) The 2nd National Science & Technology Plan (1996-2000)

- Budget: SGD4 billion
- Attraction of R&D units of multinational corporations
- Human resources development to support R&D centers of the MNCs

3) The 3rd Science & Technology Plan 2005 (2001-2005)

- Budget: SGD6 billion
- Local human resources development and recruitment of global human resources
- Promotion of business-academic collaborations by A*STAR and EDB (SGD4 billion for A*STAR to further boost research capabilities in Singapore and SGD2 billion for EDB to encourage attraction of R&D-intensive corporations)
- Investment to biomedical sector (Biopolis established in 2003)

4) The 4th Science & Technology Plan 2010 (2006-2010)

- Budget: SGD13.9 billion
- R&D expenditure increase to 3% of GDP by 2010 (not achieved yet; stood at 2.28% as of 2011)
- Identified "water and environment," and "interactive media and digital media" as new economic strategic sector
- Support for R&D work undertaken by corporations
- Enhancement of business-academia collaborations; Industry Alignment Fund (IAF) program launched

5) The 5th Research, Innovation & Enterprise Plan 2015 (2011-2015)

- Budget: SGD16.1 billion
- Investment into basic research aimed at future innovation
- Recruitment and development of human resources
- Enhancement of competitive funds
- Promotion for further strong business-academia collaborations (support for specific research fields expected to bring positive economic outcome, support for technology transfer and industrialization)

2.4 Promotion Bodies of Science and Technology

With the "Research Innovation and Enterprise Council (RIEC)" at the top, which is a science and technology-related policy council institution, there are the Ministry of Health (MOH), the Ministry of Education (MOE), and the Ministry of Trade and Industry (MTI). These are the executive branch, respectively responsible for medical and public health, education and basic industrial and applied research. As independent, or as funding agencies of each jurisdiction ministries, there are the National Research Foundation (NRF) and the Agency for Science, Technology and Research (A*STAR). Furthermore, as a research and development body, there are universities and national research institutes belonging to A*STAR.

In Singapore, the key and leading research and development engines in terms of comprehensive fields are A*STAR and two R&D-intensive universities, namely, the National University of Singapore (NUS) and Nanyang Technological University (NTU)

The National Research Fund (NRF), established in 2006, is also a key science and technology body and serves as a funding agency for the research institutes mentioned above. It allocates external research funds according to the National Science and Technology plan.

Generally, in Singapore, with a respective research fund operated by funding agencies, including NRF, a virtual funding agency such as the Environment and Water Industry Programme Office (EWI), which is described later, is set up to allocate funds to actual research implementing institutes, including A*STAR-affiliated research units and the two universities mentioned above.

2.4.1 Research Innovation and Enterprise Council (RIEC)

Established in 2006, RIEC comprises Cabinet Ministers and distinguished local and foreign members from the business, science and technology communities. It is chaired by the Prime Minister of Singapore, who appoints members to two-year terms.

RIEC is a decision-making body that provides strategic direction for national R&D. It has two main goals: to advise the Singapore Cabinet on national research and innovation policies and strategies to drive the transformation of Singapore into a knowledge-based society, with strong capabilities in R&D, and to lead the national drive to promote research, innovation and enterprise by encouraging new initiatives in knowledge creation in science and technology, and to catalyze new areas for long-term economic growth.

This high-level council underscores the political commitment to and importance placed on the national R&D agenda.

2.4.2 Agency for Science, Technology and Research (A*STAR)

In 1967, the Science Council was set up in order to raise the level of science and technology in Singapore. In the following year, 1968, the Ministry of Science and Technology was established with the primary mission to increase highly skilled human resources that sustain advanced industrial technology and to integrate science and technology research capabilities. After the functions of the Ministry of Science and Technology were incorporated into the Science Council (the Ministry of Science and Technology was dissolved) in 1981, the National Science and Technology Board (NSTB) was established in 1991 under the Ministry of Trade and Industry (MTI) to promote the integration of business and R&D (science and technology) for further development of Singapore's industry that creates high-added value. In 2002, by integrating the national research institutes of Singapore into one organization to avoid duplication of research, NSTB was dissolved and reorganized into Agency for Science, Technology and Research (A*STAR) with the goal of promoting joint work by each respective research institute. A*STAR currently oversees 8 Engineering Institutes and 12 biomedical-specified institutes and is leading industry-oriented R&D through promotion of industry-academia cooperations.

2.4.3 National Research Foundation (NRF)

The NRF was established in 2006 as a funding organization directly under the Prime Minister's Office, and is responsible for developing national research and development guidelines. As of 2014, the NRF operates a SDG5-billion fund for the development of strategic research areas, including biomedical science, translational clinical research, environment, water technology, interactive digital media, marine and offshore technology, and satellite and space

The NRF has established five cutting-edge research centers (Centre for Quantum Technologies, the Mechanobiology Institute, and the Cancer Science Institute etc.) under its "Research Center of Excellence" programme with SGD150 million in funding over a five- to ten-year period.

2.4.4 National University of Singapore (NUS)

NUS was established in 1905, originally as a medical school. The National University of Singapore was formed with the merger of the University of Singapore and Nanyang University in 1980. NUS has 16 faculties and schools as of 2013, covering a wide range of fields such as law, business management, science and engineering, medicine, and dentistry. It is interesting to note that NUS also has a Music Conservatory. It is a mega-university with an enrollment of 37,000 students (undergraduates: about 27,000) and about 10,000 faculty members.

In recent years, NUS has received high acclaim internationally. According to the world university rankings in 2014, of its Natural Sciences areas, Science, Engineering, and Life-Sciences are ranked 13th, 7th, and 27th, respectively, by the QS rankings and 41st, 13th, and 34th, respectively, by the Times Higher Education World University Rankings (THE). Furthermore, NUS offers a curriculum that combines biomedical research and clinical practice in Duke-NUS Graduate Medical School, which is jointly run with Duke University. Emphasizing activities as a global research and development university in recent years, NUS has established more than 20 research centers specific to Engineering Mathematical Sciences, Biomedical and Life Sciences, Nanotechnology, Marine Science and Asia.

2.4.5 Nanyang Technological University (NTU)

NTU was inaugurated in 1955 on the premises of the former Nanyang University, established originally for Chinese-descended children. In 1981, it was reorganized as Nanyang Technological Institute (NTI) when Nanyang University was legislated to merge with the University of Singapore and became NUS. In 1991, NTI merged with the National Institute of Education (NIE) to form Nanyang Technological University.

As of 2013, it has four colleges: Engineering (6 departments), Science (2 departments), and Management, Humanities, Arts and Social Sciences (3 departments). In 2013, the School of Medicine was set up with the cooperation of Imperial College. It is home to about 33,000 students (with 24,000 undergraduates), and approximately 7,000 faculty members.

In various college and university rankings such as THE World University Rankings, NTU has been placed amongst the top R&D-intensive universities in such a short period of time. According to the 2014 QS and THE World University Rankings, NTU was respectively ranked 39th and 61st in the world. NTU particularly has put a lot of work into research activities conducted based on industry-university cooperation. According to the 2013 THE, NTU is ranked 1st for the amount of industry funding.

NTU has boasted a strong engineering college right from its foundation, and has more than 20 research centers, including nanoscience and nanotechnology and information technology. NTU also hosts the two NRF-led Centers of Excellence: the Earth Observatory of Singapore and the Singapore Centre on Environmental Life Sciences Engineering.

2.4.6 Singapore University of Technology and Design (SUTD)

SUTD is Singapore's fourth national university (the third is Singapore Management University: SMU) and opened its doors in 2012. SUTD was developed in collaboration with Massachusetts Institute of Technology (MIT) and Zhejiang University in China.

SUTD teaches its students and engages in research from the perspective of technically grounded design. It also seeks a solution based on design for real life issues through research work on sustainability, transportation, clean energy, health care and defense innovative technology. In January 2014, SUTD's formal campus was completed in Changi district, where it has started activities more vigorously.

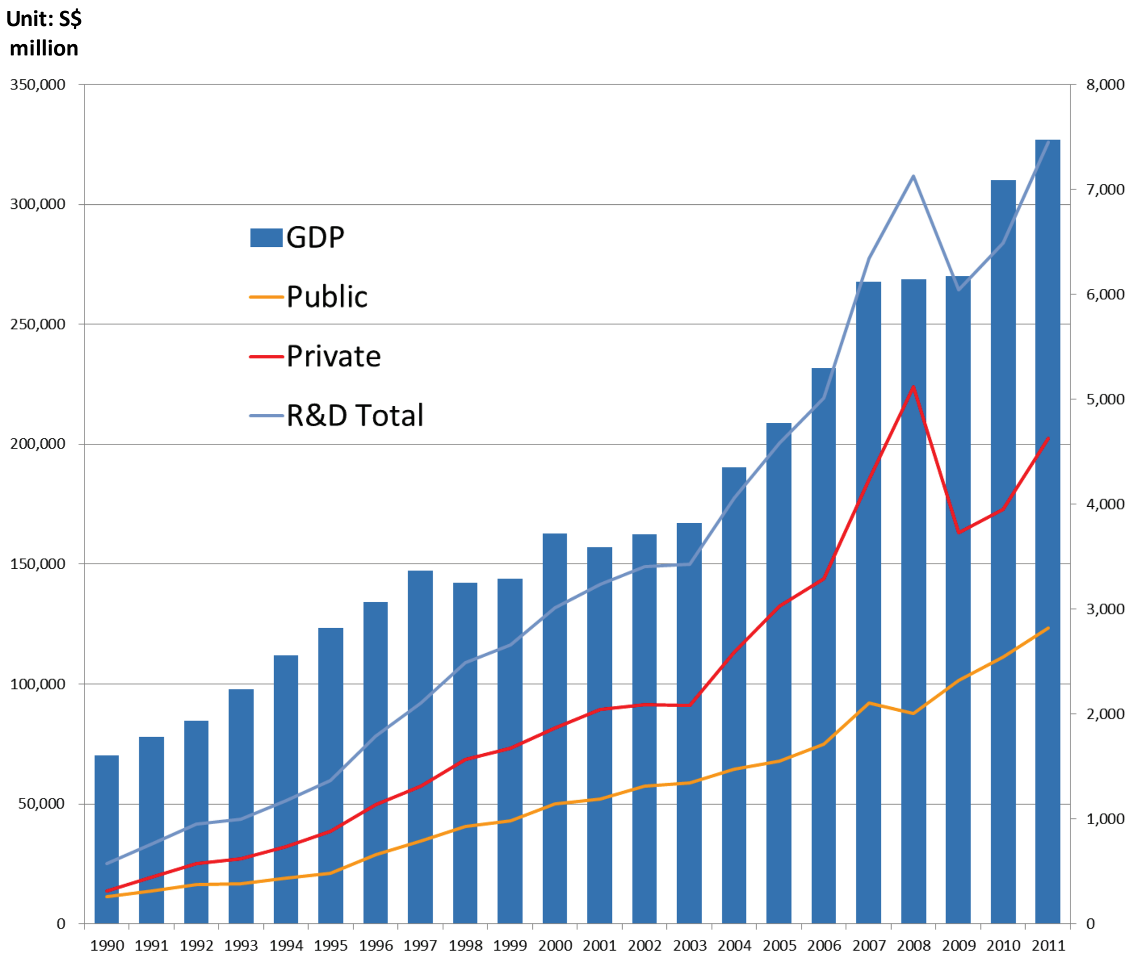
2.5 Input Index of Science and Technology

2.5.1 Expenditure on R&D and Expenditure Ratio by Type

In Singapore, investment in R&D has been steadily increasing in response to GDP growth. Its GDP and R&D expenditure in value terms increased from SGD70.391 billion and SGD572 million, respectively, in 1990 (0.81% of GDP) to SGD326.832 billion, SGD7.448 billion in 2011 (2.28% of GDP). It suggests that Singapore's GDP increased 4.64 times and R&D expenditure 13 times in two decades.

Looking closely at Singapore's policy, the government first committed to massive R&D investment in the science and technology fields that are politically considered to be pillars of the nation's industry in the next 10 to 15 years. With that incentive, it attracted foreign R&D-oriented companies in such field. It can be considered as a pattern that Singapore has gradually improved its science and technology level, leveraging the university-industry synergies created by research and development investment in these companies. IT and electronics, in the 1990s, biomedical science from the early 2000s and environment and water from the later 2000s follows the pattern. In its 4th Science and Technology Plan (2006-2010), with reference to the EU's Lisbon Strategy, the government first planned to increase R&D investment by 3.0% of its GDP during the term of the plan, but failed to achieve this because R&D investment by the private sector declined due to events such as the Lehman Brother's collapse in 2008. Currently, the ratio of private and public in terms of R&D investment is 6 to 4.

Figure 2-2: GDP and R&D investment of Singapore



*GDP (left axis), R&D investment (right axis)
Source: A*STAR National Survey of R&D in Singapore 2011

In respect of types of R&D, the field of engineering technology, including the electronics and machinery industry, as of 2011 the private-to-public ratio was SGD3.520 billion to SGD1.155 billion (77 to 25). It can be said the R&D efforts by private R&D-oriented companies in such field has been well-established. However, in the biomedical sector, which has been emphasized since 2000, the private-public ratio was SGD142 million to SGD305 million (32 to 68) in 2002, it still stood at SGD517 million to SGD855 million (38 to 62) as of 2011. It suggests that the biomedical industrial development by the government with an incentive for public investment will continue to be enhanced.

Figure 2-3: Type of R&D Expenditure in 2002, 2007 and 2011
(Sum of private and public sectors)

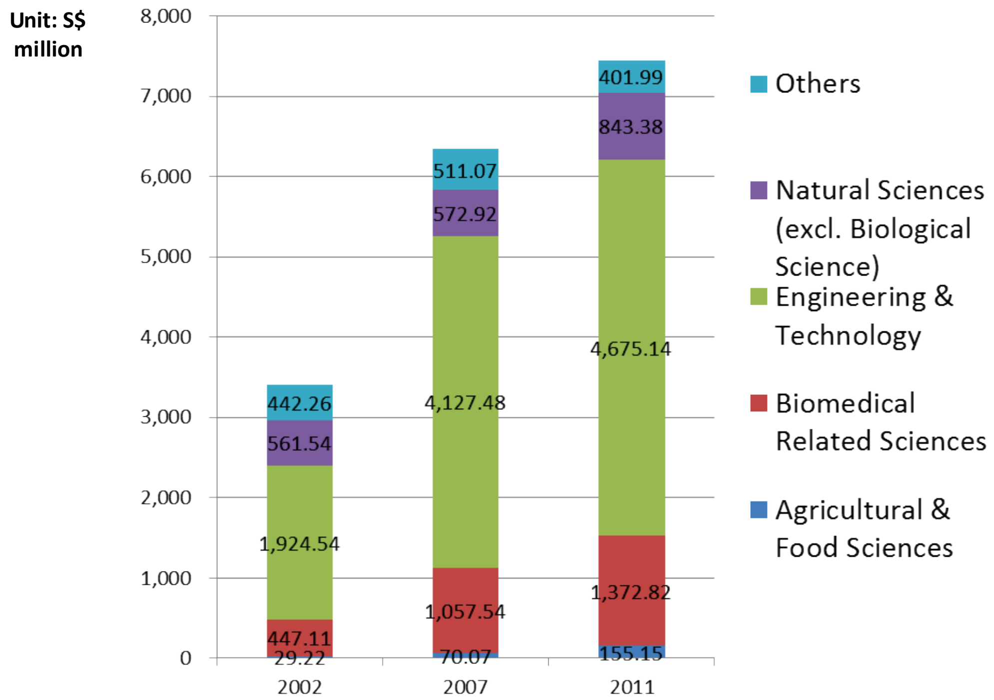
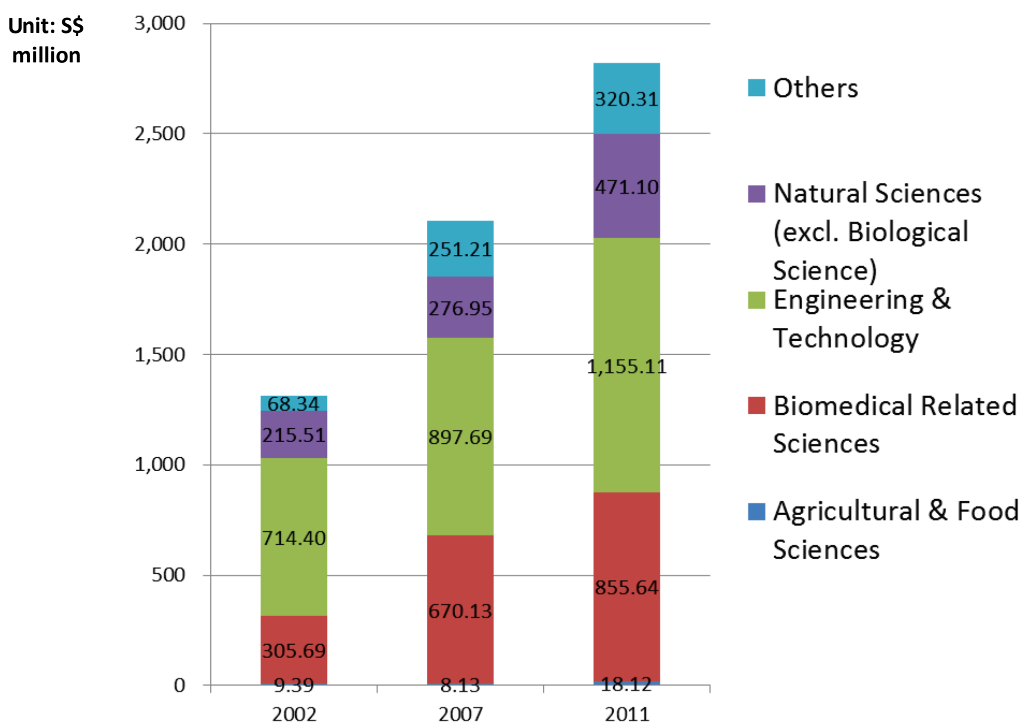


Figure 2-4: R&D Expenditure by Field in 2002, 2007 and 2011 (Public sector)



(Referenced year obtained from A*STAR National Survey of R&D in Singapore)

Singapore

2.5.2 Type of Expenditure

According to A*STAR National Survey of R&D in Singapore 2011, the R&D expenditure ratio by type, in the field basic research, applied research, and externally oriented experimental development field, is respectively 19% (SGD1.420 billion), 33% (SGD2.451 billion), and 48% (SGD3.577 billion). It shows that overwhelming and intensive investments were made into the applied research and experimental development fields and that the government promoted research work with an eye to industrialization as a policy to be implemented.

Also it should be noted that the 19 % (SGD1.420 billion) comprises private sector 6% (SDG478 million) and the government, higher education, and public sector 13% (SGD942 million). The latter can be categorised into pure basic research and strategic basic research in line with the specific fields identified by the government. In this case, research expenditure on pure basic research field is only 4% (SGD299 million), suggesting how heavily the applied research has been core-focused for the final goal.

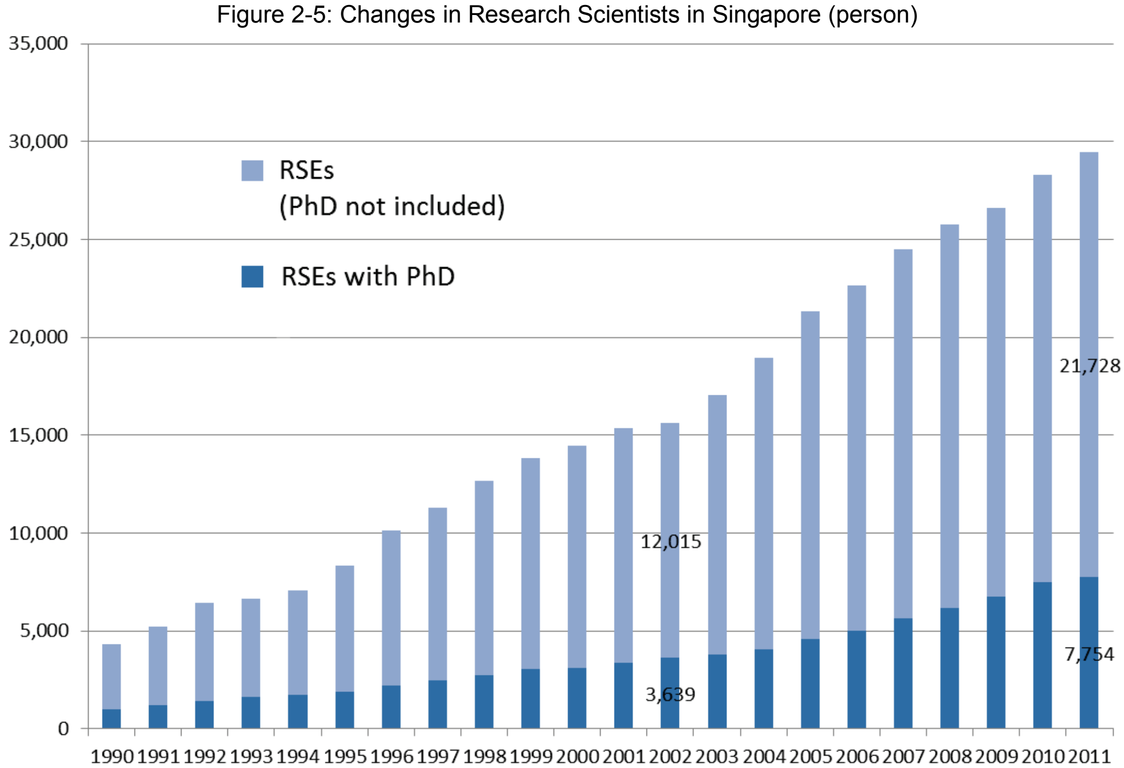
2.5.3 Total Research Scientists

The statistics of research personnel is given below.

First, as of 2011, the number of RSEs (Research Scientist and Engineer) is 29,482 including 7,754 PhD RSEs (the remaining 21,728 are master degree or bachelor degree holders). The number of RSEs as a whole grew 6.8 times compared with that of 1990. The number of RSEs with PhD has increased about 8 times.

Of the 29,482 RSEs, 16,535 RSEs or 56% are working in the corporate sector. Also, 7,780 RSEs or 36% of the total are Singapore citizens and permanent residents.

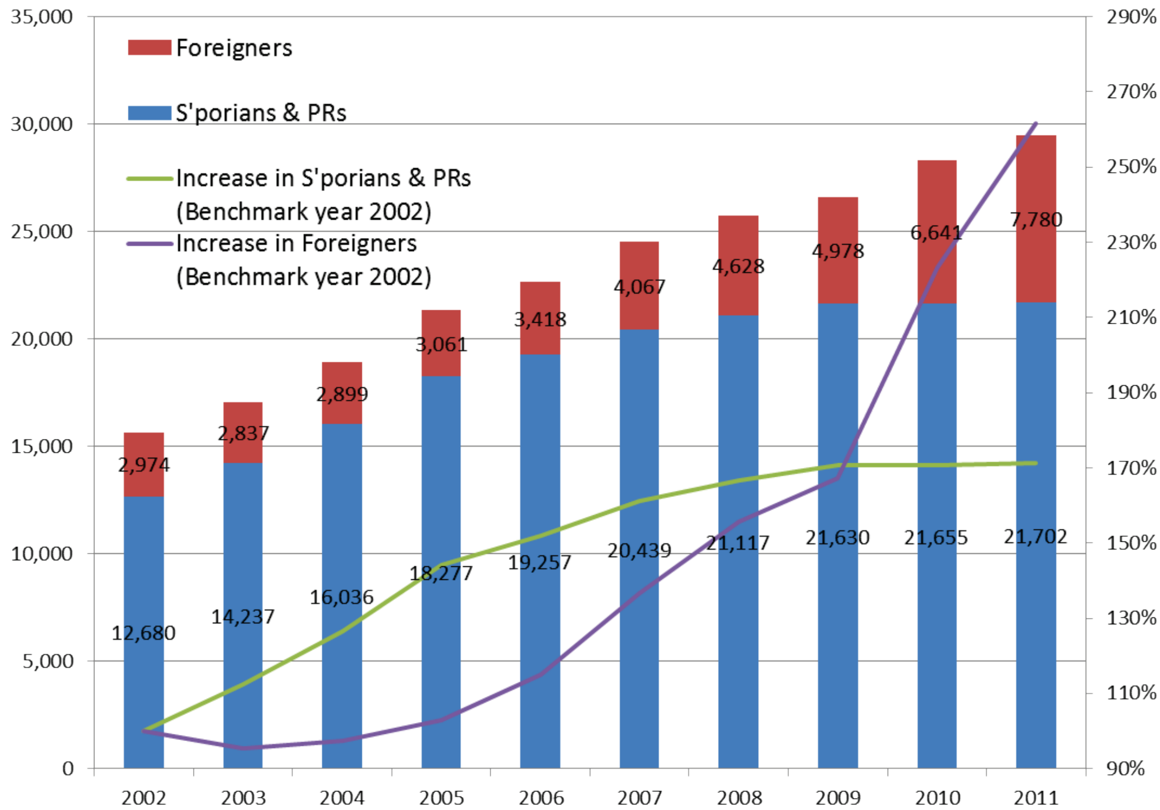
Figure 2-5: Changes in Research Scientists in Singapore (person)



Source: A*STAR National Survey of R&D in Singapore 2011

In particular, as large-scale clusters such as Biopolis are on the right track and the 4th Science and Technology Plan with greatly increased national research budget has been successfully implemented, the number of Singaporean and permanent resident RSEs remained stable in 2002. In contrast, the number of foreign RSEs grew significantly. This shows Singapore has been successful in attracting globally oriented human resources.

Figure 2-6: Changes in RSEs (Singaporeans and Foreigners) (person)



Source: A*STAR National Survey of R&D in Singapore 2002-2011

2.5.4 RSEs per 1,000 People in the Labor Force[1]

In respect to researchers per 1,000 people in the labor force, it grew from 5.03 in 1996 to 10.13 in 2006, two-fold in a decade, and increased to 11.58 in 2011. This is larger than that of Japan at 10.06 and the US at 7.87 in the same year. As described earlier, it can be said that this is a result of Singapore aggressively undertaking development and recruitment of highly talented and skilled researchers with advanced knowledge during its several Science and Technology Plans.

2.6 Output Index of Science and Technology

This section will discuss the current performance of Singapore's science and technology using several indexes.

2.6.1 Science Research Papers

First, the total number of research paper regarded as an indicator of basic research will be

[1] UNESCO Institute for Statistics （http://data.uis.unesco.org/Index.aspx?queryid=64#）

discussed.

Based on indicators of the Elsevier research analysis tool (SciVal), the number of science papers published, number of citations, number of authors and international co-authorship rate are compared with that of Japan and other 10 ASEAN countries (see figure 2-7).

Although Singapore is in second place, after Malaysia, in terms of the number of papers published in ASEAN countries, its number of citations is two times that of Malaysia. This shows the high quality of those research papers.

In addition, according to the NISTEP material, the average number of papers released by Singapore is 9,259 (0.78% world share) in 2012. Compared with Japan's average number of papers in the same period is 76,285 (6.39% world share), and considering that its population is about one twenty-fourth of Japan's, paper production volume per person is calculated to be about three times that of Japan.

Figure 2-7: Comparison of Selected Countries by Number of Science Paper

Item / Country	Number of Papers	Number of Citations	Number of Authors	International Co-Authorship
Japan	648,938	3,534,908	599,167	23.6%
Malaysia	93,406	292,001	76,671	31.3%
Singapore	80,680	701,014	48,757	51.5%
Thailand	53,334	257,150	48,585	37.4%
Indonesia	15,728	58,632	17,247	55.0%
Vietnam	12,696	60,540	13,670	67.9%
Philippines	7,354	47,088	7,747	57.3%
Cambodia	1,064	10,905	1,258	88.8%
Brunei	879	2,373	747	48.9%
Laos	750	4,237	810	93.6%
Myanmar	558	1,651	663	60.8%

Source: Elsevier, SciVal Database

2.6.2 University Rankings

Singapore's universities have been ranked among the best by various world university rankings.

As partially mentioned in the description of each university in the previous section "Promoting body of Science and Technology" of this paper, NUS has been placed 22nd in the QS World University Rankings 2014 and 25th in the Times Higher Education Rankings (THE). NUS's Natural Science subjects are ranked among the top worldwide. This includes Science, Engineering and Life Science, which are ranked 13th, 7th and 27th, respectively, by the QS, and are also ranked 41st, 13th, and 34th, respectively, by THE. Similarly, NTU is ranked 39th (by QS) and 61th (by THE), and for its Natural Science subjects, Science in 59th, Engineering in 9th and Life Science in 208th by QS, and not –ranked, 29th and not -ranked by THE.

Regarding NTU, its Science and Life Science faculties have not been highly evaluated. This may be attributed to the fact that NTU originally started out as an Engineering college and has a short history of Science and Life Science research areas.

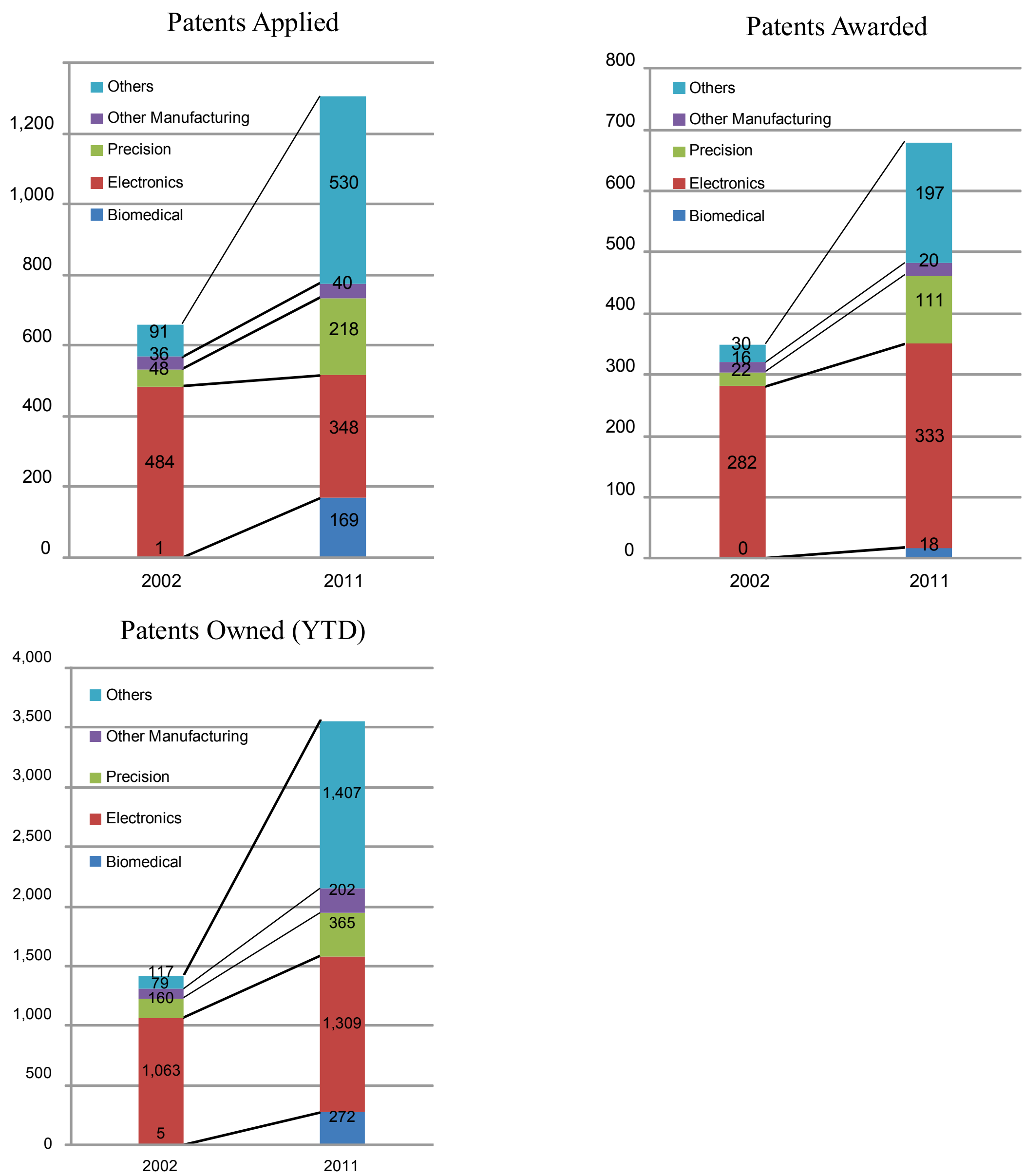
2.6.3 Patents

For the patent number index, when the public sector was compared with the private sector in

2002 and 2011, respectively, in terms of patents applied, awarded and owned (public to private in 2002, public to private in 2011), it was as follows: patents applied: 276 to 660, 608 to 1,305; owned 101 to 350, 176 to 679; and owned 315 to 1,424, 1,203 to 3,555. The private sector outnumbers the public sector, demonstrating its strong R&D capabilities.

The indexes of the private sector by field show that electronics and precision machinery, emphasized as a high-value-added technology-intensive industry since 1990, have been continuously strong. Also, in respect to the biomedical sector, which has been enhanced strategically since 2000, the R&D capabilities of the private sector were only 5 in terms of the cumulative number of patents owned in 2002, but it increased to 272 in 2011. The total number of patents applied also grew from 1 in 2002 to 169 in 2011, showing its steady progress over the decade.

Figure 2-8: Patent Indexes in Singapore



Source: A*STAR National Survey of R&D in Singapore 2002 and 2011

2.7 Foreign Relations

2.7.1 Japan

(1) Bilateral Joint Research Efforts by Japan Science and Technology Agency (JST) and A*STAR

In 2009, A*STAR and the Japan Science and Technology Agency (JST) started a research cooperation and support scheme in a joint fund format for the purpose of achieving the promotion of research exchange activities between the two countries. In 2014, researchers of Japan and Singapore were invited to submit their research proposals in physical materials and devices, photonics and nano-optics, and bioelectronics. Six projects in total have been supported jointly by the two organizations.

(2) Another interesting effort in addition to intergovernmental cooperation is an international industrial-government partnership in the field of medical technology. It was launched by A*STAR and the Osaka Chamber of Commerce and Industry (OCCI) in October 2012.

This partnership will provide opportunities for Japanese MedTech companies (members of OCCI) to tap into Singapore's robust R&D infrastructure and talent. The MedTech firms will be able to fast-track research and product development of medical technology and devices for the Asian market.

(3) Research Centers facilitated by Keio University and Waseda University

In April 2009, with the invitation of an Interactive Digital Media Research and Development Programme Office funded by a grant from NRF, Keio University in collaboration with NUS set up Keio-NUS CUTE (Connective Ubiquitous Technology for Embodiments) Center on the campus of NUS. Research into lifestyle media in a ubiquitous society and research on global computing that leverages the most advanced network have been carried out in collaboration through interactive digital media research.

In September that year, Waseda University established the Waseda Bioscience Research Institute in Singapore (WABIOS) within Biopolis with its own capital. In areas such as physical biology and bio-imaging currently under four Principal Investigators from Japan, it has been actively engaged in joint projects with researchers from institutions such as NUS, NTU, and A*STAR.

2.7.2 Other Foreign Countries

(1) CREATE (Campus for Research Excellence and Technological Enterprise)

The CREATE program, which is supported by the NRF, is an international interdisciplinary research center for universities in Singapore in collaboration with 10 excellent[2] research universities throughout the world including MIT, Swiss Federal Institute of Technology (ETHZ), Cambridge, and Peking University etc.

At CREATE, researchers in various fields carry out joint work in strategic research areas of Singapore such as human, energy, environment and urban systems to contribute to the social application of state-of- the art technology which brings economically and socially positive results.

[2] Swiss Federal Institute of Technology (ETH), Zurich, Massachusetts Institute of Technology, Technical University of Munich, Technion-Israel Institute of Technology, Hebrew University of Jerusalem, Ben-Gurion University, University of California, Berkeley, Peking University, Shanghai Jiao Tong University, Cambridge University

For example, the University of California, Berkeley, one of the partner universities, has developed research collaboration with NUS and NTU called SinBerBEST (Singapore Berkeley Building Efficiency and Sustainability in the Tropics) since 2012. Under the theme of "technology that contributes to energy efficiency and the sustainability of buildings in the tropics", about 100 researchers and staff including 33 PIs from three universities (10 from UCB, 13 NTU and 10 NUS) have been conducting research in six areas (Thrust) such as sensing and data collection, simulation, interactive technology and environment between residents and buildings, and theory and practice-based test bed facilities.

(2) The UK

With strong historic ties to the UK, A*STAR has jointly conducted studies with the Medical Research Council in the infectious disease field since 2009, and also has a collaboration with the University of Southampton in the field of marine science and ocean engineering.

(3) France: Merlion Program

Launched in 2005, the Merlion Program is a joint French-Singaporean collaboration, managed by the Institut Français de Singapour in partnership with Singaporean institutions to encourage academic and research personnel exchange. Its participants from Singapore include NUS, NTU and A*STAR.

(4) Germany: Singapore - Germany research project funding

This is a research personnel exchange program between Singapore and Germany that was started in 2013, managed by the German Federal Ministry of Education and Research (BMBF). Its participants from Singapore include NUS, NTU and A*STAR.

2.8 Topics on Science and Technology

This section will discuss topics that characterize S&T development in Singapore.

Singapore has invested intensively in the R&D areas likely to have economic ripple effects. This paper touches upon two distinguished sectors that were identified as strategic R&D areas, respectively, in the early and late 2000s. One is the biomedical sector, which has strongly contributed to innovation improvement in the country, and the other one is the water research sector, which has been ranked the world's top, especially for its recent innovation capacity.

2.8.1 Biomedical Research

In its 3rd five-year plan known as "Science & Technology Plan 2005" (2001 - 2005), Singapore's biomedical sector was identified as an industry that needs to be intensively enhanced, with the expectation of being a pillar of high-value-added industry in the 21st century.

To establish a world-class biomedical research hub, the Biopolis plan was launched in 2001. An R&D cluster of seven buildings was completed in 2003 (Phase I) and it has been expanded to Phase V. As of October 2013, Biopolis boasted 12 buildings including a currently completed building of Phase 4. The new addition increased the Biopolis complex to a total of about 295,000 m^2 and hosts 38 bio-med companies, 10 public institutes and more than 2,500 researchers from 70 countries, which has now become a great bio-cluster.

For land and building development of this complex, while SDG500 million, SDG70 million and SGD100 million were invested to construct Phase I, II and III, respectively, Phase IV was established by Procter & Gamble (P&G) with an investment of SDG250 million. Most of P&G's Asian research and development function located at the Kobe Biomedical Innovation Cluster were relocated there.

At the time the Biopolis was founded in 2000, the biomedical-oriented research infrastructure of Singapore was still vulnerable. Even NSTB (the precursor of A*STAR) was mostly an engineering-dominant institute. The Institute of Molecular and Cell Biology (IMCB), which was established in NUS in 1985, was the only bio-based research institution in Singapore, and bio-based research personnel had also been very limited.

To address this, Mr. Philip Yeo, the former A*STAR Chairman, who played a leading role in formulating the Biopolis plan and in implementing policies, has launched 11 national biomedical-oriented research institutes and research consortiums one after another in the Bioplis between the years 2000 and 2010, starting with the Genome Institute of Singapore.

Expressed as "Whales (overseas tycoon researchers) nurture (human resource development) guppies (Singaporean researchers), with abundant research funds (both basic and applied research)", he recruited, amongst many others, accomplished researchers from abroad and was dedicated to human resource development, which is a strong pillar of the R&D environment of the country.

In 2010, as the human resource development and advancement of R&D-oriented firms progressed to a certain level and its fundamental infrastructures were improved, Singapore shifted its research and development focus on more industry oriented research by introducing a funding scheme called the Industry Alignment Fund (IAF) in which its research grant allocation focus is changed to more industry-related research efforts

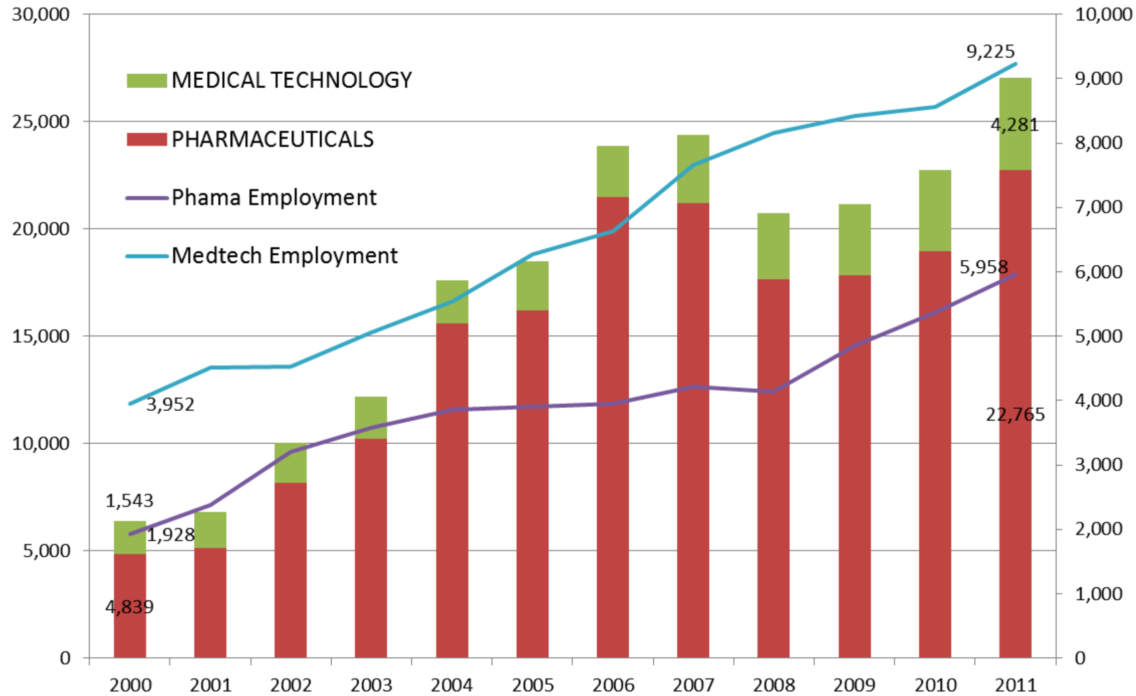
This trend, given the nature of Singapore's science and technology, is a quite natural movement. However, many of those overseas heavyweight scientists who were invited to Singapore during the founding period of Biopolis left Singapore one after and another, seeking to engage in scholarly scientific and technical basic research, and this was once ridiculed as "the honeymoon at the end." by newspaper.

A quantitative examination of the impact of biomedical science research given to Singapore over the years from early 2000 to 2011 when the Biopolis plan was moving into high gear is shown below.

1)Sales and employment scale, respectively, of biomedical industry started to grow from 2002.

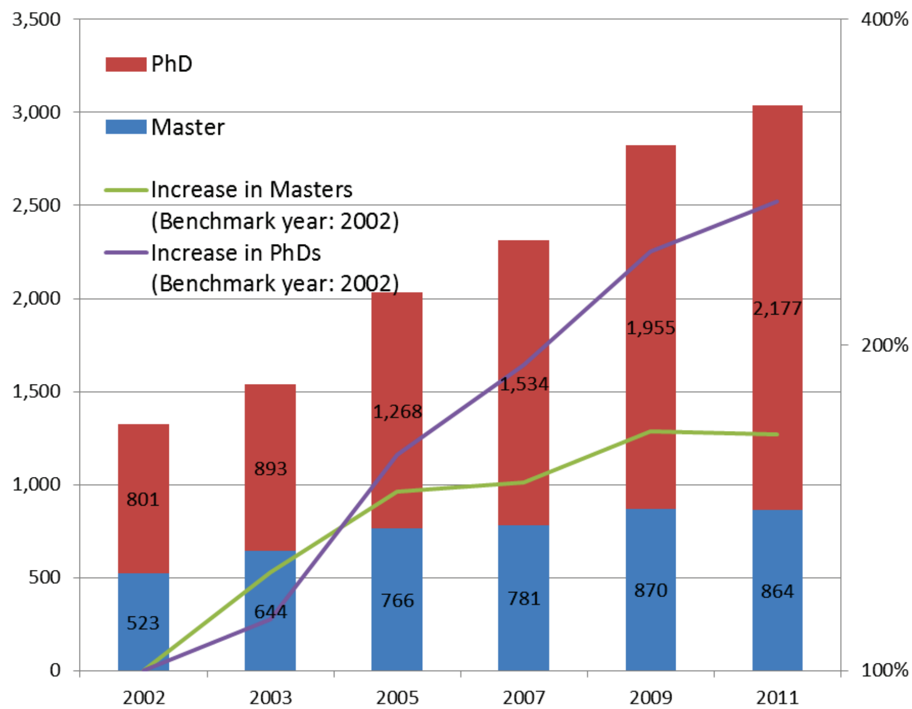
2)In human resources development, the number of biomedical researchers grew, especially the number of PhD researchers increased, upgrading the level of research.

Figure 2-9: Changes in Sales and Employment of Biomedical Industry
(Left axis: Sales (S$ million) Right axis: Employment (persons))



Source: Based on the data obtained from Principal stats of mfg
by industry cluster, Department of Statistics in Singapore

Figure 2-10: Changes in RSEs (PhDs and Masters) of Biomedical Industry



Source: Referenced year A*STAR National Survey of R&D in Singapore

As for the bio-based research institutions other than A*STAR-affiliated, government or corporate-managed institutes, this section will describe a non-profit, bio-based institution named "Temasek Life Sciences Laboratory (TLL)".

TLL was founded in 2002 when the bio-based study of Singapore was starting. It is a private non-profit institute set up in the NUS campus with the assistance of the Temasek Trust, which belongs to the non-profit grant department of Temasek Holdings, an investment company in Singapore investing in Asia. At TLL, there are 240 researchers gathered from 21 different countries for the common good of people of Asia, engaging in the field of biological molecular science such as cell biology, neuroscience, pathogenesis research and bioinformatics to meet both the short- and long-term needs of life science industry.

Among about 30 principal investigators (PI) at TLL, 6 are from Japan, demonstrating a high Japanese PI ratio (as of 2013).

2.8.2 Water-related Technology

In Singapore, about 5.18 million people are living in high-population-density areas of about 710 square kilometers, which slightly exceeds the 23 wards of Tokyo. Singapore is located almost on the equator, at latitude 1° 22' north, and is classified as a tropical rainforest climate area. Although Singapore’s annual rainfall is 2,400 mm (about 1,700 mm for Japan), there is not enough land area to catch the abundant rainfall due to the narrow nature of the country. Furthermore, because of the absence of large rivers, natural aquifers and groundwater, how to secure the water as a resource has been a vital issue for Singapore since its independence. Human beings can live without petroleum energy, but will die without water. At the time of independence in 1965, there were two historic events that strongly reminded then Prime Minister Lee Kwan Yew of the importance of water. One was a lesson learned from the Japanese military invasion of 1942. Since Japanese troops destroyed the water pipelines between Malaysia and Singapore, the UK and allied forces, with their water supply disrupted, were forced to quickly surrender. The other was a form of potential diplomatic pressure expressed on August 9, 1965 (Singapore’s Independence Day) by the then Prime Minister of Malaysia, who said "We are ready to stop the water of Johor at any time if Singapore takes an adverse policy toward Malaysia."

At the time of independence in 1965, there were only two kinds of water supply sources: import from Malaysia via Johor water and small reservoirs. The realization of a stable water supply was vital to maintain the living standards of the people and for industrialization, which is the only option for the small island nation to take as a means of national growth. In other words, "a drop of water is as precious as a drop of blood" and "water independence" has been placed as a top priority in its national development plan. To achieve this, the development of a legal system, national land development securing multiple water supply sources for risk diversification, infrastructure construction, and research and development have been steadily carried out since independence.

In respect to the risk diversification, the following measures, named as the "Four Tap Strategy," have been implemented to achieve water independence.

(1) Rainwater: Efficient Rainwater Storage System with Effective Urban Design.

One of the examples is the Marina reservoir that was constructed as a freshwater reservoir by damming the sea in the Marina Bay Area in 2008. Currently, 17 reservoirs are in place. There is a rainwater catchment system in which gutters and drainage are systematically established. Two-thirds of the national land has become a rainwater storage area. Institutionally, the Public Utilities Board

(PUB[3]), which manages the entire water cycle in Singapore, has a plan to expand rainwater storage areas up to 90% until 2060.

(2) Imported Water: Two Johor Water Agreements

The State of Johor and a Singapore government agency signed two agreements[4] to sell and purchase water.

However, it can be said that it is unfavorable to Singapore given that it must provide treated water at 50 cents/one thousand gallons to the Johor government in return as specified in both agreements; it costs actually 240 cents/one thousand gallons; the remaining 190 cents/one thousand gallons for the water purification process is covered by Singapore government subsidies. On the other hand, it is supposed to be able to review the sale price every 25 years; the fact that the procurement cost of water is dependent a great deal on diplomatic negotiations was one of the concerns for Singapore when implementing a water intake policy that is well-planned and cost-effective.

In 1986 and 1987 when the water price was revised for the first time, the sales price was unchanged. In the second round of negotiations in 2011, the sales price negotiation was not settled resulting in expiration of the Tebrau and Scudai Rivers Water Agreement.

(3) NEWater (Reclaimed Water):

NEWater is the brand name given to reclaimed water introduced in 2002. It is treated wastewater (sewage) that has been purified using chemical (UV sterilization) and physical (microfiltration) treatment technologies. It has undergone more than 100,000 scientific examinations and satisfied WHO standards. Currently, because of its ultra-pure characteristics, NEWater is mostly used by industries such as semiconductor factories. With the success of NEWater, Singapore has become the world's leader in innovative water treatment technologies. As of 2011, five treatment plants have been running, accounting for 30% of the total supply.

(4) Seawater Desalination:

Surrounded by the sea, Singapore has abundant seawater resources. It is reasonable for Singapore, if the effective cost and energy consumption are secured, to implement a research and development policy focusing on desalination technology development of the inexhaustible supply of seawater to secure fresh water. In 2005, Singapore's first desalination plant was opened in Tuas industrial park. This desalination plant (SingSpring) was established by a public-private partnership (PPP) between PUB and Hyflux[5], producing 30 million gallons of water per day. Furthermore, in

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[3] PUB: Public Utility Board Singapore is a government agency responsible for managing the entire water cycle: reservoir management, water intake, water purification, water distribution, sewage treatment, water recycling process, and rainwater drainage. Established as a supply agency of the water, gas and electricity infrastructure under the Ministry of International Trade and Industry in 1963. In 2001, when gas and electricity was privatized, the sewage water division, an intra-ministerial bureau in the Ministry of the Environment was transferred to be under the jurisdiction of the Ministry of the Environment and Water Resources (MEWR).

[4] 1) 1961 - 2011 Tebrau and Scudai Water Agreement: providing Singapore the right to draw up to 86 million imperial gallons per day from Tebrau river and Scudai river (note: the spelling of the two rivers is different to the spelling at the beginning of the sentence. Check all references)
2) 1962 - 2061 Johor River Water Agreement provides Singapore the right to draw up to 250 million gallons per day from the Johor River.

[5] Founded in 1989, Hyflux is a leading water utility operating company in Singapore. It drew attention when it was awarded a project for contracting and operating the country's first "NEWater" plant from the government. In the plant, wastewater is treated and reclaimed, to be reused as potable and industrial water. In following year, the plant started operation. In 2005, Hyflux opened Asia's largest desalination plant (SingSpring), which has a 30 million gallon/day treatment capacity. Combined with NEWater plant, Hyflux

September 2013, the second desalination plant, known as Tuaspring, started operation through Hyflux, supplying 70 million gallons of water per day. As of 2011, it can supply up to 10 % of the total supply of water for the nation.

According to the PUB, as of 2010, the total demand of water is 380 million gallons/day, of which 45% is for households and 55% for non-household use. However, it is estimated that water demand double, with the proportion being 30% for households and 70% for non-household use in 2060. As of 2011, NEWater for 30% and desalinated water accounts for 10% of the total water supply as described above.

From 2006, Singapore has been supporting research and development to secure water from the two "taps", 50% and 25%, respectively, of the total water supply by 2060.

Of the four "taps", NEWater and seawater desalination technologies are largely dependent on research and development using science and technology.

After the successful development of NEWater in 2002, and the start of operations of the large-scale desalination plants in 2005, Singapore’s research and development policy, which was relatively inward (domestic and passive) about aiming to secure the water supply for domestic use, has become more outward (external and proactive). Singapore, thereby, has succeeded in attracting more foreign companies that focus on research and development, reflecting the very type of Singapore's growth strategy, industrial development and employment creation. The water sector can be regarded as the driving force of the various efforts above. The Singapore government identified water as one of the prioritized fields in the 4th Science and Technology Plan (2006-2010, 5-year plan) and committed to invest SGD330 million over 5 years (another SGD140 million allocated in 2011, bringing the total to SGD470 million).

To efficiently operate the fund for research and development in accordance with the guidelines of the government and to comprehensively lead environment water-related industry development, the "Environment and Water Industry Programme Office (EWI)" was established by the Ministry of the Environment and Water Resources in May 2006.

EWI is a virtual interagency body responsible for organizing comprehensive guidelines on the development of the water and environment industry in Singapore (tentatively set up for 5 years from 2006 to 2010 and the following 5 years from 2011 to 2015) and is substantially operated by the resources of PUB (human resources and facilities, etc.).

EWI is mainly responsible for organizing various components and research and development programs that are expected to contribute to the water and environment industry. It also supports various kinds of activities with a vision of developing Singapore into a global hydrohub as early as possible.

Although EWI is administratively operated by the PUB, it is in a position to be able to operate resources and personnel of government organizations relating to the environment and water industry development, such as Singapore Economic Development Board (EDB), International Enterprise Singapore (IES) etc. Under the leadership of EWI, different government organizations together closely coordinate and effectively put into practice environmental and water policy.

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is providing about 35% of Singapore's water demand. It also operates businesses in 400 places overseas, including China and the Middle East.

Based on the three main strategies as given below, EWI supports environment and water-related industrial development in Singapore.

1) Cluster development by attracting foreign enterprises and improving local companies
2) Research capacity development by supporting research and development and human resource development
3) Internationalization of local companies by government-led support for exporting water-related industry and branding

Figure 2-11: Environment & Water Industry Programme Office: EWI

Excerpt from "Ensuring Water Sustainability in Singapore", PUB

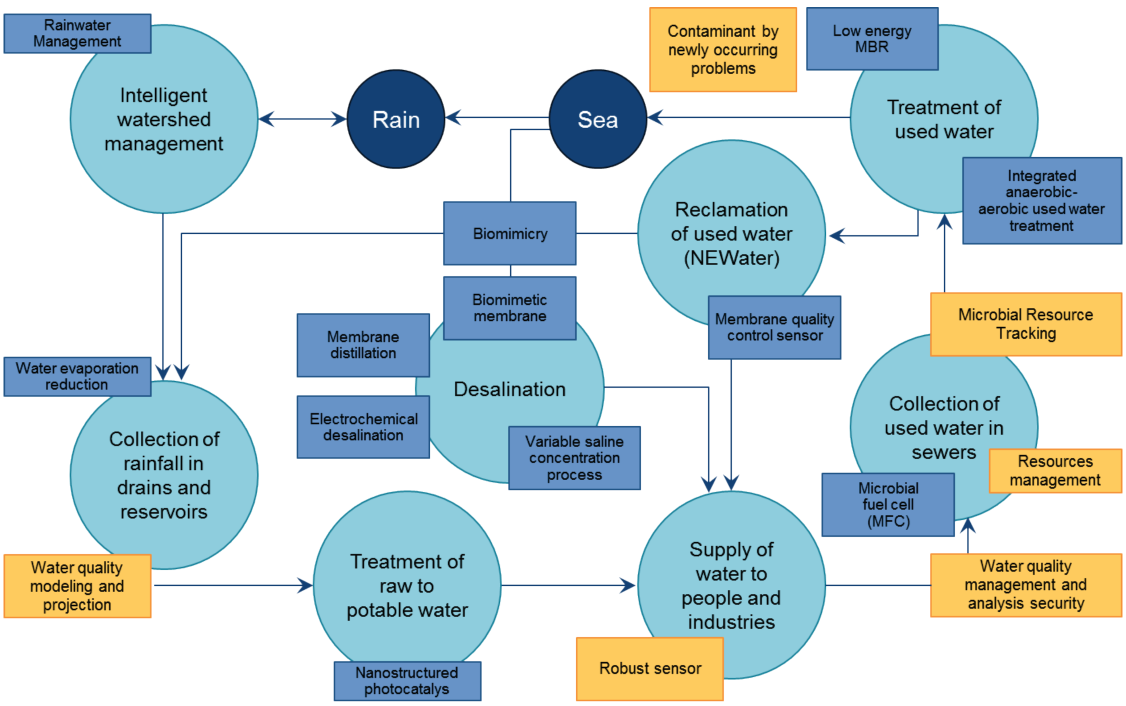
One of the main strategies undertaken by EWI to promote research and development into the most advanced water treatment technology is the "Environment and Water Research Program (EWRP)". This is a competitive funding program to promote top-down research and development in line with government policy.

In this program, the research field that is needed to ensure the status of Singapore as a global leader in water-related technology is the main subject to be supported.

In the EWRP, regardless that the research practitioner is a university/public research institutions or private companies, funding is available for a wide range of research subjects from basic to applied research that is innovative and pursues new ideas. However, any research should have a vision of ultimate industrialization in order to obtain grant. In addition, implementing agency/organization needs to be based in Singapore (residing in Singapore, not necessary to have a corporate status in Singapore).

EWRP has two types of fund scheme: one is only for private companies, and the other is for all research institutions, including private companies, universities and public research organizations. Funds can be allocated to personnel, equipment, services and training expenses etc. The research costs of public institutions will be covered 100% and 70% for private companies by the EWRP fund.

Figure 2-12: Research and Development in the Water Loop



(Note) Excerpt from "Ensuring Water Sustainability in Singapore", PUB 5

In Singapore, major organizations that conduct water-related research both at basic and applied levels are NUS, NTU and PUB. NUS and NTU are the research universities representing Singapore. In order to contribute to water research, the two universities have been systemically engaged in R&D on water-related science and technology by facilitating research units such as the NUS Environmental Research Institute (NERI) and Nanyang Environment and Water Research Institute (NEWRI).

As for PUB, in 2002, it started an R&D program in cooperation with local and foreign companies and undertaken 364 R&D projects valued at SDG214 million. In 2010, PUB's annual R&D budget increased from SDG5 million to SDG 20 million, making its role as R&D player of water much larger.

In 2004, PUB established WaterHub to make a water research hub of industry-government cooperation on water research and development. WaterHub serves as a place for academic knowledge, academic acquisition, research and development and networks for water-related industrial organizations located in Singapore. It is more like a small version of Biopolis, which was completed in 2003 as a cluster for industry- academia and government interdisciplinary cooperation and human resources development contributing to the next generation of industrial development in the biomedical field of Singapore.

Currently at WaterHub, several efforts have been implemented to meet the concept of EWI centering on R&D and technology development. For human resources development, a program (Academy@WaterHub) is under way aiming to produce experts who can contribute to the water-related industry. For cluster development and internationalization, an incubation center (R&D@WaterHub) was launched from 2007 in order to encourage cooperation from local and international water-related companies. In addition, networking events and interactive exchange opportunities (Connect@ WaterHub) have been provided.

2.9 Summary

The most important issue from its founding in 1965 for Singapore was "how to feed the people," in order to build a stable society; this was the top-priority to be addressed. Given that such a small land with no sufficient natural resources and a small population, from the early days of independence, Singapore has disregarded primary industry such as agriculture and mining and also moved away from labour-intensive industry regarding it as non-competitive in other Asian countries. Taking account of its comprehensive national capacity, one perfect option left for Singapore was to differentiate itself from others by promoting high-value-added industrial realization with advanced knowledge and technology based on the development of science and technology capacity.

To put it in an extreme way, Singapore’s science and technology and R&D is a development of the means to contribute to the attraction and development of industry, which is a source of earnings for the population. To that end, it is probably fair to say that the development of human resources and infrastructure improvement attractive to such industries have been carried out continually over the past 50 years.

Also, given the fact that it is a small nation with limited resources, the means of the science and technology and R&D investment must be top-down, not omnidirectional applying to various fields of science and technology, but targeting such areas likely to support industries that guarantee employment for the next generation and return wealth to the nation.

Intensive and heavy investment in R&D in the bio-medical field and water sector in the early and late 2000s is a prime example of the growth strategy of Singapore that had no specific high-value-added industry. Singapore has been forming a state with "Eco-system development, as a measure to attract foreign companies, through strengthening R&D capabilities with intensive government funding, industrial promotion by further R&D efforts, job creation, and a growth loop for the development of advanced skilled human resources," and this pattern will be carried on with aggressive R&D investment practices.

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See also:

- S&T related links (Ministries, Research Institutes and Universities)
- A*STAR http://www.a-star.edu.sg/

- NRF http://www.nrf.gov.sg/
- NUS http://www.nus.edu.sg/
- NTU http://www.ntu.edu.sg/Pages/home.aspx
- SUTD http://www.sutd.edu.sg/
- PUB http://www.pub.gov.sg/Pages/default.aspx

3. Malaysia

3.1 Outline

Malaysia is seeking to establish a nation focusing on the sustainability of the country after 2020 by supporting S&T. The government is promoting key areas, i.e., technology development related to palm oil as Malaysia's major primary product, and ICT. Malaysia has a system that a Science Advisor to the Prime Minister provides the Prime Minister with scientific advice. However, the R&D expenditure is strikingly small, and the number of research personnel is extremely low. In order to promote S&T, it is absolutely imperative to expand the size of the budget for S&T and to develop human resources.

3.2 Current Socioeconomic Trends and Background

3.2.1 Basic Information

The official name of Malaysia is "Malaysia". Its capital is Kuala Lumpur in which about 1.6 million people reside. Land area is about 330,000 km^2, about 90% of that of Japan. While Malaysia is a multi-ethnic state with a population around 30 million, the size of the population is relatively small among the ASEAN countries. It is the 6th largest after Indonesia, Philippines, Vietnam, Thailand and Myanmar.

3.2.2 History

Malaysia has its origin in the Malacca Kingdom, which was a Malayan Islamic port state that flourished in the south coast of the Malay Peninsula in the 15th century. From the 16th to 17th century, it was dominated by the East India Company of Portugal and the Netherlands and after the 19th century, put under colonial rule by Great Britain. During the early to late modern period, Malacca, which is known as "Historical City" today, immensely prospered as the key junction of trade in Asia. After experiencing temporary occupation by the Japanese Army during the World War II, the British Malaya Federation was formed in 1948, and it became independent in 1957. In 1963, joined by Singapore, Sabah and Sarawak in the northern part of Borneo Island, Malaysia was founded. In 1965, Singapore became independent from Malaysia and continued up to the present day.

3.2.3 Politics

Since independence, the ruling coalition led by UMNO (United Malays National Organization) consistently remained in power and has established a stable political regime in Malaysia. The political stability has significantly contributed to the development of Malaysia.

Malaysia is a federal country consisting of 3 Federally Administered Areas (Capital Kuala Lumpur, Labuan Island and Putrajaya) and 13 provinces (11 provinces of the Malay Peninsula plus Sabah and Sarawak provinces). The government system is constitutional monarchy, and the current head of state is Abdul Halim Mu'adzam Shah XIV who assumed the post in December 2011. The head of the state is elected among 9 Sultans by mutual vote in a Sultan meeting. The term is 5 years.

The Federal Parliament is bicameral and the Malaysian Congress consists of the King, Senate, and the House of Representatives. The Senate and Representatives are comparable to the upper house and lower house respectively. The leader of the largest ruling party in the lower house is elected as the Prime Minister through election, and appointed by the head of the state of Malaysia.

Mr. Najib Razak (Haji Mohammad Najib bin Tun Haji Abdul Razak) has been in office since 2009 as the 6th Prime Minister of Malaysia.

The ruling coalition won the Lower House General Election in May 2013 by consolidating rural support, however, the coalition of opposition parties made big strides mainly in urban areas which are largely populated by Chinese, and the aggregate votes exceeded that of the ruling coalition. Thus, we can see an increase in opposition power in recent years. The problems that the current administration faces are difficult maneuvering required to implement political measures, such as desertion of Chinese and younger generation supporters, emerging conservative wing among Malayan people who have been their support base, TPP negotiation, and introduction of the indirect tax, the goods and services tax (GST).

The current Najib administration is widely thought to be stable until the next general election in 2018. It is becoming apparent that coalition of opposition parties are not moving in step with each other after the general election in 2013, and it is unpredictable whether or not the cooperative framework among them will be maintained after the next general election.

3.2.4 Ethnic Group, Languages and Religions

Malaysia is a typical multi-faith/multi-ethnic country with over 60% Malayan, over 20% Chinese, and about 10% Asian Indians. The "Bumiputraism," or native-first doctrine, provides Malayan people[6] with preferential treatment in economic activities e.g. in starting business and tax relief, in hiring of public servants, or in admission to state universities but it caused brain drain of Chinese people who are frustrated with such policy. To prevent such brain drain, the Prime Minister Najib has been encouraging for all ethnic groups to blend into each other and unite as one nation, however, some Malayan people have grievance against such stance. As proof of this, the ruling coalition that holds a majority in Congress has been losing a number of seats, although gradually, after the general election in 2008 and 2013.

The official language of Malaysia is Malaysian. In a broad sense, "Malay" sometimes includes Indonesian, etc., so the name "Malaysian" has been officially used as national language since 2007. English, which had been official language until 1967, is still popular as a quasi-official language and it is used as common language among each ethnic group along with Malaysian. Basically, the mother language for Chinese people is Mandarin and that for Indian people is Tamil, which created the world's leading multilingual environment in Malaysia.

The constitution stipulates that Islam is national religion in Malaysia but it also stipulates norms for protecting religious freedom of individual citizens. Mainly Malay people are of the Islamic faith. In many cases, Chinese people believe in Buddhism, and Indian people believe in Hinduism.

3.2.5 Education System

Malaysia has a 6-3-2 system of education (6 years of elementary school, 3 years of middle school identified as lower secondary education, 2 years of high school identified as upper secondary education, and preparatory courses for universities). Usually, after completing high school, students are supposed to go to preparatory courses for universities and make necessary arrangements for STPM (Malaysian Higher School Certificate) which is considered as a pre-university examination. After passing STPM, students can enroll in universities or colleges.

The Rate of literacy in Malaysia is 93.1 %, using the CIA World Factbook in 2010.

[6] In a narrow sense, Bumiputraism includes almost all the indigenous ethnic minorities, such as Orang Asli, as eligible for preferential treatment.

3.2.6 Economy

As for the size of the economy, nominal GDP of Malaysia exceeds 300 billion dollars. The nominal GDP per capita reached 10,000 dollars in 2011, which is the 3rd among the ASEAN countries. Economically, it is no longer appropriate to call Malaysia an underdeveloped country, but rather it should be recognized as a medium-sized semi-developed country.

Under the former Prime Minister Abdullah who took over power in 2003, steady economic progress has been achieved as was the case under the preceding administration, and maintained 5% growth even when it faced financial crisis in 2008. It also maintained 5% growth under the current Najib administration, but the real GDP growth rate in 2013 was 4.7%, less than that of previous year's 5.6%. It was caused by the slower growth of export in the first half of the year due to sluggish foreign demand, and it was the lowest growth rate since 2009, when it recorded minus growth.

Figure 3-1: Summary of Malaysia's Economy

	2011	2012	2013
Real GDP growth rate (%)	5.2	5.6	4.7
Nominal GDP per person (USD)	10,068	10,440	10,538
Unemployment rate (%)	3.1	3.0	3.1
Current account (1 million ringgit)	102.426 billion	54.460 billion	39.907 billion

Source: The World Bank / JETRO World Trade Investment Report (2014)

(1) Trade

Exports increased for 4 consecutive years to record 719.8 billion ringgit (about 22,300 billion yen) in 2013, a 2.4% increase over the previous year, but only slightly. Import also increased for 4 consecutive years to a record 649.1 billion ringgit (about 20,100 billion yen), a 7% increase[7]. As the increase of import exceeds that of export, the trade surplus decreased for 2 consecutive years.

The export trade that holds the largest share is electric/electronics products, which account for about 30%. The second largest items in monetary terms are palm oil and palm oil products. The export of petroleum and gas accounts for about 20% of total export. As for the import, similar to the export, electric/electronics products are at the top of the list accounting for slightly less than 30%. The petroleum and gas account for less than 15% of the total[8].

As for the major trading partners, Singapore is the largest trade partner for export, and China is the largest trade partner for import. Japan is the 3rd ranked trade partner for both export and import and is thought to be an important trading partner for Malaysia

Figure 3-2: Major trade partners of Malaysia (2013) (Unit: million ringgits)

	Export	Import
No. 1	Singapore (14.0%) (100,439)	China (16.4%) (106,264)
No. 2	China (13.5%) (96,966)	Singapore (12.4%) (80,226)
No. 3	Japan (11.1%) (16,686)	Japan (8.7%) (56,360)

Source: JETRO World Trade Investment Report (2014)

7 Malaysian ringgit is the currency of Malaysia. As of 2013, 1 ringgit was converted to 31 yen.
8 https://www.jetro.go.jp/world/gtir/2014/pdf/2014-my.pdf

(2) Industrial Structure

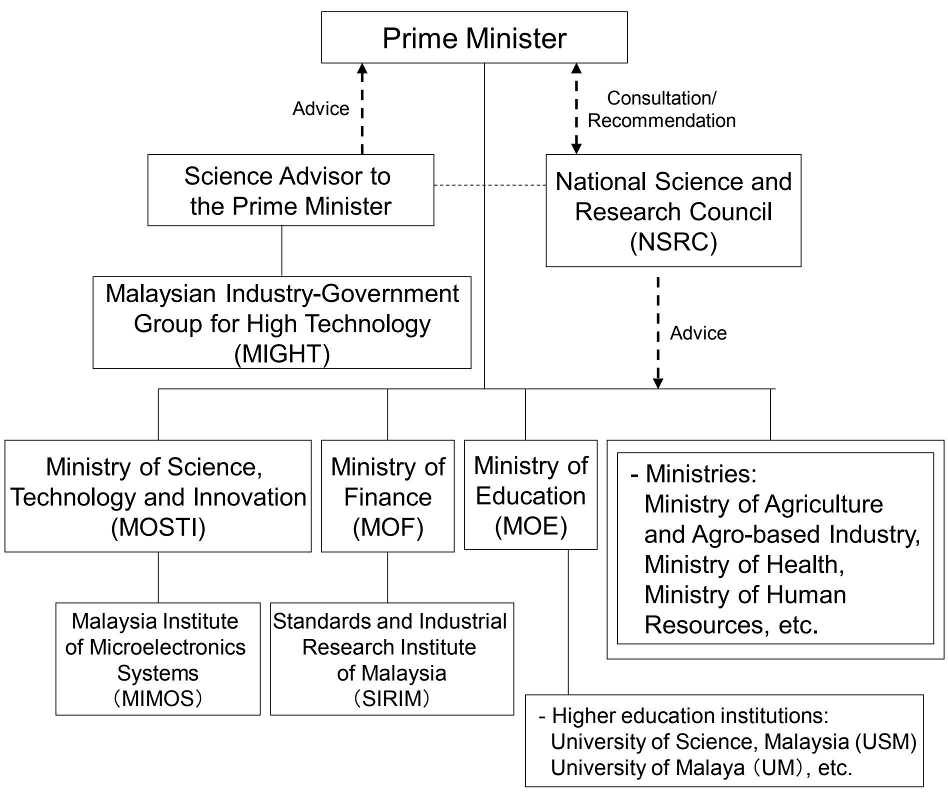
Traditionally, the industries in Malaysia were dependent on the export of primary products such as rubber and tin, but it has succeeded in industrialization by inviting foreign investments to promote the manufacturing industry. The major industries at present are manufacturing (electrical equipment), agriculture and forestry (natural rubber, palm oil and lumber), and mining (tin, crude oil and natural gas (LNG)). In 1991, then Prime Minister Mahathir announced “WAWASAN2020 (Vision 2020)” as the national goal to become part of the developed countries by 2020. The economy has shifted to manufacturing/export of industrial products as shown in the “2013 GDP breakdown by industry” in which the agriculture/forestry/fisheries industry accounts for about 7%, mining/manufacturing/construction industry accounts for about 36%, and the finance/service industry accounts for about 13%.

3.3 Science and Technology Policy

3.3.1 S&T Related Organizations

The following figure 3-3 shows the governmental organization chart related to S&T in Malaysia. Government ministries related to S&T are the Ministry of Science, Technology and Innovation (MOSTI) and Ministry of Education (MOE).

Figure 3-3: Governmental Organization Chart Related to S&T in Malaysia



3.3.2 Scientific and Technological Planning and Policy

(1) Mid-term National Development Plan

Malaysia has a 5-year plan to promote national socioeconomic development, and the 1st 5-year plan has started in 1996. Currently, it is in the last year of the 10th 5-year plan (Tenth Malaysia Plan: 10MP, 2010-2015).

In the past, Prime Minister Mahathir implemented various economic policies and especially focused more energy on promoting ICT. A typical related policy was the construction of a cluster zone called the Multimedia Super Corridor (MSC) with improved ICT infrastructure. This policy was aimed to form an industrial cluster by providing an incentive for domestic / overseas enterprises and research institutions, and to encourage technology transfer, human resource development, promotion of new industry and job creation. It achieved some positive results, and 2,170 companies acquired MSC status and 97,000 jobs were created in 2007.

Along with ICT, another area on which the Malaysian government focused its energy in their 9th 5-year plan (9MP, 2006-2010) was biotechnology. In this area, a series of measures was implemented in the Prime Minister Abdullah era (2003-2009), the most typical of which was the introduction of “BioNexus” Status that provided an incentive to enterprises and R&D institutions in the biotechnology area, such as corporate tax exemption and easier employment of foreigners, etc. as well as the establishment of Malaysia Biotechnology Corporation that centrally controls the biotechnology-related measures (See below for details).

Malaysia, a medium-sized semi-developed country, is no longer able to compete with China, Vietnam, etc. with its labor-intensive industry due to surging personnel costs. Under such circumstances, the Malaysian government has repeatedly appealed to move away from a labor-intensive to a knowledge-based economy, which was also emphasized in 9MP. In 9MP, under the slogan of “Join the ranks of developed countries by 2020,” they set a target to expand the ratio of R&D expenditure on GDP to 1.5% by 2010, but things did not work out as intended, and its ratio reached only 1.01% in 2009[9]. The major items related to S&T listed in 9MP were 1) Promotion of ICT industry and creation of international hub, 2) Scale expansion of manufacturing and related service industry, 3) Creation of wealth by promoting biotechnology in agriculture, healthcare and other industries, 4) Educational reform to develop human resources, 5) Utilization of science and technology innovation (Enhancement of innovation systems and human resource development for S&T), and 6) Sustainable development of energy.

In current 10MP, they aim to join the ranks of high-income countries by 2020 by keeping the real growth rate of 6.0%, however, reflecting the lessons from 9MP, they set a moderate goal, i.e. R&D expenditure of 1% to GDP by 2015. This goal was already achieved when they recorded 1.07% in 2011[10]. In 10MP, they articulated the innovation-driven growth and clearly described the building of IT infrastructure toward formation/promotion of innovation eco-system, enhancement of education and trainings. Policies and directions related to S&T are described below in detail.

(2) S&T Policies

As a policy specialized in S&T field, the 3rd stage (2013-2020) of “National Policy on Science, Technology & Innovation (NPSTI), 2013-2020” is currently underway.

The outcome of the 1st stage of National Science and Technology Policy (STP1) started in 1986 are 1) Integration of S&T in the national development plan, 2) Funding and management of R&D, 3) Enhancement of S&T infrastructure, and 4) Building of a S&T consultative system.

9 UNESCO Institute for Statistics
10 UNESCO Institute for Statistics

Subsequently, the 2nd stage of National Science and Technology Policy (STP2) was implemented during 2002-2010, which focused on the setting up of the integrated approach between the public sector and industry toward the development of S&T, which clearly described 6 expected outcomes; 1) Enhancement of systematic framework, 2) Enhancement of efforts toward commercialization of the results of R&D, 3) Enhancement of human resource development and specialized knowledge and skills in S&T areas, 4) Introduction of S&T policy management in the critical areas, 5) Building of specialized knowledge of R&D, and 6) Creation of a dynamic S&T environment that promotes a knowledge-based economy.

In STP2, as with the case of 9MP, they set specific numerical targets to increase the ratio of R&D expenditure on GDP to 1.5% by 2010, increase the number of RSEs (researchers/scientists/engineers) per 10,000 labor workforce population to a minimum of 60 people (Later revised downwardly to a minimum of 50). Also, as the critical technology fields for Malaysia to maintain industrial development, it put emphasis on 11 fields including advanced manufacturing, advanced materials, electronics engineering, biotechnology, ICT, multimedia technology, energy, aerospace, nanotechnology, photonics and pharmaceutical technology.

NPSTI commenced from 2013 with a new name by adding the term "Innovation," but it is actually "STP3," the subsequent stage of STP2. NPSTI is a strategic guideline for the science and technology innovation, and was created based on 5 foundations; 1) Science and technology innovation for the policy, 2) Policy for the science and technology innovation, 3) Industry commitment to science and technology innovation, 4) Governance of science and technology innovation, and 5) Science and technology innovation for a steady, peaceful, prosperous, cohesive, resilient society, and these foundations are promoted by the following 6 strategic actions.

1) Promotion of scientific/social research, development and commercialization

2) Development, utilization and enhancement of talent

3) Revitalization of industry

4) Transformation of governance of science and technology innovation

5) Promotion of science and technology and strengthening of sensitivity

6) Enhancement of strategic international alliance

NPSTI puts emphasis on the critical field of science and technology announced by the National Science and Research Council (NSRC). They cover 9 fields; life's diversity, cybersecurity, energy security, environment and climate change, food security, medical and healthcare, plantation crop and commodity, transportation and urbanization, and water security.

The policy has 2 major numerical targets, i.e., to increase the ratio of R&D expenditure on GDP to a minimum of 2% by 2020 (revised upwardly from 1% stated in 10MP) and to expand the number of researchers per 10,000 labor force population to a minimum of 70 researchers by 2020.

(3) Science to Action (S2A)

Science to Action (S2A) is an initiative launched by the Prime Minister Najib in anticipation of sustainable growth of the nation after 2020, i.e. a government-led S&T support program based on the concept that the progress of society and business world depend to a large extent on the development of S&T. The Prime Minister instructed the Science Advisor to the Prime Minister of Malaysia (Mr. Zakri Abdul Hamid) to review and introduce the S2A program. The purpose of this program is to vitalize the S&T activities and to give back the results to society. In Malaysia, there already is a nation-wide objective called "Vision 2020" advocated by then Prime Minister Mahathir in the early '90s. Following this "Vision 2020," S2A seeks to build a nation by focusing on the sustainability of the nation after 2020 through S&T support. As part of S2A, various novel ideas have been executed to coordinate R&D.

(4) Higher Education Policy

Since the 1990s, Malaysia has been working to promote diversification of higher education, to prevent the brain drain and to strengthen its competitiveness in international society through the privatization of national universities, permission of establishment/operation of private education institutions. The college-going rate in Malaysia is relatively high, 40%. Aiming at the internationalization of higher education institutions, and in collaboration with overseas educational institutions, it is promoting the Twinning Program to encourage foreign universities to open branch schools in Malaysia by making a plan to receive 100,000 foreign students. They are actively receiving students especially from Indonesia, the Middle East and Africa, the number of which exceeded 80,000. The reason why Malaysia has been receiving many foreign students from such areas is that Malaysia has a good environment that it is easy to receive students from the Middle East as they are both Muslim countries and the low tuition is a big attraction for these students. MOE has established a center for supporting Malaysian students in many countries around the world.

Based on "Vision 2020," the national target to join the ranks of developed countries by 2020, the "Higher Education Strategic Plan (2007-2020)" was announced in 2007. The Higher Education Strategic Plan sets the top 7 goals based on the concept that, in order to promote economic development of the nation, it must be founded on superior knowledge based on an academic base and innovation, skilled performance and superior individuals. The top 7 goals are as follows.

1) Expansion of access to education
2) Improvement in the quality of education
3) Enhancement of R&D
4) Upgrading and expanding of higher education institutions
5) Promotion of internationalization
6) Upgrading and expanding of lifelong learning
7) Enhancement of structure of the Ministry of Education

Based on this strategic plan, they are currently working to enhance R&D, to upgrade and expand higher education institutions, and to promote internationalization. Speaking of the former, they aim to 1) establish 1 or 2 national key university(ies) and have at least 3 universities ranked in the world's top 100, and at least one ranked in the world's top 50 by 2020, 2) while designating 5 key universities as Research Universities (described below), certify MARA University of Technology and other 4 universities as Specific Field Research Universities to strengthen them in each area, as well as to strengthen research/educational function of University of Technology, Malaysia (UTM) and other 12 universities as comprehensive universities. Speaking of the latter, they aim to enhance collaboration with overseas higher education institutions by inviting foreign universities to establish their branch schools, and set targets to increase foreign students to 10% of total students and to increase foreign teachers of key research universities to 15%, etc.

Currently, 90% of administrative cost of national universities is covered by the government budget, but they are required to self-finance 25% of the administrative cost by 2020.

3.4 Promotion Bodies of Science and Technology

In addition to MOSTI that has several research institutions under it, R&D is also carried out by SIRIM Berhad ("SIRIM Berhard" is hereinafter referred as to "SIRIM") as well as in other national research institutions and universities. SIRIM is an institution, the function and role of which is comparable to AIST (National Institute of Advanced Industrial Science and Technology) of Japan.

First, as explained in more depth below, let us introduce MOSTI that plays a key role in policymaking and planning of science and technology policy and in implementing researches. Then, we will introduce SIRIM, the key R&D institution in Malaysia. As some other universities also play important roles in developing R&D, we will introduce major universities after mentioning MOE.

3.4.1 Ministry of Science, Technology and Innovation (MOSTI)

The concept of MOSTI is to create science, technology and innovation that will produce knowledge, create wealth, and enhance the well-being of society, and its missions are 1) to create an environment as a means to produce knowledge and wealth that contributes to the progress of S&T, as well as to improve the quality of life through sustainable development, and 2) to harness science, technology and innovation for the benefit of agricultural and industrial areas, especially, for the development of new economy through ICT and biotechnology. The objectives of MOSTI are summarized into the following 4 points: 1) Promote understanding, recognition, evaluation of S&T, 2) Promote R&D of S&T, 3) Protect and monitor the environment, and 4) Provide efficient technology control support service.

Looking at the organizational structure of MOSTI, one Deputy Minister and one Secretary General are assigned under the Minister, and one Deputy Secretary General each, respectively in charge of policy and in charge of science, are assigned under them.

The Malaysian Science and Technology Information Centre (MASTIC) in the policy division carries out various research as part of the S&T information activities, and publishes national surveys on R&D and the Malaysian S&T Index Report, etc. every 2 years as feedback to policymakers. It seems to be partially overlapped with the activities of CRDS under JST. MASTIC mainly promotes collection and distribution of strategic information related to S&T activities, and provides support to government policy-makers and private sector decision-makers and other organizations, who are interested in research cooperation, commercialization and technology transfer, with the specific database related to the S&T that are put on the Malaysian government website or on the knowledge network. MASTIC also provides a web-based information collection service related to S&T, and conduct activities to disseminate nationwide R&D activities, human resources for S&T, list of specialists, R&D projects in the country, etc. to the users.

Looking at the division in charge of science, they are working on the promotion of government-led biotechnology and ICT. The National Biotechnology Division has implemented R&D in the biotechnology area, and is providing support to the biotechnology sector in their business development by making agriculture and healthcare as the priority areas. The National Biotechnology Division is positioned as the cluster of this field, and it focuses on studying/taking advantage of the possibility of the biotechnology area for economic growth.

ICT Policy Division, as the secretariat under the agency responsible for MSC administration, deals with clarification of the strategic directions, policy planning and adjustment, assessment and adoption of technology, and industrial promotion, in addition to the coordination of the ICT cluster. It also conducts monitoring and adjustment of technical evaluation of ICT projects. Further, it conducts management/coordination of participation status to the ICT cluster, and while promoting development and recognition of ICT at the federal government/provincial government/international level, it carries out international operations related to ICT.

3.4.2 Science Advisor to the Prime Minister of Malaysia

A system is in place to provide the prime minister with scientific and technological advice as there is a Science Advisor to the Prime Minister, and the Malaysian Industry-Government Group for High Technology (MIGHT), an organization under direct supervision of the Advisor to implement the Advisor's instructions, etc. The post of Science Advisor to the Prime Minister was created in the Mahathir era, and currently, Mr. Zakri Abdul Hamid serves as the third-generation Advisor.

MIGHT was established in 1993 as an NPO specialized in industry, and was later placed under MOSTI during 2004-2010. Then, it was placed under the direct supervision of the Science Advisor to the Prime Minister in 2011. Agency Innovation Malaysia (AIM), which is under supervision of the Prime Minister's Office, is different from MIGHT, which is under direct supervision of the Science Advisor to the Prime Minister, in the way that AIM carries out investment in technology transfers and commercialization.

MIGHT is an organization consisting of representatives from industrial circles and government (ministries and agencies) in accordance with the industrial policy of the government, and chaired by successive Science Advisors to the Prime Minister. MIGHT provides advice on policy issues and indicates strategic directions. It also conducts technological management of the country. In this technological management, it provides advice to ministries and agencies on which technology area they should focus on, etc. In this manner, MIGHT does not directly implement plans and political measures but it is an organization to offer insight into such issues, and the insight/advice they offer must always be impartial, and some of them may have viewpoints from cross-sectional perspective across the ministries and agencies. MIGHT does not impose its insight/advice one-sidedly to ministries and agencies, but it tries to make content that can gain consensus from the subject agencies.

3.4.3 SIRIM

SIRIM was established in 1975 through the merger of Standards Institution of Malaysia (SIM) and National Institute for Scientific and Industrial Research (NISIR). SIRIM Berhad was reorganized in 1996 and got corporate status.

The concept of SIRIM is to join the ranks of the world's highest organizations in its quality and technology, and its mission is to improve its business competitiveness through the quality and engineering innovation. Four concrete roles of SIRIM are to 1) promote improvement of quality, 2) become a national science and technology development corporation, 3) serve as the medium of technology transfer, and 4) provide a system and technological infrastructures to the government.

In addition to research facilities for each field within the premise of SIRIM, there are the Advanced Materials Research Centre, National Metrology Laboratory, Automotive Engineering Centre, Incubation Center, etc., and it has research stations all over Malaysia. It also has a research station on Penang Island. It has 2,500 members of staff in total, among which 500 are researchers. Although their budget is 200 million ringgit (about 6.6 billion yen), about 15% of which is the government subsidy and the rest is funded by commercialization-related funds such as licensing.

The proper authority of SIRIM is the Ministry of Finance but actually most of the project cost comes from MOSTI as it undertakes public projects of MOSTI or MOE.

3.4.4 Ministry of Education (MOE)

In Malaysia, there used to be Ministry of Higher Education (MOHE) that deals with higher education and Ministry of Education (MOE) that deals up to secondary education, but they were merged in 2013 to form the current MOE. MOE is the 2nd largest ministry in the scale.

Currently, there are 535 private universities (among which 443 are single-department colleges) and 20 public universities. Among national and public universities, 5 universities are designated as "Research Universities" that focuses on scientific and technological researches; University of Malaya (UM), University of Science, Malaysia (USM), National University of Malaysia (UKM), Universiti Putra Malaysia (UPM) and University of Technology, Malaysia (UTM).

The overall direction of educational environment is such that, by bringing in as many as students to technical colleges, they can acquire skills and accelerate building of an industrial base. There is an intention to generate economic effects by increasing industry-ready human resources after graduation in society, rather than to increase the number of students in doctoral or master's courses.

As for the research cost, the trend is to impose realistic requirements such as commercialization in trying to encourage universities' voluntary efforts to manage their own operations. The above 5 Research Universities have their respective realms of expertise. Comparison based on QS World University Rankings shows that, for example, while USM excels in environmental science, pharmaceutical science and civil engineering fields, UM and USM are strong in computer science and industrial chemistry areas.

3.4.5 University of Science, Malaysia (USM)

USM, founded in 1969, currently has 30,000 students, among whom 10,000 are graduate students. Its campus is on Penang Island in the western part of the Malay Peninsula in the Straits of Malacca, where Mr. Zakri Abdul Hamid, current Science Advisor to the Prime Minister, was temporarily enrolled in this university. There are about 1,500 faculty members, among whom foreign teachers slightly exceed 100.

USM is one of the 5 Research Universities in Malaysia and it covers not only natural science but also the social science area. The realms of expertise of this university are IT, chemical engineering, civil engineering, aerospace engineering, mechanical engineering, pharmaceutical science, etc. in addition to environmental science.

Collaborative Research in Engineering, Science and Technology (CREST) is one of the Funding Programs provided by USM. It is a program in which an enterprise and the government each contribute half of the fund, aiming to deepen cooperation with enterprises and accelerate technology transfer. On Penang Island where USM is located, there are many semiconductor factories and close relationships with the enterprises are built. High employment rate in such enterprises is a big reason for the students to select USM. USM intends to further advance research on industrial technology by taking advantage of the location.

3.5 Input Index of Science and Technology[11]

3.5.1 R&D Expenditure

Gross expenditure on R&D (GERD) in Malaysia is about 4.9 billion dollars and its ratio to GDP is 1.07% (2011). Compared to GERD in Japan, which is about 150 billion dollars (2011), we can see how small the R&D scale is in Malaysia. The strikingly small absolute amount of R&D is a serious problem for the development of S&T in Malaysia.

3.5.2 R&D Expenditure Ratio by Sector

Looking at the R&D cost burden by organization, about half of R&D cost is borne by the government and the other half by industry; 41.4% by government and 55% by industry (2011). According to the data of 2008, government burden was 30.1% and industry burden was 66.4%, from which we can say that the government burden to total burden is slightly increasing.

3.5.3 Percentage of R&D by Type of Activity

Percentage of R&D by the nature of R&D is such that the basic research accounts for 17.2%, applied research accounts for 66.4% and development research accounts for 16.4% (2011). In the data of 2008, percentage for basic research was 12.4%, applied research was 75.6%, and development research was 12%, which show that they are increasing percentage of basic research and development research and decreasing that of applied research.

3.5.4 The Number of Researchers

Based on the data as of 2011, the number of researchers in Malaysia is 73,752 (HC) and 47,242 (FTE). Looking at the number of researchers per 1,000 labor force, the size of researchers in Malaysia is 5.9 researchers (HC) and 3.8 (FTE).

The number of researchers in Malaysia is overwhelmingly low, compared to numbers in developed countries like Japan and the US. Fostering and retaining of excellent human resources has become a big challenge in promoting R&D.

3.6 Output Index of Science and Technology

3.6.1 Science Research Papers

First, let us look at the number of scientific articles that is the indicator of basic research. Based on SciVal, which is the research analysis tool of Elsevier B.V., we compared the number of scientific articles, citation count and number of authors in Japan and that of the 10 ASEAN countries (see figure 3-4). If we look only at the number of scientific articles, Malaysia is tops among the ASEAN countries surpassing Singapore.

[11] UNESCO Institute for Statistics

Figure 3-4: Comparison of Selected Countries by Number of Science Paper

Item / Country	Number of Papers	Number of Citations	Number of Authors	International Co-Authorship
Japan	648,938	3,534,908	599,167	23.6%
Malaysia	93,406	292,001	76,671	31.3%
Singapore	80,680	701,014	48,757	51.5%
Thailand	53,334	257,150	48,585	37.4%
Indonesia	15,728	58,632	17,247	55.0%
Vietnam	12,696	60,540	13,670	67.9%
Philippines	7,354	47,088	7,747	57.3%
Cambodia	1,064	10,905	1,258	88.8%
Brunei	879	2,373	747	48.9%
Laos	750	4,237	810	93.6%
Myanmar	558	1,651	663	60.8%

Source: Elsevier, SciVal Database

3.6.2 University Rankings

As we have seen in the scientific articles section, it is not that the level of scientific research of Malaysian universities is low. However, no university is ranked highly in the international ranking of universities. According to the QS World University Rankings 2013, UM was ranked 167th, UKM was 269th, USM was 355th, UTM was 355th, and UPM was 411-420th.

3.6.3 Patent

There is no technology or products that are typical for Malaysia. For instance, Malaysia has not been able to produce products such as automobiles in Japan, and the domestic civilian industry is too weak to carry out R&D and obtain patents to compete in the domestic or international market. Consequently, compared with Europe, Japan, China, and Korea, the number of patents obtained is overwhelmingly small. Compared with the 2012 data, the number of patents obtained is about 7,000 in Malaysia while that of Japan is 343,000 and that of the US is 543,000[12].

3.7 Foreign Relations

3.7.1 Japan

The "Look East Policy (Eastern Policy)" advocated by the Prime Minister Mahathir in 1981 shows a strong bond between Japan and Malaysia. It is a policy to contribute to the development of economic society and to build industrial infrastructure in Malaysia based on the notion that the key to economic success and development of Japan (and South Korea) was the work ethic, motivation to learn/work, and managerial approach, and by learning these factors. It can be said to be a very unique policy in that to single out a specific country and to learn the culture, ethics and moral values of that country.

Following this proposal, attention to Japan increased in Malaysia and the number of students to study in Japan and Malayan corporate researchers dispatched to Japanese enterprises suddenly increased, as part of human resource development. As a result, it provided Japanese enterprises with human resources who understand not only Japanese work ethic or morals but also the Japanese

[12] WIPO website: http://www.wipo.int/portal/en/index.html

language, which supported Japanese enterprises to advance into Malaysia.

However, as the Malaysian economy became a middle-income country, the number of students who want to study in Japan is slightly decreasing recently. As previously mentioned in the higher education section, Malaysia is trying to attract overseas universities and to grade up the level of all universities in Malaysia. Under such circumstances, and under the Look East Policy, the number of Malaysian people sent to Japan in the last 30 years is around 15,000 in total. On the other hand, studying abroad to the US and China is increasing, and some worry about the decreasing presence of Japan in Malaysia. If such situation goes on, the importance of Japan will decrease in Malaysia and there is a fear that the number of pro-Japanese people will also decrease.

Actually, the Japan Foundation, which aims to provide Japanese language education in Malaysia, is not going very smoothly. For example, about 10 Japanese-language teachers visit Malaysia in a year. Meanwhile, China sends about 2,000 Mandarin-language teachers a year to Malaysia to spread Mandarin, and the difference is obvious in the number of teachers. The Malaysian government is trying to develop science and technology by improving the educational level, so they have strong interest in what actually works for the development. In that sense, it can be said that Japan is in a slump in terms of a low level of activity including dispatching Japanese teachers, although their interest in Japanese language is still high.

(1) Co-authorship of scientific articles with Japan

With regard to the co-authorship of scientific articles, the data (1999-2001, 2009-2011) of the “Benchmarking Scientific Research 2012” of National Institute of Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology, Malaysia is not ranked in the key top 10 countries seen from the Japan side in any specific area, e.g. chemistry, material science, physics/cosmic science, computer science/mathematics, engineering, environmentology/ecology/earth science, clinical medicine/psychiatric medicine/psychology, and basic biological science. There may be several reasons for it but the biggest reason is that the gap in the scientific and technological capabilities is too big between the two countries, and Japan has not considered Malaysia as the most important country to work with. For instance, one of the major assistances provided by Japan to Malaysia is ODA, mainly cooperation through yen loans that commenced from 1966, which has significantly contributed to the society and economy of Malaysia including the building of power plants, railways, airports and other infrastructures.

(2) Establishment of universities to provide Japanese-style engineering education

The Malaysia–Japan International Institute of Technology (MJIIT) was founded as an academic institution aiming to provide Japanese style engineering education to foster Japanese style work ethic in Malaysia, as the culmination of the “Look East Policy”.

MJIIT was built within the Kuala Lumpur campus of UTM in 2010, financed by yen loans. It accepted its first students in September, 2011, and since then almost 3 years will have passed in October, 2014. As the first graduates will be produced, 2015 will be a crucial test of the university’s ability to lead students to a good job. Originally, MJIIT was planned to be established as an independent university, but finally it was established as one of the faculties of UTM due to lack of funds. For MJIIT, 20 billion yen was contributed during 7 years, about 30% of which was borne by Japan. Along with the faculty, MJIIT has established master and doctoral courses. At present, there are 4 fields, 3 of which provide both courses and the other provides only undergraduate courses.

Generally, Malaysian universities make internship compulsory and particularly MJIIT considers sending interns to Japanese enterprises. The summer vacation immediately before going on to 4th grade (12 weeks) is used for internship.

As for the curriculum, the university has introduced a course system based on international standards. It runs 31 courses (laboratories) and students are assigned to laboratories from the fourth year. Meanwhile, it is also trying to strengthen Japanese-language education and provides Japanese language credits for the 1st and 2nd year of undergraduate courses. For the Japanese language education, dispatched teachers and locally-hired Japanese instructors are teaching. In the future, there is a plan to assign Japanese language teachers from Japan Overseas Cooperation Volunteers.

MJIIT had difficulty in inviting young researchers from Japan, but the situation has been gradually improved and at present, there is 1 researcher in their 30s, 2 researchers in their 40s and 2 researchers in their 50s. According to a JICA specialist who works at this university, Japanese universities seem to have been adopting a flexible stance and they started sending young researchers in the form of “loaned staff.”

As for the postgraduate school, there are two courses, i.e. “research only course” and “research and lecture course,” and in addition, a “lecture-based course” has started. In the master and doctoral courses, a teacher from other universities in partnership with MJIIT is supposed to join as mentor. Students are scheduled to receive 3 months to 1 year of short-term study abroad programs in Japan. Further, it is considering offering double degrees in collaboration with partner universities.

Currently, MJIIT has 500 undergraduate and 300 graduate students. As for the overseas students, there are 9 undergraduate and 59 graduate students. The largest number of overseas students is from Indonesia, because they have similar language and culture. The next highest is students from Iran, which is in the same Islamic zone. Apart from the similarity of culture and religion, we need to note that one of the reasons that so many students come from these countries is that it is difficult for them to study in Europe and the US. MJIIT is intending to increase the number of undergraduate students to 1,200 and graduate students to 1,400 by 2020. As can be seen from these numbers, it is likely that MJIIT will shift its focus to postgraduate education and graduate study in the future.

Programs to invite Japanese students have also been started. For example, Tokyo University of Agriculture and Technology is using MJIIT for its 2-week language study program. This is for students who feel that the barriers are too high to study in Europe and the US. Also, as the Tokyo University of Agriculture and Technology was selected for “Re-Inventing Japan Project” for 2013, there are students who visit Malaysia on one-semester short study programs using the project funding.

(3) Research cooperation among universities

USM and RIKEN exchanged the Comprehensive Agreement Memorandum in 2012. Before that, both institutions had promoted multiphase research exchange/people-to-people exchange since 1993, and RIKEN has been accepting graduate students from USM through its human resource development system. Joint research areas include biomass, biochemistry, immunity/allergy, etc. In 2011, USM-RIKEN Joint Laboratory for Bioprobe Discovery was established as a research center to promote utilization of vast natural resources of south-eastern Asia. Also, USM is planning to jointly set up the USM-RIKEN International Center for Aging Society (URICAS) with RIKEN.

UM was founded in 1905 and has the oldest history among 5 Research Universities. It has a strong partnership between Japanese universities including Osaka University, Tohoku University, Tokyo University, Kyoto University, Chiba University, Nagoya University, Yokohama National University and Tokyo Metropolitan University, etc. Kyoto University has set up its hub office within UM campus and is conducting joint study of hydrology. Osaka University has set up a common laboratory for the materials science field, and is providing students with a special study abroad program to Japan after their having completed Japanese language trainings in UM. The number of UM students who wish to study in Japan is quite stable and about 100 students participate in the program every year.

UM currently forms 5 hub clusters. They are 1) Aging Society, 2) Pursuing Economic Boarder, 3) Equal Resilient City, 4) Sustainable Bio-resource and Technology, and 5) World without Conflict.

(4) SATREPS: Cooperation with Japan Science and Technology Agency (JST)

Science and Technology Research Partnership for Sustainable Development (SATREPS) is a Japanese governmental program that promotes international joint research. The program is structured as collaboration between JST, which provides competitive research funds for S&T projects, and the Japan International Cooperation Agency (JICA), which provides Official Development Assistance (ODA). Based on the needs of developing countries, the program aims to address global issues and lead to research outcomes of practical benefits to both local and global society.

3 SATREPS projects are currently ongoing in Malaysia, and a new project as for 2015 has just adopted. Existing 3 projects are as follows.

Japanese institutions	Malaysian institutions	Agendas
- National Institute of Advanced Industrial Science and Technology (AIST) - Kyushu University	- Putra University, Malaysia (UPM) - Sabah University of Malaysia (UMS) and others	Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation
- National Institute for Environmental Studies (NIES) - Okayama University	- University of Technology, Malaysia (UTM) - Iskandar Regional Development Authority (IRDA) and others	Development of Low Carbon Society Scenario for Asia Regions
- Chiba University - National Research Institute for Earth Science and Disaster Prevention (NIED) - Public Works Research Institute (PWRI)	- Malaysia Multimedia University (MMU) - University of Science, Malaysia (USM) - Tenaga Nasional University (UNITEN)	Research and Development for Reducing Geo-Hazard Damage in Malaysia Caused by Landslide and Flood

(5) Others

MIGHT has created a fund for engineering development of reusable energy in collaboration with Asian Energy Investments Pte Ltd. of Japan. The total amount of the fund is 100 million dollars and it will be operated by a joint venture company.

3.7.2 Other Foreign Countries

The research collaboration is made mainly with the UK, the US and Germany other than Japan. For example, MIGHT is running the “Newton-Ungku Omar” fund set up in cooperation with the UK.

The cooperation of UM with overseas universities includes Cambridge University of the UK. (air pollution), Max Planck Institute of Germany (organic chemistry), etc. Its medical department is affiliated with several Ivy Leagues in the US. It also is affiliated with universities in the Islamic zone (Qatar, Sudan and Egypt).

3.8 Topics on Science and Technology

The following passages describe the topics that characterize the situation of science and technology in Malaysia.

3.8.1 Promotion of Biotechnology Industry

Malaysia has announced its "National Biotechnology Policy (NBP)" in 2005, and has been making strong effort to vitalize the biotechnology area as the driving force of future growth of the country by strictly selecting budget priorities and by adopting a plan to promote the biotechnology industry. With this background, they expected that the biotechnology area, which is thought to produce enormous value and profit even from a world perspective, could become an important driving force of growth for Malaysia, and to realize its vision to become a member of the "advanced knowledge economy community" by 2020.

This NBP aims to build a traditional environment for R&D and industrial development by using the nation's existing strength, which is comprised of 9 key points; 1) Development of biotechnology in agriculture, 2) Development of biotechnology in healthcare, 3) Development of biotechnology in industry, 4) R&D and technology acquisition, 5) Human capital development, 6) Development of funding infrastructure, 7) Development relating to lawmaking and regulatory framework, 8) Strategic positioning of Malaysia as a center of contract research and contract manufacturing, and 9) Establishment of specialized agencies to supervise the development of biotechnology industry. NBP is planned to be realized by going through 3 phases; the 1st phase (2005-2010) Ability development, the 2nd phase (2011-2015) From science to business, and the 3rd phase (2016-2020) Have an established presence in the world.

Let us mention the following 2 characteristic efforts for the realization of the above 9 key points.

First, Malaysia Biotechnology Corporation (BiotechCorp) was established as a one-stop agency to achieve the objective, i.e. development of nation's biotechnology industry. At present, BiotechCorp is under the supervision of MOSTI, and receives advice from the Biotechnology International Advisory Panel chaired by the Prime Minister of Malaysia. The BiotechCorp has 3 major functions as follows; 1) Take a role as a catalyst for the commercial by-products and private sector, 2) Promote market-led R&D and commercialization through financing and industrial development service, 3) Promote R&D and commercialization of the biotechnology area in agriculture, healthcare, and industry.

Secondly, BioNexus was created. The basic concept of BioNexus Network is to create a network between biotechnology companies and institutions by using existing facilities and infrastructures of domestic universities and research institutions as leverage, without being restricted by geographic conditions. Another important characteristic of BioNexus Network is the establishment of COE, which promotes and supports R&D in the biotechnology area. Major COE includes Agriculture Biotechnology Institute (ABI) under the supervision of MOSTI and Malaysian Institute of Pharmaceuticals and Nutraceuticals (IPHARM), etc. The latter is a cross-sectoral research institute established within the above-mentioned USM that focuses on discovery and development of new medicine.

In 9MP, commenced from 2006, the measures to promote biotechnology were set forth, which consisted of 3 pillars; 1) Establishment of “Inno Biologics,” a government-linked biopharmaceutical manufacturer, 2) Introduction of “BioNexus” status to qualify for preferential treatment, and 3) Foundation of the government-sponsored “Malaysian Life Science Fund.”

The above 1) Inno Biologics Sdn Bhd is under the supervision of Ministry of Finance, but it also has a close relationship with MOSTI. It is a contract manufacturing organization (CMO) of biopharmaceutics, who provides services of all stages of manufacturing related to mammalian cell-based therapeutic protein and monoclonal antibody. Target markets are foreign markets, especially they expect that biopharmaceutics and pharmaceutical makers in advanced countries would become their major clients.

The above 2) “BioNexus” status means a series of various benefits given to promising biotech companies, such as freedom of accepting knowledge workers, freedom of funding source, use of BiotechCorp, application of tax breaks (100% exemption of corporate tax for 10 years), exemption of import levy and sales tax for materials and equipment.

This concept is similar to that of MSC that aimed at foundation of the ICT business hub, but it is not just to become a cluster zone of biotech companies but aims to draw in the best brains in the world from universities, R&D institutions, government agencies and private sectors to one market and have them mutually linked through the internet, etc.

The above 3) “Malaysian Life Science Fund (MLSCF)” is a venture funding for life science that makes investment exclusively in the initial stages of biotechnology researches in agriculture, healthcare, and industry areas to vitalize bio-based industry. It is run by Malaysia Technology Development Corporation (MTDC) and the US-based Brill Company. There are 3 areas as investment destinations; 1) Healthcare biotechnology, 2) Agriculture biotechnology, and 3) Industry biotechnology. In the above 1), MLSCF is giving attention to companies that are developing vaccines, diagnostic methods, and other products/technologies that can be applied to infectious diseases that are spreading in Asia. There are needs for investment destinations that can be used to access biodiversity-based natural products, details of which are discussed later. In the above 2), the focus is on the biotechnology to provide food by conserving farm land and water resources, and on the development of new plants for biomass/biomaterials. In the above 3), biotechnology that enables manufacturing of products using recyclable resources is attracting attention. Also, there is a lot of attention given to companies that are studying new biocatalyst and new bioprocess and its technology.

The areas BiotechCorp focuses on fostering are biotechnology related to agriculture, crop, healthcare, and industry.

3.8.2 Abundant Biodiversity and Availability of Land Use

In Malaysia, it is considered that its abundant biodiversity, abundant natural resources, and boundless agricultural sites will be the key to its competitiveness. To encourage discovery of the potential of generating products out of the unexploited nature, the federal government, jointly with the provincial government, has been fostering collaborative relationships with universities and research institutes for a long time, in order to conserve the great reaches of forest (Sabah, Sarawak, etc.). The Forest Research Institute Malaysia (FRIM) under the Ministry of Natural Resources and Environment has a huge variety of expertise and has a biotechnology department that created plant materials through genetic engineering. Sarawak Biodiversity Centre in Sarawak Province is concentrating at the provincial level on biotechnology-based R&D of biological resources, and is actively supporting documentation of knowledge of plants traditionally handed down by the nation, which have been used by the natives from old times but now are disappearing.

Also, Malaysian Herbal Corporation (MHC), a government agency under MIGHT, is making effort to spread the herb industry of Malaysia to the world.

3.8.3 R&D of Agricultural Crops, the Primary Products (Crop Biotechnology)

Malaysia excels at the study of agricultural crops, the primary products such as palm oil and rubber, and at running large-scale plantations. In the palm oil industry, Malaysia has been conducting extensive R&D of palm oil over a period of decades as an engineering pioneer, driven by Malaysian Palm Oil Board (MPOB). Also in the rubber industry, Malaysian Rubber Board (MRB) has been conducting R&D specialized in the development of natural rubber. In this way, sustainable growth of Malaysian primary products seems to depend to a large extent on the use of biotechnology. The priority area of the crop biotechnology includes bioprospecting and application of microscopic organism, domestic use and production of biofertilizer and biopesticide, etc. Also, the priority area of technology includes cell culturing, genomics, proteome analysis of protein substance, etc.

3.8.4 Development and Manufacturing of Medicines

As it takes a long time and a huge amount of cost to develop medicines, international pharmaceutical companies outsource clinical testing to commissioned research organizations (CRO), with which they can significantly save cost and time. In recent years, there is a strong tendency that outsourcing orders are increasing in Asia, and the Malaysian government has been actively encouraging attraction of such orders.

The clinical research in Malaysia is made mainly by Clinical Research Center (CRC). There are about 30 CRCs nationwide, more than 50 well-equipped hospitals, and more than 100 healthcare clinics that might be able to conduct clinical research. CRC is a medical research organization of the Ministry of Health, under supervision of the National Institute of Health.

The government, noticing the growth of the pharmaceutical market in the Asia-Pacific region and high profit ratio, has been trying to attract manufacturing of medicinal chemicals such as vaccines and R&D by providing resources, an investment-friendly environment, tax exemption, subsidies and preferential treatment.

There are mainly 9 priority areas; 1) CMO and CRO, 2) Molecular marker for diagnosis and disease detection, 3) Vaccine and vaccine distribution system, 4) Tropical or emerging genetic disease, 5) Molecular/cell engineering, 6) Organizational study, stem-cell engineering, 7) Sophisticated treatment/diagnosis, 8) Development of pharmaceutical ingredient and combination system, and 9) Medical genome diagnosis and individual therapy.

3.8.5 Reuse and Productization of Biomass Waste

In 2011, Malaysia announced the National Biomass Strategy aiming to generate innovative bio industry that will lead the world. Currently, they are promoting R&D and commercialization related to productization of biomass waste associated with palm oil extraction.

Malaysia boasts the largest production of palm oil next to Indonesia and exports most of it, so it has been seen as one of its important export industries. However, in the process of palm oil production, a huge amount of waste is discharged. Formerly, only 10% of total waste was finally productized and the remaining 90% (empty fruit cluster, string, seed leaf, palm kernel meal, waste fluid) was discarded. Consequently, only Malaysia has been generating more than 100 million tons of waste a year.

Currently, biomass of palm e.g. palm oil waste is being closely watched as a valuable energy resource and especially as raw materials of bio-based products e.g. biopolymer. By promoting reuse and productization of biomass waste, it aims at new revenue growth and job creation. Priority areas are 1) Bioprocess (reprocessing/metabolic engineering) of fine chemicals e.g. enzyme and specialty chemicals, 2) Biocatalyst for diagnosis, application to value-added foods, medicines, functional food, chiral intermediate products for specialty chemicals, 3) Biofuel, and 4) Bioremediation (environmental reclamation technology by organisms).

3.8.6 Research of Oil Palm

About 17 million tons of palm oil is produced a year in Malaysia. The climate condition of Malaysia is especially suited for oil palm cultivation and, together with Indonesia, Malaysia is producing nearly 90% of the palm oil of the world. Palm oil is very much in demand in foreign markets, accounting for about 9% of total export of Malaysia in 2013, and has become its main primary product.

Study of oil palm in Malaysia has a history. The Palm Oil Research Institute of Malaysia (PORIM) was founded in 1979, and its R&D cost was determined to be financed by the tax collected from the palm oil industry. A lot of research is being made, e.g. research of cultivar improvement aiming to increase the crop yields and palm oil processing, as well as research of biofuel and biomass. Generally, it is said to be difficult to continuously obtain a constant amount of biomass, but in Malaysia, homogeneous biomass can be collected from oil palm in large scale because there are more than 350 oil mills throughout Malaysia.

In 2005, the Malaysian Palm Oil Board (MPOB) was founded by integrating the functions of 3 organizations, PORIM, Palm Oil Research and Development Board (PORDB), and Palm Oil Registration and Licensing Authority (PORLA). MPOB administrates and coordinates R&D related to palm oil and palm oil industry and all activities related to the palm oil industry.

3.8.7 Development of Biofuel

The Malaysian government is focusing on the development of biofuel aiming to promote demand for its primary products, palm oil, while reducing imports of fuel. The National Bio-fuel Policy announced in 2005 has set its concept to 1) reduce dependence on depleting fossil fuel by promoting the use of environmentally-friendly sustainable and viable energy source, and to 2) improve the prosperity and well-being of the entire agriculture industry and commodity-based industry through steady and competitive price. As 5 strategic promotional items that support the policy, it set “biofuel for transportation,” “biofuel for industrial use,” “biofuel technology,” “biofuel for export,” and “clean biofuel for environment.”

3.8.8 Effective Utilization of Land for the Development of S&T

About 70% of the land is covered with forest in Malaysia. It provides a vast extent of land for oil palm plantations. Because the geological formation and environment are easy for effective use of land, the construction of Putrajaya, the new administrative capital, took only 3 years in the Prime Minister Mahathir era. The strength that they can effectively use land in their land development is also a big merit for them to promote R&D. They also put emphasis on R&D taking environmental problems into consideration, for instance, they formed an artificial pond at a former site of tin and bauxite mining.

3.9 Summary

As nominal GDP per capita exceeded 10,000 dollars (The 3rd among the ASEAN countries), now Malaysia has become a medium-sized semi-developed country, and the government clearly set its direction toward the realization and development of sustainable economic growth through S&T. The system to support the Prime Minister in the S&T area is in place. However, there are still a lot of problems such as an insufficient R&D budget and research personnel, inadequate communication/transportation infrastructure, etc. Meanwhile, issues like R&D in higher education institutions and human resource development are also important factors that may affect the future S&T of Malaysia.

The key technologies for Malaysia to promote should be biotechnology and ICT. Especially for the biotechnology, which they expect to serve as an important driving force in growth, various promotional measures for R&D and industrial development have been systematically set out. By using Malaysia's existing strength, they have been accelerating development by prioritizing budget allocation in areas such as biodiversity, effective land use, R&D of agricultural crops, development and manufacturing of medicine, reuse and commercialization of biomass waste, development of biofuel.

As for the relation with Japan in the research area, traditionally they have conducted joint research with Japanese major research institutions including RIKEN. However, from the human resources aspect, Malayan people, who have actually been sent to Japan under the "Look East Policy", were not very abundant. Also, while the number of students to the US and China is increasing in recent years, the number of students to Japan from Malaysia is decreasing. However, as shown in the establishment of MJIIT, which aims to realize a university that can provide engineering education comparable to that of Japan, there must be an urgent need to build a bilateral framework that ensures sharing of what Japan has experienced.

Reference:

- OECD Reviews of Innovation Policy: Innovation in Southeast Asia (OECD, 2013)
- Yoshiki Mikami, ed., "Strategy for Technology Development in ASEAN" Japan External Trade Organization (JETRO), 1998 (in Japanese)
- Takashi Shiraishi, "Marine Empire - How to think about Asia -" Chuokoron-Shinsha, 2000 (in Japanese)
- Toshio Miki, "Malaysia Era - Becoming a High-income Country" Soseisha, 2011 (in Japanese)

See also:

- S&T related links (Ministries, Research Institutes and Universities)
- The World Bank http://data.worldbank.org/data-catalog/world-development-indicators
- JETRO http://www.jetro.go.jp/world/asia/idn/
- Prime Minister of Malaysia https://www.pmo.gov.my/home.php
- Ministry of Science, Technology and Innovation (MOSTI) http://www.mosti.gov.my/en/
- LIPI http://www.lipi.go.id/www.cgi?depan&&&2015&&eng&
- BPPT http://www.bppt.go.id/english/

4. Thailand

4.1 Outline

In 2008, Thailand established the National Science, Technology and Innovation Policy Office (STI) under the Ministry of Science and Technology (MOST) in order to promote policies of innovation that serve for social changes. Organizations that actually conduct research leading to science, technology and innovation are the National Science and Technology Development Agency (NSTDA), an independent agency under the MOST, and Thailand Institute of Scientific and Technological Research (TISTR), a state-owned enterprise under the MOST, conducting integrated research and development on industrial technology in core areas of food, pharmaceutical and natural products, bioscience agriculture, materials innovation, renewable energy and environment. Major areas of science and technology include biotechnology, material science, nanotechnology and information communication, and its respective core research center is located at the NSTDA.

4.2 Current Socioeconomic Trends and Background

4.2.1 Basic Information

Thailand officially is the "Kingdom of Thailand". The capital city is Bangkok. Its population is about 65.14 million people (2014) in a total area of approximately 513,000 km^2. It is a rapidly aging country with its strict family planning, and more likely to face a significant population decline if no measures are taken to increase the birthrate.

4.2.2 History

Among Thais, it has been recognized that the establishment of the State of Thailand began in 1238 when Thai ethnic groups defeated the Khmer in Sukhothai, and established the Sukhothai Kingdom. After the Sukhothai Kingdom declined, another state, the Ayutthaya Kingdom emerged in 1350. The Ayutthaya Kingdom fell in the war with Myanmar (Burmese–Siamese War) in 1767. Then, the Siamese dynasty was established after the Thonburi.

Even after experiencing various turmoils such as the Opium War of 1840, the Great Depression of 1929, the World War II in the 1940s, Thailand has continued to pursue modernization under an absolute monarchy. King Mongkut (Rama IV, reign 1851 - 1868) especially initiated modernization. He devoted himself to the study of astronomy and was able to predict the occurrence of a total solar eclipse, being known as "The Father of Science and Technology in Thailand".

After repeated military opposition to the absolute monarchy and public protests for democratization, it became a constitutional monarchy in 1932. In 2006, then Prime Minister Thaksin, who tried to reduce economic disparities by providing assistance to the poor, was forced out of the power for corruption allegations. In 2011, Thaksin's youngest sister, Yingluck took office, but this triggered large-scale anti-government protests led by a vested interest group called the yellow shirt faction, causing the security situation in Thailand to deteriorate. In May 2014, Yingluck was removed from office for unconstitutional personnel assigning. Today, Thailand is politically stable after General Prayut (born in 1954), chairman of the National Council for Peace and Order Council (NCPO) became interim Prime Minister.

4.2.3 Politics

Bhumibol Adulyadej (Rama IX) (born in 1927, reigned from 1946) is the head of state of Thailand.

The National Assembly of Thailand is a bicameral legislature and comprises of two houses: the Senate and the House of Representatives. The current Senate has 200 members and the House comprises 500 members, elected to 6-year and 4-year terms, respectively. Although the Pheu Thai Party (For Thais Party) had a majority in the House of Representatives, it is currently dissolved as the election held in February 2014 was judged to be invalid. The next election schedule remains undecided, but there is concern there will be more confusion when it is held.

After experiencing various events causing negative influences on the people, such as the Lehman Brothers' collapse, the great Chao Phraya River flood, and anti-government protests by pro-Thaksin factions, Thailand is now returning to stability under the Army Commander-led interim government, as the current king of Thailand, Rama IX, has a greater respect from its people.

4.2.4 Ethnic groups, Languages and Religions

The majority of the population is ethnically Thai, which is divided into many tribes. Others are Thai Chinese, those of significant Chinese heritage and Thai Malays. The country's official language is Thai and the primary religion is Buddhism, which is practiced by 94.8% of the population, with the remainder consists of Muslim 4.5% and Christian 0.7%.

4.2.5 Education System

Thailand has a 6-3-3 system (elementary school 6 years, junior high school 3 years, and high school 3 years), which is the same as Japan. Its compulsory education is also 9 years, the same as in Japan. The enrollment rate for elementary and junior high schools is 95% or more, 70% or more for high schools. The literacy rate for adult is very high, at 98% or more.

4.2.6 Economy

The nominal GDP of Thailand is about US$387.3 billion, which came in 30th in the world. Thailand's nominal 2013 GDP per capita was US$5,676, which is 93rd in the world.

Figure 4-1: Summary of Thailand's Economy

	2011	2012	2013
Real GDP growth rate (%)	0.1	6.5	2.9
Nominal GDP per person (USD)	5,115	5,390	5,676
Unemployment rate (%)	0.68	0.66	0.72
Current account (USD)	8.887 billion	-1.47 billion	-27.9 billion

Source: The World Bank / JETRO World Trade Investment Report (2014)

(1) Trade and Economic Condition

Trade in 2013 saw exports of 225.4 billion dollars (year-on-year decrease by 0.3%), and imports of 219 billion dollars (year-on-year increase by 0.3%), which represents 6.4 billion dollars surplus.

Major exports (2012) include computers and computer components, automobiles and their parts, machinery and equipment, electronic integrated circuits, and natural rubber. Its imports are crude oil, machinery and appliances, and electronic components.

In terms of employment makeup for 2012, Thailand's agricultural, forestry and fishing industries employs 16.35 million people (41.4%) and industry, construction and services 23.18 million people (58.6%).

Thailand's global competitiveness (WEF) ranking in 2014 was 31st (out of 144 countries).

Entering 2014, investment from foreign countries in Thailand centering on the automotive industry has increased significantly, but its market share both in Japan and China has plummeted.

The GDP, on a declining trend before the interim government, has started to increase for the first time.

Figure 4-2: Major trade partners of Thailand (2013) (Unit: million dollars)

	Export	Import
No. 1	China (11.9%) (27,238)	Japan (16.4%) (41,082)
No. 2	The US (10.0%) (22,959)	China (15.0%) (37,727)
No. 3	Japan (9.7%) (22,236)	UAE (9.1%) (17,286)

Source: JETRO World Trade Investment Report (2014)

(2) Economic Relations with Japan

With the Japan-Thailand Economic Partnership Agreement (JTEPA) that came into effect on November 1, 2007, followed by the comprehensive agreement on such as trade in goods, mutual recognition of customs procedures, trade in service, investment, movement of natural persons, intellectual property, government procurement and competition, personal exchange and trade between the two countries have been enhanced.

In meetings between Prime Minister Abe and Prime Minister Prayuth held during the ASEAN Summit in November 2014, the improvement of import regulations on Thai food and cooperation over Thailand railway improvement were discussed.

Loan assistance was not made. Grant aid was 8.986 billion yen (FY 2012) and technical cooperation completed was 3.479 billion yen (FY 2012).

The total number of Japanese companies in Thailand is about 1,552 (registered at the Japanese Chamber of Commerce in Bangkok as the end of April 2014).

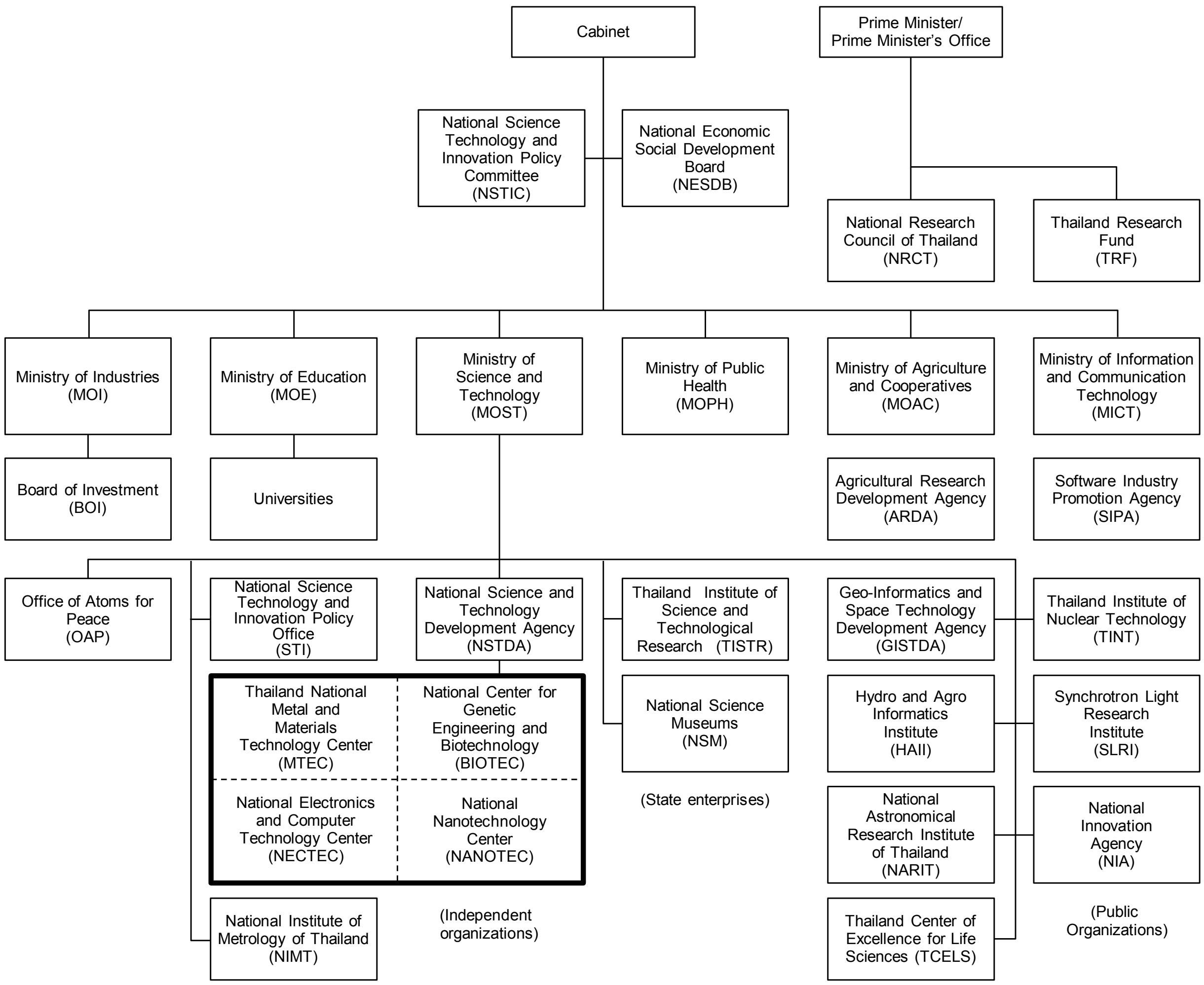
In bilateral trade, Thailand's exports to Japan amounted to 2.15 trillion yen, imports from Japan amounted to 3.5 trillion yen (FY 2012), indicating that Thailand has a substantial deficit with Japan. The top three exports to Japan are naturel rubber, automobiles and parts and computers and parts; on the other hand, imports from Japan are machinery and parts, iron and steel and automobile parts.

4.3 Science and Technology Policy

4.3.1 S&T Related Organizations

The following figure 4-3 shows the governmental organizations related to S&T of Thailand. The Ministry of Science and Technology (MOST) plays a central role of the science and technology policy. Its umbrella organization, the National Science and Technology Development Authority (NSTDA) and the Thailand Institute of Scientific and Technological Research (TISTR) are the major drivers for the science and technology innovation. Besides MOST, there are various ministries in charge of related fields such as biomedical science and information communication.

Figure 4-3: Governmental Organization Chart Related to S&T in Thailand



4.3.2 Policy and Trends in S&T

(1) S&T Innovation promotion policy in Thailand

In 2004, Thailand launched the National Science and Technology Strategic Plan 2004-2013. Four priority technologies selected are "information and communication technology," "material technology", "biotechnology" and "nanotechnology" as the respective strategic plans were developed. Those strategic plans include: "National Information Technology Policy Framework (2001-2010)" and "ICT Master Plan (2007-2011)" for information and communication technology; “National Materials Technology Strategic Plan (2006-2015) for material technology, "National Biotechnology Policy Framework (2004-2011)" for biotechnology; "Nanotechnology Strategic Plan (2004-2013)" and "National Nanotechnology policy framework (2004-2013)" for nanotechnology.

In 2007, NRCT developed the national research policy and strategy for 2008-2010, and set the following four goals: to secure a research budget of 1.3% or more out of the annual government budget; set the total research and development expenses of the country to 0.5% or more of its GDP; to make the research investment in the private sector equivalent to the public sector; and to make the research personnel ratio 8 per 10,000 people. The government has allocated 69 billion baht (about 220 billion yen) for three years to research that is expected to generate positive outcomes for achieving the four goals. This also includes social science-related research.

In 2008, in addition to the science and technology policy, the innovation policy was developed. National Science, Technology and Innovation Policy Office (STI) was established under the National Science, Technology and Innovation Act (STI Act), promulgated on February 13, 2008, The STI is an autonomous public agency that operates in compliance with policy guidance from the National Science, Technology and Innovation Policy Committee (NSTIC), chaired by the Prime Minister of Thailand.

In April 2012, the Cabinet approved the National Science and Technology Basic 10-Year Plan (2012-2021). This is designed to provide a mechanism to enrich the innovation system at all levels from the national to regional and local in the country.

As of 2014, a mid-term plan for each research institute has been developed based on the 11th Economic and Social Development Five-Year Plan (2012-2016).

(2) National STI Master Plan 2012-2021

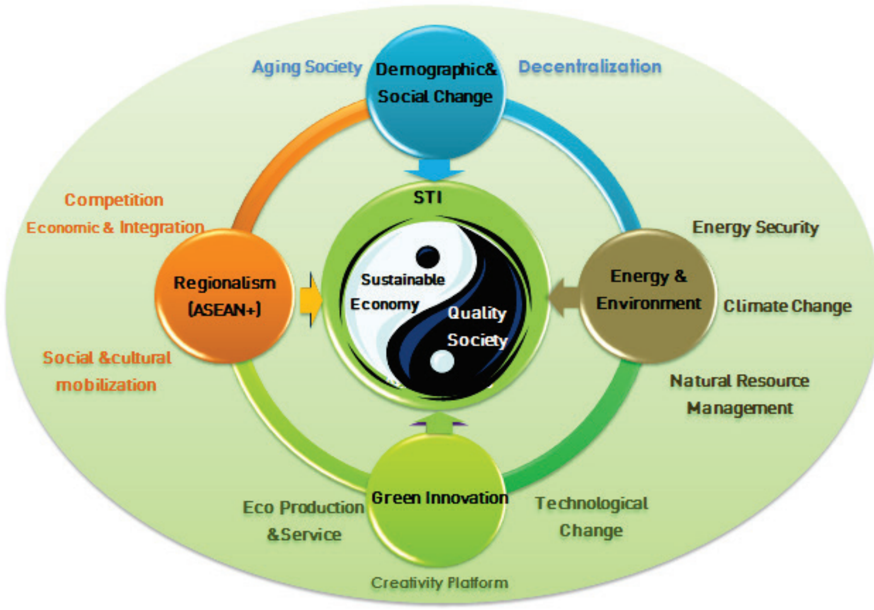
The National Science Technology and Innovation Master Plan 2012-2021, hereinafter referred to as the "National STI Master Plan 2012-2021"[13]. Its goal is to unify STI commitments among public agencies and to strengthen the collaboration with and among the private sector, academics, and research institutes. The coverage is designed to network knowledge from the grassroots community level up to international cooperation. In order to create a thriving innovation system, the STI office now focuses on institutional and international collaborations that are based on knowledgeable human capital, sufficient scientific and technological infrastructure and other enabling factors. At the foundation, the Master Plan states that knowledgeable and skilled human capital along with sufficient scientific and technological infrastructure and enabling factors are vital to the creation of a thriving innovation system. Therefore, the following strategies and measures are mapped out to develop these vital factors, resulting in human capital development programs:

(1) science education improvement through enquiry-based learning,
(2) vocational skill improvement through work- integrated learning,
(3) and enhanced university-industry-research institute collaboration via cooperative education and improved academic/research personnel mobility
(4) infrastructure/enabling factor development programs—such as regional science parks[14], industrial technology assistance, tax incentives[15], and innovation financing.

The strong foundation will support the application of STI for development in three strategic areas—namely, 1) society and local communities, 2) economy, and 3) energy and environment with the ultimate goal of having a quality society and a sustainable economy driven by green innovation. Strength in science, technology and innovation will help the country cope with emergent issues and future challenges, such as an ageing society, social disparity, globalization, regionalism, climate change, water-food-energy security, and emerging diseases. An overview of the national STI Basic Plan 2012-2021 is shown in Figure 4-4.

[13] National STI Master Plan
http://www.most.go.th/eng2012/index.php?option=com_content&view=article&id=101:national-sti-master-plan&catid=86:book-store&Itemid=490
[14] In addition to the Thailand Science Park (TSP), there are another four regional Science Parks.
[15] The preferential expansion of the tax credits for research and development spending of companies (tax deduction for R&D spending) means raising the deductible research and development expenses from 200% to 300%, thus, aiming at increasing the investment in research and development willingness of companies.

Figure 4-4: National STI Master Plan 2012-2021



4.3.3 Higher Education

The following are the top ranked universities in Thailand with science and technology research capability. Research status related to fields such as biotechnology, material science and environmental study will be described later. Here is a list of university ranked top according to QS World University Rankings 2014.

(1) Chulalongkorn University (CU)

It is the oldest and most prestigious university in Thailand, founded in 1917. It comprises 19 faculties (natural science study includes engineering, medicine, pharmacy, physiotherapy, etc.) and 10 institutes (biotechnology, genetic engineering, energy science, environment, metallurgy, materials science, etc.). "Chulalongkorn" is named after King Rama V (King Chulalongkorn (reign 1868-1910), the father of its founder King Rama VI (reign 1910-1925). King Rama V is regarded as having laid the foundation of modern education in Thailand. The total number of students as of 2014 is about 38,000, of which about 35 percent are enrolled in graduate programs.

CU has partnership programs with 17 Japanese universities, including the University of Tokyo, Kyoto University and Tokyo Institute of Technology.

A building called CU Engineering Centennial Memorial Building was completed in 2013, attracting research institutes from both local and overseas. The Asia Collaboration Center for National Institute of Information and Communications Technology of Japan (NICT) currently located in the NSTDA/NECTEC of TSP has just moved in 2015 to this building.

(2) Mahidol University (MU)

Mahidol University is a medical school, one of the top universities of Thailand in terms of education and research.

It was founded in 1943 by hosting Siriraj Medical School, which was the first medical school in Thailand. With its historical foundation as a medical school, the university originally focused on medical sciences, but it has also expanded to other fields in recent years, which covers a wide range from natural science to music. The university is one of the oldest universities in Thailand, and comprises16 undergraduate faculties (natural sciences include engineering, environmental and resource, medical engineering, medicine, pharmacy, public health, science, and tropical medicine) and a number of research institutes (science and technology for R&D, molecular biology, genetics, etc.).

The university has currently enrolled about 28,000 in 2014, of which about 32% are enrolled in graduate programs. In terms of fiscal budget and portion of budget spent on research programs, MU receives the highest budget of any public university; about 10.1 million baht out of a 40.9 million baht budget for 2012 was funded by the government. The other 30.8 billion baht is its self-earned revenue; nearly 60% is funded from outside, of which about 15% is provided from abroad. MU has concluded partnership agreements with about 270 universities and research institutions in and outside Thailand (more than 40 countries). Forty universities from Japan also have partnerships with Mahidol University.

(3) Chiang Mai University (CMU)

Chiang Mai University was the first university founded in northern Thailand in 1964. When founded, it only had 3 faculties offering science, social sciences and humanities, but it expanded to education and research fields. Today, CMU offers 20 undergraduate programs (agriculture, agro-industry, medical science, engineering, medicine, pharmacy, physiotherapy, veterinary medicine, etc.) with various research centers and independent institutions/organizations.

The university enrolls about 36,000 students on four campuses (as of 2014); about 30 percent of them are enrolled in graduate programs. In terms of its relationship with Japan, CMU has partnerships with 31 universities such as Keio University and 3 organizations including the Japan International Cooperation Agency (JICA).

4.4 Promotion Bodies of Science and Technology

4.4.1 National Economic and Social Development Board (NESDB)

The National Economic and Social Development Board (NSEDB) formulates the National-Economic and Social Development Plan utilizing science technology every five years. NSEDB serves as a key agency on planning and formulation of economic and social development strategies based on balanced and sustainable development, public participation, and flexibility meeting the changing environment and needs of the Thai people.

4.4.2 National Research Council of Thailand (NRCT)

The National Research Council of Thailand (NRCT) is a key government agency responsible for implementing and promoting the following work in both natural and social sciences in Thailand: to formulate a well-balanced and sustainable research policy and strategy; oversee and assess research standards; to enhance national research systems; and to fund research; to promote international research cooperation; coordination for research works and offer technical assistance. It was also involved in drafting the national STI Master Plan for 2012-2021.

4.4.3 National Science Technology and Innovation Policy Committee (NSTIC)

The National Science Technology and Innovation Policy Committee (NSTIC) was launched in 2008 after the National Science and Technology Committee (NSTC), founded in 2001, was reorganized to provide a wide range of policies and plans in terms of science, technology and innovation. This committee has played a key role in drafting National Science Technology and Innovation Policies and Plans for 2012~2021. Serving as a leading agency to coordinate related government ministries and agencies, it also oversees and evaluates the results. NTICS is chaired by the Prime Minister of Thailand.

4.4.4 Thailand Research Fund (TRF)

The Thailand Research Fund (TRF) is Thailand's leading funding agency. It was established in 1993 under the 1992 Research Endowment Act. Although it is part of the government system, it lies outside government administrative bureaucracy. This freedom allows great efficiency in research support.

4.4.5 Ministry of Science and Technology (MOST)

The former Ministry of Science, Technology and Environment (MOSTE) was reorganized into the following three separate ministries in 2002: Ministry of Science and Technology (MOST), Ministry of Natural Resources and Environment (MNRE) and Ministry of Energy (MOE). This is to efficiently implement development works in their respective fields.

Affiliated institutions of MOST are classified into three organizations: the autonomous agencies, state enterprises and public organizations. It has been said that these organizations outside the government can perform relatively freely without receiving many constraints from the government.

4.4.6 National Science Technology and Innovation Policy Office (STI)

The National Science Technology and Innovation Policy Office (STI) was established under the National Science Technology and Innovation Act, promulgated on 13 February 2008. The office is an autonomous public agency that operates in compliance with policy guidance from the National Science Technology and Innovation Policy Committee (NSTIC). The STI office has been established specifically to provide support to the government in terms of STI policy formulation, coordination, and promotion.

The office is committed to strengthening the country‘s capacity in its move towards a knowledge-based economy. The STI strategic plan and policy recommendations provided to the government by the office are expected to improve the country's competitiveness and enhance socio-economic sustainability.

The STI office is responsible for overseeing the implementation of the Master Plan. Collaborative networking is an essential part of the office's strategy and is emphasized by the creation and promotion of active collaboration through strong linkages and exchange programs with local, overseas, and international organizations.

STI capability is considered a major driver of the nation toward future growth and sustainability; the STI Office is therefore committed to fulfilling its mission and assisting the nation (the people) towards a better future.

4.4.7 National Science and Technology Development Agency (NSTDA)

The National Science and Technology Development Agency (NSTDA) was founded in December 1991 as an autonomous state agency that is responsible for driving the science and technological capabilities of Thailand. It is responsible not only for research work but also for funding.

NSTDA has its role in helping Thailand prosper in the increasingly competitive global economy. Its mission is to promote R&D for strengthening sustainable competitiveness, technology transfer, human resources and scientific and technological infrastructure development, and business-academic collaboration. Its past achievements, missions and future strategic business development plan (projects) are described in the NSTDA Strategic Plan 2012-2016. It is located within the Thailand Science Park (TSP), north of Bangkok.

NSTDA has four affiliate National Research Centers: BIOTEC (biotechnology), MTEC (materials technology), NANOTEC (nanotechnology), and NECTEC (information technology), and one dedicated as a leading R&D organization in Thailand.

(1) BIOTEC

The National Center for Genetic Engineering and Biotechnology (NCGEB) set up in September 1983 under the Ministry of National Science, Technology and Energy (MOSTE).

Later, it was merged into the NASDA, which was founded in 1991, and accordingly renamed BIOTEC.

The major role of the BIOTEC is to vitalize biotechnology research, development and applications in Thailand propelling technology development and learning in both public and private sectors. Its activity involves research work in its own laboratory and provides research funding inside and outside BIOTEC. Others are human resource development, technical assistance, technology investment, public awareness regarding biotechnology, information dissemination as well as projects to promote international cooperation.

Research activities carried out by BIOTEC reach from basic technology to advanced technology, and have been working on human resources development and technological development in order to contribute to the country's development at the same time. Major research programs include biotechnology related to shrimp and rice, and programs relating to new diseases, natural products and pharmaceuticals.

The center had a full-time staff of 510 people as of November 2014. Of that, 345 accounting for 68% are research-based staff, including 130 PhD holders (37%).

BIOTEC is aiming to increase PhD holder researchers to 220 by 2017, the majority of those having received a PhD or been educated overseas.

(2) MTEC

The National Metal and Materials Technology Center (MTEC) was established aiming to support R&D for metal and materials that contribute to the development of the manufacturing sector and the country by the Cabinet Resolution in 1986 as a project under the Office of the Permanent-Secretary of the then Ministry of Science and Technology. On December 1991, it was merged into the National Science and Technology Development Agency (NSTDA) in the Ministry of Science and Technology.

The MTEC program focuses on the following five areas:

- Technical development for high-value-added products from natural resources
- Manufacturing design and product development
- Renewable energy
- Medical Applications
- Agricultural Promotion

In addition to the research work of the five areas mentioned above, MTEC has also been funding R&D institutions of both public and private sectors. It also actively engages in contract research, providing technical information such as technical consultant planning and offering training programs for human resource development in cooperation with other R&D institutions, universities and industry.

The MTEC was engaged in drafting and coordinating the National Strategic Plan for Materials Technology (2006-2015) at the request of the government. This plan has proposed a materials technology development strategy in the following key areas and industry. It has been used as a guideline along with other specific national strategies (ICT, biotechnology and nanotechnology) for national economic and social development toward science and technology knowledge-based society and economy.

(3) NANOTEC

Keeping pace with the rapidly growth in nanotechnology throughout the world and its application to manufacturing technology in the 21st century, the NANOTEC was approved by the Cabinet and set up under the NDTDA in August 2003. Its missions are as follows:

- coordinate and promote cooperation among industry, academia and government
- create a network of talented researchers and educators in the field of nanotechnology
- identify a niche field related to nanotechnology and improve competitiveness of the country for the targeted area
- encourage industrial circle and government agencies to transfer and spread their knowledge and technology.
- carry out research in both the core area and general field of nanotechnology.
- establish a state-of-the-art research infrastructure that can be shared by other research institutions
- develop a national nanotechnology roadmap

Its major activities include R&D, technology transfer, and human resources development through seminars, research funding, infrastructure development and development of related policies (such as the first national nanotechnology strategic plan).

The NANOTEC is a leader of Thailand's research and development related to nanotechnology, and a funding agency to provide research funds to universities and public institutions as well. Research funds are given for development of R&D human resources and science and technology capabilities of nanotechnology.

There are three areas of NANOTEC for research: nanomaterialism, nanobiotechnology, and nanoelectronics

(4) NECTEC

The NECTEC was established as a central agency to develop and promote information technology as a project under the Science and Technology Department of Energy in September 1986. Later, it was integrated into the NSTDA when it was established in December 1991.

The major role of the NECTEC is to support and boost technology development in the area of electronic, computer and telecommunications of Thailand through R&D efforts.

The NECTEC owns Thai Microelectronics Center (TMEC) in a different area from Thailand Science Park and has been developing semiconductors and sensors.

It has been collaborating with industry clusters and funding research based on proposals.

4.4.8 Thailand Institute of Scientific and Technological Research (TISTR)

The Thailand Institute of Scientific and Technological Research (TISTR) is the first national research center for science and technology established on May 25, 1963. It is now classified as a state enterprise under the jurisdiction of the Ministry of Science and Technology, aiming to conduct research on industrial technology that contributes to sustainable social and economic development.

While having its own research facilities, TISTR supports Thai companies mainly related to science and technology applications and coordinates cooperation with foreign countries. Researches are conducted mainly on food, pharmaceutical and natural products, bioscience agriculture, materials innovation, renewable energy and environment.

TISTR carries out the following functions:

a) lead and maximize integrated research and development (R&D) and innovation in food, pharmaceutical and natural products, bioscience agriculture, materials innovation, renewable energy and environment management;
b) provide scientific and technological services in compliance with the quality management system (analysis, testing, calibration and verification) and international standards;
c) match R&D and innovation and service of TISTR to meet the client's needs in the manufacturing field and service sectors, and expanding the reliability and excellence of Thailand’s industry in the ASEAN market with effective business management and marketing;
d) manage the ultimate utilization of human resources and promote a good governance and organizational culture.

4.4.9 Thailand Center of Excellence for Life Science (TCELS)

The Thailand Center of Excellence for Life Science (TCELS) is a leading agency in life sciences and innovation in the country. It became a public organization under the supervision of MOT in 2012. With its crucial mission for life science business and industry in Thailand, TCELS carries out the following:

(i) To promote, support and develop life sciences business and industries in Thailand.
(ii) To promote and develop potential research into life science products and services that can create commercial value-added.
(iii) To improvement infrastructure and promote human resource development as needed.
(iv) To propose strategic planning of life sciences business and industries.

(v) To coordinate collaboration nationally and internationally between Thai companies and other government organizations and private sectors.
(vi) To serve as an information and knowledge center.

TCELS offers programs such as medical equipment, drugs, health supplements, cosmeceutical products and health care services. It promotes life science-related business innovation in Thailand through human resources development, facility development, corporate assistance and information services.

Two flagship missions were launched in 2014: one is a Center for Advanced Medical Robotics and the other is a Cell and Gene Therapy center.

For other special projects, an Advanced Dental Technology Center was initiated; where dentists are stationed (no TCELS researchers positioned in other research areas).

TCELS also plays a significant role as the National Focal Point for Life Sciences in the APEC Life Sciences Innovation Forum.

4.5 Input Index of Science and Technology[16]

4.5.1 R&D Expenditure

Gross expenditure on R&D (GERD) in Thailand was US$1.7 billion in 2013 accounting for 0.5% of GDP. The ratio of GERD to GDP is quite low compared with Japan. It is lower than that of Singapore and Malaysia, but higher than Vietnam, Indonesia, and the Philippines among ASEAN nations,

4.5.2 R&D Expenditure Ratio by Sector

The contribution percentage of the government in 2013 was 51.3%, with the private contribution 48.7%. In order to enhance investment in research and development for the entire country, the government is planning to increase the private contribution to 55%, which brings the total to US$2.4 billion by deploying tax incentives to attract private investment while increasing the contributions of the government.

4.5.3 Percentage of R&D by Type of Activity

It shows a very high percentage of applied research as compared with basic research.

4.5.4 The Number of Researchers

Based on the data as of 2009, the number of researchers in Thailand is 38,506 (HC) and 22,000 (FTE). Looking at the number of researchers per 1,000 labor force, the size of researchers in Thailand is 1 researcher (HC) and 0.6 (FTE). This size of researchers is about twentieth part of Japan.

[16] UNESCO Institute for Statistics

4.6 Output Index of Science and Technology

4.6.1 Science Research Papers

Based on the indicators of the Elsevier research analysis tool (SciVal), the number of science papers published, the number of citations, the number of authors and international co-authorship rate are compared with that of Japan and the 10 other ASEAN countries (see Figure 4-5).

Thailand was in third place in terms of number of papers published (second only to Malaysia and Singapore in ASEAN countries).

Figure 4-5: Comparison of Selected Countries by Number of Science Paper

Country \ Item	Number of Papers	Number of Citations	Number of Authors	International Co-Authorship
Japan	648,938	3,534,908	599,167	23.6%
Malaysia	93,406	292,001	76,671	31.3%
Singapore	80,680	701,014	48,757	51.5%
Thailand	53,334	257,150	48,585	37.4%
Indonesia	15,728	58,632	17,247	55.0%
Vietnam	12,696	60,540	13,670	67.9%
Philippines	7,354	47,088	7,747	57.3%
Cambodia	1,064	10,905	1,258	88.8%
Brunei	879	2,373	747	48.9%
Laos	750	4,237	810	93.6%
Myanmar	558	1,651	663	60.8%

Source: Elsevier, SciVal Database

Thailand

4.6.2 University Rankings

Chulalongkorn University has been ranked at 243 according to the QS University Rankings 2014, leading Thai universities. Mahidol University came in 257 and Chiang Mai University has been included in the group of 501-550.

4.6.3 Patents

The total number of patents applied to Thailand Patent Office in 2010 was 1,925, while the patents awarded was 772. More than half of the applications were by non-residents, accounting for more than 90% of those awarded.

Before joining in the Patent Cooperation Treaty (PCT), the number of patents applied by Thai residents still stood at 10%. However, the proportion of Thailand residents has increased by about 50% after becoming a PCT member in 2010. This may suggest that the main change factor is a significant decrease in the number of applications by foreigners given that the number of patent applications by Thai people has decreased. With respect to the number of patents awarded, it has remained unchanged even after 2010. For the 2013 budget for NSTDA, revenue was 4.43 billion baht (including 3.05 billion baht from the government) and expenditure was 4.16 billion baht. The number of staff as of 2014 is 2,934 including 536 PhD holders. The total number of patent holders was 77 (1,420 applied). The total number of publications written in English was 588 in 2013.

4.7 Foreign Relations

4.7.1 Japan

Japan and Thailand have enjoyed a close relationship with frequent exchanges between their leaders. Furthermore, Japan is the largest aid donor to Thailand, having strong economic ties. S&T cooperation agreement between the two countries has not yet been concluded but the need is recognized. A Japan-Thailand nuclear cooperation agreement is in the negotiation process in 2014.

(1) Cooperation with Japan Society for the Promotion of Science (JSPS)

JSPS has been collaborating with its counterpart organization, the National Research Council of Thailand (NRCT) through bilateral exchange programs (joint research and seminars). There have been joint research projects on two or three themes conducted every year among Japanese universities, independent administrative institutions and universities in Thailand.

(2) Core-to-Core Program: Establishment of Research Hub by JSPS

Research and education institutions around the world have been cooperating in building world-level or regional core research exchange hubs. The following is a list of research projects associated with Thailand from 2012.

A: Advanced Research Networks (5 years)

Core Institute, Coordinator in Japan	Core Institute in Thailand	Program Title
Yamaguchi University	Kasetsart University	Establishment of an international research core for new bio-research fields with microbes from tropical areas (World-class research hub of tropical microbial resources and their utilization)

B: Asia-Africa Science Platforms (3 years)

Core Institute, Coordinator in Japan	Core Institute in Thailand	Program Title
Kobe University	Chiang Mai University	Study on Education Finance and Administration in Asia and Africa/ A Sustainable Program to Nurture Young Researchers
Kyushu University	Chulalongkorn University	New Consortium Creation and Cultivation of Young Scientist on Earth Resources in Asia and Africa Region
Kyoto Institute of Technology	Chiang Mai University	Establishment of Asia insect biomedical research network
Kyoto University	Chulalongkorn University	Asian Vertebrate Species Diversity Network Platform with Combining Researchers, Specimens and Information

(3) Cooperation with Japan Science and Technology Agency (JST)

・ Strategic International Research Cooperative Program (SICP)

3 projects have been under way with Thailand since 2012.

Leading institute in Japan	Leading institute In Thailand	Project Title
Hiroshima University	NSTDA/BIOTEC	Bacteriophage Biocontrol for Sustainable Crop Production: Application to Bacterial Wilt
University of Tokyo	Mahidol University	DNA chip for identification and typing Mycobacterium tuberculosis using DigiTag platform
Ishikawa Prefectural University	NSTDA/BIOTEC	Identification of genes confer high Fe and Fe toxic tolerance in rice

・ Science and Technology Research Partnership for Sustainable Development (SATREPS)

SATREPS is a Japanese governmental program that promotes international joint research. The program is structured as collaboration between JST, which provides competitive research funds for S&T projects, and the Japan International Cooperation Agency (JICA), which provides Official Development Assistance (ODA). Based on the needs of developing countries, the program aims to address global issues and lead to research outcomes of practical benefits to both local and global society.

8 SATREPS projects have been already funded in Thailand, and 2 new projects as for 2015 have just adopted. Ongoing 8 projects are as follows.

Japanese leading institution	Thai institutions	Agendas
University of Tokyo	- National Institute of Health (NIH) / Ministry of Public Health	Integrative Application of Human and Pathogen Genomic Information for Effective Tuberculosis Control
Kyoto University	- The Joint Graduate School of Energy and Environment / King Mongkut's University of Technology Thonburi (JGSEE-KMUTT) - PTT Public Company Limited	Development of Clean and Efficient Utilization of Low Rank Coals and Biomass by Solvent Treatment
Tokyo University of Marine Science and Technology	- Department of Fisheries (DOF) - Kasetsart University - Chulalongkorn University - Walailak University	Development of Aquaculture Technology for Food Security and Food Safety in the Next Generation
National Institute of Advanced Industrial Science and Technology (AIST)	- NSTDA - TISTR - King Mongkut's University of Technology North Bangkok (KMUTNB)	Innovation on Production and Automotive Utilization of Biofuels from Non-food Biomass
University of Tokyo	- Kasetsart University - Thai Meteorological Department (TMD) - Royal Irrigation Department (RID) and others	Integrated Study Project on Hydro-Meteorological Prediction and Adaptation to Climate Change in Thailand (Terminated)
University of Kitakyushu	- Chulalongkorn University	Development of New Biodiesel Synthesis in Thailand (Terminated)
University of Tokyo	- Environmental Research and Training Center (ERTC) - Chulalongkorn University - Kasetsart University	Research and Development for Water Reuse Technology in Tropical Regions (Terminated)
Osaka University	- National Institute of Health (NIH) / Ministry of Public Health - Mahidol University (MU)	Research and Development of Therapeutic Products against Infectious Diseases, especially Dengue Virus Infection (Terminated)

・ e-ASIA Joint Research Program (e-ASIA JRP)

The e-ASIA JRP was officially launched in June 2012. It has been formulating and supporting international joint research projects in the East Asian Region on the multilateral basis as well as promoting researchers interaction through workshops, etc. The projects will be selected through open Call for Proposals. The Secretariat office is located in the building of NSTDA at the Thailand Science Park (TSP).

The e-ASIA JRP has currently 16 member organizations from 12 countries, consisting of Japan, Cambodia, Indonesia, Laos, Malaysia, Myanmar, New Zealand, the Philippines, Thailand, the US, Vietnam and Russia (as of June 2015). Ministries, agencies or other public/governmental bodies that provide research funds, might be a member organization of the e-ASIA JPR. From the Japanese side, MEXT, JST and the Japan Agency for Medical Research and Development (AMED) have been participating to support research projects.

In respect to the Thai-related projects, 6 joint research projects in total have been carried out as follows.

(i) Nanotechnology and materials (3 projects)
(ii) Biomass and plant science (1 project)
(iii) Health research (2 projects)

(4) Collaboration with Institute of Advanced Energy at Kyoto University (IAE)

Centered on the exchanges between Japan and Thailand through the 21st Century COE Program "Establishment of COE on Sustainable Energy System", it has been promoting the SEE Forum (Sustainable Energy and Environment Forum), which is an international network of researchers, in order to further enhance cooperation and partnerships in Asia since 2006.

In 2001, the institute collaborated with Rajamangala Institute of Technology regarding generation, conversion and utilization of energy and resources as well as manufacturing of advanced functional materials. In addition, Kyoto University has had academic exchanges with the Joint Graduate School of Energy and Environment (joint agreement made with the Graduate School of Energy Science and Graduate School of Engineering) in the field of energy and environment for five years from October 19, 2009.

(5) Others

In addition to the above, the Japan Atomic Energy Agency has been proving support to Thailand for human resources development and in the field of light-water reactor-type test research reactors. The Japan Aerospace Exploration Agency (JAXA) is cooperating with the Geo-Informatics and Space Technology Development Agency and (GISTDA) in areas such as flood observation and heavy rains observed in Thailand.

4.7.2 Other Foreign Countries

(1) The US and Europe

The US Agency for International Development (USAID) and European countries such as Germany, have undertaken decisive support for Thai's science and technology infrastructure from the 1950s. Research cooperation activities carried out in Thailand by those such as the French Agricultural Research Center for International Development (CIRAD) and the University of Innsbruck of Austria as well as the ASEAN-EU program and framework program (FP) of the EU have contributed to the development of the science and technology of Thailand.

(2) ASEAN Countries

The Ministerial Committee on Science and Technology in the framework of ASEAN-COST has been held every year. It is expected that the streamlining of trade and investment in the region will be achieved in ASEAN integration from 2015 onward.

Basically, Thailand is pursuing an omni-directional foreign policy given that it shares borders with Cambodia to the east, Malaysia to the south, Myanmar to the west and Laos to the north. There are no border disputes owing to the fact that all of them are ASEAN member countries. Thailand is a key US security ally.

Thailand has been negotiating with China to cooperate in high-speed railway construction up to the border with Laos. Regarding the space program, Thailand is a signatory of the Asia-Pacific Space Cooperation Organization (APSCO), which is led by China.

Thailand became a member of the United Nations in 1946, the second year of its foundation; it was 10 years earlier than Japan in joining the United Nations. Thailand is one of the founding members of ASEAN, launched in 1967 with five countries; APEC, launched in 1989 with 12 countries years; and WTO, established in 1995 with 77 countries.

4.8 Topics on Science and Technology

4.8.1 NSTDA's research on agricultural products packaging technology with use of Active film

Dr. Wannee at NSTDA/MTEC is a researcher in polymer material science, who received her PhD from the Pennsylvania State University in the United States. She is currently the coordinator of the plastic packaging program at MTEC. Dr. Wannee succeeded in significantly extending the salable period of vegetables after being shipped by making nanometer-sized holes in films used for packaging vegetables and also in realizing a high market value for agricultural products. For this achievement, she was awarded first prize in the International Packaging Symposium, which was held in Finland in 2013.

In respect to polymers, which are given a specific function by nanostructures, their various functions have been studied in Japan as well. The main characteristic of Dr. Wannee's work is that gas (oxygen) permeability is controllable.

Polymer exports from Thailand increased to $800 million in 2013. Polymer pen lithography (PPL) accounts for 60% market share in Asia. When agricultural products are packaged in conventional biodegradable synthetic polymers (poly-epsilon-caprolactone: PCL), which is a kind of polyester, only 30 to 40% are left fresh after being harvested, resulting in a loss of 10 billion THB. For example, asparagus with international competitiveness only last three days after their shipment to market. However, when using the nanometer-size perforated film developed by Dr. Wannee with the cooperation of botanists, this period is extended up to 29 days, making its export to foreign markets possible. The film can control the permeability of oxygen, and prevent carbon dioxide from entering. Therefore, this enables the vegetables that usually fall into a state of suspended animation after being packed to keep breathing with oxygen supplied constantly.

For making the holes, a biaxial stretching machine manufactured by Bruckner GmbH of Germany is used. This is a technique for controlling the nanometer-sized holes.

According to Mr. Atomo Yukimune who moved to MTEC from Dainippon Ink and Chemicals

Co., Ltd. and taught plastic packaging technology since 13 years ago, this type of packaging technology has had a significant influence on Thailand’s economic development. Although remarkable results have been recognized, it is difficult to understand its mechanism. In addition, it is considered that further spread of technology and market deployment becomes necessary to cooperate with foreign technology hold manufacturers and related companies.

4.8.2 Research on non-food biofuels and Culture Collection at TISTR

As for recent notable projects conducted in TISTR, there is non-dietary biofuel research. This research involves Culture Collection, in other words, a sample collection of microorganisms has served as a basis for the research.

The microorganisms specimen collection of TISTR includes bacteria, fungi, yeast and micro-algae.

Non-food biofuel research in Japan has been performed by DENSO Co., Ltd., which is known as an automotive parts manufacturer in Japan. DENSO has been engaged in biofuel research by cultivating microalgae called "Pseudochoricystis ellipsoidea" (size of 5 microns) in a culture pond (33,000 liters) built in Aichi Prefecture. Algae has a high CO_2 absorption capacity compared with trees and an algae cultivated pond is said to have 10 times higher CO_2 absorption capacity that a forest when compared in isometric conditions. Taking this technology, TISTR has set up a culture pond the same size as the pond of DENSO at its site in order to conduct its own on-food biofuel research.

Unlike DENSO, TISTR has been collecting cultures together with entities such as NSTDA/BIOTEC and conducting research on its own samples.

4.8.3 TCELS Medical Robotics

A project on medical robot development carried out by TCELS is very significant. Although medical robots have already been put into practical use in such areas as surgery, TCELS has a plan to develop more than 11 types of cutting-edge medical robots. It is also planned that R&D infrastructure and facilities will be completed by 2015 and five models will be developed by 2017. In particular, it is noteworthy that a robot can perform cancer screening accurately in a short time. While this kind of medical robot development requires an interdisciplinary research effort, not only medical but also other areas such as nanotechnology and information technology, TCELS has been playing a key role of promoting the development by coordinating researchers from institutions such as Mahidol University, NSTDA / NANOTEC and NECTEC.

4.9 Summary

Science, technology and innovation in Thailand have progressed rapidly since 2008. It has been emphasized that such major research boosting organs as NSTDA, TISTR and TCELS not only perform in-house research but also actively cooperate with universities and companies as well as to maximize science and technology as a tool for solving issues facing society.

Thailand’s manufacturing industry has been largely dependent on the local production of foreign firms, generating little scientific and technological research results. However, it has started to find ways to improve this lost factor in such technology development related to health and medical care and food safety, and has the potential to grow as a science and technology powerhouse specific to biotechnology and medical technology.

Furthermore, as a future direction, the policy trend to significantly increase R&D spending in the private sector with tax incentives deserves attention.

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- Natuional BiotechnologyPolicyFramework (2004-2011)
  http://www.business-in-asia.net/biotech_policy.html
- Natuional NanotechnologyPolicyFramework (2012-2021)
  http://www.nanotec.or.th/en/wp-content/uploads/2012/02/The-National-Nanotechnology-Policy-framework-exe-sum.pdf
- NSTDA Presentation (stored in JST)
- Brochure of MTEC (stored in JST)
- Brochure of TISTR (stored in JST)

See also:

- S&T related links (Ministries, Research Institutes and Universities)
- National Economy and Social DevelopmentBoard (NSEDB) http://eng.nesdb.go.th/
- National Research council (NRCT) http://en.nrct.go.th/en/Home.aspx
- National STIPolicy Committee (NSTIC)
  http://ostc.thaiembdc.org/13en/national-science-technology-and-innovation-policy-office-sti/
- Thailand Research Fund (TRF) (text in Thai)
  http://www.trf.or.th/index.php?option=com_content&view=article&id=15&Itemid=139
- MOST http://www.most.go.th/eng2012/index.php
- NSTDA http://www.nstda.or.th/eng/
- BIOTEC http://www.biotec.or.th/en/
- NANOTEC http://www.nanotec.or.th/en/
- MTEC http://www.mtec.or.th/en/
- NECTEC (text in Thai) http://www.nectec.or.th/
- TISTR http://tistr.or.th/tistr_en/index_en.php?pages=home
- GISTDA http://www.gistda.or.th/old-web/en/
- TCELS http://www.tcels.or.th/en/home/page

5. Vietnam

5.1 Outline

In Vietnam, science and technology is considered a driving force for the development of a modern industrial society. Legislation, planning and organizations related to science and technology have been developed and policies implemented in line with the “Science and Technology Development Strategy (2011-2020).” However, the research and development expenditures as a percentage of GDP is low at 0.21% (2011) and the government research institutes are spending about 60% of the total research funds. Therefore, strengthening research and development in universities and enterprises is a future challenge.

5.2 Current Socioeconomic Trends and Background

5.2.1 Basic information

The official name of Vietnam is the Socialist Republic of Viet Nam and the capital is Hanoi. The total land area is 329,000 km^2, which is 87% of Japan’s area. The population of Vietnam is approximately 89.71 million (2013), the 13^{th} largest in the world and approximately 70% of Japan’s population.

5.2.2 History

As the land of Vietnam is elongated north-south, different ethnic groups built nations at the same time. It also has a complicated history with repeated control by neighboring China and resistance to said control.

The name “Vietnam” was adopted by the Emperor of the Nguyen Dynasty when the name Viet Nam (Southern Viet) was recognized by the Qing Dynasty of China in 1802. In 1884, Vietnam (Nguyen Dynasty) and France concluded the Treaty of Hue, which made Vietnam a protectorate of France. French Indochina was established in 1887.

Later, after the occupation by the Japanese Army, the Democratic Republic of Vietnam (DRV) declared independence under president Ho Chi Minh in 1945 and the Indochina War between Vietnam and France began. The Soviet Union and China supported the DRV, and France and the US supported the State of Vietnam, which was established by France. This developed into a conflict between capitalistic states and socialist states. In 1954, France withdrew when the Geneva Accords were concluded. However, the Republic of Vietnam (Prime Minister Ngo Dinh Diem) was established with the support of the US in 1955, and Vietnam was divided between the north and south.

After that, from 1965, intervention by the US military increased bomb attacks in the north and the Vietnam War intensified. Following the Paris Peace Accords signed in 1973, the war ended and US military forces withdrew. In the same year, Vietnam established diplomatic relations with Japan. In 1975, Saigon fell to North Vietnam and the Republic of Vietnam (South Vietnam) collapsed. North and South Vietnam were merged to form the Socialist Republic of Viet Nam in 1976.

Following the outbreak of the Cambodian-Vietnamese War in 1978 and the China-Vietnam War in 1979, all countries suspended support for the country, causing Vietnam to be isolated. However, after following a socialist-oriented market economy policy, in 1986, the country shifted to a route of reform and liberalization known as *Doi Moi* (renovation). After signing the Paris Peace

Accords in 1991, Vietnam concentrated on omnidirectional diplomacy and normalized diplomatic relations with China in the same year, followed by the normalization of diplomatic relations with the United States in 1995.

5.2.3 Politics

(1)Political regime

The head of state is the president and is chosen from members of the Diet. The current president is Truong Tan Sang (born in 1949). He became president in the 13th Diet in 2011.

The Diet is unicameral, with 500 assembly members, and the term is five years. More than 90% of Diet members are members of the Communist Party, and the leadership of the party is absolute.

The Communist Party is the only legal political party in Vietnam and the current leader is Nguyen Phu Trong (born in 1944), the General Secretary of the party. He became General Secretary in the 11th party convention in 2011.

The Prime Minister is Nguyen Tan Dung (born in 1949), who assumed the position in the 11th session of the Diet in 2006. Politics in Vietnam is based on the three-person collective leadership of the above-mentioned President, General Secretary and Prime Minister.

(2)Domestic affairs

Based on the *Doi Moi* (renovation) policy adopted in the 6th party convention in 1986, Vietnam is working toward structural reform for the introduction of a market economy system and foreign capital, and strengthening of international competitiveness.

In the 11th party convention in 2011, the party continued the policy of aiming at rapid growth with the goal of becoming a modern industrial nation by 2020.

At the same time, as *Doi Moi* has advanced, negative aspects have come to the surface such as the widening gap between the rich and poor, rampant government corruption and the adverse effects of bureaucracy. In order to address these problems, the party and the government have strengthened corruption prevention measures, implemented administrative and official reforms and improved economic efficiency through the disposal of non-performing loans and reform of state-owned enterprises.

(3)Diplomacy

Based on omnidirectional diplomacy, Vietnam is trying to expand friendly relations with neighboring countries, especially with ASEAN and the Asia-Pacific countries. However, it has a territorial problem with China (Paracel Islands and Spratly Islands), including a dispute that arose after China deployed an oil rig (the oil rig in the Paracel Islands was later removed by China).

Vietnam's participation in international organizations is also promoted. The country became a full member of ASEAN in 1995, APEC in 1998 and WTO in 2007. Vietnam was awarded a non-permanent seat on the United Nations Security Council in 2008 and 2009.

(4)Relations with Japan in recent years

Prime Minister Abe selected Vietnam as the destination for first official trip overseas after his assumption of the post. He visited Vietnam in January 2013 and declared the 2013 to be the "Vietnam-Japan Friendship Year" (40th anniversary of establishment of bilateral diplomatic relations). Prime Minister Dung visited Japan in December of the same year.

5.2.4 Ethnic Groups, Languages and Religions

The Kinh (Viet) people, accounting for approximately 86% of the country's population, and 53 other ethnic minority groups reside in Vietnam. The official language is Vietnamese, but words of Chinese origin and Khmer are also used. Some people can understand French because the country was once a French colony. English education has been generally provided in recent years. Most people are Buddhist (mainly Mayahana) and others include Catholic, Protestant, Muslim, Caodaist and the Hoa Hao. The latter two are indigenous Vietnamese religions.

5.2.5 Education System

Primary and secondary education in Vietnam uses the 5-4-3 year system (5 years in primary education, 4 years in secondary education and 3 years in higher secondary education). The first 9 years, until the end of lower secondary education, are compulsory (extended from 5 years to 9 years in 2005).

There are normal secondary schools (high schools) and various other technical and vocational schools (secondary technical schools, secondary vocational schools) in higher secondary education.

As an education policy, the country formulated the "Education for Everyone National Activity Plan 2003-2015" in June 2003, and basic education has been promoted.

Higher education includes public universities (national universities, local universities and vocational colleges), private universities and open universities (refer to page 10). The school attendance rate in higher education was 10% in 2002 (UNESCO Educational Statistics).

5.2.6 Economy

As a result of the *Doi Moi* (renovation) policy adopted in 1986, Official Development Assistance (ODA) and foreign investment has helped Vietnam's economy, and economic growth has continued to be high. The growth rate did once decrease due to the rapid drop in foreign direct investment caused by the influence of the Asian financial crisis. However, foreign direct investment steadily increased in the 2000s and the average economic growth between 2000 and 2010 marked a high rate of 7.26%. The economy has been growing at the stable rate of around 5% in recent years and the unemployment rate has been low.

Nominal GDP was about 170 billion dollars (2013), the 58th in the world. The nominal GDP per capita is currently low (135th in the world) but steadily increasing. The "social and economic development strategy (2011-2020)" set the goal of increasing the nominal GDP per capita to 3,000 – 3,200 dollars by 2020.

Figure 5-1: Summary of Vietnam's Economy

	2011	2012	2013
Real GDP growth rate (%)	6.2	5.3	5.4
Nominal GDP per person (USD)	1,532	1,753	1,902
Unemployment rate (%)	3.6	3.2	3.5
Current account (USD)	200 million	9 billion	11.1 billion

Source: The World Bank / JETRO World Trade Investment Report (2014)

(1) Trade

As for trade, total exports were 132,135 million dollars and total imports were 132,125 million dollars in 2012, showing a slight surplus. The main trading partners are listed below. Vietnam has its largest trade deficit with China.

Telephones and related parts are the top export items (21,244 million dollars, 16.1% composition). This is largely due to the local production and export of the products of Samsung Electronics (Korea). Exports by foreign companies account for 61.2% of total exports. The top import items are machinery equipment and related parts (18,687 million dollars, 14.1% composition). This shows that local supporting industries haven't been developed in Vietnam.

Production of Samsung products in Vietnam is focused on assembly work to secure low-cost labor. The company imports parts from overseas and exports assembled mobile phones.

Figure 5-2: Major trade partners of Vietnam (2013) (Unit: million dollars)

	Export	Import
No. 1	The US (21.48%) (23,869)	China (28.0%) (36,954)
No. 2	Japan (10.3%) (13,651)	Korea (15.7%) (20,689)
No. 3	China (10.0%) (13,259)	Japan (8.8%) (11,612)

Source: JETRO World Trade Investment Report (2014)

(2) Industrial Structure

Looking at the industrial structure, the breakdown of GDP composition is: primary industry (agriculture, forestry and fishery): 20%; secondary industry: 39% and tertiary industry: 41%. The number of workers engaged in agriculture, forestry and fishery industries accounts for 53% of total workers, which plays a large part in the economy.

(3)Economic Relations with Japan

Japan is the largest aid donor and the largest foreign direct investor in Vietnam. For Japan, Vietnam is the largest ODA recipient country.

Yen loans have reached more than 200 billion yen per year. Direct investment by Japan in 2013 (new and additional) was 5.75 billion dollars (the largest investor; the second largest was Singapore) and Japan invests the largest accumulated amount.

The number of Japanese companies in Vietnam is approximately 1,300 (April 2014).

As for bilateral trade, exports from Vietnam to Japan are 13.65 billion dollars, and imports from Japan are 11.61 billion dollars (2013), showing a surplus for Vietnam. The main export items from Vietnam are sewn products and crude oil, and import items are machinery equipment and related parts, iron and iron scrap.

5.3 Science and Technology Policy

5.3.1 S&T Related Organizations

The following figure 5-3 shows governmental organizations related to science and technology. The summary of the main organizations is as follows.

(1)Office of the Government

The Department of Science and Education is in the Office of the Government.

The National Council for Science and Technology Policy (NCSTP) is positioned as an advisory body to the prime minister. NCSTP comprises 31 members, and the chairman is Chau Van Minh, the former Minister of Science and Technology.

VAST (Vietnam Academy of Science and Technology), VASS (Vietnam Academy of Social Science) and Vietnam National Universities (Hanoi, Ho Chi Minh) are organizations under the direct control of the prime minister.

(2)Ministry of Science and Technology (MOST)

Ministry of Science and Technology (MOST) is positioned as the ministry administering science and technology affairs.

The Minister, Nguyen Quan (born in 1955, PhD) served as the senior department chair of Hanoi University of Science and Technology, the Vice Minister of Science and Technology in 2007 and the Minister of Science and Technology in 2011.

MOST administrates general science and technology affairs and also implements planning and coordination of the entire government. It is also in charge of nuclear power, intellectual property and standards and metrology. The Ministry of Science and Technology has research, analysis and planning institutions and research and development support organizations (refer to page 93 for details).

(3)Ministries

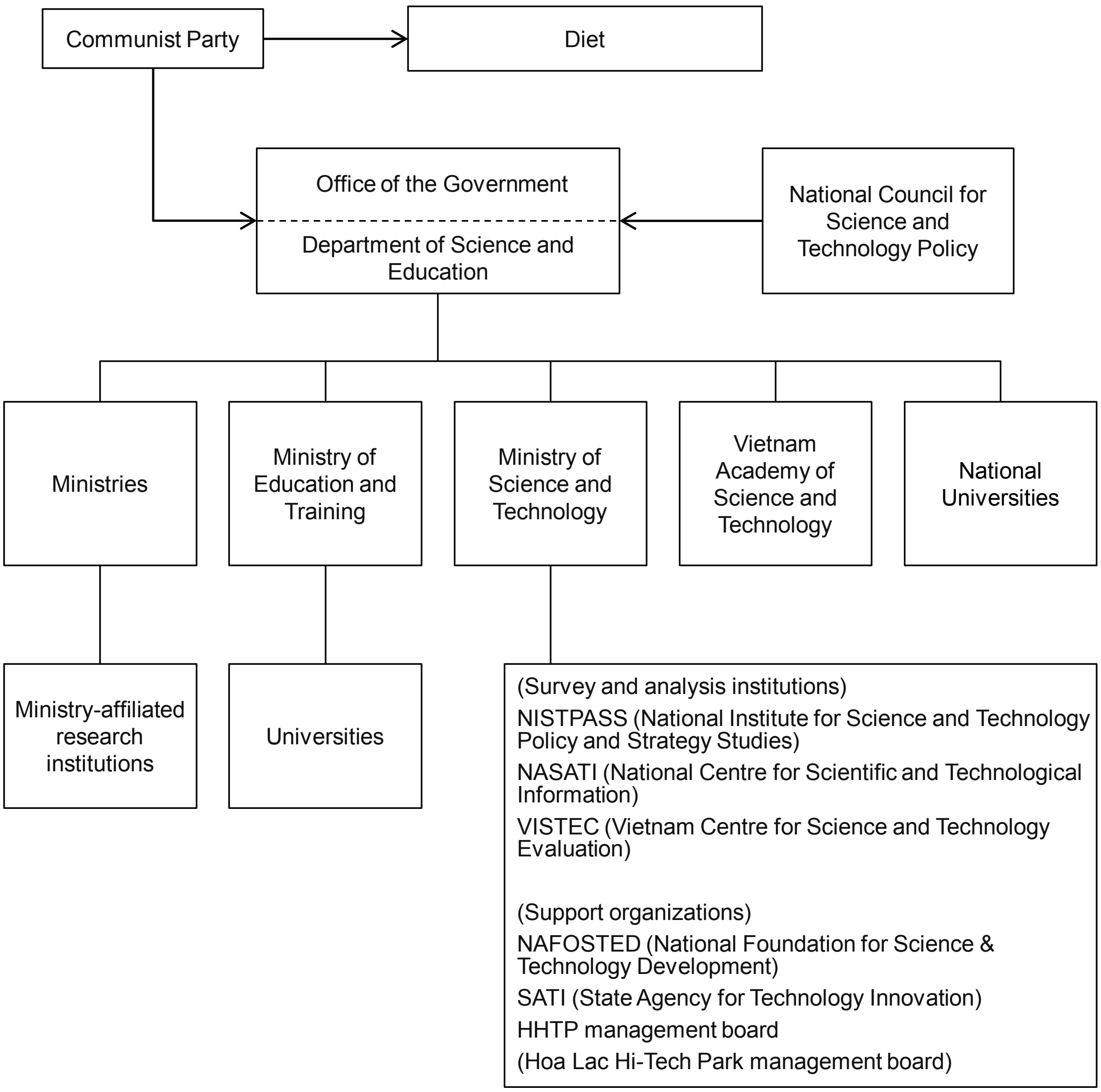
Each Ministry in the central government has affiliated research institutes, which implement activities concerning science and technology. It is important to know the activities of not only the Ministry of Science and Technology but also of all the other Ministries when understanding science and technology in Vietnam.

The Ministry of Education and Training (MOET) is in charge of higher education institutions such as universities. There are many research institutes, including the Vietnam Academy of Agricultural Sciences, affiliated with the Ministry of Agriculture and Rural Development. The Ministry of Health and the Ministry of Industry and Trade also have many research institutes.

(4)Local government

Local governments have the department of S&T (DOST) and a science committee as advisory bodies. Meetings are held regularly for information sharing and cooperation with the Ministry of Science and Technology of the central government, along with participation by local governments.

Figure 5-3: Governmental organization chart (central government) related to science and technology



5.3.2 Laws concerning the promotion of science and technology

In Vietnam, the following laws on science and technology have been established. It is a characteristic of Vietnam to promote science and technology by improving laws.

- Law on Science and Technology, 2000
- Law on Intellectual Properties, 2005
- Law on Technology Transfer, 2007
- High-Tech Law, 2009

The key points of the basic law, the Law on Science and Technology, are as follows:

- Purpose of promoting science and technology (socioeconomic development, effective use of resources, environmental protection, formulation of culture, improvement in the quality of people's life, national defense and security, etc.)

- Responsibilities and prohibited matters (anti-party activities, harmful behavior, ethical violations, etc.)
- Roles, rights and duties of research and development institutions, universities, science and technology service organizations and researchers.
- Planning by national and local governments and selection of an implementing agency
- Evaluation of research and development achievements, handling and use of outcomes
- Investment in high-tech development, international cooperation, industrial development
- Policies for scientific and technological promotion
  - Human resources development, employment and benefits in science and technology
  - Preferential budget allocation, securing private investment
  - Establishment of a science and technology development fund (at national, ministerial, local, private and individual levels)
  - Use of tax system, loans and ODA
- Promotion of international cooperation
- Government management and roles of the Ministry of Science and Technology

The High-Tech Law mentions the following four technologies:

- Information technology
- Biotechnology
- New material technology
- Automation technology

5.3.3 Scientific and technological strategy and planning

Corresponding to the Socio-Economic Development Strategy (2011-2020) (January 2011), which is the basic national plan, the Strategy for Science and Technology Development (2011-2020) (April 2012, hereafter referred to as "10-Year Science and Technology Strategy") was formulated.

The general goals of the Socio-Economic Development Strategy (2011-2020) are to become a modern industrial country by 2020 and stabilize the political community, improve people's lives, protect the country's sovereignty and achieve an advanced status in the global market.

Main points of the 10-Year Science and Technology Strategy are as below.

(1) General goals

- To harmonize humanities and social sciences, natural science and technological development and make science and technology a driving force for the development of a modern industrial society.
- To reach an ASEAN/global level in some areas by 2020.

(2) Numerical goals

The main numerical goals are as follows:

Figure 5-4: Numerical goals of S&T strategy

	2015	2020
High-tech products as a percentage of GDP		45%
Science and technology expenditures as a percentage of GDP	1.5%	2%
Government budget for science and technology in total budget	More than 2%	More than 2%
Number of researchers and engineers per 10,000 people	9-10	11-12
Development of high-tech engineers	5,000	10,000
Number of international-level research institutions	30	60
Number of science and technology companies	3,000	5,000
High-tech incubators	30	60

(3) Promotion system

VAST (Vietnam Academy of Science and Technology) and VASS (Vietnam Academy of Social Science) are taking the lead to promote science and technology with the aim of strengthening the basic research capabilities of universities and research activities of private entities.

(4) Development of important technologies

- Information and communications technology

  This field is expected to develop and double to triple average GDP.

  Promotion of R&D, electronic payment, e-government, etc.

- Biotechnology

  Promote this area for health and medical industry, agriculture, forestry and fishery industry, and environmental protection.

- New material technology

  Materials for defence industry, manufacturing industry, construction and transport industry and environmental protection industry.

  Electronic and luminescence materials, nanomaterials

- Machinery manufacturing and automation technology

  Manufacturing technology of devices used in the manufacturing lines of oil, electricity, shipbuilding, etc.

- Environmental technology

  Waste treatment technology and clean manufacturing

(5) Application fields in S&T

Agriculture, pharmaceutical products, energy (including the safe use of nuclear power), transport, construction, marine use, use of natural resources, space development, community development

(6) Development of services regarding S&T

Development of standards, metrology, intellectual property system, science and technology information and statistics

(7) Promotion measures

- Promotion of two policies: enhancement of economic competitiveness and improvement of scientific and technological capabilities
- Development, employment and favorable treatment of young researchers (including overseas researchers)
- Development of intellectual property system and advanced technology market
- Promotion of international cooperation and attraction of overseas companies and human resources
- Promotion of people's understanding of science and technology

(8) Promotion organization

- Promotion centred around the Ministry of Science and Technology (including budget allocation planning)
- The Ministry of Planning and Investment implement coordination through the nationwide socioeconomic development plan.
- The Ministry of Finance determines budgets.

Although the direction and operation of scientific and technological activities in 2011 to 2015 has also been decided, the contents are almost the same as the above-mentioned 10-Year Science and Technology Strategy.

For areas of important technologies, the government as a whole established 16 National Key Laboratories (17 at first) in the previous 10-Year Strategy (2001-2010). The table below is the list and these are the science and technology areas that the Vietnamese government focuses on. A total of approximately 950 billion dong was invested in the National Key Laboratories (= about 5 billion yen, converted at the rate of 1 dong = 200 yen).

Figure 5-5: List of National Key Laboratories

Information technology	National Key Laboratory of Information and Security
	National Key Laboratory for Network Technology and Multimedia
	National Key Laboratory of Specialized Microelectronics Circuits
Biotechnology	National Key Laboratory of Gene Technology
	National Key Laboratory of Enzyme and Protein Technology
	National Key Laboratory of Vaccine and Biomedical Goods Technology
	National Key Laboratory of Animal Cell Technology
	National Key Laboratory of Plant Cell Technology
Material technology	National Key Laboratory of Polymer and Composites Materials
	National Key Laboratory of Material and Electric Component
Mechanical engineering/automation	National Key Laboratory for Welding Technology and Surface Treatment
	National Key Laboratory of Numerical and System Technic Control
Petroleum	National Key Laboratory for Filtration and Petroleum Technologies
Energy	National Key Laboratory of High Voltage Electric
Infrastructure	National Key Laboratory of Measurement and Standard National Key Laboratory for River and Sea Dynamics

Higher education was previously provided mainly in special colleges of engineering and medicine, but comprehensive universities have been developed. The existing universities were merged into two national universities under the direct control of the prime minister, and local universities have also been established by merging other universities.

At present, universities mainly offer education; strengthening research activities is a future issue.

5.3.4 Budget for S&T

The science and technology budget of the Vietnamese government is shown in the following figure 5-6. Although the amount is increasing significantly, the budget of the whole government is also increasing and the ratio of the science and technology budget in the total budget is slightly decreasing.

A target of more than 2% as a percentage of the total budget for science and technology budget is set in the 10-Year Science and Technology Strategy, which hasn't been achieved yet.

Figure 5-6: Budget for science and technology in Vietnam

(Unit: Trillion dong)

Year	Budget for science and technology	Increase rate (%)	Percentage in total budget (%)
2006	5.429		1.85
2007	6.310	16.22	1.81
2008	6.585	4.36	1.69
2009	7.867	19.46	1.62
2010	9.178	16.66	1.60
2011	11.499	25.28	1.58
2012	13.168	14.51	1.46
2013	14.144	7.41	1.44

Source: Science and Technology in Vietnam 2013

When converted at a rate of 1 yen = 200 dong, the 2013 budget was about 70 billion yen. As the budget of the whole government in 2013 was about 1,000 trillion dong, it is considered that the target for the science and technology budget is about 20 trillion dong (about 100 billion yen).

The ratio of the central government budget and local government budget is about 6 to 4, showing a greater burden in local government compared to Japan. 40 to 45% of the budget is used for facilities and equipment, and 55 to 60% is used for research expenses.

(Note) The conversion rate of yen into Vietnamese dong can fluctuate, but the amount is converted at a rate of 1 yen = 200 dong in this paper.

5.4 Promotion Bodies of Science and Technology

The research and development institutions in Vietnam are as follows:

(i) Government research institutions, etc.

VAST and VASS are under the direct control of the prime minister. Some research institutions are affiliated with the Ministries of the central government and others are affiliated with local governments.

(ii) Universities

The total number of universities is 150. The two national universities (in Hanoi and Ho Chi Minh City) are under the direct control of the prime minister.

Others include public and private universities.

(iii) Companies, etc.

State-run enterprises, private enterprises and foreign-owned enterprises conduct restrictive research activities.

The characteristics of Vietnam are: activities of (i) government research institutions are active and the activities of (ii) universities and (iii) companies are stagnating. The comparison in the percentage of using research and development expenditures between Japan and Vietnam is as follows, although there is some difficulty to compare.

Figure 5-7: Percentage of using research and development expenses (%)

	Government	University	Company
Japan (2012)	7.9	20.6	71.5
Vietnam (2011)	58.1	14.4	27.4

Source: Japan: Science and Technology Indicators (2014),
Vietnam: Science and Technology in Vietnam 2013
(Note) Vietnamese companies include state-owned enterprises.

The outline of the Ministry of Science and Technology, the promoter of science and technology policies, and major research and development institutions is as follows.

5.4.1 Ministry of Science and Technology

The Ministry of Science and Technology (MOST) is in charge of general science and technology affairs as well as nuclear power, intellectual properties and standards and metrology. The Vietnam Agency for Radiation and Nuclear Safety, Hoa Lac High-Tech Park Management Board, National Office of Intellectual Property (NOIP) and Directorate for Standards, Metrology and Quality are placed under MOST.

As institutions that support investigation, analysis and planning of science and technology policy, the following three institutions are designated:

- National Institute for Science and Technology Policy and Strategy Studies: NISTPASS
- National Agency for Science and Technology Information: NASATI
- Vietnam Center for Science and Technology Evaluation: VISTEC

The following research and development support institutions are also designated:

- National Foundation for Science and Technology Development: NAFOSTED

  NAFOSTED was established in 2008, and the annual budget is approximately 10 million dollars (1.1 billion yen). It mainly funds basic research (60% of the budget), but also subsidizes the research activities of small and medium-sized enterprises, fellowship programs and participation in international conferences. The number of subsidies provided for the basic research of natural science was about 1,100 in the six years from 2009 to 2014.
- State Agency for Technology Innovation: SATI

5.4.2 Vietnam Academy of Science and Technology (VAST)

The precursor of VAST, the Vietnam Science Academy, was established in 1975 and became the Science and Technology Academy in 2008. The mission of VAST is research on natural science, technology development and human resources development.

The institution under the direct control of the prime minister in Vietnam, other than VAST, is VASS (Vietnam Academy of Social Science), while VAAS (Vietnam Academy of Agriculture and Science) is under the control of the Ministry of Agriculture and Rural Development.

30 national research laboratories and 7 units (nature museum, science information centers, presses, etc.) and 9 state-run enterprises are under the control of VAST. The following data is shown in the annual report of VAST (2013):

(i) Personnel: 2,453 staff including 205 professors and assistant professors and 706 PhDs.
(ii) Budget: 2013 budget: 853 billion dong (approximately 4 billion yen)
(iii) Papers: Total number of papers in 2013: 2,298 (including 660 international papers)
(iv) Major research institution:
- ○ Four Key laboratories (16 nationwide)
  Genetic technology (biotechnology laboratory)
  Network technology and multimedia (information technology laboratory)
  Materials and Electronic Components (material science laboratory)
  Plant cell (tropical plant laboratory)
  A budget of 6.6 billion dong (approximately 30 million yen) is provided to these key laboratories by MOST.
- ○ High Performance Computing Center (mathematic laboratory)
- ○ Space technology laboratory

(v) International cooperation: Cooperate with 52 overseas institutions and signed MOU with 13 organizations.

5.4.3 VAST/Vietnam National Satellite Center

VAST conducts a satellite development project using ODA from overseas.

- Earth observation (VNREDSat-1: France, launched in 2013)
- Ditto (VNREDSat-1B: Belgium, under consideration)
- Disaster and climate control (2 satellites will be launched with Japan’s ODA)

Construction of Vietnam Space Center (Japan’s ODA): The center is expected to be built in Hoa Lac High-Tech Park, and Vietnam is currently working on land development. Human resources development programs through studying in Japanese universities (master’s course) are under way

5.4.4 Research Institutions under Central Government Ministries

According to “Science and Technology in Vietnam 2013,” the number of research institutions under central government ministries is about 160 (excluding the Ministry of Defence and Ministry of Public Security). The ministries and agencies with the large number of research institutions are as follows:

- Ministry of Agriculture and Rural Development: 65
  (Number of staff is 5,000, more than that of VAST)
- Ministry of Health: 25
- Ministry of Science and Technology: 10
- Ministry of Industry and Trade: 10

The Ministry of Agriculture and Rural Development has three academies including VAAS. VABIOTECH under the control of the Ministry of Health is known as a vaccine laboratory.

5.4.5 Hoa Lac Hi-Tech Park

Hoa Lac Hi-Tech Park is a top priority project promoted by the Vietnamese government. The park is located 30 km west of Hanoi. The total area is 1,568 ha. The distance to Noi Bai International Airport is 47 km and 150 km to Hai Phong Port, which offers convenient transportation.

Hoa Lac Hi-Tech Park is modelled after Tsukuba Science City, and Japan extends full cooperation to the park. In 1998, JICA conducted a development survey and created a master plan. In 2010 and 2012, Japan decided upon the provision of ODA for infrastructure development.

The following are the main area structure and functions.

(i) Research and Development Zone (229 ha)
National research and development institutions and high-tech human resources development institutions are established.

(ii) High-Tech Industrial Zone (549.5 ha)
Companies in high-tech industries and business incubation facilities are established.

(iii) Software Park (76 ha)
Area for the development, production and export of software. It also has the function of supporting start-up companies and follow-up support.

(vi) Education and Training Zone (108 ha)
Universities and training centers are established.

FPT University and Viettel (telecommunications company) have already been established in Hoa Lac Hi-Tech Park. Three Japanese companies (Noble Electronics, Nissan Techno, VINA-SANWA (shutter manufacturing) are operating there, but full-scale development has yet to be seen. FTP University is a university for human resources development, which was established by Vietnamese top IT company, FPT Corporation. It focuses on the development of IT engineers for the Japanese market and is enthusiastic about Japanese education.

5.4.6 University

The following is the description of three representative universities. (As mentioned on page 99, these three universities are in the top 300 in Asia 2014 of QS University Ranking, surveyed by the U.K. Quacquarelli Symonds.)

(1) Vietnam National University, Hanoi

Hanoi University and other universities were reorganized into Vietnam National University, Hanoi in 1993. It is the largest comprehensive university and under the control of the prime minister.

Number of staff: 3,316

1,675 teachers, 44 professors, 243 assistant professors and 754 PhDs

Number of students: Faculty Full-time: 21,806, Part-time: 1,820

Number of graduates: 10,334

The university has i) an information and technology laboratory, ii) Vietnam research and development science laboratory, iii) educational quality assurance laboratory, vi) microbiology and biotechnology laboratory, v) Francophone information and science laboratory and puts focus on Humanities and Social Sciences.

Dr. Vo Quy of the university was a recipient of the Blue Planet Prize (environmental protection).

(2) Vietnam National University, Ho Chi Minh City

Several universities in Ho Chi Minh City were reorganized into the National University, Ho Chi Minh City in 1995.

It consists of the following six affiliated universities, laboratories, faculties and centers.

Universities: University of Technology,

University of Science,
University of Social Sciences & Humanities,
International University,
University of Information Technology,
University of Economics & Law

Laboratories: Institute for Environment & Natural Resources

Faculty: Faculty of Medicine

Number of staff: 5,514 (including 215 professors and assistant professors and 2,565 teachers)

Number of students (Faculty Full-time): 51,000

(3) Hanoi University of Science & Technology

It was established in 1956 as the first technological university in Vietnam.

Number of staff: 1,800

1,500 teachers, 240 professors and assistant professors, 450 Dr.Sc. and PhD

Number of students: Faculty 35,000 (including various types of students)

Number of graduates: 2,000

The university has 20 laboratories and research centers for material science, information science, bioelectronics, software engineering, satellite navigation, precision machine engineering, etc.

(4) Other universities

Major science and technology-related universities other than the above-stated are as follows:

- Ho Chi Minh City University of Technology
- Hanoi Medical University
- University of Danang
- Can Tho University

5.5 Input Index of Science and Technology

5.5.1 R&D Expenditure

According to a survey conducted by the Vietnamese government in 2012, total R&D expenditures in Vietnam in 2011 were 5,294 billion dong (about 26.5 billion yen) and the ratio against GDP was 0.21%. This value is considerably low compared to that of Japan, lower than that of Singapore and Malaysia, the same level as that of Thailand and higher than that of Indonesia and the Philippines among ASEAN countries. It hasn't changed much from the 2002 value (2002: 0.19% Source: UNESCO SCIENCE REPORT 2010).

(Note) About the total research and development expenditures in Vietnam

In Vietnam, science and technology statistics have previously been inadequate. In 2012, a statistical survey was conducted in compliance with the OECD method under the direction of the prime minister. The results are published in "Science and Technology in Vietnam 2013."

The above-mentioned total research and development expenditures are lower than the science and technology budget of the government in 2011. There is a worry that the figure of total research and development expenditures is not adequate. In fact, NISTPASS of MOST independently shows a trial calculation of about 0.8% for the ratio of total research and development expenditures against GDP.

Personnel of MOST and NASATI provided the following explanation for this point in the survey.

- ○ The "science and technology budget" has a wider use than "research and development expenditures."
- ○ The capital investment for research and that for production cannot be divided. The science and technology budget includes capital investment, while the other doesn't.

As investigating this point is beyond the coverage of this survey, the figures that are officially published are used as they are.

5.5.2 R&D Expenditure Ratio by Sector

The composition of research and development expenditures by source of funds in 2011 were: the government: 64.47%, companies (including state-run companies): 28.4%, universities: 3.13% and overseas: 3.99%. In 2002, that of the government was 74.1% and that of companies was 18.1%, showing that the proportion of the government is decreasing. The Ministry of Science and Technology has the intention of increasing research and development expenditures by companies and decreasing the proportion of payment by the government to around 50%.

5.5.3 Percentage of R&D by Type of Activity

Data on research and development expenditures by type of activity is published for public research institutions and universities excluding company sections ("Science and Technology in Vietnam 2013"). According to the data, the ratio for basic research is 30%, that for applied research is 53% and that for development and experiments is 17%. Figures for public research institutions are 35%, 50% and 15%, and those for universities are 41%, 50% and 9%, respectively. Corresponding figures for Japan are 20.8%, 31.1% and 48.1% (public institutions) and 53.2%, 37.6% and 9.2% (universities) (Indicators of Science and Technology 2012).

In Vietnam, the activities of public research institutions are predominantly larger than those of universities. Therefore, it is considered that VAST and other public research institutions are working on basic research. It is considered that the large development projects equivalent to those in Japan is not conducted by public institutions.

5.5.4 The number of researchers

According to “Science and Technology in Vietnam 2013,” the total number of researchers in 2011 was 105,230. The number of female researchers was 43,844, which accounts for 41%. This proportion is rather high compared to that of Japan (14%).

5.5.5 Number of researchers per 10,000 people

The number of researchers per 10,000 people is 11.97, which is low compared to that of developed countries.

The following figure 5-8 shows the comparison of the above-mentioned input index between Vietnam and Japan.

Figure 5-8: Input in science and technology (comparison with Japan)

	Vietnam (2011)	Japan (2012)
Gross R&D Expenditures (GERD)	5,294 billion dong (About 26.5 billion yen)	17 trillion and 324.5 billion yen
GERD as a percentage of GDP	0.21%	3.67%
Percentage of R&D expenditures financed by the government	64.5%	19.1%
Number of researchers	105,230	835,701
Number of researchers per 10,000 people	11.97	65.6
R&D expenditures per researcher	50.3 million dong (About 250,000 yen)	20.73 million yen

Source: Japan: Indicators of Science and Technology (2014),
Vietnam: Science and Technology in Vietnam 2013

5.6 Output Index of Science and Technology

5.6.1 Science Research Papers

Based on the benchmark of SciVal (research and analysis tool) developed by Elsevier, the number of science papers, quotes, authors, etc., of papers published between 2009 and 2013 are compared with Japan and 10 ASEAN countries (see figure 5-9).

The number of papers in Vietnam is about the same as that of Indonesia and the Philippines and smaller than that of Malaysia, Singapore and Thailand among ASEAN countries. The number of quotes, which represents the quality of the papers, also falls short of that of Singapore.

Figure 5-9: Comparison of Selected Countries by Number of Science Paper

Country \ Item	Number of Papers	Number of Citations	Number of Authors	International Co-Authorship
Japan	648,938	3,534,908	599,167	23.6%
Malaysia	93,406	292,001	76,671	31.3%
Singapore	80,680	701,014	48,757	51.5%
Thailand	53,334	257,150	48,585	37.4%
Indonesia	15,728	58,632	17,247	55.0%
Vietnam	12,696	60,540	13,670	67.9%
Philippines	7,354	47,088	7,747	57.3%
Cambodia	1,064	10,905	1,258	88.8%
Brunei	879	2,373	747	48.9%
Laos	750	4,237	810	93.6%
Myanmar	558	1,651	663	60.8%

Source: Elsevier, SciVal Database

5.6.2 University ranking

The World University Ranking (2013-2014) by Times Higher Education, which is often used for university ranking, no universities in Vietnam are in the top 400. On the other hand, in the QS World University Rankings, Asia 2014 of the UK's Quacquarelli Symonds, three universities (Vietnam National University Hanoi, Vietnam National University, Ho Chi Minh City and Hanoi University of Science and Technology) are in the top 300.

161-170 Vietnam National University, Hanoi

191-200 Vietnam National University, Ho Chi Minh City

251-300 Hanoi University of Science and Technology

5.6.3 Patents

The table below shows data on patents in Vietnam. It indicates that both application and registration of patents are predominantly by non-residents (foreigners). This is common to all ASEAN countries. In Japan, application and registration of patents by foreigners are both around 15%. The number of international applications based on the Patent Cooperation Treaty in Vietnam was 18 in 2011. This number is small compared to more than 600 in Singapore.

Figure 5-10: Number of applications and registrations to the National Office of Intellectual Property (NOIP) (2012)

	Total numbers	Residents	Non-residents
Application	3,805	382 (10%)	3,423 (90%)
Registration	1,068	52 (5%)	1,016 (95%)

Source：WIPO

5.6.4 International awards

No Vietnamese has yet been awarded the Nobel Prize. (In 1973, Le Duc Tho was nominated as the winner of the Nobel Peace Prize with Henry Kissinger of the United States but he declined. Henry Kissinger was awarded the prize.)

In 2010, Ngo Bao Chau received the Fields Medal. However, he is a professor of the University of Paris-Sud and does not reside in Vietnam.

In 2003, Vo Quy (Vietnam National University, Hanoi) received the Blue Planet Prize (he conducted an investigation into forests destroyed during the Vietnam War and contributed to their restoration and preservation. The prize was awarded for his achievements in the establishment of the Law on Environment Protection and the protection of species.)

5.7 Foreign relations

5.7.1 Japan

(1) Intergovernmental cooperation

Japan and Vietnam have close relations, with both prime ministers making frequent visits to one another. As Japan is the largest donor country to Vietnam, economic ties between the two countries are also close. The following agreements on science and technology were concluded by the two governments:

(i) Agreement on Cooperation in Science and Technology (2006)

Based on the agreement, meetings of the Joint Committee on Science and Technology have been held (First meeting: March 2007 in Tokyo, second meeting: June 2009 in Hanoi, third meeting: August 2011 in Tokyo).

(ii) Japan-Vietnam Nuclear Cooperation Agreement (2012)

(2) Cooperation with the Japan Society for the Promotion of Science (JSPS)

The Japan Society for the Promotion of Science (JSPS) offers various cooperative activities for MOST and VAST.

・ Past researcher exchanges

Figure 5-11: Researcher exchanges between Japan and Vietnam through various programs
(Number of researchers)

	FY 2010	FY 2011	FY 2012
Accepted	204	225	110
Dispatched	141	169	228

・ Bilateral exchange program (joint research and seminars)

JSPS and VAST signed a note on implementing joint research and holding seminars.

In 2013, university researchers in Japan undertook joint research and held seminars on 12 subjects with VAST and university researchers in Vietnam.

・ Core-to-Core Program: Establishment of Research Hub by JSPS

Research and education institutions around the world have been cooperating in building world-level or regional core research exchange hubs. The Program was launched in 2012, and Vietnam has been involved in it as follows.

A: Advanced Research Networks (5 years)

Core Institute, Coordinator in Japan	Core Institute in Vietnam	Program Title
Yamaguchi University	Can Tho University	Establishment of an international research core for new bio-research fields with microbes from tropical areas (World-class research hub of tropical microbial resources and their utilization)
University of Tokyo	Hanoi National University of Education	Establishment of gravitational wave astronomy

B: Asia-Africa Science Platforms (3 years)

Core Institute, Coordinator in Japan	Core Institutes in Vietnam	Program Title
Kyoto University	Hanoi University of Science	International Research Collaborations and Networking on Extreme Weather in Changing Climate in the Maritime Continent
Yamaguchi University	Hanoi University of Agriculture	Establishment of the Southeast Asia Research and Education Center for Disaster Reduction and Environmental Monitoring using Satellite Remote Sensing
Kobe University	Vietnam National University	Study on Education Finance and Administration in Asia and Africa/ A Sustainable Program to Nurture Young Researchers
Kyoto University	Institute of Ecology and Biological Resources VAST	Asian Vertebrate Species Diversity Network Platform with Combining Researchers, Specimens and Information
Kyoto Institute of Technology	University of Science VNU-HCM	Establishment of Asia insect biomedical research network
Kanazawa University	Hanoi Medical University	Development of human resources of medical science aiming to eradicate hepatitis B virus-related liver diseases in East Asia
Waseda University	Hue University	Establishment of the Network for Safeguarding and Development of the Cultural Heritage in the Mekong Basin Countries
Kyoto University	- Hue University - Hanoi University of Science and Technology - Danang University of Technology	Formulation of the cooperation hub for global environmental studies in Indochina region
Nagoya University	Hanoi University of Science and Technology	Establishment of Educational Hub on Biomass-based Material Research for Green Mobility
Tokyo Institute of Technology	Ho Chi Minh City University of Technology	Integrated Water Resource and Environmental Management for Asian and African Mega-delta under Climate Change Effects
Niigata University	National Institute of Hygiene and Epidemiology	Analyzing circulating pattern of influenza virus in tropical and subtropical Asia to contribute to global prevention and control of influenza

(3) Cooperation with Japan Science and Technology Agency (JST)

・ Science and Technology Research Partnership for Sustainable Development (SATREPS)

SATREPS is a Japanese governmental program that promotes international joint research. The program is structured as collaboration between JST, which provides competitive research funds for S&T projects, and the Japan International Cooperation Agency (JICA), which provides Official Development Assistance (ODA). Based on the needs of developing countries, the program aims to address global issues and lead to research outcomes of practical benefits to both local and global society.

8 SATREPS projects have been already funded in Vietnam, and a new projects as for 2015 have just adopted. Ongoing 8 projects are as follows.

Japanese leading institution	Vietnam institutions	Agendas
Kyushu University	- Vietnam National University, Ho Chi Minh and others	Development of a regional energy circulation system that combines high-efficiency fuel cells and renewable biogas
National Institute of Agrobiological Sciences (NIAS)	- Department of Animal Husbandry / Ministry of Agriculture and Rural Development	Establishment of a gene bank of native pig resources and development of a sustainable production system that can maintain diversity
Osaka Prefecture University	- Vietnam National University, Hanoi (VNU-Hanoi) and others	Multi-beneficial Measure for Mitigation of Climate Change in Vietnam and Indochina Countries by Development of Biomass Energy
ICL-International Consortium on Landslides	- Institute of Transport Science and Technology (ITST) / Ministry of Transport (MOT)	Development of Landslide Risk Assessment Technology along Transport Arteries in VietNam
Osaka University	- National Institute of Nutrition and others	Determine the Outbreak Mechanisms and Development of a Surveillance Model for Multi-Drug Resistant Bacteria
Nagaoka University of Technology	- Hanoi University of Science and Technology (HUST) - Rubber Research Institute of Vietnam (RRIV)	Establishment of Carbon-Cycle-System with Natural Rubber
Kyushu University	Hanoi University of Agriculture	Development of Crop Genotypes for the Midlands and Mountain Areas of North Vietnam
University of Tokyo	- Ho Chi Minh City University of Technology (HCMUT) and others	Sustainable Integration of Local Agriculture and Biomass Industries (Terminated)

・ e-ASIA Joint Research Program (e-ASIA JRP)

The e-ASIA JRP was officially launched in June 2012. It has been formulating and supporting international joint research projects in the East Asian Region on the multilateral basis as well as promoting researchers interaction through workshops, etc. The projects will be selected through open Call for Proposals. The Secretariat office is located in the building of NSTDA at the Thailand Science Park (TSP).

The e-ASIA JRP has currently 16 member organizations from 12 countries, consisting of Japan, Cambodia, Indonesia, Laos, Malaysia, Myanmar, New Zealand, the Philippines, Thailand, the US, Vietnam and Russia (as of June 2015). Ministries, agencies or other public/governmental bodies that provide research funds, might be a member organization of the e-ASIA JPR. From the Japanese side, MEXT, JST and the Japan Agency for Medical Research and Development (AMED) have been participating to support research projects.

In respect to the Vietnam-related projects, 5 joint research projects in total have been carried out as follows.

(i) Nanotechnology and materials (2 projects)
(ii) Biomass and plant science (1 project)
(iii) Health research (2 projects)

Other than the above, various cooperative activities are conducted including "Japan Atomic Energy Agency and Vietnam Atomic Energy Institute," "RIKEN and Institute of Physics, VAST" and "Japan Aerospace Exploration Agency (JAXA) and VAST."

5.7.2 Other Foreign Countires

(1) International cooperation activities of Vietnam Academy of Science and Technology (VAST)

Other than Japan, Vietnam receives cooperation from France, Russia and many other countries.

In 2013, VAST prepared a budget for 21 international projects. The total budget was 6 billion dong (300,000 dollars), and 4 billion dong (200,000 dollars) of which was spent on oceanic research with the Far East Division of the Russian Academy of Science (FED RAS). The research vessel of the Russian Academy of Science, Professor Bogorov, will be stationed in Nha Trang, Vietnam. VAST has cooperated with the National Center for Scientific Research (CNRS) in France for over 30 years.

・ Key ODA international cooperation project

Projects being advanced include the development of VNREDSat-1 and 1B Satellite (France, Belgium) using ODA and the establishment of the Vietnam Space Center (Japan).

・ Participation in international organizations, etc.

VAST participates in many international organizations. In 2013, VAST joined the Committee on Earth Observation Satellites (CEOS) and the International Institute for Applied Systems Analysis (IIASA).

(2) Partners of international joint papers

The following figure 5-12 shows the five countries with the largest share of co-authors in international joint papers written by Vietnamese researchers. It shows that Japan is top of the list, while research cooperation is also active with the USA and Korea. (Data from 2000 to 2010)

Figure 5-12: Partners of international joint papers

Ranking	Country	Share (%)
1	Japan	18.5
2	USA	15.1
3	France	14.4
4	Korea	11.0
5	UK	9.4

Source: OECD/Innovation in Southeast Asia (2013)

5.8 Topics on Science and Technology

Vietnam is the largest receiver of ODA from Japan (double the amount of the second largest receiver, Afghanistan). From the Vietnam side, Japan is the largest donor country and the largest direct investor. A total of 1,300 Japanese companies are present in Vietnam. In this way, Japan and

Vietnam have close economic ties. It should be noted that cooperation in science and technology between Vietnam and Japan is not only based on cooperation between research institutions mentioned in the "Foreign relations" section but also on a wider range of areas.

From these points of view, the following two examples are given this time.

5.8.1 Space Development using Japan's ODA

VAST (Vietnam Academy of Science and Technology) conducts space development using Japan's ODA (European ODA is also used separately). Overseas development is a challenge for Japan's space development, and projects using ODA are promoted only in Vietnam.

The total project expense is about 55.4 billion yen and a contract for financing 7.3 billion yen in loans for the first term was signed in 2011.

The project consists of the following:

(i) Human resources development support
(ii) Development of facilities and equipment
(iii) Procurement of earth observation satellites

Human resources development support has already started and 11 students are currently studying in master's courses in Japanese universities (Hokkaido University, Tohoku University, etc.). A total of 36 students will study in Japan.

(ii) The development of facilities and equipment and (iii) the procurement of earth observation satellites haven't been implemented yet. However, the Vietnam Space Center will be constructed in Hoa Lac Hi-Tech Park and land development is in progress at Vietnam's expense.

For the Japanese space equipment industry, this project is important and is expected to be successful as a precedent to future overseas operations.

Figure 5-13: Rendering of the Vietnam Space Center

Source: Copied from published material of VAST

5.8.2 Training of IT Engineers for Japanese Market (FPT University)

FPT University was established by FPT Corporation, the largest IT company in Vietnam. It was established in 2006 and currently has campuses in Hanoi (Hoa Lac Hi-Tech Park), Da Nang and Ho Chi Minh City. The number of students is about 6,000 (FPT also has colleges and high schools).

The university offers School of Engineering and School of Business programs, and English and Japanese (or Chinese) are required subjects for students majoring in Engineering. Almost all students are learning Japanese. IT education itself is provided in English and the curriculum includes the IT standards, etc., of Japan.

Some of the graduates from FPT University will be employed by FPT Corporation, but the rate is not so high and is decreasing. More than 50% of FPT Corporation's sales are for Japanese companies. As this implies, receiving orders from Japan is important and demand for IT engineers who can speak Japanese is high in Vietnam. The employment rate of FPT University graduates is nearly 100% (employment in overseas companies is not so high (3%)).

FPT University actively interacts with overseas universities and it holds student exchanges with Japanese universities including Kyushu Institute of Technology and Shinshu University.

5.9 Summary

The economy of Vietnam has been experiencing high growth through the achievements of the *Doi Moi* (renovation) policy that was adopted in 1986. However, this has been driven by the investment of foreign countries such as Japan and Korea, which pay attention to low labor costs in Vietnam. These companies import parts and assemble products to export. If labor costs in Vietnam increase, economic growth may not always continue in the future. Therefore, it is important to develop high-tech industry and supporting industries within Vietnam. Science and technology is the key to the policy, and the Vietnamese government is actively promoting science and technology. Achievements in science and technology have not been noticeable yet, but we should continue to pay attention to it in the future.

As mentioned in science and technology topics in the previous chapter, Japan and Vietnam have extremely close relations and Japan plays an important role in the field of science and technology. It is necessary to promote future science and technology cooperation with adequate knowledge of the situation in Vietnam.

6. Indonesia

6.1 Overview

In Indonesia, R&D is conducted by national research institutes, and universities are at the center of education. In the recent years, universities have also participated actively in research projects and so forth but the basic composition of national research institutes = research, universities = education is in place.

The new regime which started in October 2014 clearly announced establishment of their identity as a maritime nation. Including research on marine resources such as new drug development, it is considered that there is great potential in technological development utilizing biological resources.

6.2 Current Socioeconomic Trends and Background

6.2.1 Basic information

The formal country name for Indonesia is “the Republic of Indonesia.” Its capital is in Jakarta. Indonesia is the largest island country in the world, consisting of approximately 17,000 islands. While its area is only about 1/5 of that of the US, its width is larger than the east-west distance of the American continent. The land area is approximately 2 million km^2, and the area of their territorial waters approximately 4 times that. With an estimated total population of over 250 million (2012), Indonesia is the world’s 4th most populous country and have the largest population of ASEAN countries. Java, on which more than 100 million people live, is one of the most densely populated areas in the world.

6.2.2 History

Indonesia had been under the colonial rule of the Netherlands for a long time before it was given independence after the World War II, with the Republic of Indonesia coming into existence as a single nation in 1950 under parliamentary democracy. However, due to reasons such as dysfunction of the parliament, corruption among politicians and so forth, Sukarno who had led the Indonesian independence war declared dissolution of the Diet, and Indonesia changed to a country with presidential government, where the President is given a great authority, in 1959. In order to keep the national army in check, Sukarno, who took office as the first President, approached the Communist Party of Indonesia (PKI), a rival to the national army, and pressed forward the rapid communization of the country while also clearly indicating their anti-colony standpoint to the US Indonesia then had the PKI members as many as 3 million, and was said to be on the verge of communization.

When a coup (30 September Movement) by the national army forces in 1965 failed as an attempt, Suharto, commander of the Army’s Strategic Reserve, was temporarily handed over power to handle the situation and quickly thwarted the coup attempt. Suharto immediately blamed the PKI as masterminds of the coup, and with released pent-up communal hatreds fanned by the national army, the failed coup was followed anti-communist purge that is historically called “Indonesian killings of 1965-1966” and ranked as one of the worst mass murders of the 20th century. Communists were thoroughly purged from political and social life, and the PKI itself was banned. Communist parties still remain illegal in Indonesia to date.

Beginning in 1966, people started demonstrating against Sukarno and his pro-communist policies, demanding for the government to control spiraling inflation. By January 1967, Suharto has removed all significant support for Sukarno within the armed forces. Sukarno was stripped of his remaining power and was placed under house arrest. After Sukarno's downfall and Suharto's inauguration of the President in 1968, his dictatorial regime continued for approximately 30 years.

The Asian financial crisis in 1997-1998 brought about Indonesian rupiah's devaluation, and led to sharp increase in unemployment and poverty across the country. The economic meltdown was accompanied by increasing political and social tensions. In parallel with pervasive anxiety about the future, frustration and complaints that had been accumulated during Suharto's thirty-year presidency, public support for Indonesian Democratic Party for Struggle led by Megawati who is the daughter of Sukarno has been rising. In March 1998, anti-governmental protests and demonstrations organized by university students and ordinary citizens happened in Jakarta, and its movement had been promoting violent behavior, demanding Suharto's resignation. Taking a situation seriously, Suharto himself announced his resignation on May 1998, upon which vice-President Habibie assumed the presidency in accordance with the constitution.

After Habibie' short-time incumbency in the President, However, Indonesia has been steering for conversion to a democratic regime through the rules of Presidents Wahid, Megawati and Yudhoyono. In 2004, Yudhoyono was inaugurated as the President as a result of the first direct presidential election held in the history of Indonesia. It is not too much to say that the current stability of the country is founded on the democratic system that has become well-rooted. The most recent presidential election was held in July 2014 peacefully without the chaos that might concur with elections.

6.2.3 Politics

Indonesia has a presidential system where the President is both head of state and head of government. Executive power is exercised by the government, and the position of Prime Minister is not created. The President has authority to appoint Cabinet ministers. The President and Vice-President are selected by vote of the citizens for five-year times. The President is directly elected for a maximum for two five-year terms. The last election was held on July 2014, and Joko Widodo became the Indonesian President without any political turbulence.

The People's Consultative Assembly is the legislative branch in Indonesia. The Assembly became a bicameral parliament, following elections in 2004, and consists of the People's Representative Council (the lower house, seats: 560) and the Regional Representative Council (the upper house, seats: 132)

6.2.4 Ethnicity, languages and religions

Indonesia is a multiracial state comprising of over 300 ethnic groups, such as Javanese (45%), Sundanese (14%), Malay (7.5%), Madurese (7.5%), Chinese descent (5%) and others (26%).

It is the existence of the national Indonesian language that plays an important role in unifying this diversity. Instead of specifying Javanese, which was the language for Javanese with the largest population, as the national language, Indonesia selected Indonesian, developed based on Malay language, after independence in the 20th century. Although it is said that the number of people who use Indonesian as the everyday language is about 30 million, the number of people who speak Indonesian as the second language is fairly large since Indonesian is used for conversations in public or with people of different ethnic groups. Because Indonesian which depends on none of the ethnic groups is specified as the national language, it is utilized effectively as a tool to unify the nation. They use the languages for different purposes, with the ethnic mother tongue at homes and private scenes and the national Indonesian language in school education, workplace and so forth, allowing the several hundred ethnic languages and the national language to coexist.

Regarding religions, Islam comprises approximately 90% of the population, making Indonesia the world's largest Muslim country. The remaining 10% include Protestants, Catholics, Hindus and Buddhists.

6.2.5 Education system

The Indonesian education system is 6-3-3 system (primary school: 6 years, middle school: 3 years and high school: 3 years), and it falls under the jurisdiction of Ministry of Education and Culture as well as the Ministry of Religious Affairs. 6 years in primary school was made compulsory in 1984, and 9 years including the 3 years of middle school was made compulsory in 1994 as basic education. By the middle of the 1990s, entry for the 6-year primary school was nearly perfect (95% or higher), but the school attendance rate for middle schools was approximately 78% and approximately 58% for high schools as of Fiscal 2011. The regional difference in school attendance rates for middle and high schools is large.

While the rate of illiteracy in population aged 15 to 59 is approximately 4.5%, there are also large regional differences in illiteracy, with the rate being less than 1% in capital Jakarta compared to more than 35% in West Papua for example.

6.2.6 Economics

The nominal GDP of Indonesia is 863.3 billion, and its economy size is ranked 16th in the world and 1st within ASEAN countries with a long lead from Malaysia. However, the nominal GDP per person is approximately 3,500 dollars, which is ranked 5th among ASEAN countries.

The real GDP growth rate for 2013 fell below 6% for the first time in 4 years at 5.8% indicating deceleration in investments, but private consumption has steadily grown from 2012 to 2013.

Figure 6-1: Summary of Indonesia's economy

	2011	2012	2013
Real GDP growth rate (%)	6.5	6.3	5.8
Nominal GDP per person (USD)	3,470	3,551	3,475
Unemployment rate (%)	6.6	6.1	6.3
Current account (USD)	1.685 billion	24.418 billion	29.129 billion

Source: The World Bank / JETRO World Trade Investment Report (2014)

(1) Trade

Indonesia has continued with trade deficits after recording the highest 2.39 billion dollars in red in July 2013. Export in 2013 was 182.5676 billion dollars (3.9% decrease compared to the previous year) and import 186.6313 billion dollars (2.6% decrease compared to the previous year), and both export and import decreased compared to the previous year. Foreign trade statistics indicate that the trade deficit reached 4.0637 billion dollars in 2013, further growing from the 1.6692 billion dollars.

In Indonesia, articles other than petroleum and gas comprise more than 80% of exports. When seen by the article, mineral fuels take up the largest ratio. Petroleum and gas comprise only a little less than 20% of entire exports, with gas taking up a slightly larger ratio. Regarding imports, articles other than petroleum and gas take up a little less than 80%, and the ratios of products such as machinery and electrical devices are large. Petroleum and gas take up 1/4 of the overall imports, with the ratios for petroleum and petroleum products being largest.

Major trade partners include Japan as the largest, followed by China and Singapore for exports. For imports, the largest partner is China, followed by Singapore and Japan. Japan can be said as a major trade partner for Indonesia.

Figure 6-2: Major trade partners of Indonesia (2013) (Unit: million dollars)

	Export	Import
No. 1	Japan (14.8%) (27,086)	China (16.0%) (29,850)
No. 2	China (12.4%) (22,602)	Singapore (13.7%) (25,582)
No. 3	Singapore (9.1%) (16,686)	Japan (10.3%) (19,285)

Source: JETRO World Trade Investment Report (2014)

(2) Industrial structure

Industrial structure indicates that Indonesia has the potential to grow in all of primary, secondary and tertiary industries. The ratio of each industry in GDP in 2009 was 22% primary industry, 33% secondary and 46% tertiary. As primary industry, rare metals and rare earth elements are produced in addition to petroleum, gas, nickel, tin and gold. Export of natural rubber, coffee and palm oil is also popular. As an example in the secondary industry which mainly comprises of manufacturing, the annual production of automobiles is currently the largest among ASEAN nations, exceeding Thailand (95% of the automobile production is by Japanese companies). In the tertiary industry, substantiation of the service industry has advanced in concurrence with the increase in the middle class.[17]

(3) Needs for development of petroleum refinement technologies

It has been pointed that one of the reasons why Indonesia imports resources even though their land is rich in resources is that they do not have advanced petroleum refining technology. They are exporting petroleum excavated in Indonesia to nearby countries to be refined and import it again at higher prices. So far the Indonesian government has maintained a subsidy system for high fuel costs in order to distribute the fuel to the poor, but its rate has reached 30 to 40% of the national budget and is pressing on the finances. However, the new regime under the President, Joko Widodo, which started up in late October 2014 announced that they would re-examine this subsidy system soon after its inauguration; and subsidy on gasoline was abolished on January 1, 2015. In parallel to this movement, prices of gasoline and so forth increased by approximately 30%, resulting in complaints from some of the people. However, domestic companies have welcomed this abolishment. This was because it was finally possible to prevent the companies of other countries from buying up the gasoline with reduced price thanks to the subsidy from the Indonesian government. With such circumstances in the background, development and advancement of petroleum refinement technology is considered one of the future challenges in technological development in Indonesia.

[17] http://www.meti.go.jp/meti_lib/report/2011fy/E002000.pdf

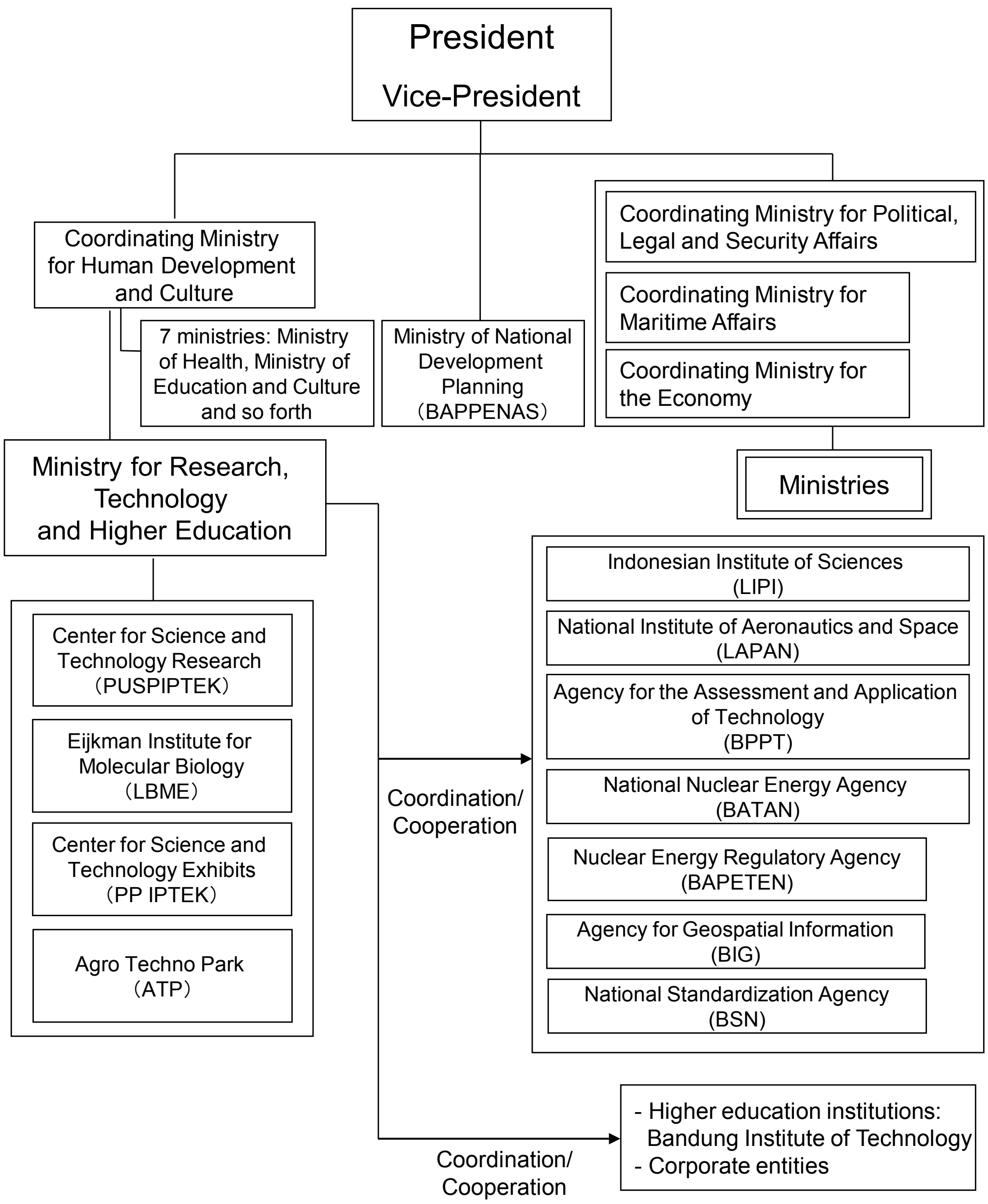
6.3 Science and Technology Policy

6.3.1 Organizations related to science and technology

The organization chart for the Indonesian government related to science and technology is shown below.

Ministry of Research, Technology and Higher Education is mainly responsible for science and technology policy. This Ministry has just been established in late October of 2014, unifying State Ministry of Research and Technology (RISTEK) and the higher education section of the Ministry of Education and Culture, immediately after the inauguration of the new President as a part of reorganization of the ministries, and abbreviation for the organization has not been determined (as of December 2014). The functions of RISTEK are described in detail later.

Figure 6-3: Organization chart for government agencies related to science and technology



Source: Prepared by the author based on various materials including RISTEK website

Indonesia

6.3.2 Major trends in science and technology policy

In Indonesia, long-term strategy for S&T "Visions and Missions 2025" was prepared under the law on national system for research, development and utilization of S&T (enacted in 2002) and law on national development system (enacted in 2004). Under the same strategy, development of long-term plan "Indonesia 2005-2025," development of medium-term "National Development Plan (2010-2014)" and so forth are being implemented. It is State Ministry of National Development Planning: BAPPENAS that has jurisdiction over the development of medium- and long-term plans for S&T. BAPPENAS is responsible for preparing the national development plan including S&T.

"National Development Plan (2010-2014)" specifies development in S&T as the basis to improve the welfare and living standard for people and deliver them high standards of life in economic, social and cultural manners as "science to contribute to the development of welfare and civilization (life)."

"National Research Agenda 2010-2014," which is a part of National Development Plan (2010-2014), specifies 1) food security, 2) new/renewable energy, 3) technology and transport management, 4) telecommunication technology, 5) national defense and safety, 6) health and medicine, and 7) advanced material technology as the 7 important fields of S&T development.

At present (December 2014), the new regime is currently in discussion on what strategic matters the national medium-term development plan (2015-2019) for the next 5 years should contain. It is expected that it will be based on the 2010-2014 plan with some changes including addition of maritime affairs and marine research contents. Some claim that fields involved in disaster prevention should also be included as new important fields.

Regarding higher education policy, the secondary long-term national development plan for 1994-2018 prepared by the national government specifies 1) effort to expand occupational training/ S&T education for human resource development meeting the demands of economic development, 2) effort to promote research at higher education institutes, and 3) efficient management of educational administration, with focus on development of human resources to address continuous economic development of the country.

There are 2 types of universities in Indonesia: private and national, national universities are further broken down into semi-autonomy types and full-autonomy types. There are only 5 full-autonomy universities: Institut Teknologi Bandung, University of Indonesia, Bogor Agricultural Institute, Gadjah Mada University and Airlangga University. For universities that are given full autonomy, there is no obligation to report to the government on university achievements, financial audit and so forth, and they are completely free to make their own decisions regarding budgets.

6.4 Promotion Bodies of Science and Technology

Research and development in Indonesia have been implemented in national research institutes such as Indonesian Institute of Sciences (LIPI) and Agency for the Assessment and Application of Technology (BPPT). Meanwhile, universities are mainly responsible for education. While there is a trend for the universities to promote research and development gradually, there is a basic structure for research institutes such as LIPI and BPPT = research and universities = education. Based on the quality of facilities and so forth, the research level at universities is assumed to remain low. Although there are cases in which universities participates in projects such as SATREPS, the basic fact is that university instructors cannot spare enough time for research as they are responsible for all 3 of education, contribution to society and research. It is assumed that those who mainly conduct research at universities are not the professors but the graduate students who are required to publish reports in scientific journals and give presentations in society meetings in order to obtain doctoral degrees.

The following section first discusses RISTEK, which has played an important role in coordination of S&T policy. It will be followed by instruction on LIPI and BPPT, which are the major research and development institutes in Indonesia. As described previously, the main function of universities is education. However, some of them play an important role in R&D and thus this section mentions Institut Teknologi Bandung at the end.

6.4.1 State Ministry of Research and Technology (RISTEK)

RISTEK is the organization which has been responsible for policy development and implementation in the field of research and technology. There were 5 Director-Generals under the Minister, each having jurisdiction on S&T system, S&T resources, S&T network, popularization and productivity in S&T, and utilization of S&T. RISTEK functioned as the hub organization in the field of S&T and coordinated with other fields.

The main functions of RISTEK included 1) coordination of policy implementation in the field of science and technology, 2) management of national assets and resources, 3) supervision on the main directions in scientific and technological development and whether the priority issues are implemented, and 4) preparation of strategic S&T policy for national development.

RISTEK can be seen as an organization similar to Council for Science, Technology and Innovation (CSTI) in Japan in the sense that it was responsible for adjustments and coordination. However, RISTEK had its own public-application competitive funding system for researchers and thus also played a role as a funding organization for research and development. The 7 important fields of research specified by RISTEK were 1) food, 2) health and medicine, 3) energy, 4) transport, 5) ICT, 6) national defense and security, and 7) material science.

There are 7 independent national research institutes which were directed or supervised by RISTEK and functions coordinated. The 7 research institutes are National Institute of Aeronautics and Space (LAPAN), Geological Survey Agency (BIG), National Standardization Agency (BSN), National Nuclear Energy Agency (BATAN), and Nuclear Energy Regulatory Agency (BAPETEN), as well as LIPI and BPPT. The budgets for these institutes are 100% provided from the government.

As research institutes directly belonging to RISTEK, there are also the Centre of Science and Technology Research of the Republic of Indonesia (PUSPIPTEK), Eijkman Institute for Molecular Biology, Science & Technology Center Indonesia (PP IPTEK), and Agricultural Technology Park.

Indonesia has spared fairly large budgets (budget for Fiscal 2015: 41.6 trillion IDR (approx. 416 billion yen) for higher education in the past, while the annual budget for RISTEK had been less than 1/10 of that. Since the budgets have also been unified for RISTEK and higher education in the recent central government reform, it is anticipated that the ratio of expenditures on research funding and so forth will increase compared to the higher education budget in the future.

6.4.2 Indonesian Institute of Sciences (LIPI)

Founded in 1967, LIPI is the oldest and most advanced research institute in Indonesia. It has approximately 4,600 employees in total, of which about 1,600 are researchers. The main research facility is located on Java island and smaller facilities scattered over other islands. LIPI has 26 research centers, 16 technical demonstration facilities, 4 administrative offices, 2 international centers, and 4 botanical gardens scattered over 11 provinces. There are about 200 new recruitments every year. At present, it has approximately 600 young researchers planning to get Ph.D., and LIPI has the policy to encourage them to study overseas to accumulate experience, though it depends on various conditions such as scholarship acquirement, whether there are instructors, and match in research theme. The most popular study abroad destination in Asia is currently South Korea, followed by Japan and then Taiwan. They even loan money from the World Bank sometimes to have them study abroad.

Management of botanical gardens is also one of the jobs for LIPI, and they currently have 4 of them. While a botanical garden is to be constructed in each province by the policy of the President, LIPI is responsible giving them instructions including selection of plants. Construction of botanical gardens is extremely significant from the standpoint of preserving the local species and plant resources.

LIPI mainly works on basic research. In Japan, its equivalent organization would be RIKEN. This is because the former President Habibie advocated during his time as BPPT Director (1974 - 1998) clear role-sharing so that LIPI would conduct basic research and BPPT would take over and conduct evaluation, technology transfer and so forth if technology is found. However, more recently LIPI has announced its stance to conduct a wide scope of research projects including applications as well as basic.

LIPI conducts basic research in a wide variety of fields such as social sciences, humanities, and S&T policy, in addition to biotechnology, earth sciences, physics, chemistry, electricity, and information science. For example, Science and Research Policy Center has functions like a think-tank for the President, and approximately 40 employees implement collection of political evidence and data and so forth.

The annual budget for LIPI is only about 1.2 trillion Indonesian rupia (IDR) (approx. 12 billion yen). Of this, most is used up in fixed expenses such as salary for the researchers, leaving little to be used for the actual research. There are thus voices demanding for large increase in research expenses.

LIPI is currently constructing a science center focusing on bioscience research and a botanical garden on a large lot with area 180 hectares in Chibinong (approx. 50 km south of Jakarta). An incubation center is also constructed to try to nurture the technology and send out the new research outcomes to the society. Most expect that this center will take about 2 years to deliver specific successful cases and outcomes, though it is intended to lead technologies (research outcomes) to patent acquisition and eventually commercialization. This science center has biological laboratory, microbiology laboratory, and bio-material laboratory, which conduct application research projects as well as basic research projects. The bio-material laboratory is also deeply involved in the SATREPS project (Japanese member: Kobe University). The new Joko Widodo regime has been trying to construct total of 100 techno-parks in various islands of Indonesia, but none has been successfully constructed so far. There are also high expectations within LIPI to demonstrate a successful model with the science center in Chibinong.

6.4.3 Agency for the Assessment and Application of Technology (BPPT)

Like LIPI, BPPT is one of the best research institutes in Indonesia which was founded in 1974. There are 5 divisions under the director, and these 5 divisions - technology policy evaluation; natural resource development technology; technology for agricultural industry and biology; information, energy and material technology; industrial technologies; and design and engineering - conduct technological development, evaluation and popularization as well as human resource development projects.

BPPT has approximately 3,000 employees in total and is often mentioned as an organization similar to AIST in Japan. While more than 200 employees work at the headquarters building in

Jakarta, other major research sites are the 6 clusters in Serpong (approx. 35 km southwest of Jakarta) including the information system cluster in, defense cluster and earth sciences cluster. A total number of about 2,000 researchers work at these clusters.

The 5 tasks of BPPT are Assessment, Application, Clearinghouse of technology, Audit of technology and Technology transfer. Assessment is normally conducted before Application to study whether the new technology can be applied and promote utilization at related agencies and so forth if no problem is found. Although no other agencies in the world has Assessment in their names, this reflected the special intention of Habibie, who had been the Director then.

The annual budget for BPPT is 1 trillion IDR (approx. 10 billion yen), which is nearly the same amount as that of LIPI mentioned previously. However, appropriate additional budgets are received from other agencies for Application and so forth.

Although BPPT is a large research institute next to LIPI, focus of BPPT is placed on technology while the interest of LIPI lies in overall science including social science. Even though it is sometimes difficult to clearly distinguish the two, BPPT basically places importance on technology as well as its evaluation and application. While BPPT has functions concentrated at the center (Java island), LIPI has several research centers used as bases on many islands with activities more regionally diversified.

BPPT has actively worked in research cooperation with other countries including Japan in the S&T field. Research cooperation relationship with Japan has been strong and going very well. The current BPPT director also has experience of studying abroad at Kyushu University. Such circumstances are not specific to BPPT but common to the research institutes in Indonesia. Many leaders at organizations such as LIPI and BATAN have studied in Japan in the past.

The most popular fields of cooperation with Japan are marine science, marine systems, air observation, development of remote sensing technology with satellites, while there are exchanges in a wide range of fields including medicine and agriculture. Especially regarding satellite technology, it is considered important to cooperate with Japan in this field including identification of types of satellites Indonesia needs. It is because Indonesia is susceptible to disasters such as volcanic explosion, earthquakes and tsunamis and satellite research contributes to the reduction of damages caused by such disasters. In this field, they are cooperating with Ministry of Economy, Trade and Industry (METI) and Japan Aerospace Exploration Agency (JAXA), and have already implemented several projects including feasibility studies on energy assessment for (Indonesian national) satellite. There are also 3 missions regarding satellite remote sensing based on national policy. Indonesian Earth Observation Satellite System (Ina-SAT), a comprehensive research project on development of small-satellite technologies, is expected to address the launch of the first satellite by BPPT at an early stage, although it will also depend on what kind of plan the new regime which has just begun will announce for the Fiscal 2015.

6.4.4 Bandung Institute of Technology (ITB)

The history of ITB goes back to 1920, when it was established as Bandung Technical High School under Dutch occupation. Its name being changed to the current one after the World War II, they have worked on education and research in the field of engineering and technology. However, in the recent years, they have grown beyond this field to cover basic research, craft and design, business and management. At present (December 2014), ITB has 12 faculties, covering a wide range of fields from mining and petroleum engineering to electronics and informatics. They have approximately 1,000 faculty members and 20,000 students. Although the number of students entering the college every year is approximately 3,000, the number reaches about 6,000 in total with students in master’s and doctoral degree courses.

They currently run 13 education programs. Of these, 7 programs such as chemical engineering, electronics and so forth have been examined and certified by Accreditation Board for Engineering and Technology (ABET) in the US, and 2 more programs will be certified by ABET in the future. ITB is the only university examined and certified by ABET in Indonesia.

In international efforts, they concluded double master's degree program agreements with 4 overseas universities as graduate programs. One of these universities is Hiroshima University in Japan, and the other are in Taiwan, France and the Netherlands. In 2015, ITB intends to start up a program called "3+1+1" in which a student can attain the master's degree in total of 5 years by substantiating the contents. In this program, a bachelor's degree is given from ITB when a student studies at the overseas university for 1 year after learning at ITB for the first 3 years. The student is given a master's degree by the overseas university when he/she completes the master's course at the overseas university in the following year. ITB plans to actively promote further international cooperation measures with other universities overseas in addition to the program with these 4 universities.

Revocommunity Corporation (founded in 2009, headquarters address: Tokyo) recently concluded an agreement in joint implementation of a project to support employment at Japanese companies (measures to comprehensively support foreign students to be employed in Japan) with 6 universities in 3 ASEAN countries (Indonesia, Thailand and Vietnam). Based on this, they launched a project to provide education in Japanese that the students need by sending Japanese staffs with qualification in Japanese language education to these 6 universities. The 6 universities are ITB and University of Indonesia in Indonesia, Chulalongkorn University and Thammasat University in Thailand, and Hanoi University of Science and Technology and Vietnam National University, Ho Chi Minh City - University of Technology in Vietnam. Starting in Fall 2014, lecture on Japanese language has been given at ITB free of charge for 1 year.

Revocommunity has always been a company that worked on projects to support the young human resources mainly in Southeast Asia to be recruited at Japanese companies. This project was launched based on the needs of Japanese companies to recruit excellent human resources in science, engineering and technology from Southeast Asia. The purpose is to raise the proficiency of students in Japanese to a certain level by sending Japanese language instructors in order to solve the problem of language (Japanese) which is the largest barrier. At present, about 20 Japanese companies have joined as cosponsors in this project. What will be very significant in the future developments is how many students will actually be recruited by Japanese companies at the end of the lecture course in Fall 2015. It is expected that whether there are human resources matching the needs of the Japanese companies will be key.

6.5 Input indexes for science and technology[18]

6.5.1 R&D Expenditure

Gross expenditure on R&D (GERD) in Indonesia is approximately 804 million dollars, and its proportion to GDP is 0.08% (2009). Compared to approximately 150 billion dollars (2011) for the R&D expenditure in Japan, it is evident how small the scale is in Indonesia.

The fact that the absolute cost for R&D is extremely small is a serious problem for the development of S&T in Indonesia. Private companies conduct little R&D, and there is no cooperation from the private sector in R&D. The corporate entities only purchase the entire research outcomes that have been completed and are not interested in doing R&D on their own.

[18] UNESCO Institute for Statistics

6.5.2 R&D Expenditure Ratio by Sector

When focusing on the ratio of burdens in R&D expenditure by organization, it shows that the current ratio for the government is 70 - 80% in Indonesia and about 15% for the industry, indicating that the ratio for the government is extremely high. This fact indicates limited participation from the industry, which seems to be a cause for preventing competition in R&D and the environment to create innovations from being formed. Considering that the ratio for the government in major countries generally remains smaller than 30% including Japan with 16.4%, this high value in Indonesia is almost exceptional. Some people in RISTEK wish to reverse this value, that is, 20% from the government and 80% from the private sector in 5 years in the future.

6.5.3 Percentage of R&D by Type of Activity

The ratio in R&D expenditure by type cannot be summarized in accurate figures as statistical data by UNESCO and OECD are lacking. However, according to a LIPI executive, the current ratio is 60% basic research and 40% application research, and their goal is to reverse this ratio in the future. Although national research institutes had been free to decide how their research funds were used, from now on the research funds from the national government will be supplied with clear purposes and uses from the beginning with 40% for basic research and 60% application.

6.5.4 The number of researchers

Based on the data as of 2009, the number of researchers in Indonesia is 41,143 (HC) and 21,349 (FTE). Looking at the number of researchers per 1,000 labor force, the size of researchers in Indonesia is 0.36 researchers (HC) and 0.19 (FTE).

Some fear that the absolute number of employed Indonesian nationals will decrease as better human resources with advanced skills will come into Indonesia from other ASEAN countries in concurrence with the start of ASEAN Community in 2015. It can be said that Indonesia is behind other ASEAN countries in human resource development. One of the reasons for this is that the number of students entering universities is extremely small. There is also a tendency for young people with high potential to directly find overseas aids and study in foreign universities, and development and acquisition of trained human resources has been a challenge in promoting R&D.

6.6 Output Indexes for Science and Technology

6.6.1 Science Research Papers

First, we focus on the number of scientific articles, which is an index for basic science. Items such as the number of scientific articles, number of citations and number of authors were compared among Japan and 10 ASEAN countries based in the indexes from SciVal, a research analysis tool by Elsevier (see figure 6-4).

The number of articles in Indonesia is rather small like those of Vietnam and the Philippines. It is far from the high quality of articles in Singapore, which stands out among ASEAN countries.

Figure 6-4: Comparison of Selected Countries by Number of Science Paper

Country \ Item	Number of Papers	Number of Citations	Number of Authors	International Co-Authorship
Japan	648,938	3,534,908	599,167	23.6%
Malaysia	93,406	292,001	76,671	31.3%
Singapore	80,680	701,014	48,757	51.5%
Thailand	53,334	257,150	48,585	37.4%
Indonesia	15,728	58,632	17,247	55.0%
Vietnam	12,696	60,540	13,670	67.9%
Philippines	7,354	47,088	7,747	57.3%
Cambodia	1,064	10,905	1,258	88.8%
Brunei	879	2,373	747	48.9%
Laos	750	4,237	810	93.6%
Myanmar	558	1,651	663	60.8%

Source: Elsevier, SciVal Database

6.6.2 University ranking

As seen with scientific articles, universities in Indonesia are generally low in scientific research level. Therefore none of them is ranked high in international university rankings.

The only university that was ranked within 400th in the QS World University Rankings 2014 was University of Indonesia, whose place was 310th. Bandung Institute of Technology (ITB) was the next highest, ranked between 461st - 470th. A Japanese university that was close to University of Indonesia in rank was Hiroshima University, which was 314th. A Japanese university that was close to ITB in rank was Tokyo Metropolitan University which was at 441st - 450th.

6.6.3 Patents

Indonesia does not have any technology or product that may represent the country. They have not achieved something that would correspond to automobiles in Japan, for example, and the private demands industry which competes in domestic and international markets with patents through research and development remains weak. Thus the number of patents obtained is much smaller than other countries such as the US., Europe, Japan, China and South Korea. Comparing the data for 2012, the number of patents obtained in Indonesia was approximately 6,000, while it was 343,000 in Japan and 543,000 in the US[19].

6.7 Foreign Relations

6.7.1 Japan

Indonesia is the closest country in Southeast Asia for Japan. Especially after the end of the World War II, the relationship was extremely close that it meant Indonesia when they mentioned Southeast Asia due to the issues of war compensations with other neighboring countries. In the S&T field, research exchanges between the two countries have been active, with many researchers from Indonesia studying abroad in Japan as a part of such exchanges. At present, many of the executives at major research institutes have experience in studying in Japan, indicating their extremely high expectations about Japan.

19 WIPO http://www.wipo.int/portal/en/index.html

(1)Co-authorship of scientific articles with Japan

However, according to the data (1999 - 2001 and 2009 - 2011) on joint authorship in scientific articles in “Benchmarking Scientific Research 2012” by National Institute of Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology, Indonesia is not ranked within the 10 most popular countries for joint authorship seen from Japan in any of the individual fields, which are chemistry, material science, physics and space science, computer science and mathematics, engineering, environmental science/ecology and earth sciences, clinical medicine and psychiatry/psychology, or basic life science. There seem to be several reasons, but the greatest of them is that Japan has not considered Indonesia as a major partner for cooperation due to the extreme difference in the level of S&T between them.

Most measures by Japan regarding Indonesia had been attempts to actively roll out the advanced S&T and the research outcomes of Japan in Indonesia, such as support for capacity development or capacity building.

(2) Intergovernmental cooperation

The Agreement on Cooperation in Science and Technology between Japan and Indonesia was concluded in 1981. The 1st Joint Committee on Japan-Indonesia S&T Cooperation was held in January 1982 based on this agreement but this Committee has not been held since then. However, Japan has continuously sent policy advisors to give advice on S&T from 1982 to 2010 upon request from Indonesia. Advisor to BPPT Director was sent during the period between 1997 and 2010.

(3) Cooperation with Japan Society for the Promotion of Science (JSPS)

・ Core-to-Core Program: Establishment of Research Hub

Research and education institutions around the world have been cooperating in building world-level or regional core research exchange hubs. The following is a list of research projects associated with Indonesia from 2012.

A: Advanced Research Networks (5 years)

Core Institute, Coordinator in Japan	Core Institute in Indonesia	Program Title
Yamaguchi University	Brawijaya University	Establishment of an international research core for new bio-research fields with microbes from tropical areas (World-class research hub of tropical microbial resources and their utilization)

B: Asia-Africa Science Platforms (3 years)

Core Institute, Coordinator in Japan	Core Institute in Indonesia	Program Title
Kyoto University	Syiah Kuala University	Regional Platform for Disaster Risk Reduction in Asia with Networking Researchers, Practitioners and Information
Kyoto University	Bandung Institute of Technology (ITB)	International Research Collaborations and Networking on Extreme Weather in Changing Climate in the Maritime Continent
Yamaguchi University	Udayana University	Establishment of the Southeast Asia Research and Education Center for Disaster Reduction and Environmental Monitoring using Satellite Remote Sensing
Kyushu University	University of Indonesia	Continuous remote medical education for the diagnosis of early gastric cancer in Asia
St. Luke's International University	Universitas Islam Negeri (UIN) Syarif Hidayatullah Jakarta	Development of midwifery personnel training model for maternal and newborn mortality reduction in Asia and Africa
Kyushu University	Gadjah Mada University	New Consortium Creation and Cultivation of Young Scientist on Earth Resources in Asia and Africa Region
Hokkaido University	Research Center for Physics / the Indonesian Institute of Sciences (LIPI)	Resources Oriented Sanitation Model for Developing Regions
Kyoto University	Research Center for Biology / LIPI	Asian Vertebrate Species Diversity Network Platform with Combining Researchers, Specimens and Information
Nagoya University	National Institute of Aeronautics and Space	Observations of the equatorial ionosphere in south-east Asia and west Africa
University of Tokyo	ITB	Standardization and dissemination of mitigation technologies for landslide disasters

・ International Training Program (ITP)

ITP was launched in 2007 for the purpose of developing young human resources. This program aims to provide support for development and implementation of excellent programs for young Japanese researchers to conduct research activities overseas for certain periods in systematic collaboration between Japanese universities and overseas partner organizations with the goal to nurture highly skilled researchers with international viewpoint who would be responsible for the future of academics. ITP has already implemented and completed 6 projects, and one of them was titled “establishment of international collaboration system for researcher development in Asian and African regions” and had University of Indonesia and Gadjah Mada University as Indonesian participants, and from overseas 13 countries including Japan, the UK, Singapore, Vietnam, China and South Korea participated.

(4) Cooperation with Japan Science and Technology Agency (JST)

・ Science and Technology Research Partnership for Sustainable Development (SATREPS)

SATREPS is a Japanese governmental program that promotes international joint research. The program is structured as collaboration between JST, which provides competitive research funds for S&T projects, and the Japan International Cooperation Agency (JICA), which provides Official Development Assistance (ODA). Based on the needs of developing countries, the program aims to address global issues and lead to research outcomes of practical benefits to both local and global society.

12 SATREPS projects have been already funded in Indonesia, and a new projects as for 2015 have just adopted. Ongoing 12 projects are as follows.

Japanese leading institution	Indonesian institutions	Agendas
Kyoto University	- Bandung Institute of Technology (ITB)	Technology Development of Steam-spot Detection and Sustainable Resource Use for Large Enhancement of Geothermal Power Generation in Indonesia
University of Tsukuba	- Agency for the Assessment and Application of Technology (BPPT)	Searching Lead Compounds of Anti-malarial and Anti-amebic Agents by Utilizing Diversity of Indonesian Bio-resources
Nagoya University	- Bogor Agricultural University	Ecological Studies on Flying Foxes and their Involvement in Rabies-related and Other Viral Infectious Diseases
Kyoto University	- Center for Volcanology and Geological Hazard Mitigation - Gadjah Mada University and others	Integrated Study on Mitigation of Multimodal disasters caused by Ejection of Volcanic Products
Gunma University	- BPPT	Development of a Model System for Fluidized Bed Catalytic Gasification of Biomass Wastes and Following Liquid Fuel Production in Indonesia
Kobe University	- Indonesian Institute of Sciences (LIPI) - University of Indonesia (UI)	Innovative Bio-production in Indonesia (iBioI): Integrated Bio-refinery Strategy to Promote Biomass Utilization using Super-microbes for Fuels and Chemicals Production
Kyoto University	- ITB - Delft University of Technology (TU Delft) and others	Pilot Study for Carbon Sequestration and Monitoring in Gundih Area, Central Java Province, Indonesia
Biological Resource Center, National Institute of Technology and Evaluation (NITE)	- Research Center for Biology / LIPI	Development of Internationally Standardized Microbial Resource Center to Promote Life Science Research and Biotechnology
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	- BPPT - Agency for Meteorology, Climatology and Geophysics (BMKG) - National Institute of Aeronautics and Space (LAPAN)	Climate Variability Study and Societal Application through Indonesia - Japan "Maritime Continent COE" - Radar-Buoy Network Optimization for Rainfall Prediction (Terminated)
Hokkaido University	- LIPI - BPPT - LAPAN - State Ministry of Research and Technology (RISTEK) and others	Wild Fire and Carbon Management in Peat-forest in Indonesia (Terminated)
University of Tokyo	- LIPI	Multi-disciplinary Hazard Reduction from Earthquakes and Volcanoes in Indonesia (Terminated)
Kobe University	- UI - Airlangga University (AU) - LIPI	Identification of Anti-Hepatitis C Virus (HCV) Substances and Development of HCV and Dengue Vaccines (Terminated)

・ e-ASIA Joint Research Program (e-ASIA JRP)

The e-ASIA JRP was officially launched in June 2012. It has been formulating and supporting international joint research projects in the East Asian Region on the multilateral basis as well as promoting researchers interaction through workshops, etc. The projects will be selected through open Call for Proposals. The Secretariat office is located in the building of NSTDA at the Thailand Science Park (TSP).

The e-ASIA JRP has currently 16 member organizations from 12 countries, consisting of Japan, Cambodia, Indonesia, Laos, Malaysia, Myanmar, New Zealand, the Philippines, Thailand, the US, Vietnam and Russia (as of June 2015). Ministries, agencies or other public/governmental bodies that provide research funds, might be a member organization of the e-ASIA JPR. From the Japanese side, MEXT, JST and the Japan Agency for Medical Research and Development (AMED) have been participating to support research projects.

In respect to the Indonesia-related projects, 2 joint research projects in the field of “Health research” have been carried out.

(5) Hasanuddin University Faculty of Engineering Enhancement Project

As an example of measures led by JICA, let us introduce Hasanuddin University Faculty of Engineering Enhancement Project. This is a technical cooperation project with a purpose to enhance the research capabilities matching the local needs and develop and send out excellent human resources by taking in the characteristics of engineering education in Japan in a comprehensive manner with a yen loan. This project was launched in 2009 upon request from Indonesia. The cooperating organizations in Japan are 4 universities including Kyushu University and Hiroshima University. Hasanuddin University is located on Sulawesi Island in the northeast part of Indonesia, and it is intended that highly capable human resource be developed to implement industry and academic promotion and that the foundation for education and research be reinforced through effective utilization of this university which is an intellectual resource in the region.

6.7.2 Other Foreign Countries

The US and Germany are popular for research cooperation with countries other than Japan. Furthermore, fellowships and research grants from South Korea is increasing in Indonesia in recent years. The fact that it is much easier to gain fellowships through Korea International Cooperation Agency (KOICA) and so forth lie in this background. This resulted in increased number of people from Indonesia visiting South Korea for active research exchanges.

6.8 Topics in Science and Technology

The following section discusses the topics that characterize the situation surrounding S&T in Indonesia.

6.8.1 R&D utilizing the Diversity in Biological Resources

First is the importance of bio-resource development and utilization. While development in S&T using bio-resources as foundation for research will match the local needs for research in Indonesia, it is expected that research and development utilizing the diversity in biological resources delivers great potential. SATREPS projects related to diversity in bio-resources are good examples that utilize this potential. In the background of these projects lies the fact that there are demands that the potential of microbial resources be utilized in development of agricultural and environmental technology, but a system to continuously utilize the microbial resources has not been established, although interests in bio-resource preservation are high in Indonesia, which prides in the 2nd highest biodiversity in the world.

When focusing on bio-resources, Indonesia has a wealth of diverse biomass and bio-resources. At present, a study to supply sustainable energy or produce chemical products is being conducted using biomass waste from palm (such as waste from oil expression plant), and they are trying to establish a biomass conversion technology in a form that would suit the circumstances in Indonesia.

For Indonesia which is trying to reform itself as a major maritime nation under the new regime of Joko Widodo, it is inevitable that interests will be attracted to the ocean in addition to the land. Under such circumstances, great possibilities are found in marine studies such as one on marine life habitation at the bottom of deep sea as well as development of new drugs (drug discovery research) using marine bio-resources. In Indonesia, interests in resource preservation are growing in concurrence with those in R&D, with some complaining that researchers from Europe, America and so forth taking bio-resources out of Indonesia and not returning the research outcomes to the Indonesian society.

6.8.2 Research Contribution using the Geographical Characteristics

Second characteristic is the contribution to meteorology and geophysics by utilizing the geographical characteristics of being a country directly under the equator. Indonesian islands play the role of “the heart” to dam up the high-temperature current heading from the Pacific to Indian Ocean, generate active clouds and circulate the atmosphere over entire earth. Therefore, it is possible to improve the climate prediction precision over the earth by dramatically developing the capability to observe the sea and rain in Indonesia. Such studies can contribute to the improvement of the position of Indonesia in climate fluctuation research.

6.8.3 Hazard Reduction Studies

Last topic is about research studies related to hazard reduction from natural disasters such as earthquakes and volcanoes in Indonesia. Indonesia has 127 active volcanoes and is subject to frequent earthquakes. For the purpose of reducing risk of multimodal disasters due to volcanic eruptions, for instance, a SATREPS project is under way to develop an integrated observation system and stimulators to mitigate various volcanic disasters, developing a decision making support system for multimodal sediment disasters.

6.9 Summary

As discussed in this chapter, S&T in Indonesia have the power to demand changes over the entire nation even though they have quite a few problems including small budgets and unestablished infrastructure, and increase in middle class within the population is backing up the maturity of domestic consumption and market. It can be said that it has large potential for the future.

If Indonesia intends to join advanced countries in the future, 1) establishment of infrastructure, 2) human resource development, 3) entrepreneurship are important to maintain international competitiveness, and it is also necessary to make things with additional values in fields such as manufacture and services at the same time.

While the new Joko Widodo regime announced its policy to return 10% of the research outcomes to the society, it is nearly impossible under the current circumstances. It seems necessary to share the experience of Japan well in which we utilized S&T effectively in the growth of the country.

Reference:

- Yoshiki Mikami ed., “Technological Development Strategies in ASEAN” JETRO, 1998 (in Japanese)
- Takashi Shiraishi, “Empire of Seas - How We Should Think of Asia -” Chuko-Shinsho, 2000 (in Japanese)

See also:

- S&T related links (Ministries, Research Institutes and Universities)
- The World Bank http://data.worldbank.org/data-catalog/world-development-indicators
- JETRO http://www.jetro.go.jp/world/asia/idn/
- ASEAN-Japan Centre http://www.asean.or.jp/ja/
- RISTEK http://international.ristek.go.id/
- LIPI http://www.lipi.go.id/www.cgi?depan&&&2015&&eng&
- BPPT http://www.bppt.go.id/english/
- ITB http://www.itb.ac.id/en/

7. The Philippines

7.1 Outline

The extent of the Philippines' R&D is moderate compared to other ASEAN countries. Activities in the fields of medicine and agriculture are relatively strong Universities such as the University of the Philippines and research institutes such as the International Rice Research Institute play a leading role in such activities. What is required is research and development directly related to social issues such as reduction of poverty and responses to natural disasters such as typhoons, volcanic eruptions and earthquakes.

7.2 Current socioeconomic trends and background

7.2.1 Basic information

The official name of the Philippines is the Republic of the Philippines and its capital city is situated in Manila. 7,000 islands comprise this island country. Its land size is 300,000 km^2 and its population is 97.4 million (estimate as of 2013). The population is growing at an annual pace of 2% and the Commission on Population of the Philippine government announced an estimate that the population reached 100 million on July 27, 2014. People in the country are young with an average age of 23, and it is said that the demographic dividend in which economic growth is driven by the workforce will continue for the time being.

7.2.2 History

After Ferdinand Magellan arrived in the Philippines in 1521, the country had been under the colonial control of Spain for a long time since 1571. Then, the sovereignty over the Philippines was transferred to the US at the end of the Spanish–American War, which started in 1898. Following the Philippine–American War and other events, the entire Philippines was put under control of the US in 1915. In 1916, the US Congress enacted the Jones Act (the Philippine Autonomy Act), which declared that the Philippines would become independent in the future. The country had been under control of the US until it gained sovereignty in July 1946 following the Japanese occupation period of 1942 to 1945.

7.2.3 Politics

Since the Philippines achieved independence in 1946, the county has adopted the political system of a constitutional republic. However, Ferdinand Marcos, who assumed the presidency in 1965, ruled the Philippines based on the state power. Meanwhile, the Communist Party of the Philippines (CPP) which adhered to Maoism was re-established in 1968 and in March 1969, it organized the New People's Army (commonly known as NPA) and started guerrilla warfare. Also, in 1970, dissident group of Muslims founded the Moro National Liberation Front in the southern part of the country and began a rebellion on the Mindanao Island. Marcos was re-elected through vote rigging in 1969, and, in 1972, declared martial law across the country by reason of insurgencies by the above two groups, closed down Congress, removed the existing ruling class from power and had the military take control of government functions under the banner of creating a New Society. Although martial law was lifted in 1981, Marcos and those around him continued to take the politics into their own hands until he and his wife fled their country to Hawaii in the wake of the EDSA

Revolution in February 1986.

Thereafter, following the terms of several Presidents, Benigno Aquino III (the oldest son of the late President Corazon Aquino) has been the President since he assumed office in 2010. President Aquino declared his commitment to eradicating improprieties and corruption and also has important policies of achieving peace in Mindanao and strengthening the public security.

7.2.4 Ethnic groups, Languages Religions

As for ethnic groups in the Philippines, Malay Filipinos make up a large part of the total population. The rest are of Chinese or Spanish origin, mixed race with these groups and minority groups. The national language is Filipino and official languages are Filipino and English. Overall, there are about eighty languages in use.

In addition, the Philippines is the only Christian nation in the ASEAN group. 83% of the population are Catholic and other Christian denominations account for 10%.

7.2.5 Educational System

The educational system of the Philippines was renovated in June 2011 (an academic year starts in June in the Philippines) and adopted the 6-6 system (6-year primary education and 6-year secondary education). Up until then, the 10-year basic education (6-year primary education and 4-year secondary education) was provided. The basic education is supervised by the Department of Education. The rate of enrollment for the basic education period was 88.2% according to data of 2009.

7.2.6 Economy

Nominal GDP of the Philippines in 2013 was approximately 270 billion dollars, which ranks the country in the fifth position after Singapore among the ASEAN countries. However, the country's per capita nominal GDP was approximately 2,765 dollars and occupied the sixth position among the ASEAN countries.

Actual GDP growth rates of 2012 and 2013 were 6.8% and 7.2%, respectively and were in a strong upward trend. However, the unemployment rate remained around 7% and no improvement was seen in 2011 to 2013. The current account marked the surplus of 10,393 million dollars in 2013, which doubled from 2011.

Figure 7-1: Summary of the Philippines' economy

	2011	2012	2013
Real GDP growth rate (%)	3.6	6.8	7.2
Nominal GDP per person (USD)	2,358	2,588	2,765
Unemployment rate (%)	7.0	7.0	7.1
Current account (USD)	5.643 million	6.949 million	10.393 million

Source: The World Bank / JETRO World Trade Investment Report (2014)

Taking a look at the share of GDP of the Philippines by industry, according to 2013 data, the primary, secondary and tertiary industries account for 11.5%, 31.7% and 56.8%, respectively.

The country's trading partners are Japan, U.S. and China in terms of export and China, the US and Japan in terms of import.

Figure 7-2: Major trade partners of the Philippines (2013) (Unit: million dollars)

	Export	Import
No. 1	Japan (21.2%) (11,423)	China (13.0%) (8,033)
No. 2	The US (14.5%) (7,813)	The US (10.8%) (6,686)
No. 3	China (12.2%) (6,583)	Japan (8.4%) (5,184)

Source: JETRO World Trade Investment Report (2014)

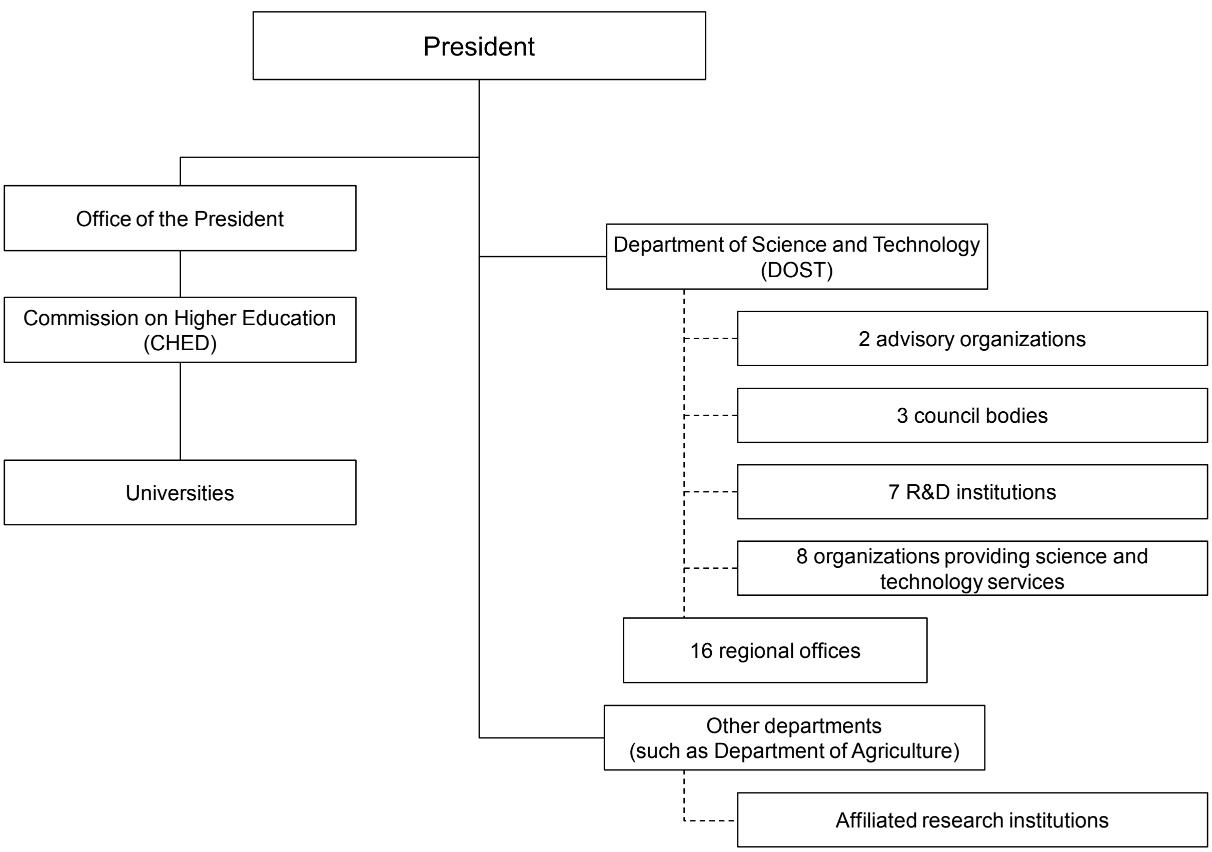
7.3 Science and Technology Policy

7.3.1 S&T Related Organizations

The Department of Science and Technology (DOST) is mainly in charge of the science and technology policies of the Philippines. Under the DOST, there are 19 organizations, which consist of 2 advisory organizations, 3 council bodies in charge of promoting the policies, 7 R&D institutions established according to the fields, and 8 organizations that provide science and technology services (such as provision of information). Further, the DOST has an office in each of the 16 regions.

On the other hand, universities are supervised by the Commission on Higher Education (CHED) established under the Office of the President.

Figure 7-3: Governmental Organization Chart Related to S&T in the Philippines



7.3.2 Policy and Trends in S&T

This section describes the science and technology strategy and higher education policy of the Philippines.

The Philippines' basic strategy for S&T is shown in the "National Science and Technology Plan 2002 – 2020," which sets out a long-term plan that covers nearly 20 years. This document puts forth visions and goals related to S&T, and describes strategic areas.

Visions related to S&T are presented for three points in time: 2004, 2010 and 2020. The vision for 2004 is "Science and technology significantly contributes enhancing the national productivity and competitiveness and solving urgent national issues." The vision for 2010 is "The Philippines has created a niche market and provides and utilizes world-class knowledge and expertise in the fields it selected. The country also fosters a vibrant culture of science and technology." The vision for 2020 is "The Philippines develops world-class competitive products and services based on high technical capabilities."

Strategic areas based on the above visions are classified into 9 categories: (1) Pursuit of a niche and formation of clusters, (2) efforts to tackle urgent national issues (poverty, inadequate medical system, increase in population, food, water, energy, housing and employment, low income, productivity, environmental devastation, cyber terrorism, fragile governance), (3) cultivation of human resources in the fields of science and technology, (4) provision of support to small-to-medium enterprises, (5) promotion of technology transfer and utilization, (6) building and upgrading of infrastructure in the fields of science and technology, (7) enhancement of the relationship between government, industry, academia, civil society and foreign countries, (8) improvement of administrative ability in the fields of science and technology and (9) fostering of scientific, technological and innovative culture.

In addition, some strategies were updated in the National Development Plan 2011-16. The following priority issues were presented with an aim of building innovative industries and service sectors: (1) widening access to cost-effective and useful technologies in order to enhance innovation capabilities of small-to-medium companies, (2) providing state-of-the-art equipment and other support to assist local industries in creating innovations, (3) utilizing ICT to expand economic opportunities, and (4) Motivating researchers and engineers to create social and technical innovations.

The website of the DOST shows 8 outcomes to be pursued, which represent the detailed contents of results to be expected from the implementation of the above strategies. The above 8 outcomes are as follows: (1) science-based expertise and tools for achieving world-class productivity in the field of agriculture, (2) revolutionary, cost-effective and appropriate technologies for small-to-medium companies to develop and produce world-class competitive products, (3) state-of-the-art facilities and equipment for achieving a world-class competitive edge while improving values chains of domestic industries, (4) the Philippines as a world leader in the IT field (realization of business process management services that create 1.3 million jobs including 520,000 jobs outside the capital region), (5) transforming the government based on ICT in a manner that widens access to government services (medical and education) in non-urban areas (with the aim of getting a place in the top 50 countries in the field of e-government in the world by 2016), (6) improving medical care and QOL by scientific and technical innovation, (7) fostering highly capable and world competitive human resources in the fields of science and technology through national science and technology programs (making PSHS [Philippines Science High School] a top level science high school in the ASEAN region by 2015 and assigning at least one DOST scholar to each town by 2016), and (8) providing science-based weather and climate information along with impact assessment results (thereby providing support to organizations that work out measures against disasters and climate changes and making the Philippines a resilient country).

Overall, the above strategies indicate the direction of advancing efforts related to science and technology that contribute to solving social issues and the direction of developing human resources, infrastructure, administrative systems, etc. to facilitate the first direction.

Meanwhile, the current higher education policy is based on the basic policy of trifocalization revealed in 1992. In other words, since that time, the education policy has maintained the concept that the Commission on Higher Education, the Department of Education and the Technical Education and Skills Development Authority (TESDA) under the Department of Labor and Employment are in charge of higher education, primary education, and mid-level technical and vocational training, respectively.

Basic measures taken by the Commission on Higher Education are summarized in a strategy document entitled the Strategic Plan for 2011-2016. This document sets out the following basic policies: (1) enhancing the quality of higher education (including promotion of education based on international standards and securing of international competitiveness of former students), (2) providing opportunities to access higher education to everyone who wishes to receive higher education, (3) protecting academic freedom firmly, and (4) making a commitment to improving morals to eradicate corruption.

Intensive support is provided by, for example, designating organizations as a center of excellence (COE) and a center of development (COD).

7.4 Promotion Bodies of Science and Technology

Organizations that are particularly important as a major promotion body of science and technology are (1) institutions affiliated with the Department of Science and Technology, (2) the University of the Philippines and (3) the International Rice Research Institute. Institutions in (1) are not only major bodies to promote policies of science and technology but also conduct research on their own, through their internal research laboratories, etc. The university indicated in (2) is the only national university in the Philippines and is ranked at the highest level in the Philippines in terms of production of academic papers, which is discussed later. The institute indicated in (3) is ranked in second place after the University of the Philippines in terms of production of academic papers and actively carries out international cooperation.

This section first describes institutions affiliated with the Department of Science and Technology and then provides information on the University of the Philippines. The International Rice Research Institute is described in the section regarding relationships with overseas bodies.

7.4.1 Institutions Affiliated with the Department of Science and Technology

(1) Overall view of the Department of Science and Technology (DOST)

The DOST is an organization with the Secretary at the top. Under the Secretary, there are three Undersecretaries as well as four Assistant Secretaries. The three Undersecretaries supervise science and technology services, regional businesses and research and development. Each of the four Assistant Secretaries is in charge of technology transfer, strategic plans and programs, financial, general and legal affairs, and reduction of climate change and disaster risks, respectively. The DOST has internal bureaus, each of which corresponds to the Secretary and other abovementioned positions and supervises its affiliated institutions.

According to the FY2013 performance report of the DOST[20], the budget for the DOST itself was approximately 2,370 million pesos, which is converted to approximately 55 million US dollars at the average exchange rate of 2013. In addition to the above, the total budget for all DOST-affiliated institutions for FY2013 was approximately 10.1 billion pesos (approximately 236 million US dollars). In short, the total annual budget for the DOST as a whole including regional offices stands at the level of nearly 300 million US dollars. The number of personnel working at all DOST-affiliated institutions was 5,056.

Taking a look at the structure of research institutions under the DOST reveals some characteristics of research promoted by DOST-affiliated institutions. There are seven research institutions under the DOST, which are as described as follows. First, we have the Advanced Science and Technology Institute (ASTI), which is an organization that gives priority to ICT, microelectronics, biotechnologies, etc. but at the same time, promotes research across all science fields. The Food and Nutrition Research Institute conducts research on malnutrition in the general public and other issues. The Forest Products Research and Development Institute (FPRDI) conducts applied research related to forestry. The Industrial Technology Development Institute (ITDI) conducts research in the fields of manufacturing, processing and energy. The Metals Industry Research and Development Center (MIRDC) has the largest budget among seven research institutions and engages in technology transfer and research in the field of the metals industry. The Philippine Nuclear Research Institute conducts research on application of nuclear power to agricultural, medical and industrial uses. The Philippine Textile Research Institute engages in applied research and technology transfer in the field of the textile industry. The ASTI covers a relatively wide range of fields while the other institutes engage in research, technology transfer and other activities focusing on specific industrial fields.

The sections below provide descriptions on the National Research Council of the Philippines from the advisory organization category and the Philippine Council for Industry, Energy and Emerging Technology R&D from the council body category. Also, information on the two R&D institutions, the Advanced Science and Technology Institute and the Philippine Institute of Volcanology and Seismology is provided. These descriptions are intended to provide an outline of institutions affiliated with the DOST.

(2) The National Research Council of the Philippines (NRCP)

The NRCP was established in 1931. Currently, it has 35 members of personnel and its annual budget is approximately 60 million pesos (approximately 1.4 million US dollars). Its mission is to promote basic and issue-based research (especially, inter-disciplinary ones that contribute to solving national issues and including the field of social science). More specifically, the NRCP takes on the following four functions: (1) promoting and supporting basic research that contributes to continuous development of abilities of individual or group researchers, (2) promoting cooperation with international scientific organizations to facilitate development and sharing of scientific information, (3) providing advice on problems and issues that affect national interests and (4) getting scientific and technical culture entrenched in society. In short, the NRCP takes on the functions of funding research and providing advice and information to the DOST and other organizations.

As for the funding function, the NRCP has determined thirteen priority science and technology areas and provides funding based on such areas. The thirteen areas are physics, engineering, veterinary medicine, earth and planetary science, chemistry, agriculture and forestry, biology, medicine, pharmacy, mathematics, humanities, social science and public policy. Although the

[20] http://www.dost.gov.ph/index.php/transparency/reports/performance/viewdownload/45-performance-reports/364-2013-dost-performance-report

amount of funds appropriated to support research activities is anything but a large number, the NRCP works to provide wide-ranging support.

Also, the NRCP gives an award to researchers who produce excellent results in the field of basic research. Further, it provides a program called a master's thesis and doctral thesis grants. In this program, 10,000 pesos for a master's course student for a two-year period and 15,000 pesos (approximately 200 to 300 US dollars) for a doctral course student for a three-year period are distributed to organization to which the relevant student belongs.

As for the advisory and information provision functions, the NRCP provides information to facilitate formulation of national development plans, determination of DOST priority areas and other activities. In doing so, it establishes several committees that include outside experts to discuss issues.

(3) The Philippine Council for Industry, Energy and Emerging Technology R&D (PCIEERD)

The PCIEERD was formed through a merger of the Philippine Council for Industry and Energy Research and Development (PCIERD) and the Philippine Council for Advanced Science and Technology Research and Development (PCASTRD). As of 2013, the PCIEERD had 112 members of personnel and its total budget was approximately 447 million pesos (approximately 10.5 million US dollars). Its mission is to guide public and private organizations and facilitate their collaborations in regard to the production of technologies that contribute to scientific and technical policies and strategies and national economic development. More specifically, in the fields of industry, energy and emerging technology, the PCIEERD engages in (1) developing and providing support to policies, (2) supporting research and development, (3) developing human resources and organizations, (4) disseminating scientific and technical information, and (5) supporting technology transfer and commercialization. In short, the PCIEERD is a funding organization that aims to facilitate research and development and technology transfer. Also, it works to prepare R&D roadmaps in the technical areas it is in charge of.

Distribution of budgets for the PCIEERD is managed from three aspects. Viewed from the aspect of social issues, the budget is divided into reduction of poverty and empowerment of the needy and the socially vulnerable (4%), fast, comprehensive and sustainable economic growth (94%) and measures for environmental conservation and climate changes and for mitigating their effects (1%). In addition, from the perspective of final output, the budget is divided into R&D policies and strategies (4%), R&D management (90%) and commercialization of technologies (6%). Further, looking at the budget by application, personnel costs, management costs, and competitive funds distributed account for 11%, 3% and 86%, respectively. In other words, a focus is placed on activities that distribute competitive funds to R&D projects in the fields that contribute to economic growth.

The priority areas set by the PCIEERD are: (1) industry (electronics, semiconductor, food processing, metals, engineering, mining and minerals), (2) energy (alternative energy, efficiency of energy, efficient transport), (3) emerging technology (biotechnology, genomics, ICT, material science, nanotechnology, photonics, space technology), and (4) special issues (adaptation to climate changes and mitigation of their impacts, reduction and management of disaster risks, environmental issues).

(4) The Advanced Science and Technology Institute (ASTI)

As mentioned earlier, the ASTI is an organization that gives priority to ICT, microelectronics, biotechnology and other areas but at the same time, promotes research across all scientific fields. If we look for a similar organization in Japan, the ASTI can be likened to RIKEN.

The FY2013 budget for the ASTI was approximately 71 million pesos (approximately 1.7 million US dollars) and it had 68 members of personnel. The size of its budget is the sixth largest among seven research institutions. However, the amount spent for R&D projects is the highest among seven research institutions, which indicates that the ASTI has acquired a large amount of competitive funds.

Projects delegated by the ASTI are: (1) research and development in the application of ICT, (2) long-term research to enhance scientific and technical infrastructure, (3) research and development in the advanced areas such as biotechnology and microelectronics, and (4) supplementing activities in important areas related to computer and information technologies.

Projects promoted by the ASTI are classified into five categories: (1) governance that focuses on anti-corruption, transparency and accountability, (2) reduction of poverty and empowerment of the needy, (3) measures for environmental conservation and climate changes and for mitigating their effects, (4) fast, comprehensive and sustainable economic growth, and other projects. Ten projects promoted in category (1) tend to use ICT technologies to visualize administrative activities. Visualizing administrative processes aims to reduce room for fraudulent activity. Five projects in category (2) tend to provide administrative services such as education using ICT. Ten projects in category (3) focus on monitoring. Two projects in category (4) make efforts toward incubation and the operation of a technology development center. One project in category (5) makes efforts toward the EU-Southeast Asia Cooperation (SEACOOP) project.

(5) The Philippine Institute of Volcanology and Seismology (PHIVOLCS)

The PHIVOLCS is an organization classified into the category “service agency.” It conducts activities such as providing information on disasters. In 1952, it was founded as the Commission on Volcanology (COMVOL) based on the reflection on the past performance at the time of volcanic eruption of Mt. Hibok in 1951. The COMVOL transformed to the current PHIVOLCS after it undertook tasks in the field of seismology that were transferred from another organization in 1984.

The FY2013 budget for the PHIVOLCS was approximately 270 million pesos (approximately 6.3 million US dollars) and it had 195 members of personnel. Slightly more than 7% of the total budget is spent for R&D activities and the rest is appropriated for technical/information provision services, training, etc. However, roughly 90% of 80 million pesos (approximately 1.87 million US dollars) in expenses incurred by the PHIVOLCS for R&D projects was sourced from overseas entities and therefore the scale of the institute’s R&D activities is relatively large among DOST-affiliated institutions.

The PHIVOLCS’s missions are: (1) prediction of volcanic eruptions, earthquakes and crustal phenomena, (2) judgment of forms of volcanic eruptions and earthquakes and affected areas, (3) drawing on positive aspects of volcanoes and volcanic areas in order to stimulate social and economic development, (4) production of sufficient data for predicting volcanic eruptions and earthquakes, and (5) formulation of disaster preparedness and impact reduction plans.

In cooperation with Japan, the PHIVOLCS works on the following four issues in a five-year timeframe under the SATREPS program: (1) real-time earthquake monitoring, (2) evaluation of earthquake generation, (3) real-time volcano monitoring in an integrated manner, and (4) promotion of information provision and utilization to mitigate disaster impacts.

The PHIVOLCS published ten academic papers and conducts relatively active research activities compared to the other DOST-affiliated institutions.

The scale of each DOST-affiliated institution is anything but large, but the organizations are divided according to the functions and their positions are clearly defined. Receiving advice from advisory organizations, each institution decides a policy, which a policy promotion institution led by a council pushes ahead with through a funding program. In this process, seven DOST-affiliated research institutions and universities play a major role. Also, the PHILVOLCS provides services to users (the general public) through a service agency and conducts some research on its own. Meanwhile, there is a possibility that since a small amount of resources are distributed to various activities, sufficient resources cannot be appropriated to each activity.

7.4.2 The University of the Philippines

The University of the Philippines (UP), founded in 1908, is the only national university in the Philippines. Currently, it takes the form of the UP System that consists of seven Constituent Universities and one Autonomous University. Each Constituent University has a Chancellor and conducts R&D activities based on its own strategy, complying with the standards for the UP as a whole.

The number of students attending the UP System as a whole was approximately 60,889 in FY2013, of which 46,112 and 14,777 were undergraduate and graduate students, respectively. The number of teachers was approximately 4,500. The total budget was approximately 10 billion pesos (approximately 234 million US dollars).

The UP System covers a wide range of academic disciplines and has departments for medicine, mathematics, physics, chemistry, biology, computer science, engineering, agriculture, forestry and fishery, humanities, etc. The UP System also has the Open University that offers correspondence courses.

The education policy consists of: (1) ensuring fair access and gathering the most excellent students in the Philippines, (2) modernizing teaching methods, (3) developing a quality assurance system (for students), (4) devoting energy into internationalization, and (5) devoting energy into sports activities.

The research policy consists of: (1) increasing the percentage of graduate students,(2) increasing the percentage of teaching staff with a doctoral degree, (3) expanding the production of intellectual property rights, (5) optimizing research programs, and (6) promoting inter-disciplinary research and international cooperation.

According to SciVal, the UP System published 632 academic papers in the period of 2012 to 2014, which makes the UP System an institution that produced the largest number of papers in the Philippines. The fields covered by the papers are engineering, computer sciences, environmental science, agriculture and biology, social science, physics and space science, mathematics, medicine, etc. in a descending order according to the number of papers. 54% of all papers were co-authored through international collaborations.

All Constituent Universities are designated by the CHED as a center of excellence or center of development. They are said to be the most excellent universities in the Philippines.

7.5 Input Index of Science and Technology[21]

What effect does the situation mentioned above have on the index of science and technology? Discussed below is the input index of S&T. Among statistical data on the Philippines made available by the UNESCO, the latest data are for 2007. This section describes the content of the data and

[21] UNESCO Institute for Statistics

provides some additional information.

7.5.1 R&D Expenditure

According to UNESCO statistics, the US dollar equivalent amount of investments in R&D in the Philippines in 2007 was approximately 340 million US dollars, and accounted for 0.11% of GDP. It is difficult to compare this number with those of the other ASEAN countries because sufficient statistical data of the ASEAN countries are not available. However, when comparison is made using the latest available data of such countries, for the amount of investments in R&D and its percentage of GDP, the Philippines is ranked in fifth and sixth place, respectively.

7.5.2 R&D Expenditure Ratio by Sector

Turning to expenses for R&D by organization, expenses by companies, government agencies, higher education institutions and overseas entities accounted for 66%, 26%, 6% and 4%, respectively. In terms of programs for R&D, private organizations, government agencies, and higher education institutions accounted for 57%, 18% and 23%, respectively. In recent years, the amount of R&D budget has been in an upward trend in the public sector, and the share of R&D activities in the public sector appears to be expanding. As described above, however, the latest available UNESCO statistical data are for 2007, and it is not possible to ascertain the current situation using statistical data.

7.5.3 The Number of Researchers

Based on the data as of 2007, the number of researchers in the Philippines is 11,490 (HC) and 6,957 (FTE). Looking at the number of researchers per 1,000 labor force, the size of researchers in the Philippines is 0.32 researchers (HC) and 0.19 (FTE). When comparison is made using the latest available data of each country, the Philippines is ranked fifth and stands at a slightly lower level than Indonesia.

7.6 Output Index of Science and Technology

What does performance related to S&T in the Philippines look like? This section looks at the above performance based on some indices.

7.6.1 Science Research Papers

We start with the number of scientific papers which is the index of basic science. Based on indices of the research analysis tool SciVal made by Elsevier, Japan and the ten ASEAN countries are compared in terms of the number of scientific papers, the number of citations and the number of authors (see figure 7-4).

The number of papers of the Philippines is ranked after Indonesia and Vietnam and is relatively small. In terms of quality of papers, the Philippines falls far behind Singapore, which stands out among the ASEAN countries. Note that fields covered by the papers are medicine (17.3%), agriculture and biology (15.1%), social science (9.7%), biochemistry, genomics and molecular biology (8.1%) and environmental science (6.6%).

Figure 7-4: Comparison of Selected Countries by Number of Science Paper

Country \ Item	Number of Papers	Number of Citations	Number of Authors	International Co-Authorship
Japan	648,938	3,534,908	599,167	23.6%
Malaysia	93,406	292,001	76,671	31.3%
Singapore	80,680	701,014	48,757	51.5%
Thailand	53,334	257,150	48,585	37.4%
Indonesia	15,728	58,632	17,247	55.0%
Vietnam	12,696	60,540	13,670	67.9%
Philippines	7,354	47,088	7,747	57.3%
Cambodia	1,064	10,905	1,258	88.8%
Brunei	879	2,373	747	48.9%
Laos	750	4,237	810	93.6%
Myanmar	558	1,651	663	60.8%

Source: Elsevier, SciVal Database

7.6.2 University rankings

According to the QS World Universities Rankings 2014, only the University of the Philippines was ranked within the top 400 universities and stood in 367th place, followed by the Ateneo de Manila University, which was ranked in the range of 461-470. A Japanese university ranked close to the University of the Philippines was Hiroshima University, which was ranked in 314th place. A Japanese university ranked close to the Ateneo de Manila University was Tokyo Metropolitan University, which was ranked in the range of 441-450.

7.6.3 Patent

In the era when the Philippines was a colony of the US, the Patent Law of the Philippines started its history as applying the US Patent Law to the islands of the Philippines which paved the way to the patent application of inventions created in the Philippines under the US Patent Law. An independent patent system was established in the Philippines in 1947.

The constitution of the Philippines provides for protection of intellectual property and the Patent Law, the Trademark Law and the Copyright Law are integrated into one legal system as the Intellectual Property Law. The scope of protection under the Intellectual Property Act covers semiconductor integrated circuits, utility models, botanical varieties, optical media, etc. as well.

In the 2005-2009 period, the number of patent applications was approximately 3,000 to 3,500, and the number of registrations was approximately 800 to 1,700. Note that for a majority of the applications and registrations, foreign parties played a main role. On the other hand, the number of applications for utility models remained at approximately 500 annually and for a majority of the applications, domestic parties played a main role[22].

[22] Masanobu Ono and Tatsuo Okada, eds. “Intellectual Property Systems of Asian Countries” Seirin Shoin, 2010

7.7 Foreign Relations

7.7.1 Japan

Japan regards the Philippines as an important country from the perspective of geopolitics and regional security. This is reflected in the fact that Japan is the largest Official Development Assistance (ODA) provider for the Philippines. Meanwhile, in the field of science and technology, the Philippines is not included in the total of 47 countries and institutions with which Japan has signed a science and technology agreement so far and there is no comprehensive cooperation framework between the two countries. For this reason, this section looks at individual topics concerning cooperation between Japan and the Philippines.

(1) Co-authorship of scientific articles with Japan

The relationship between Japan and the Philippines in terms of joint authorship of scientific papers is a close one. For example, according to “Benchmarking of Scientific Research 2012” by the National Institute of Science and Technology Policy, Japan was in the second active country in regard to joint authorship with Philippines for 2009-2011. Especially material sciences (1st) and engineering (1st) were prominent.

Philippines were 67th (among 200 countries) in the world ranking by the article above, and the number of publications in 2009-2011 was 2,318. And the most active countries in joint authorship with Philippines were United States, Japan, Australia, China, and the UK.

To understand some aspects of the recent relationship of joint authorship, this section examines the international co-authorship relationship of the top 4 institutions (among all Philippine institutions that produced a certain number of papers and were recognized by SciVal) in terms of the number of papers recorded in SciVal. The number of papers of the Philippines produced under international co-authorship projects during this period was 2,880, and the above four institutions produced up to 1,054 of such papers, which accounted for slightly less than 40% of the total. Therefore, it is not possible to argue that the papers produced by the four institutions indicate the overall trend in internationally co-authored papers in the Philippines, but data to grasp such overall trend are not available. Thus, limited data are provided below.

Institutions of the Philippines that produce many papers are the University of the Philippines, the International Rice Research Institute, De La Salle University Manila and the Ateneo de Manila University in a descending order according to the number of papers produced. Overall, the Philippines has a close relationship of co-authorship with the US but Japan is ranked in second or third place as a co-authorship partner. As for fields covered by papers jointly authored with Japan, the share of agriculture and biology is the largest.

Figure 7-5: Internationally co-authored papers of major institutions in the Philippines

Institution	No. of papers*	No. of Internationally co-authored papers*	Top co-authorship partners*	Fields of papers co-authored with Japan*
University of the Philippines	632	342	US: 84, **Japan: 79**, Taiwan: 54, Australia: 34, Germany: 30	Agriculture and biology: 19, Engineering: 14, Biochemistry, genomics, molecular biology: 12, Earth and planetary science: 11, Environmental science: 11
International Rice Research Institute	479	407	US: 82, India: 79, China: 69, **Japan: 52**, Australia: 51	Agriculture and biology: 37, Biochemistry, genomics, molecular biology: 24, Medicine: 8
De La Salle University Manila	456	230	Taiwan: 52, US: 51, **Japan: 48**, Malaysia: 39, India: 17	Medicine: 11, Environmental science: 8, Computer science: 7
Ateneo de Manila University	230	75	US: 29, Australia: 13, **Japan: 10**, Thailand: 9, Taiwan: 8	Agriculture and biology: 6, Biochemistry, genomics, molecular biology: 3, Social science: 3

* Not mutually exclusive. Example: A paper co-authored by the Philippines, the US and Japan is counted as one paper for each of the US and Japanese co-authorship relationships.
Source: Compiled based on SciVal database[23]

(2) Cooperation with Japan Science and Technology Agency (JST)

JST has been conducting joint researches with the Philippines through the following programs: J-RAPID, SATREPS and e-ASIA JRP.

・ J-RAPID

J-RAPID is an international support program for urgent joint research/investigation. 11 projects related to Typhoon No. 30 that struck the Philippines in 2013 were adopted, and the JST has been conducting joint research on various aspects of responses to disasters with the Department of Science and Technology of the Philippines (DOST). Support period ranges from half a year to one year and approximately 3 million yen was granted for each research task.

・ Science and Technology Research Partnership for Sustainable Development (SATREPS)

SATREPS is a Japanese governmental program that promotes international joint research. The program is structured as collaboration between JST, which provides competitive research funds for S&T projects, and the Japan International Cooperation Agency (JICA), which provides ODA. Based on the needs of developing countries, the program aims to address global issues and lead to research outcomes of practical benefits to both local and global society.

4 SATREPS projects have been already funded in the Philippines as follows.

[23] http://www.elsevier.com/research-intelligence

Japanese leading institution	The Philippines institutions	Agendas
Tohoku University	- Research Institute for Tropical Medicine (RITM) / Department of Health	Comprehensive Etiological and Epidemiological Study on Acute Respiratory Infections in Children: Providing Evidence for the Prevention and Control of Childhood Pneumonia in the Philippines
Tokyo Institute of Technology	- Marine Science Institute, College of Science / University of the Philippines, Diliman (UPMSI) and others	Integrated Coastal Ecosystem Conservation and Adaptive Management under Local and Global Environmental Impacts (Terminated)
Disaster Risk Research Unit, National Research Institute for Earth Science and Disaster Prevention	- Philippine Institute of Volcanology and Seismology (PHIVOLCS)	Enhancement of Earthquake and Volcano Monitoring and Effective Utilization of Disaster Mitigation Information in the Philippines (Terminated)
Kyushu University	- Collage of Public Health / University of the Philippines Manila (CPH-UPM)	Prevention and Control of Leptospirosis in the Philippines (Terminated)

・ e-ASIA Joint Research Program (e-ASIA JRP)

The e-ASIA JRP was officially launched in June 2012. It has been formulating and supporting international joint research projects in the East Asian Region on the multilateral basis as well as promoting researchers interaction through workshops, etc. The projects will be selected through open Call for Proposals. The Secretariat office is located in the building of NSTDA at the Thailand Science Park (TSP).

The e-ASIA JRP has currently 16 member organizations from 12 countries, consisting of Japan, Cambodia, Indonesia, Laos, Malaysia, Myanmar, New Zealand, the Philippines, Thailand, the US, Vietnam and Russia (as of June 2015). Ministries, agencies or other public/governmental bodies that provide research funds, might be a member organization of the e-ASIA JPR. From the Japanese side, MEXT, JST and the Japan Agency for Medical Research and Development (AMED) have been participating to support research projects.

In respect to the Philippines-related projects, 4 joint research projects in the field of “Health research” have been carried out.

In respect to the Philippines-related projects, 5 joint research projects in total have been carried out as follows.

(i) Nanotechnology and materials (1 project)

(ii) Health research (4 projects)

7.7.2 Other Foreign Countries

(1) Signing of S&T agreements

To date, the Philippines has signed 46 science and technology agreements with a wide range of partners. As for the ASEAN region, the country signed an agreement with Indonesia, Thailand and Vietnam. In addition, as for multilateral frameworks, the Philippines is a member of the ASEAN Committee of Science and Technology (ASEAN COST) and the International Atomic Energy Agency (IAEA).

According to the website of the Department of Science and Technology, countries which the

Philippines currently works with on an ongoing basis through international cooperation are the following six countries: the US, Japan, Italy, Thailand, South Korea and China.

(2) International cooperation through the International Rice Research Institute (IRRI)

The International Rice Research Institute is a private research institute based in the Philippines, and mainly conducts a study on rice, a theme common to Asia. Such theme is considered to allow the IRRI to serve as a base for international cooperation. For this reason, this section provides information on the institute.

The IRRI was a research institution established by the Rockefeller Foundation and the Ford Foundation in 1959. The IRRI has 1,350 members of personnel, of which 1,110 are based in the Philippines. 120 and 50 members of personnel carry on activities in Bangladesh and India, respectively. Scientists at the IRRI are hired through the international recruiting process and top level researchers in each field have gathered there.

The revenue in 2013 was 93.5 billion dollars, slightly less than half of which came from a CGIAR (Consultative Group on International Agricultural Research) support program. Further, funds from governments of multiple countries and donations from charity organizations accounted for 32% and 12% of all revenue. In addition, 2% of funds were sourced from the private sector.

The mission of the IRRI is to reduce poverty, contribute to improvement in health conditions of rice farmers and consumers and enhance the sustainability of rice farming. The IRRI has set the following four goals: (1) to ensure that rice production is stable and sustainable, has a minimum impact on the environment and can respond to climate changes, (2) to improve health and nutritional status of poor rice consumers and rice farmers, (3) to ensure that more people have access to information on rice in order to foster next-generation rice scientists, and (4) to provide genetic information and genetic materials to rice scientists and farmers, develop optimum technologies supporting the agriculture industry and enhance productivity.

The IRRI has set the following six research subjects: (1) utilization of genetic diversity for a new level of productivity, product quality and health, (2) development, distribution and introduction of improved rice varieties, (3) ecological and sustainable management of production systems with a focus on rice, (4) increase in added value through improvement in regard to quality, processing and market systems and new products, (5) policy options for technical evaluation, targeting and strengthening influence, and (6) support for fostering a global rice sector (knowledge capacity building).

According to SciVal data for 2012-2014, 85% of papers produced by the IRRI were the ones jointly authored with foreign partners, which indicates a high degree of internationality of the IRRI. Countries of such partners are as described in the previous figure, and many of the papers were written for the US, India, China, Japan and Australia. Meanwhile, activities were conducted within the ASEAN region including Cambodia, Indonesia, Laos, Myanmar, the Philippines, Thailand and Vietnam but the percentage of papers co-authored with these countries was low.

7.8 Topics on Science and Technology

A finding from the above discussion is that R&D activities in the Philippines focus on fields such as medicine and agriculture that contribute to the life of local people. Likewise, policies of the Philippines focus on these fields, which were covered by a large percentage of scientific papers as well. Another finding is that the Philippines, an island country, channels energy into ICT solutions in order to provide administrative and education services to local areas and to enhance transparency in processes taken by governments that are rife with corruption. Furthermore, due to geographical conditions coupled with frequent natural disasters such as typhoons, volcanic eruptions, and earthquakes, service agencies actively give predictions and forecasts and provide other information based on them. On the other hand, the number of papers that cover these fields was not necessarily large.

The following topics on science and technology for the Philippines are selected based on the above findings: (1) necessity to meet local needs, (2) importance of utilizing ICT and (3) importance of research for dealing with natural disasters. This section explores each of the topics in depth.

7.8.1 Necessity to Meet Local Needs

It is generally said that the geographical situation where the Philippines consists of approximately 7,000 islands leads to decentralization in the country. In addition, one of important local needs is to promote the local industry and reduce poverty. It is considered that these circumstances, as an underlying factor, have a major influence on measures taken for science and technology in the Philippines. Such influence is considered to be reflected in the fact that many programs that do not necessarily assume utilization of science and technology are pushed ahead with, for example, in an industrial cluster project called NICCEP described below.

NICCEP is an abbreviation of National Industry Cluster Capacity Enhancement Project. This project is promoted by the Department of Trade and Industry of the Philippines and the JICA. This project is driven based on the Philippine Development Plan 2011-2016. This plan sets out support for small-to-medium companies and expansion of industrial clusters in the context of a mid-term strategy for building competitiveness. To respond to these two issues, the project is being pushed forward.

The goals for the project are: (1) job creation, (2) development of small-to-medium companies, (3) enhancement of added value, and (4) improvement of business environment (approach to poverty, in particular). To achieve these goals, clusters in selected industrial sectors are planned, introduced, supported and evaluated on a nationwide scale with an aim of strengthening industrial competitiveness. The NICCEP management office provides the following support: (1) dispatch of experts on industrial cluster development, (2) provision of training and workshops, and (3) provision of opportunities for overseas training on an as-necessary basis.

Selected industrial sectors are: (1) Luzon area: milkfish, daily necessities, coffee, sightseeing, ICT, health and welfare, handicrafts, (2) Visayas area: gifts, ornaments and household goods, sightseeing, ICT, health and welfare, and (3) Mindanao area: banana, mango, coconut, seaweed, timber, mining, sightseeing, ICT, rubber, domestic poultry, tuna, oil palm. Individual projects do not necessarily require advanced technologies. However, shared services and other frameworks are used to provide technologies to clusters as necessary.

In general, the term “industrial cluster” refers to comprehensive measures to be taken in the industrial field, including research and development activities and the relevant industries are often based on science and technology. However, the NICCEP project does not assume the application of science and technology in many cases. This may reflect the fact that many local areas in the Philippines face more urgent issues than the application of science and technology. It is considered that people in local areas give priority to increasing the sales of their local products and other items to bring economic benefits to the local areas in a short time, rather than improving technologies to enhance productivity and the quality of agricultural products. The policies adopted by the government also aim to meet such needs.

7.8.2 Importance of Utilization of ICT

As mentioned above, since the Philippines is a country consisting of numerous islands, providing administrative, education and other services using ICT solutions is a major issue. According to statistics prepared by a telecommunications company in the Philippines, almost 100% Internet coverage has been achieved in the country, but the actual situation seems to be different. For example, there are stories like the following: Voting results are transmitted electronically from local public schools that are used as voting places at the time of national elections, but it is said that such transmission was successfully made in only about 60% of all regions of the country. Thus, the need for developing high quality networks is strong.

Meanwhile, the government and congress are said to be rife with corruption. For example, recently, a charge was brought for an unauthorized use of the "Priority Development Assistance Fund (funds from government budget that are allocated to each lawmaker)" called pork barrel against over 90 people including active senators and key government officials. One of the reasons for this is an administrative process lacking in transparency. A focus is placed on eliminating room for fraudulent activity by making such process electronic.

In addition, another focus is placed on utilizing high English proficiency to conduct the business of operating call centers for overseas parties. For smooth implementation of this business as well, high quality ICT systems are very important.

7.8.3 Importance of Research for Dealing with Natural Disasters

The Philippines has the issue of preparing against natural disasters because of frequent typhoons and many active volcanoes. For example, the volcanic eruption of Mt. Pinatubo (Luzon Island) in 1991 is said to stand as one of the largest volcanic eruptions in the 20th century, and its height, which was 1,785 meters before the eruption, was reduced to 1,486 meters after the eruption. It is said that over 300 people lost their lives and the number of totally-destroyed houses exceeded 7,000. Further, there was an increased probability that Mt. Mayon (Luzon Island), which has erupted 46 times since 1616, would erupt in September 2014, and approximately 50,000 people were ordered to evacuate immediately.

Typhoons also cause considerable damage every year. For a recent example, Typhoon Yolanda (Filipino name), which caused extensive damage in 2013, is still fresh in our minds. Due to this typhoon, whose maximum wind speed was said to be close to 100 meters, the number of fatalities and missing persons mainly in areas such as the southern end of Samar Island, the northern part of Leyte Island, the town of Daanbantayan on the northern end of Cebu Island, Bantayan Island in the province of Cebu, and the northern part of Panay Island reached approximately 8,000. Because there are many people in areas where roads, sewers, communication networks, and other infrastructures are not adequately developed, once a natural disaster occurs, the damage it inflicts is likely to become extensive.

Dealing with natural disasters is a very important theme, and provision of information by service agencies and other activities are conducted effectively. However, there appears to be still room for improvement in the function of information provision. For example, it is said that when a typhoon approaches, a security level is immediately raised and commercial facilities and other buildings are instructed to be closed in many cases. In such cases, however, a large typhoon does not always hit the Philippines directly.

It may be necessary to issue a warning at an early state and make due efforts to minimize damage under circumstances where sewers and other infrastructures are not adequately developed. But if accuracy of information on which the issuance of warnings is based is improved by raising the accuracy of predictions, it may become possible to deal with disasters in a manner that has less impact on social activities.

For this reason also, it is considered to be meaningful to move forward with research and development for dealing with disasters. Also, since these issues are common to Japan, international joint research that works on such issues would be meaningful, like in the case of research and investigation on Typhoon Yolanda under the ongoing J-RAPID program that is hosted and promoted by the JST and the PCIEERD.

7.9 Summary

It is generally said that since the Philippines is a country consisting of many islands, it has a decentralized nature and puts emphasis on meeting local needs. On the other hand, although the Philippines' economy grows rapidly, benefits from the growth are not brought to local communities adequately. Therefore, when promoting research and development activities, a focus is placed on reduction of poverty. This would also be an underlying factor for particularly active research and development in the fields of medicine and agriculture. In addition, because of the need to achieve transparency in the administrative process that is rife with corruption, research is conducted in the field of ICT. Further, since the Philippines has geographic conditions with frequent natural disasters such as typhoons, volcanic eruptions and earthquakes, an emphasis should be put on scientific and technical research that constitutes a basis for dealing with them. In considering international cooperation with the Philippines, it would be important to take the above factors into account.

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  http://www.pcieerd.dost.gov.ph/images/downloads/publications/Annual_Report_FINAL_2013.pdf
- ASTI Annual Report 2012:
- http://www.asti.dost.gov.ph/images/citizensCharter/annualReports/ASTI_AR_2012_20131204_web.pdf
- IRRI Annual Report 2013: http://books.irri.org/AR2013_content.pdf
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  http://www.dost.gov.ph/index.php/transparency/reports/performance/viewdownload/45-performance-reports/364-2013-dost-performance-report
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- Strategic Plan for 2011-2016, CHED website:
  http://www.ched.gov.ph/wp-content/uploads/2014/12/CHED-Strategic-Plan-2011-2016.pdf

See also:

- S&T related links (Ministries, Research Institutes and Universities)
- DOST http://www.dost.gov.ph/
- NRCP http://nrcp.dost.gov.ph/
- UP http://www.up.edu.ph/
- UP strategy http://www.up.edu.ph/about-up/strategic-plan-2011-2017/
- UP Diliman http://upd.edu.ph/

- OVCRD http://www.ovcrd.upd.edu.ph/
- PHIVOLCS http://www.phivolcs.dost.gov.ph/
- SATREPS http://satreps.phivolcs.dost.gov.ph/
- IRRI http://irri.org/
- NICCEP http://www.niccep.dti.gov.ph/index.php

8. Cambodia

8.1 Outline

Twenty years have passed since the 1993 national constitutional election, held under the supervision of the United Nations Transitional Authority in Cambodia (UNTAC). With 70% of the population under the age of 30, Cambodia has recovered from the destruction of wars that lasted three decades and is now politically stable. The country's key industry is agriculture, which accounts for a third of its GDP and takes up around 70% of its working population. Emerging recently is tourism, especially around Angkor Wat, which was designated as a UNESCO World Heritage Site in 1992. Service industries now account for nearly 40% of GDP. The country actively invites direct investments from abroad on the strength of low labor costs, which are about one-third of those in Thailand and China. In order to move a step upward from simple assembly and other subcontracting work, Cambodia needs scientific and technological prowess. Accelerated development of human resources to meet the needs of industry is a must.

8.2 Current Socioeconomic Trends and Background

8.2.1 Basic Information

Officially designated as the Kingdom of Cambodia, the country, with its capital in Phnom Penh, had a population of 14.7 million in 2013, not particularly large compared with other ASEAN countries. Its total landmass is 181,000 km^2, slightly less than half that of Japan. The trans-boundary Mekong River flows through the middle of the land. Lake Tonle Sap, which is fed by the Mekong River, is the largest lake in Southeast Asia. The lake expands during the rainy season as the Mekong swells, and floods the surrounding land and forests, creating an extremely rich ecosystem for fish breeding. The fish caught in the lake are a valuable source of protein for Cambodian people.

8.2.2 History

In 1867, Cambodia's suzerain Thailand recognized France's protectorate over Cambodia, which was then incorporated into French Indochina in 1887, officially becoming a French colony. Though Cambodia was occupied by Japan during the World War II, the country was returned to French protection after the end of the war. Cambodia gained independence in 1953. King Norodom Sihanouk, who had played a significant role in winning independence, abdicated in favor of his father Norodom Suramarit, and became prime minister. Cambodia became politically unstable in the 1960s due in part to the war in neighboring Vietnam. Pro-American General Lon Nol's coup d'état and the resultant formation of the Khmer Republic in 1970 triggered the Cambodian civil war, and the following military regime of the Khmer Rouge threw the entire country into chaos as it forced city dwellers to live and work in agricultural regions, and many of the rich and intellectuals in cities were killed by the military. Continuous bombing destroyed infrastructure in rural areas, causing a sharp decline in agricultural production. The Khmer Rouge leader Pol Pot adopted an extreme agricultural fundamentalism based on China's Maoism from 1975 to 1979 – a disastrous experiment that ended up in mass starvation and rampant malaria mainly owing to the inefficient farm work by former city dwellers in farmlands already devastated by the civil war. In the 1980s, the Vietnamese military intermittently intervened in the civil war, and pro-Vietnamese forces established the People's Republic of Kampuchea. The civil war went on between the new pro-Vietnam regime, anti-Vietnam Pol Pot troops and other forces. It was not until 1991 when international peace efforts finally culminated in the signing of the Cambodian peace settlement accord in Paris, which set up the United Nations Transitional Authority in Cambodia (UNTAC), illegalized and disarmed the Khmer Rouge, ended the civil war, arranged the return of refugees, and decided on the implementation of general elections, after which the Cambodian constitution was formulated. The election of National Assembly in 1993 led Cambodia to adopt a constitutional monarchy, re-establishing the Kingdom of Cambodia after 23 years of chaos, with Norodom Sihanouk again ascending the throne. In the 1997 election, the Cambodian People's Party led by Hun Sen won, and the regime continues today in its fourth term. Sihanouk's son, Norodom Sihamoni, has been Cambodia's king since his coronation in 2004. Cambodia became a member of ASEAN in 1999, and served as a chair country in 2012.

8.2.3 Politics

The king was reinstated by the 1993 Constitution of the Kingdom of Cambodia, with a bicameral parliament consisting of a 61-member upper house and 123-member National Assembly (lower house). The national budget is still way from being fiscally sound, depending on Official Development Assistance (ODA) from other countries for 30% of the budget. In an effort to break away from overdependence on ODA, Hun Sen's government aims at economic growth driven by foreign direct investment, through preferential treatment given to such investments, and by business activities in newly established special economic zones.

8.2.4 Ethnic groups, Language and Religion

Of the people in Cambodia, Khmers comprise 86% of the total population. Chinese and Vietnamese each account for about 5%. Though the numbers are small, the two ethnic groups have significant influence over the country's economy. Prime Minister Hun Sen is reportedly of Chinese ancestry. Signboards of banks and corporations affiliated to Chinese capital are ubiquitous, especially in the Cambodian capital of Phnom Penh. With Vietnam located just down the Mekong River, ties with Vietnam are also strong. The country's official language is Khmer, as provided in the constitution of 1993. French, the language of Cambodia's former colonial power, is spoken only to some degree by senior citizens and intellectuals, whereas English is more widely understood, partly due to flourishing tourism.

Buddhism is the country's official religion, as laid down by the constitution, and is followed by approximately 90% of Cambodians. Freedom of religion, nevertheless, is assured, and Chams and other minority ethnic groups practice Islam. During the period of the Khmer Rouge, religion was forbidden, resulting in the destruction of numerous temples and the killing of priests.

8.2.5 Education System

The literacy rate differs among age groups. As the Khmer Rouge banned education, the literacy rate among people aged 45 and above is only about 20%, whereas the rate for the young is above 80% for males and reaches 60% for females. Like Japan, the Cambodian educational system is 6 years for primary education, 3 years for lower secondary education, and 3 years for upper secondary education; the first 9 years being compulsory. Children receiving primary education account for 96% of the age group, but the ratio declines to 34% for lower secondary education and a mere 21% attend upper secondary schools[24]. Schools in Cambodia operate in two shifts: morning and afternoon. As teachers are not well paid and many have second jobs, the main problem is low educational motivation among teachers.

[24] UNICEF Annual Report 2012 for Cambodia, EAPRO

Cambodia

8.2.6 Economy

Cambodia has two seasons: the rainy season (May-October), and the dry season (November-April). While double cropping of rice is possible in areas with good irrigation, most rice farmers do only single cropping during the rainy season. The rate of agricultural production is on the rise in regions where the use of agricultural machinery is gradually becoming common, but poor irrigation facilities in many regions make rice farming in the dry season difficult, with unstable crops. Nevertheless, as agriculture accounts for more than 30% of GDP, primary industry is still Cambodia's key industry. In the 1950s, Cambodia was the world's 5th largest rice exporter, and the nation's agriculture had great potential for growth in the land made fertile by the periodic flooding of the Mekong River. But decades of civil war and fighting has devastated the land, keeping agricultural productivity low. Cambodia is one of the poorest among ASEAN countries. While the increase in agricultural productivity and the escape from poverty is closely linked, Cambodia still suffers from low productivity, and has just started moving toward agricultural mechanization.

Figure 8-1: Summary of Cambodia's economy

	2011	2012	2013
Real GDP growth rate (%)	7.1	7.3	7.5
Nominal GDP per person (USD)	852	971	1,040
Unemployment rate (%)	n.a.	n.a.	n.a.
Current account (USD)	1.122 million	1.437 million	1.441 million

Source: The World Bank / JETRO World Trade Investment Report (2014)

(1) Trade

In the industrial sector, labor-intensive manufacturing centering on sewing businesses is gradually advancing. In 2012, 88% of industrial exports were articles of apparel and clothing accessories. Exporting and processing of light industry products, especially sewn goods, shoes, electronic components, processed foods, and furniture, is expected to grow against the backdrop of low-cost and abundant youth labor. Economic growth in 2009 was minus 2% due in part to the global economic crisis, but bounced back to more than 6% the next year. The average growth of real GDP over the 5 years from 2007 to 2011 registered 6.0%. Cambodia's largest trading partner is China, which also tops the list of foreign investors, even though the country fell second to the Republic of Korea in 2012, with cumulative investment greater than any other country backed by Cambodia's Chinese population, which has a significant influence over the Cambodian economy.

Figure 8-2: Major trade partners of Cambodia (2013) (Unit: million dollars)

	Export	Import
No. 1	The US (33.8%) (2,079)	China (34.3%) (3,043)
No. 2	Hong Kong (25.8%) (1,587)	The US (12.6%) (1,119)
No. 3	Singapore (12.9%) (793)	Thailand (12.3%) (1,095)

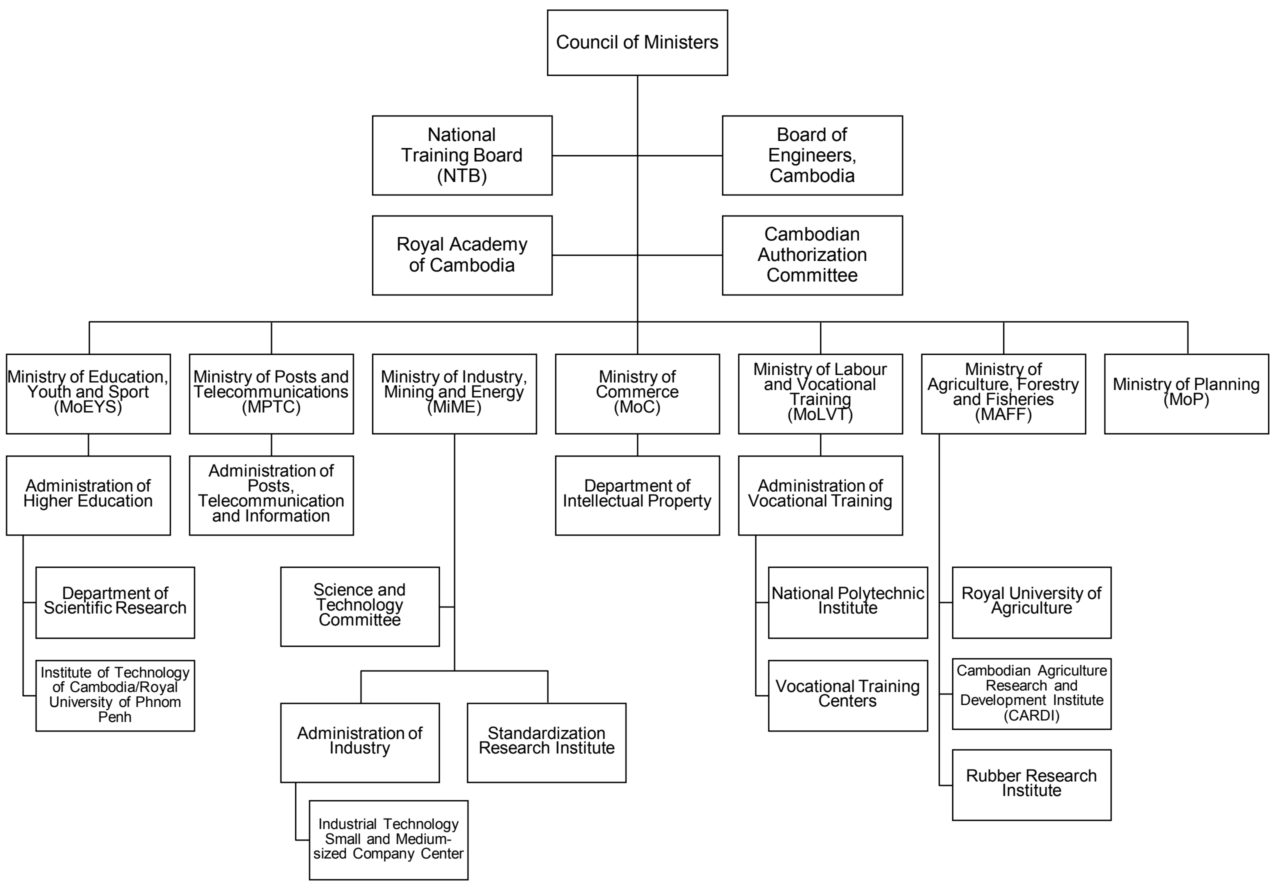
Source: JETRO World Trade Investment Report (2014)

8.3 Science and Technology Policy

8.3.1 S&T Related Organizations

Cambodia lacks a ministry of science and technology that could implement a science and technology policy. Neither does the country have, as of 2014, a science and technology policy; however, formulation of one is under way at the Supreme National Economic Council (SNEC), comprised of a committee established to draft scientific and technological strategy and of members from the Ministry of Education, Youth and Sport, the Ministry of Posts and Telecommunications, the Ministry of Labour and Vocational Training, the Ministry of Industry, Mining and Energy, the Ministry of Planning, and the Ministry of Economy and Finance. However, the council is still at the stage of understanding the basic situation of each area of science and technology, and identifying problems, which means it is unlikely that a strategy will be disclosed soon. Important strategies that form the base of the country's science and technology policy are indicated hereafter.

Figure 8-3: Governmental Organization Chart Related to S&T in Cambodia



8.3.2 Policy and Trends in S&T

(1) Rectangular Strategy

This is the national development strategy set forth by Prime Minister Hun Sen in 2004. Placed in the center of the rectangle is “Good Governance”, surrounded by four priority agendas: fighting corruption, legal and judicial reform, public administration reform, and armed forces reform. Considered as the most important prerequisites for the enforcement of these reforms are: peace and political stability, strengthening of a favorable macroeconomic environment, and promotion of sustainable development and reducing poverty. The government’s top priority is the achievement of peace, which, together with political stability and improved social order, is expected to create a reliable image of Cambodia and foster the trust of investors and tourists.

(2) National Strategic Development Plan (NSDP)

Cambodia has promoted development based on two national plans: the second phase of the Socio-Economic Development Plan (SEDP II 2001-2005) and the National Poverty Reduction Strategy (NPRS 2003-2005). In 2006, in an attempt to set forth a development plan on the basis of the rectangular strategy, the government formulated NSDP, which consolidated the third phase of the Socio-Economic Development Plan and the next phase of NPRS (2006-2008), which was later extended to 2018, the end of Hun Sen’s term of office. The plan hammers out such agendas as the build-up of the country’s agricultural sector, creation of a favorable environment that invites foreign direct investment, job creation by private businesses, construction of infrastructure, and development of human resources. However, the plan lacks the development of the nation’s innovation system, a concept crucial to the achievement of these goals[25].

8.4 Promotion Bodies of Science and Technology

While the literacy of the youth living in cities exceeds 90%, educational levels differ significantly depending on life environment, due in part to the total neglect of education under the military regime, especially that of Pol Pot. World Bank data indicates that about 10% of the population receive a tertiary education, but the inequality in educational opportunities is becoming fixed, as universities are concentrated in the Phnom Penh area, and literacy and school attendance are both low in rural regions. With the country still in the phase of promoting education, research at universities is not actively sought. But the needs for well-developed human resources are growing along with the stabilization of Cambodia, development of infrastructure and industrial sectors. Illustrated hereafter is the current state of leading universities in Cambodia. With the lack of a ministry of science and technology, as previously noted, Cambodia’s science and technology policies are implemented by the Ministry of Education, Youth and Sport (MoEYS), which supervises institutions of tertiary education, the Ministry of Industry, Mining and Energy (MiME), and the Ministry of Labour and Vocational Training (MoLVT) in a somewhat fragmented manner.

8.4.1 Ministry of Education, Youth and Sport (MoEYS)

With no ministry supervising science and technology, MoEYS, founded in 1993, that governs national universities is the center of research and development policy enforcement. The ministry supervises, among others, the Institute of Technology of Cambodia (ITC) and the Royal University of Phnom Penh (RUPP) as shown hereafter. Cambodia has 91 institutions of tertiary education, of which 35 are national universities and 56 are private universities. Some private universities are

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governed by the Ministry of Labour and Vocational Training (MoLVT), rather than by MoEYS.

8.4.2 Institute of Technology of Cambodia (ITC)

ITC is a national university founded in 1964. Its facilities were built with support from the French government, Cambodia's former colonial power, and were initially managed with the cooperation of the Soviet Union. The university is currently run with the assistance of the French government in a tie-up with Belgium, Japan, and the Republic of Korea. Though the university is "national", it has a significant degree of independence in curriculum design and distribution of funds, with government assistance limited to personnel expenditure. The university actively seeks the assistance of such institutions as Agence universitaire de la Francophonie (AUF), a network of French-speaking higher-education institutions, Commission universitaire pour le Développement (CUD), a Belgian assistance framework, ASEAN University Network/Southeast Asia Engineering Education Development Network (AUN/SEED-Net) of the Japan International Cooperation Agency (JICA), and Korea International Cooperation Agency (KOICA), and manages many programs including scholarships, student exchange, and invitation of faculty members. Students total approximately 4,000, of whom 25% are females studying mostly chemistry and information technology. Around 70 students go on to master's degree courses, and about 7 students proceed to PhD courses. Undergraduate students study for five years, including corporate training in the final year as a part of the curriculum, which facilitates students' job hunting after graduation. The system seems to be working relatively well in matching students' career pursuits and industry's needs for educated human resources. Future agendas are (1) to establish a management-of-technology course, and (2) to create a PhD course for engineering. The doctorate course is to start in 2015 under the Co-Advisor system (AUN-SEED Net) with Japan. The university currently emphasizes education rather than research, which accounts for only about 10% of its efforts, and the target for the present is to increase the ratio to about 50%. There are seven faculties in the university: chemistry/food technology, civil engineering, electric and electronic engineering, geology/geotechnical engineering, information and communication technology, industrial and machine engineering, and agricultural engineering. Now, 30 researchers with PhDs are employed.

Fields of ongoing research include:

- civil engineering, water quality control, water supply and sewerage system
- food processing, agricultural product quality improvement
- bio-diesel, resources re-processing, waste control
- development of less industrialized regions
- climate change
- application of computer-processing in native language

8.4.3 Royal University of Phnom Penh (RUPP)

RUPP is the country's largest university, founded in 1964, and is the only university in Cambodia that offers fundamental science courses. RUPP has 18,000 students in total, both undergraduate and graduate. An annual average of 1,000 students are enrolled in the Faculty of Science, of whom about 800 study computer science, with the remaining 200 students majoring in mathematics, physics, chemistry, biology, and environmental science. The high popularity of computer science is due in part to the probability of employment, but getting a job in the private sector is not always easy, and many graduates go back home to become teachers. As professors at national universities earn only the equivalent of 200 US dollars per month on average, and often need a second job to make ends meet, not many undergraduates go on to graduate school and choose a life of research. Even though the need for research is apparent, as set forth in the national development strategy, the level of research is still rudimentary. Together with the shortage of research funds and facilities, research activities are difficult to conduct unless foreign grants are obtained. RUPP plans to launch a PhD course in approximately 2020.

RUPP's Institute of Foreign Language (IFL) offers nation's highest level programs. One target is to provide more classes taught in English in tertiary education, with the integration of ASEAN countries in view, but the target is not easy to achieve, especially in the provinces. RUPP has 660 faculty members and 420 teaching staff, of whom 24 are PhDs. Faculties are organized as follows:

Faculty	Course
Science	Biology, Chemistry , Information, Environment, Mathematics, Physics
Social and humanity studies	Geography, History, Khmer literature, Media and communication, Philosophy, Sociology, Welfare, Tourism
Engineering	Information technology, Communication and electric engineering, Biotechnology
Development	Regional development, Economic development, Resources management
Foreign Language	Chinese, English, French, International relations, Japanese, Korean

8.5 Input Index of Science and Technology[26]

8.5.1 R&D Expenditure

Gross expenditure on R&D (GERD) in Cambodia is about US$6,820,000, accounting for 0.05% of GDP (2002). Even though the figures are arguably old, they still indicate a vast gap compared with Japan's R&D expenditure, which totalled US$150 billion in 2011.

Extremely small R&D expenditure is a serious problem for scientific and technological development in Cambodia. The country has little industry to speak of, and its capacity for research and development is regrettably low. Since there is little accurate data related to science and technology, understanding the current situation is possible only through field surveys and interviews of officials at related ministries and agencies.

8.5.2 The number of researchers

There are only about 800 researchers in Cambodia in 2002. Based on the data as of 2002, the number of researchers in Cambodia is 774 (HC) and 223 (FTE).

The figure is one of the lowest, after Laos and Brunei, among ASEAN countries. This is partly due to the very small number of students who go on to higher education, and also to the low level of researchers' income, which does not encourage young people graduating from universities or graduate schools to enter a career path as researchers. Highly talented students sometimes directly obtain foreign scholarships, go to universities abroad, and later find jobs and stay there. To educate the best and the brightest and to prevent a brain drain is a big agenda in promoting research and

[26] UNESCO Institute for Statistics

development in Cambodia.

Looking at the number of researchers per 1,000 labor force, the size of researchers in Cambodia is 0.12 researchers (HC) and 0.04 (FTE). Extremely small compared with 10.06 in Japan and 7.87 in the US in 2011.

8.6 Output Index of Science and Technology

8.6.1 Science Research Papers

First is the analysis of scientific papers, an index for basic science, based on the benchmarks of SciVal, Elsevier's research analysis tool. The number of papers, citations and authors in Japan and 10 ASEAN countries are compared (see figure 8-4).

The number of scientific papers of Cambodia is slightly larger than that of Brunei and Laos, but the quality lags far behind that of Singapore, which rises significantly above other ASEAN countries.

Figure 8-4: Comparison of Selected Countries by Number of Science Paper

Item / Country	Number of Papers	Number of Citations	Number of Authors	International Co-Authorship
Japan	648,938	3,534,908	599,167	23.6%
Malaysia	93,406	292,001	76,671	31.3%
Singapore	80,680	701,014	48,757	51.5%
Thailand	53,334	257,150	48,585	37.4%
Indonesia	15,728	58,632	17,247	55.0%
Vietnam	12,696	60,540	13,670	67.9%
Philippines	7,354	47,088	7,747	57.3%
Cambodia	1,064	10,905	1,258	88.8%
Brunei	879	2,373	747	48.9%
Laos	750	4,237	810	93.6%
Myanmar	558	1,651	663	60.8%

Source: Elsevier, SciVal Database

8.6.2 University Ranking

As seen above, the ratio of papers written in international co-authorship is large in Cambodia, suggesting that many papers are from research institutions of Western countries located in Cambodia. Cambodian universities do not occupy high positions in international university rankings either. According to the list of the world's top universities by British Quacquarelli Symonds (QS), none of Cambodia's universities were within its top 700 ranking. As previously indicated, human resources matching seems to be gradually progressing between the Institute of Technology of Cambodia (ITC) and industrial sectors, but most universities are still half way to turning out talented scientists and engineers that the country dearly needs. Human resources and budgets for conducting research are far from sufficient.

8.6.3 Patents

The Ministry of Industry, Mining and Energy (MiME) governs Cambodia's patent system. JETRO Data as of 2011 shows 42 patent applications were sent but none of them was registered[27].

[27] JETRO Report on Intellectual Properties in Cambodia http://www.jetro.go.jp/world/asia/kh/ip/pdf/laws_kh.pdf

8.7 Foreign Relations

8.7.1 Japan

After dispatching Japan's self-defence forces to UNTAC, Japan has extended significant assistance to the recovery of the Cambodian economy. Cambodia and Japan are also active in research and interchange in the field of science and technology, with many Cambodian researchers coming to Japan for research and study. Quite a few top scientists in research institutions in Cambodia have experience of studying in Japan, and seem to have great expectations for Japan. In particular, they express the hope to learn about the working attitude of Japanese workers, and to introduce Japan's vocational training systems.

(1) Co-authorship of scientific articles with Japan

However, "Benchmarking Scientific Research 2012" published by the National Institute of Science and Technology Policy (NISTEP) of Japan's Ministry of Education, Culture, Sports, Science and Technology shows data (1999-2001, 2009-2011) that indicate that Cambodia was not within the top ten countries of Japanese researchers' co-authorship in any of the following fields of science: chemistry, materials science, physics and space science, computer science and mathematics, engineering, environment/ecology and geoscience, clinical medicine and psychiatry/psychology, and basic life science.

(2) Assistance for science and mathematics education by the Japan International Cooperation Agency (JICA)

During the years of the Khmer Rouge regime, Cambodia saw the collapse of the entire educational system, and still suffers structural problems such as a shortage of teachers and inequity in educational opportunities between rich and poor. While training of teachers in the field of science and mathematics is of great importance for Cambodia's future industrial advances, it was not a target for assistance in the past. From 2000 to 2005, JICA implemented the Secondary School Teacher Training Project in Science and Mathematics in Cambodia (STEPSAM), which aimed at improving the science and mathematics teaching functions and capabilities of the country's National Institute of Education (NIE), which trains high-school teachers. Following this program was the Project for Improving Science and Mathematics Education at Upper Secondary Level (ISMEC), implemented from 2005 to 2008. Thereafter, STEPSAM II was carried out from 2008 to 2012. Thus, JICA has been a vehicle for Japan's assistance for the improvement of science and mathematics education in Cambodia in cooperation with MoEYS.

8.7.2 Other Foreign Countries

The relationship with France, Cambodia's former colonial power, is still very close. Institut Pasteur du Cambodge, established in 1953 and re-opened in 1995 after the civil war, conducts research in biology and medicine. Among others, Cambodia's National Science and Technology Master Plan 2014-2020 was agreed upon between the Korea International Cooperation Agency (KOICA) and Cambodia's Ministry of Planning (MoP)[28]. The plan emphasizes agriculture and other primary industries, as well as information and communication technology. Korea provides

[28] Cambodia National Science & Technology Master Plan 2014-2020 http://www.koicacambodia.org/koica-and-mop-release-cambodia-national-science-technology-master-plan-2014-2020/

Cambodia with a total of US$3.5 million for this plan, while KOICA has so far extended assistance of more than US$20 million in this field.

8.8 Topics on Science and Technology

8.8.1 Priority Areas for Cambodia

Set forth as the four sides of the rectangular strategy are: enhancement of agricultural sector, restoration and construction of infrastructure, private sector development and employment generation, and capacity building and human resources development. Special emphasis is placed on improvement of agricultural productivity and diversity. The private sector that supports Cambodian industry is sewing businesses, which are not quite internationally competitive as those of Thailand and Vietnam. In any event, the industrial age that depends mainly on sewing businesses, a light manufacturing industry, is already over. Considered promising in the future are hydraulic power generation and other energy industries, transportation, agriculture and full use of information and communication technology in agriculture. Power generation, an important part of infrastructure, is fragile in Cambodia. As a part of the rectangular strategy, the Cambodian government encourages major local cities and the private sector to invest and participate in electric power generation and transmission in an effort to develop energy needed for generating low-cost electricity, and to build up the electric power sector. The country plans to increase the ratio of domestically generated electricity by taking advantage of its abundant water resources by building eight hydraulic power plants, so that the percentage of hydraulic power generation takes up 50% of the nation's power supply (now 5%).

A remaining concern is how to manage the electricity supply during the dry season, considering the large gap in rainfall in the rainy season and the dry season. Also, the government seeks to boost income in rural regions by developing agriculture and the agro-industry, thus avoiding a chasm in national awareness between city dwellers and rural residents due to their income gap, as seen in Thailand. In fact, the gap seems to be widening between rapidly developing Phnom Penh and other cities, and rural regions where people still live without the benefit of electricity.

8.9 Summary

The capital city of Phnom Penh is bustling with large-scale development construction work. Luxury Japanese cars cruise around the city, and signboards in Chinese advertising real estate are seen everywhere. Anticipating the economic unification of ASEAN, the southern corridor connecting Ho Chi Minh, Phnom Penh, and Yangon is expected to become a strategic route of great importance. Cambodia is one of the countries - almost the sole country in ASEAN - that is quite tolerant of foreign investment, and is therefore quite popular among foreign investors. Once the problem of an unstable electricity supply is solved, Cambodia is likely to attract attention as a possible industrial partner of China and Thailand. Another advantage is that the average age of Cambodians is young. However, it is unlikely that the county will soon be sufficiently industrialized to meet the demand of nearly 16 million Cambodians. Already, goods that are less expensive than domestic products are being imported from Vietnam and China. Although the labor-intensive sewing industry is contributing to the Cambodian economy to some degree, it is doubtful whether the industry can be influential to the nation's industrialization. In order for Cambodia to become affluent without widening the economic gap between cities and rural areas, the improvement of education - especially tertiary education - and the development of human resources needed in industries has to be promoted at a rapid pace.

Although the Cambodian political situation has stabilized since the general election in 1998, the wages of public officials are still kept low, and resultant corruption and murky administrative management have not been eliminated. For the continuous development of Cambodia, the government needs to activate the market by creating an equitable market environment, improving infrastructure and by promoting effective institutional reform and technological transfer. The government, Cambodian people, industrial sectors and universities have to work in cooperation with each other, so that the rectangular strategy will produce actual results, not just slogans.

Reference:

- UNICEF Annual Report 2012 for Cambodia, EAPRO
- IDE World Trend No. 219 (Japanese Edition) IDE-JETRO
- Innovation in Southeast Asia OECD2013
- Cambodia at the Crossroads World Bank Report 2004

See also:

S&T related links (Ministries, Research Institutes and Universities etc.)

- Ministry of Education Youth and Sport (MoEYS) http://www.moeys.gov.kh/en/home.html
- Ministry of Planning (MoP) http://www.mop.gov.kh/
- Institute of Technology of Technology of Cambodia (ITC) http://www.itc.edu.kh/en/
- Royal University of Phnom Penh (RUPP) http://www.rupp.edu.kh/
- Phnom Penh Institute of Technology(PPIT) http://www.ppit-edu.com/
- KOICA-Cambodia http://www.koicacambodia.org/
- USAID Cambodia http://www.usaid.gov/cambodia

Abbreviation:

UNTAC:	United Nations Transitional Authority in Cambodia
MoEYS	Ministry of Education, Youth and Sport of the Kingdom of Cambodia
MPTC:	Ministry of Posts and Telecommunications Cambodia
MiME:	Ministry of Industry, Mining and Energy
MoC:	Ministry of Commerce
MoLVT:	Ministry of Labour & Vocational Training
MAFF:	Ministry of Agriculture, Forestry and Fisheries
MoP:	Ministry of Planning
SNEC:	Supreme National Economic Council
NSDP :	National Strategic Development Plan
SEDP:	Socio-Economic Development Plan
NPRS:	National Poverty Reduction Strategy
ITC:	Institute of Technology of Cambodia
RUPP:	Royal University of Phnom Penh
IFL:	Institute of Foreign Languages
AUF:	The Agence universitaire de la Francophonie
CUD:	The University Commission for Development
KOICA:	Korea International Cooperation Agency
MOT:	Management of Technology

KOICA: Korea International Cooperation Agency
KISTEP: Korea Institute of S&T Evaluation and Planning

9. Laos

9.1 Outline

The extent of Laos's research and development activities is relatively modest compared to other ASEAN countries. However, the Ministry of Science and Technology, which was promoted to the ministerial level in 2011, has been leading their active efforts in the field. Science and technology in Laos is thought to be at the stage preparing for a leap into the future, while developing human resources as well as infrastructure including equipment.

9.2 Current Socioeconomic Trends and Background

9.2.1 Basic information

Lao People's Democratic Republic is a nation surrounded by five countries; i.e., China, Myanmar, Vietnam, Thailand, and Cambodia. Which means it is the only landlocked country among the 10 ASEAN member countries. Its capital is Vientiane, with the area of 236,000 km^2 and population of 6,776,000 in 2013. In recent years, its population has been increasing at around 1.8-2.0% annually. With a high ratio of younger generations, it is said to be in a period of population growth.

9.2.2 History

It dates back to the Kingdom of Lanexang established in 1353 that a nation ruling the area corresponding to the current Lao territory was built. The rule of the Lanexang Kingdom continued until around 1710, followed by the trilateral rule until around 1779 with the separation of the Luang Phabang Kingdom and the Vientiane Kingdom. Later, these three kingdoms came under the rule of Qing temporarily. Since 1893, the country had been a French colony, which continued until 1949. On July 19, 1949, the Laos Kingdom was created within the framework of the French Union. Later, after the confrontation between the Kingdom government and a minority organization (Pathet Lao), Interim National Union government was established in 1974, with the intervention of the United Nations. Afterwards, in December 1975, the Interim National Union government approved the abdication of King Savang Vatthana, declaring the abolition of the monarchy and transition to the republic. As a result, Lao People's Democratic Republic was born, with Souphanouvong as President of the Supreme People's Assembly and President of the Republic.

9.2.3 Politics

Laos, which was established as a socialist country in 1975, embarked on an economic reform called New Economic Mechanism, following the Chintanakan-mai (New Thinking) policy in 1986. As with the market-opening reform in China and Doi Moi (Innovation) in Vietnam, it was an attempt to incorporate a capitalist system in the overall socialist system. Namely, they paved the way for economic growth by tackling privatization of state enterprises, introduction of market economy, and open economic policies, etc.

Under the political system of democratic republic of people, the Lao People's Revolutionary Party is the only political party in the state. The single-chamber National Assembly consists of 132 members. At the Eighth Party Convention held in 2006, they formulated a long-term target, aiming to fundamentally resolve the poverty problem by 2010 and to grow out of being a less developed country by 2020, while resolving to maintain the existing reform policy.

9.2.4 Ethnic Groups, Languages and Religions

Laos is a multi-ethnic country, consisting of 49 ethnic groups in total. However, Lao accounts for about 60% of them. In addition, there are minority ethnic groups such as Akha and Mon.

The language is Lao, which linguistically belongs to the Tai language branch, Zhuang-Tai language branches, Kam-Tai language group, and Tai-Kadai language family. In other words, it is a regional variety of the same language as the Thai language, and speakers of the Lao and Thai languages can communicate with each other to a considerable degree by using the common parts of both languages. Many Lao people are said to learn Thai language through TV broadcasting, as Thai TV broadcasting is especially popular in Laos.

No less than 90% of Lao people are Buddhists, believing in Theravada Buddhism as in Thailand.

9.2.5 Education System

For education, Laos has a 5-4-3 system (5 years for elementary school, 4 for junior high school, and 3 for high school), which is overseen by the Ministry of Education and Sports. In FY2009-2010, the 5-3-3 system was changed to the 5-4-3 system, by increasing the number of years for junior high school to four. While currently a five year system, university will be changed to a four year system when junior high school students after the transition to the four-year junior high school graduate from university.

The enrollment rate at the school age is 84.2%. While a student younger than 6 years old may be enrolled, some are enrolled at ages over 10. Both the number and quality of schools for the enrolled number of students are not adequate, resulting in a two-part system of morning and afternoon in many instances. The drop-out rate is 8.9% on average, with the first grade showing the highest rate of 34.1%. In primary education, many pupils drop out after enrollment, partly because those from minority ethnic groups do not use Lao as their everyday language and therefore have difficulty in attending the class, in addition to poverty, difficult commutes, and low consciousness of guardians for school education. The enrollment rates for junior high school and high school are 54.8% and 34.4%, respectively[29].

9.2.6 Economy

The nominal GDP of Laos is 11,240 million US dollars (2013), placing it in the 10th position among the 10 ASEAN countries. Moreover, with the nominal GDP per capita of 1,490 dollars (2013), it is categorized into Lower Middle Income Countries (LMICs) according to the World Bank classification.

It is in the midst of rapid growth, with real GDP having grown over 8% for 2011-2013.

The unemployment rate is extremely low at 1.4%. The current account balance in 2013 showed a deficit of 376 million dollars.

[29] Ministry of Foreign Affairs website

Figure 9-1: Summary of Lao's economy

	2011	2012	2013
Real GDP growth rate (%)	8.0	8.2	8.1
Nominal GDP per person (USD)	1,252	1,380	3,475
Unemployment rate (%)	1.4	1.4	1.4
Current account (USD)	-206 million	-413 million	-376 million

Source: The World Bank / JETRO World Trade Investment Report (2014)

(1) Trade

In recent years, a substantial change has been occurring in the trade structure as well. The size of import is also expanding with the substantial increase in export of agricultural products, minerals, artifacts, and electric power.

With the mountainous areas accounting for more than 80% of its land, Laos has the annual rainfall of 3,000 mm or more. Accordingly, it is suited for hydroelectric power generation using dams. Moreover, as for the external environment, there is strong demand for electric power from Thailand and Vietnam. Furthermore, it has been able to develop dams thanks to investment from Thailand. Exporting electric power is an important means to acquire foreign currencies; the government is putting up a slogan that "We will become batteries for ASEAN."

(2) Industrial Structure

As for the industrial structure of Laos in 2012, the primary industry accounted for about 27%, secondary industry for about 28%, and tertiary industry for about 39%. The ratios were 31%, 24%, and 38% in 2009, indicating that the ratio was decreasing for the primary industry while rising for the secondary industry.

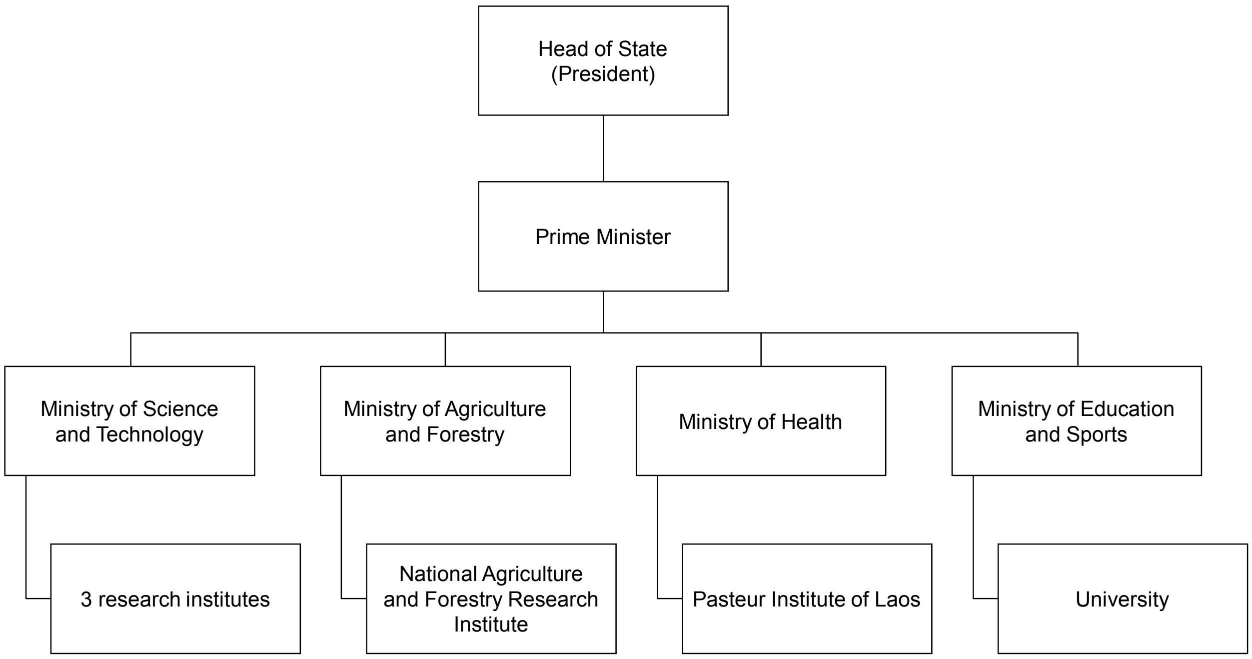
9.3 Science and Technology Policy

9.3.1 S&T Related Organizations

The following figure 9-2 shows organizations related to S&T in Laos. The Ministry of Science and Technology which is leading S&T policy in Laos, has three research institutes under itself, covering ecology and biodiversity, bio-energy and new substances, and computer science and electronics. In addition, the Ministry of Agriculture and Forestry as well as the Ministry of Health are the institutes deeply related to science and technology. There are the National Agriculture and Forestry Research Institute under the Ministry of Agriculture and Forestry, and the Pasteur Institute of Laos under the Ministry of Health.

Furthermore, higher education is in the hands of the Ministry of Education and Sports.

Figure 9-2: Governmental Organization Chart Related to S&T in Laos



9.3.2 Policy and Trends in S&T

The Science and Technology Law provides the basis for science and technology policy in Laos. Here, the Science and Technology Law, which took effect in 2013, is reviewed. Moreover, an overview is also given for policy on higher education.

The Science and Technology Law, consisting of 69 articles, stipulates the principle of promoting science and technology, the budget for science and technology, the role of the Ministry of Science and Technology and so on. The following are characteristic articles.

Article 5: Fundamental principles concerning science and technology

Activities for science and technology should follow the principles below:

1. To guide industrialization and modernization in accordance to the policies and strategies described in the social and economic development plan of the state.

(Paragraphs 2 and after are omitted)

Article 24: Investment

(Omitted)

The government shall invest 1% of the government budget every year on research and development in science and technology, and shall continue to increase the budget every year towards that end.

Article 55: Rights and Obligations of the Ministry of Science and Technology

For management of policies on science and technology, the Ministry of Science and Technology shall have the following rights and obligations:

1. To prepare draft laws concerning policies, strategic plans, development plans, and science and technology activities;

2. To reflect policies etc. stipulated in Paragraph 1 in implementation programs, plans, projects, and

regulations, as well as to manage their implementation
(Paragraphs 3 and after are omitted)

In other words, it clearly shows that policies on science and technology are subject to the social and economic development plan of the state, at the same time stipulating the level of the government budget for science and technology. Moreover, it shows that the Ministry of Science and Technology plays a central role in promoting policies on science and technology.

On the other hand, development of universities has been promoted under Laos's higher education policy in recent years. There are now four national universities in Laos, including the National University of Laos which was opened in 1996. In addition to the National University of Laos, they are Souphanouvong University (spun off from the National University of Laos in 2003) in Luang Prabang in the north, Champasak University (opened in 2002) in a southern city Pakxe, and Savannakhet University (opened in 2009) in Savannakhet in the south. While there are no less than 50 universities registered at the Ministry of Education and Sports, most of them are universities offering courses on English, accounting, and business.[30]

9.4 Promotion Bodies of Science and Technology

Overall, the efforts for research and development in Laos are relatively modest. Among them, vigorous research and development are being conducted at the National University of Laos, National Agriculture and Forestry Research Institute, and Pasteur Institute of Laos. Recently, moreover, three research institutes were established in the Ministry of Science and Technology, engaging in research as well.

In the following sections, the Ministry of Science and Technology is taken up as the promotion body of science and technology. Then, the National University of Laos, National Agriculture and Forestry Research Institute, and Pasteur Institute of Laos are introduced.

9.4.1 Ministry of Science and Technology

The Ministry of Science and Technology is a new organization, which was promoted to a ministry in 2011. Its organization consists of 7 sections (science, technology/innovation, intellectual property, standardization/measurement, IT, general administration/human resources, inspection, and planning/collaboration) and 3 research institutes (ecology/biodiversity, bio-energy and new substances, and computer science and electronics), 2 offices (State Committee for Science and Minister's Secretariat), and 18 science and technology bureaus at the province level. It is operated by about 500 members with 8 people having a doctoral degree (4 in natural science, and 4 in social science).

According to the interviews conducted with the Ministry of Science and Technology, the main mission of the Ministry's is to apply scientific knowledge especially to poverty reduction. This is consistent with Article 5 of the Science and Technology Law in that it follows the basic policy of the state to grow out of the least developed country status by 2020. A superior and urgent task of poverty reduction influences the order of priorities for the science and technology policy.

There are the following 5 important challenges for science and technology: 1) improvement of the organizational structure to promote policies (Clarification of division of labor for each organization); 2) development of the legal system related to science and technology (Rules for implementation need to be set, as the Science and Technology Law is abstract.); 3) human resource development (At the moment, researchers are overwhelmingly in short supply.); 4) infrastructure

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development; and 5) reinforcement of local functions. (For example, oil related facilities are currently not standardized, posing risks. There is a need to establish a system where the central government informs the standards to local governments, which in turn check implementation.)

In the field of science and technology, they intend to proceed focusing on the three areas of: 1) biotechnology and ecology; 2) renewable energy and materials; and 3) ICT. The backgrounds include: 1) It is important to proceed with poverty reduction by increasing agricultural productivity; 2) Securing energy sources is necessary, while the issue of deforestation is regarded as important; and 3) the environment of cloud computing needs to be prepared in order to enhance the government's function to provide information etc.

Moreover, research in the field of radiation as a new theme is also regarded as important. The purpose is the utilization mainly in the medical field. Moreover, it is also regarded as an important theme to create strong crop species by using radiation.

While Laos is trying to develop a science and technology system in this way, the bottleneck for it is the shortage of talented people. For example, it was mentioned that it would be appreciated if support would be given in the form of sending the personnel who could assist drafting a science and technology strategy.

9.4.2 National University of Laos

The National University of Laos was established in 1996. It was created by integrating 3 existing colleges and 8 higher education institutions. It currently has 11 faculties; Faculties of Science, Engineering, Economics and Management, Literature, Education, Architecture, Agriculture, Forestry, Environmental Science, Law and Politics, and Social Studies.

In 2013-2014, there were 29,633 students, of which 28,967 were undergraduates. Students in the master's course numbered 636, while those in the doctoral course 30. Faculty of Engineering is the largest among them, followed by the Faculty of Economics. The smallest are Faculties of Forestry and Environment; however, relatively vigorous research is being conducted in these faculties.

In that year, the staff numbered 1,863, of which: 581 were teachers; 909 teachers who are concurrently clerks; and 373 clerks. Among the staff, 113 were those with a doctoral degree, 744 with a master's, and 893 with a bachelor's.

While the research function of the University is not very high, it was said to be planned to create research institutes under the University by around 2020 with the support from the Asian Development Bank. In particular, creation of a policy institute is given importance. Moreover, agricultural research is also regarded as important from the viewpoint of conducting research which is useful for the community. Furthermore, in Laos where construction of water power plants are underway, research on assessment of environmental impacts and conservation of bio-diversity are important as well.

Selection of students by the University is conducted through the quota and non-quota systems. Under the former, each province is given a quota for its representatives to be accepted. Students enrolled in this way are exempt from their tuition. The latter is selection through normal entrance exams.

It should be noted that as far as the Faculty of Education is concerned, all students are exempt from tuition regardless of their method of enrollment. In exchange for that, they will have to go back to local areas to become teachers. This policy measure is taken to deal with the shortage of teachers in Laos.

For very talented but very poor students, there is a program for talented students and those of a minority. They can receive government scholarship, making their tuition, accommodation and food free.

As for students' career options, first, graduates of the Faculty of Education become teachers in schools in local areas. With such a premise, there is a system to exempt them from tuition. Next, students in the Faculty of Economics get a job in the business sector.

More than 800 overseas students come from 18 countries. They also study in Lao language.

International cooperation is regarded as important, with MOUs signed with 200 universities. With Japan, academic staff is exchanged with 33 universities. The main goals for cooperation include: 1) invitation of foreign students; 2) cultural exchange, information exchange, and infrastructure utilization; and 3) discussions on curricula.

9.4.3 National Agriculture and Forestry Research Institute (NAFRI)

Established in 1999, NAFRI is a research institution in the field of agriculture and forestry. It has 11 research centers, including those on agriculture and agricultural products, and is expanding its size. Its main mission is to promote private agriculture by providing good-quality and various kinds of crop seeds.

At 11 research centers, there are 350 members of staff, of whom 25 have a doctoral degree, and 90 have a master's. While they need further training, it was said that they have strengths in the field of rice cultivation, having 5 members of staff with a doctoral degree. It was stated that they have a sufficient number of staff, but would like to increase the ratio of talented members of staff. The average age of researchers is about 40-50 years old.

The annual budget is about 2-3 million dollars. Assistance from JICA etc. accounts for 50%. All funds come from the public sector, and private funds are not used. Research funds from the Ministry of Science and Technology are increasing. On the other hand, only small part of funds from the Ministry of Agriculture and Forestry can be spent on research. It should be noted that provinces in Laos have relatively abundant agricultural research related budgets. Each province has a research institute, which receives funds from the central government.

Main research themes are the following: 1) promotion of bio-diversity (to create a gene bank, while deepening the understanding of native plants and wild animals); 2) improvement of agricultural productivity (There is a program for each rice-plant and livestock. Moreover, they also focus on maize, cassava, and coffee etc.); 3) response to climate change (In particular, research on protecting crops from floods is given priority.); and 4) information provision to farmers (They are making efforts to establish a system to transmit information on weather and disasters to farmers quickly, and develop necessary human resources.) Furthermore, regarding the research on creating varieties of plants by utilizing radiation, they started a project in 2014 in cooperation with IAEA.

As for the background of these research themes, it was said that, in addition to poverty reduction, there still was an issue of deforestation by slash-and-burn farming. It is also an important mission to offer an alternative to farmers who engage in slash-and-burn farming which is not a sustainable method. While the government has announced the policy of targeting a 70% forest coverage rate, its achievement is difficult under the current circumstances.

Current issues include maintenance of research facilities, because there are restraints on using the funds from government for maintenance expenses. Presently, funds gained from sales of agricultural products are mainly used. As for the hiring of personnel, moreover, there is a restraint that they cannot recruit regular staff directly. It is preferable to establish a system to search for talented people directly by itself rather than through the Ministry of Agriculture and Forestry.

They are actively engaging in international cooperation; there used to be active cooperation with Sweden (they were receiving 2 million dollars annually). However, this route disappeared with the change of the government in Sweden. They are also cooperating with Switzerland, Australia, and Japan. With Korea, they are cooperating on eco-tourism. However, there is no instance of cooperation with overseas companies.

9.4.4 Pasteur Institute of Laos (Institut Pasteur du Laos)

The Pasteur Institute of Laos is a research institute under the Lao Ministry of Health. The Institut Pasteur in France has allowed it to use the name of Pasteur, and is giving certain support.

Cooperation between the Institut Pasteur and the Lao government started in 2004 when the Lao Ministry of Health requested the French government for counter-measures and capacity-building against SAAS and H5N1. Later, following the request from the Lao government for a long-term support, cooperation stared with the Institut Pasteur consequently lending its name to the institute under the Ministry of Health.

Two members of staff are sent from le Institut Pasteur headquarters in Paris. In addition, two people from France are working as foreign staff. There are 48 members of staff working, of which 37 are Laotians. Funds from overseas donors account for a large part of the operational funds (2 million dollars annually). It is receiving no money from the Lao government, which is providing the land, electricity, and water.

The missions of the Pasteur Institute of Laos are: 1) research; 2) promotion of public hygiene; and 3) human resource development. At the moment, there is a contract to allow the use of the name for 16 years. The period is set in accordance to the term of the President of the Institute, which is 4 years. The period of 16 years is renewable.

For reference, many of the recently established overseas Pasteur Institutes (such as in Korea, Hong Kong, and China) have been established with the Institut Pasteur allowing local national research institutes to use its name, as in the case of Laos.

Regarding human resource development, it endeavors to train Lao researchers, upon the request from the Lao government. Lao research staffs are mainly those who received their medical degree in Laos. On the other hand, it is said that those who received a doctoral degree in Thailand and Vietnam etc. tend not to return to Laos, and it is difficult to recruit them.

The Institut Pasteur engages in international cooperation in accordance to the philosophy at its establishment in the 19^{th} century; namely, to share knowledge with the world, to promote health of people in the world, and to eliminate threats from the world. Accordingly, it does not engage in international cooperation from the viewpoint of French interests. Nonetheless, restraining infectious diseases in developing countries consequently leads to its national interests by reducing threats to France.

To sum up the above, research activities in Laos are relatively new, and can be said still in their initial development stage. While research in the agricultural field is progressing partly due to the existence of social challenges the government regards important, a shortage of talented people was pointed out even in that field. It was often said that development of human resources was the key, including in other fields.

9.5 Input Index of Science and Technology

According to the interviews at the Ministry of Science and Technology, they had not created statistics for science and technology at the national level. While statistical data were created by the

UNESCO survey in 2002, no record remains as to how they were created. Presumably, it was created by answering the questionnaire sent from UNESCO, but its accuracy was said to be in doubt. As for statistics for science and technology, a project is in progress to develop them for the Capital Vientiane, marking the start of developing statistics.

For Laos, accordingly, input into science and technology cannot be examined objectively, using the latest data. Here, UNESCO statistical data will be introduced with some supplements.

9.5.1 R&D Expenditure

Gross expenditure on R&D (GERD) in Laos is 2.7 million dollars, or 0.04% of GDP (2002). In terms of per capita, it is 0.5 dollars, equivalent to that in Cambodia.

9.5.2 R&D Expenditure Ratio by Sector

In terms of the share of financing by organizations for R&D expenditure, the share of overseas sources is very high at 54% in Laos, while that of government and the industry are 8% and 36%, respectively (2002).

In 2011, it was stipulated by Article 24 of the Science and Technology Law that the national S&T budget should be 1% of the state budget. They are trying to increase investment in S&T towards that target. Nonetheless, this target cannot be said to be high compared to other countries' because 1% the state budget is low in terms of the ratio to GDP.

9.5.3 The number of researchers

Based on the data as of 2002, the number of researchers in Laos is 209 (HC) and 87 (FTE). As for the number of researchers per 1,000 labor force population, there is no UNESCO statistical data on Laos. However, the number of researchers per one million population was 16, which was about the same level with that in Cambodia and Myanmar.

As one of the backgrounds for few researchers, it can be pointed out that science courses are not popular (although engineering, architecture and IT are relatively popular). Business and economics are more popular than science courses, showing the trend that many of those who receive higher education want to proceed to the fields where they can acquire economic benefits more easily.

9.6 Output Index of Science and Technology

9.6.1 Science Research Papers

Based on the indexes of the research analysis tool SciVal by Elsevier, comparison was made between Japan and the 10 ASEAN countries for such items as the number of research papers, citation counts, and the number of authors (see figure 9-3).

The number of papers in Laos is at the same level with that of Brunei and Myanmar; these countries form a group of the least productive in terms of papers. Moreover, its ratio of internationally-co-authored is the highest at 93.6%, indicating the situation that many papers are produced with the help of overseas researchers.

Figure 9-3: Comparison of Selected Countries by Number of Science Paper

Country \ Item	Number of Papers	Number of Citations	Number of Authors	International Co-Authorship
Japan	648,938	3,534,908	599,167	23.6%
Malaysia	93,406	292,001	76,671	31.3%
Singapore	80,680	701,014	48,757	51.5%
Thailand	53,334	257,150	48,585	37.4%
Indonesia	15,728	58,632	17,247	55.0%
Vietnam	12,696	60,540	13,670	67.9%
Philippines	7,354	47,088	7,747	57.3%
Cambodia	1,064	10,905	1,258	88.8%
Brunei	879	2,373	747	48.9%
Laos	750	4,237	810	93.6%
Myanmar	558	1,651	663	60.8%

Source: Elsevier, SciVal Database

9.6.2 University ranking

In the QS World University Rankings 2014, Lao universities are not listed in the ranking.

9.6.3 Patent

The Intellectual Property Law in Laos was promulgated in 2007, and implemented in April 2008. It is a law consisting of 137 articles, stipulating comprehensively patents, petty patents (equivalent to utility models), designs, trademarks, layout-designs of integrated circuits, geographical indications, trade secrets, and copyrights. However, without the development of enforcement orders and ordinances, it cannot be said that it is actually implemented.

Since 2004, there had been about 10-20 applications for patents; however, no patent had been given as of 2007.

9.7 Foreign Relations

9.7.1 Japan

(1) Co-authorship of scientific articles with Japan

Co-authorship of scientific papers between Japan and Laos cannot be said to be very close. For instance, Laos does not rank within the top 10 main co-authorship countries with Japan for individual fields of chemistry, materials science, physics and space science, computer science and mathematics, engineering, environmentology/ecology and global science, clinical medicine and psychiatry/psychology, basic life science, according to the data (1999-2001 and 2009-2011) in the "Benchmarking Scientific Research 2012" by the National Institute of Science and Technology Policy (NISTEP) under the direct jurisdiction of the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

The co-authorship with Japan at the National University of Laos which produces the largest number of papers in Laos in 2012-2014 is shown in the following figure 9-4. Namely, the co-authorship with Japan ranked 5th at the overall National University of Laos, numbering 13 cases. The number of co-authored papers is relatively large in the fields of agricultural and biological studies, and engineering.

Figure 9-4: Internationally-co-Authored Papers by the National University of Laos

Organization	No. of papers	No. of internationally co-authored papers*	Highly ranked for co-authorship*	Fields for co-authorship with Japan*
National University of Laos	91	85	Thailand: 23, US:17, Sweden: 15, Australia: 14, **Japan: 13**	Agriculture and biology studies: 5, Engineering: 4, Environmental science: 2, Social science: 2

* Not mutually exclusive. Example: A co-authored paper among Laos, the US and Japan is counted as 1 co-authorship for both the US and Japan.

(2) Cooperation with Japan Science and Technology Agency (JST)

JST has been conducting joint researches with Laos through the following programs: SATREPS and e-ASIA JRP.

・ Science and Technology Research Partnership for Sustainable Development (SATREPS)

SATREPS is a Japanese governmental program that promotes international joint research. The program is structured as collaboration between JST, which provides competitive research funds for S&T projects, and the Japan International Cooperation Agency (JICA), which provides ODA. Based on the needs of developing countries, the program aims to address global issues and lead to research outcomes of practical benefits to both local and global society.

1 SATREPS projects have been already funded in Laos as follows.

Japanese leading institution	Laotian institutions	Agendas
National Center for Global Health and Medicine	- Pasteur Institute of Laos (IPL) - Center of Malariology, Parasitology and Entomology(CMPE) / Ministry of Health	Development of Innovative Research Technique in Genetic Epidemiology of Malaria and Other Parasitic Diseases in Lao PDR for Containment of Their Expanding Endemicity

・ e-ASIA Joint Research Program (e-ASIA JRP)

The e-ASIA JRP was officially launched in June 2012. It has been formulating and supporting international joint research projects in the East Asian Region on the multilateral basis as well as promoting researchers interaction through workshops, etc. The projects will be selected through open Call for Proposals. The Secretariat office is located in the building of NSTDA at the Thailand Science Park (TSP).

The e-ASIA JRP has currently 16 member organizations from 12 countries, consisting of Japan, Cambodia, Indonesia, Laos, Malaysia, Myanmar, New Zealand, the Philippines, Thailand, the US, Vietnam and Russia (as of June 2015). Ministries, agencies or other public/governmental bodies that provide research funds, might be a member organization of the e-ASIA JPR. From the Japanese side, MEXT, JST and the Japan Agency for Medical Research and Development (AMED) have been participating to support research projects.

In respect to Laos-related projects, 1 joint research projects in the field of "Health research" have been carried out.

9.7.2 Other Foreign Countries

According to interviews at the Ministry of Science and Technology, relationships with the ASEAN countries is said to be given importance. For example, there is a bilateral agreement with Vietnam. They have a cooperative relationship with the Vietnamese Ministry of Science and Technology as well as the Academy, engaging in activities such as constructing training centers and sending staff for training. On the other hand, despite their efforts to conclude an MOU with the Thai Ministry of Science and Technology, it has not yet been realized due to the political uncertainties.

Moreover, it is not limited to Laos, but the Chinese Ministry of Science and Technology is actively giving support to the ASEAN countries. While the goals differ depending on the country, the following are the main areas for Laos: 1) establishment of a joint laboratory (The Chinese side provides 1 million US dollars); 2) technology transfer (attending seminars at the technology transfer center for the ASEAN countries in the southern part of China); 3) disaster prevention utilizing remote sensing; and 4) young researcher program (sending young researchers to China to conduct joint research).

China also prepares a scholarship for Laotian students who study in China. In the case of Laotians, all expenses for transportation, stay and education are provided.

As stated above, it can be said that cooperation with overseas focuses on capacity building for human resources and facilities. It is not placed as a central activity to publish co-authored papers by conducting joint research.

9.8 Topics on Science and Technology

Until now, the social and economic situation in Laos, science and technological policies, and efforts for research and development under them have been examined. What has become clear is that in Laos it is necessary to focus on responding to challenges of economic development and poverty reduction, to which efforts concerning science and technology are highly subject. Moreover, there also appears to be a shortage of human resources in proceeding with efforts concerning science and technology. Therefore, this section examines in depth the efforts of the Special and Specific Economic Zones (SEZ) to aim at economic development by bringing in foreign capital as well as human resource development.

9.8.1 Vita Park Special Economic Zone

The Vita Park Special Economic Zone is a special economic zone based on the government policy, which was established by a proposal to the Lao government from a Taiwanese company, Nam Wei Development Pte. Ltd. It is 70% owned by Nam Wei Development Pte. Ltd. and 30% by the Lao government. While there are several special economic zones established in a similar way (About 20 of them if those owned by the government only are included.), Vita Park is the only one in the manufacturing sector and owned by a private company (Others are for casinos, eco-tourism, etc.). The Lao government plans to increase special economic zones to 25 or so in future. There is a possibility those in the manufacturing sector will be newly established.

At the moment, 110 ha has already been developed, with a further 200 ha planned to be developed in the second stage going forward. They are already 33 companies in the zone (About 200 plots are prepared), including DDK Ltd. (Japan), Mekong Industrial Co., Ltd. (China), and Thai Tsunoda Co., Ltd. (Japan).

Companies which have entered Vita Park can acquire the right of land use at 30-35 US dollars/m^2 for 75 years. Moreover, they have to pay the annual administration cost of 0.36 US dollars/m^2 in addition to that.

Entered companies also receive preferential treatments for taxation. In addition to the special treatment of tax exemption for the initial 10 years, their corporate tax rate, usually at about 20%, will be kept at 8-10% afterwards. Furthermore, they can receive one-stop services for necessary procedures with the government, including procedures for import and export as well as taxation. They will be provided with measures to make their business development easy in Laos. Currently, 7 members of staff are dealing with this operation in Vita Park.

In Laos, establishment of foreign corporations with over 50% foreign share are usually not allowed; however, foreign corporations with 100% foreign share may be established in the special economic zone.

Given the situation in Laos where supply of electric power is not stable, they are trying to develop a system to stably supply electricity in order to enable operation of precision apparatus.

9.8.2 Human Resource Development at the National University of Laos and the Vita Park Special Economic Zone

As stated above, the National University of Laos gives support to students learning in the Faculty of Education, while making their tuition free. And, students who have participated in this program are required to engage in educational activities in local areas. Presumably, the background for this is that the educational level in Laos as a whole has not been sufficiently raised. For instance, the literacy rate in Laos is 68.7%, which is the lowest in the 10 ASEAN countries (followed by Cambodia at 76.3%, while the other countries are at 90% or higher.).

Generally speaking, since it is necessary to have a pool of talented people to develop science and technology, it is thought to be an urgent task to create the basis for the whole country through this effort by the National University of Laos, etc.

On the other hand, it deserves attention that unique efforts for developing talented people are about to be made in the Vita Park Special Economic Zone as well. A facility to educate people from villages (Vita College) is planned to be built in the special economic zone, aiming to create a system to supply cheap workers with certain skills. At the same time, it is planned to offer language education for English, Chinese and Japanese etc. While workers are recruited from the surrounding villages at the moment, they do not necessarily have skills suited for the works in the industrial fields. Accordingly, they are developing a system where the special economic zone hires personnel all at once for entered companies and educate them.

The size of such an endeavor is limited, which may not have much impact in terms of considering the basis for the whole nation. Nonetheless, it could grow into an effort as a model case to aim at economic development by bringing in overseas capital.

The standard wage of workers in Vita Park is 120-150 US dollars per month. Wages for workers who have acquired skills are about 300 dollars per month. One pattern is for Vita Park to hire personnel all at once and educate them for companies in the zone; another is for companies in the zone to hire personnel individually.

9.9 Summary

In considering science and technology in Laos, it should be kept in mind that what are required in Laos at the moment are efforts directly linked to economic development. For instance, while special economic zones such as Vita Park are regarded as important venues to promote economic development, there is no room for research on science and technology that is needed there at the moment. On the other hand, such venues for economic development are likely to play a certain role in developing the human resource base in Laos which is currently limited. Through the enhancement of human resources by taking advantage of these efforts, the human resource base to promote efforts concerning science and technology is likely to be created at the stage when the issue of poverty reduction is being resolved in future. While looking sideways at the government's top priority of economic development and poverty reduction, thinking about how to bring their achievements into development of science and technology seems to be what is now required for science and technology in Laos.

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- The World Bank http://data.worldbank.org/data-catalog/world-development-indicators
- JETRO http://www.jetro.go.jp/world/asia/idn/ (in Japanese)

10. Brunei

10.1 Outline

Brunei Darussalam (Nation of Brunei) has good economic conditions thanks to the production of petroleum and natural gas. Under the "Wawasan Brunei 2035," a national vision based on a sustainable society in the future, the country is promoting the development of agriculture and information and communications. The National Development Plan (NDP), including the science and technology budget, is formulated every five years. The plan is currently in its 10th term (2012 – 2017) and the science and technology budget has rapidly increased to B$200 million, four times more than that of the previous term. The Brunei Research Council (BRC) is in charge of the allocation of the science and technology budget. The University of Brunei Darussalam and the Brunei Institute of Technology are responsible for higher education and science and technology research.

10.2 Current Socioeconomic Trends and Background

10.2.1 Basic Information

The official country name of Brunei is "Brunei Darussalam." The capital is Bandar Seri Begawan. The national area is 5,770 km^2 and the population is approximately 406,000 (2013).[31] The country is in the Borneo Island and divided into two parts across the Sarawak State of Malaysia.

10.2.2 History

The Brunei Kingdom flourished in the 15th and 16th centuries and ruled most of Borneo Island and a part of the Philippines. Later, it gradually reduced its territory to its present size after struggles with Western European countries (Spain, Portugal, the Netherlands and the United Kingdom). In 1888, Brunei became a protectorate of the United Kingdom. Petroleum was found in Brunei in 1929, which has helped the restoration of their national strength. Although Brunei was occupied by the Imperial Japanese Navy during the World War II, it has maintained the peace without suffering from major battles.

When Malaysia became independent in 1961, there was an idea of creating a federal nation including Singapore and Brunei. However, Brunei had different opinions on oil rights and refused to participate in the nation.

On January 1, 1984, Brunei achieved full independence, inheriting its national defense and foreign diplomacy from the United Kingdom and with national policies of Malay identity, Islam as an official religion and protection of imperial rule. At the same time, Brunei joined the Association of Southeast Asian Nations (ASEAN).

10.2.3 Politics

The organization and structure of the Brunei government before the nation's independence depended on the 1959 Constitution. Under the Constitution, all the regulatory authority is entrusted to the King as the head of state. After independence in 1984, the administrative system based on the

[31] BRUNEI DARUSSALAM KEY INDICATORS 2014
http://www.depd.gov.bn/download/BDKI/BDKI2014_R1.pdf

1959 Constitution continued to be in force and the country was governed in a combined structure of monarchy and a cabinet system. The legislative council was re-established for the first time in 20 years after the revision of the Constitution in 2004. Since 2006, the legislative council has held annual meetings in March.

The King is also Prime Minister, Finance Minister and Minister of Defense. The Crown Prince is in a central position as Senior Minister among the head cabinet ministers. The Prime Minister's Office is the administrative center of Brunei. The Prime Minister's Office includes organizations related to science and technology such as the Energy Agency (the Minister of Energy is the Minister of State) and the Brunei Economic Development Board (BEDB, the chairman is the vice-minister of the Prime Minister's Office).

10.2.4 Ethnic groups, Languages and Religions

Ethnic groups in Brunei comprise Malay (about 65.8%), Chinese (10.2%) and others (24.0%). The official language is Malay and some people use English and Chinese. Religions in Brunei include Islam (67%), Buddhism (13%) and Christianity (10%).

10.2.5 Education System

The education system in Brunei is the 6-5-2 school system (6 years in primary school, 5 years in secondary school and 2 years in preparatory school). Approximately 25% of students go on to university and it is possible to accelerate and enter a university during the preparatory school years. The first three years in the five-year secondary school and six-year primary school are compulsory. Brunei has focused on English education as a second language since 1984 in order to develop bilingual human resources. The student population attending kindergarten to preparatory school is approximately 100,000 (2013), accounting for a quarter of the total population.

10.2.6 Economy

Brunei's nominal GDP in 2013 was B$20 billion (US$17.4 billion), the 114th largest in the world. The nominal GDP per capita is about US$40,000, the second largest after Singapore in Southeast Asia and more than that of Japan. Table 1 shows a summary of Brunei's economy. The actual GDP growth rate in 2013 was minus 1.75%.

Figure 10-1: Summary of Brunei's economy

	2011	2012	2013
Real GDP growth rate (%)	3.43	0.95	-1.75
Nominal GDP per person (USD)	42,436	42,402	39,695
Unemployment rate (%)	0.391	0.40	0.41
Current account (USD)	6.08 billion	5.67 billion	5.07 billion

Source: The World Bank / JETRO World Trade Investment Report (2014)

(1) Trade

Exports were B$11.4 billion and imports were B$3.6 billion, showing a surplus trend.[32]

The King personally owns sales income from petroleum and natural gas, which are Brunei's

[32] the 2013 UNCTAD statistics.

key industries, and possesses personal assets of B$20 billion. Among heads of state, he is the fourth richest in the world. People have no duty to pay income tax and can use medical and educational services free of charge. The rate of automobile ownership is one car for every two people. These indexes symbolize the affluence of Brunei.

As for major trade products in 2012, natural gas (44.7%) and crude oil (51.8%) account for a large portion of exports, and imported products include machinery and transportation equipment (36.6%), industrial products (20.4%), food (13.3%), miscellaneous manufactured articles (10.6%), chemical products (8.0%), and mineral fuels and related products (7.5%).

The following figure 10-2 shows major trading partners of Brunei.

Figure 10-2: Major trade partners of Brunei (2013) (Unit: million dollars)

	Export	**Import**
No. 1	Japan (39.8%) (4,557)	Malaysia (21.9%) (793)
No. 2	Korea (25.3%) (1,866)	Indonesia (19.1%) (691)
No. 3	India (7.6%) (870)	The US (11.9%) (431)

Source: JETRO World Trade Investment Report (2014)

(2) Industrial Structure

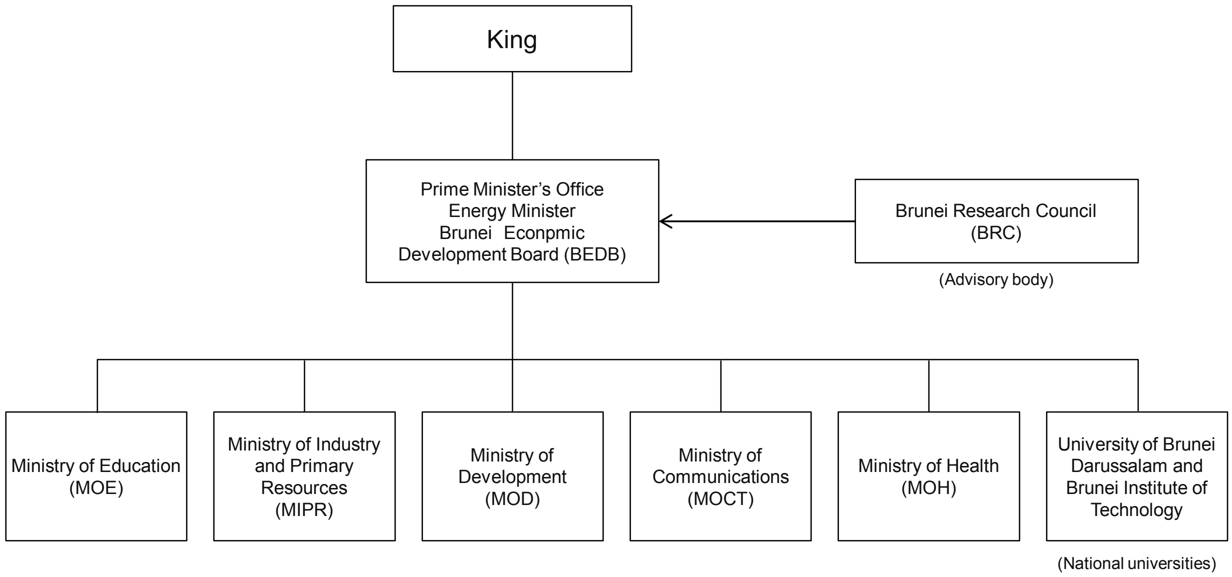
The industrial structure on a GDP basis is: primary industry (agriculture, forestry and fishery): 1%, secondary industry (industry and construction): 49%, and tertiary (service): 50%. The service industry, airline companies and catering service companies are the top companies.

10.3 Science and Technology Policy

10.3.1 S&T Related Organizations

The following figure 10-3 shows the Brunei governmental organization related to S&T in Brunei. The Ministry of Development is the main agency for Science and Technology policy. The Brunei Research Council (BRC), an advisory body of the Prime Minister's Office, coordinates research funding in Brunei. "Research" fields, which are supervised by BRC, include not only science, technology and engineering but also social science, art and culture. BRC members comprise the chairman (Energy Minister of the Prime Minister's Office), the vice-chairman (vice-minister of the Prime Minister's Office) and councilors from 12 organizations related to science and technology such as ministries, agencies and universities.

Figure 10-3: Governmental Organization Chart Related to S&T in Brunei



10.3.2 Policy and Trends in S&T

(1) National vision "Wawasan Brunei 2035"

In 2007, Brunei formulated "Wawasan Brunei 2035" as a long-term plan for 30 years. "Wawasan" refers to "insight" in Malay.

As of 2012, petroleum resources have another 19 years and natural gas 23 years. It can be seen as a measure born out of necessity to reform the nation into a sustainable society for fear of a drying up of petroleum resources around 2035.

The points that Brunei wishes all countries in the world to know that will define the nation's characteristics by 2035 are as follows:

(i) People are well educated and highly skilled.
(ii) Quality of Life (QOL) is in the top ten in the world.
(iii) Dynamic and sustainable economy.

In order to realize these goals, the country calls for loyalty to the King and the nation, faith in Islam's value, unity of people with traditional generosity and a harmonized society.

(2) National Development Plan (NDP)

The National Development Plan (NDP) including the science and technology budget is formulated every five years. In the current 10th-term NDP (2012 -2017), the science and technology budget rapidly increased to B$200 million, four times more than that of the previous term. The country set a goal of accelerating economic growth with high productivity in order to achieve an economic growth of 6% on an annual average.

10.3.3 Higher Education Policy

Higher education in Brunei is under the jurisdiction of the Ministry of Education (MOE). MOE consists of the National Education Council, Technical and Vocational Education Council and Higher Education Section.

Since Brunei has a small population, human resources development is the top priority policy. Around 25% of graduates (age 18 or 19) from secondary education go on to university. As universities are short of Bruneian instructors, scholars from China, Korea and the Philippines are invited to compensate for them. Brunei has three national universities and only the University of Brunei Darussalam and Brunei Institute of Technology have science and engineering majors. While these universities put their main focus on education for students, they are trying to improve research levels by inviting overseas teachers. Both the universities are working on the construction of new campuses as the science and technology budget has increased.

10.4 Promotion Bodies of Science and Technology

10.4.1 Brunei Research Council (BRC)

Of all "research" fields that are supervised by BRC, energy, environment, food safety, information and communications/automation, and healthcare are the priority research subjects in the science, technology and engineering area. The following eight points, which are the core of science and technology policy in Brunei, are referred to BRC.

(i) Formulation of a policy that gives direction to research.
(ii) Establishment of an evaluation method for the proposition of research projects.
(iii) Supervision of research activities' compliance with national rules and regulations.
(iv) Recognition of research clusters and placement of priority on fields that promote economic growth.
(v) Ensuring that research policy planning activities are in line with the nation's development goals stated in "Wawasan Brunei 2035."
(vi) Improvement in the quality of research within the country
(vii) Promotion of collaboration between the government institutions and non-government institutions
(viii) Ensuring the return of research achievements for government and public use.

BRC invested in 39 projects in the 9th National Development Plan, of which five projects were completed by 2012 and the rest are carried over to the 10th NDP. Thirty-one out of 39 projects were implemented by the University of Brunei Darussalam.

10.4.2 Brunei Economic Development Board (BEDB)

Brunei Economy Development Board (BEDB) is placed under the Prime Minister's Office. The main roles of the board are the promotion of foreign direct investment, division of research costs for domestic companies (Brunei Research Incentive Scheme: BRISc) and screening for public participation in domestic institutions. The key areas of BRISc include energy, environment, food safety, health care/health science and ICT. In order to promote research in these areas, the government grants 50 to 80% of R&D activity expenses depending on the project.

10.4.3 Ministry of Development (MOD)

The Ministry of Development (MOD) is the main agency responsible for Science and Technology development and policy in Brunei through the Science & Technology and International

Division (STI). MOD is responsible for general science and technology affairs, nuclear power, intellectual properties and standards and metrology. The Ministry also includes infrastructure development and environment..

10.4.4 Ministry of Industry and Primary Resources (MIPR)

The Ministry of Industry and Primary Resources (MIPR) consists of the policy planning department (Policy and Planning Division, Entrepreneurial Development Center, etc.) and the site supervising department (Agriculture and Agrifood, Forestry, Fishery, Brunei Industrial Development Authority (BIDA).

The Department of Agriculture and Agrifood supervises research and development of agricultural science and technology related to rice, vegetables, fruit and fishery products. The research institution under the department is the Brunei Agricultural Research Center (ARC). The department opened the Agro Technology Park (APT) in 2013 and changed the name to the Bio-Innovation Corridor (BIC) in 2014. The planned area of BIC was expanded to 50 km^2, 10 times larger than that of ATP.

10.4.5 University

(i) University of Brunei Darussalam (UBD)

UBD was the first university in Brunei, and was established in 1985. The vision of UBD is a “top-class international university and unique national character.”

The mission of UBD is to develop individuals and society as a whole through the development and improvement of intelligence, belief and culture by creating an environment that contributes to the achievement of excellence in education, learning, research, scholarship, public service and occupational practices.

As for the personnel size, the number of teachers is 375, and the number of students is 3,664 (faculty) and 882 (graduates).

Lower organizations include the Faculty of Science, the Faculty of Integrated Technologies, PRPRSB Institute of Health Sciences, e-Government Innovation Centre, and the Institute for Biodiversity and Environmental Research.

Major research areas are renewable energy, creative industry, modeling and simulation, biodiversity and ecology, food safety and mental health.

Research funding required from B$300,000 to B$500,000 each year before 2008, B$2.2 million in 2009, B$17.8 million in 2010 and 2011, B$54 million in 2012 and 2013. It declined sharply in 2014 to B$5.2 million.

International cooperation involves many joint research projects with US universities and some with material laboratories in Singapore.

(ii) Brunei Institute of Technology (ITB)

ITB is the first engineering college in Brunei, and was established in 1986. Although the institute didn’t have bachelor’s degree programs when it was established, it officially became a university in 2008.

The number of teachers is about 100 and the number of students is 2,273.

The Faculty of Engineering includes Civil Engineering, Electrical and Electronic Engineering, Petroleum and Chemical Engineering and Mechanical Engineering programs. A new facility has been built within the site over three terms. Major research subjects in academic areas are green technology, water and petroleum and gas.

10.4.6 Industry

In industries, petroleum companies, gas companies, shipping companies, airline companies and service industries, which total 100, constitute a majority of the top-class companies. There are about 7,000 small and medium-sized enterprises (SMEs), of which about two thirds are small-scale businesses. As for SMEs related to science and technology, some software and hardware sales companies in the information and communications sector promote their products in innovation project exhibitions. There are not so many basic research development projects, but the government provides a subsidy for some applied research projects.

10.5 Input Index of Science and Technology

10.5.1 R&D Expenditure

No budgets were allocated to S&T before the 6th National Development Plan (NDP) (1991 – 1995). In the 7th NDP (1996 – 2000), the improvement of the awareness of science and technology, development of science and technology human resources, infrastructure development for science and technology and cooperation and strengthening of relations with foreign institutions were recommended. In the 8th NDP (2001 – 2006), 0.08% (about B$5.84 million = about 400 million yen) of the whole budget (B$7.3 billion) was allocated to the science and technology measures that were recommended in the 7th NDP. Meanwhile, US$74 million was allocated to communication, broadcasting and information technology in the science and technology budget for fiscal 2004 and 2005.

The 9th NDP (2007 -2012) is positioned as the first term plan of the “Wawasan Brunei 2035” and B$50 million was allocated as the science and technology budget. Furthermore, in the current 10th NDP (2012 – 2017), the science and technology budget increased significantly to B$200 million, four times more than that in the previous term.

On the side of receiving research and project expenses, UBD has acquired the majority of R&D projects that have been approved by BRC, and it received research funding of approximately B$80 million during the six years from 2009 to 2014.

10.5.2 R&D Expenditure Ratio by Sector

The government finances almost 100% of R&D expenditure. The proportion of the private section is nearly zero.

10.5.3 Percentage of R&D by Type of Activity

The ratio of basic research and applied research is nearly 0:100.

10.5.4 The number of researchers[33]

[33] UNESCO Institute for Statistics

Based on the data as of 2004, the number of researchers in Brunei is 244 (HC) and 102 (FTE). Looking at the number of researchers per 1,000 labor force, the size of researchers in Brunei is 1.43 researchers (HC) and 0.6 (FTE).

10.6 Output Index of Science and Technology

10.6.1 Science Research Papers

Based on the indexes of the research analysis tool SciVal by Elsevier, comparison was made between Japan and the 10 ASEAN countries for such items as the number of research papers, citation counts, and the number of authors (see figure 10-4).

The number of papers in Brunei is at the same level with that of Laos and Myanmar; these countries form a group of the least productive in terms of papers.

Figure 10-4: Comparison of Selected Countries by Number of Science Paper

Item / Country	Number of Papers	Number of Citations	Number of Authors	International Co-Authorship
Japan	648,938	3,534,908	599,167	23.6%
Malaysia	93,406	292,001	76,671	31.3%
Singapore	80,680	701,014	48,757	51.5%
Thailand	53,334	257,150	48,585	37.4%
Indonesia	15,728	58,632	17,247	55.0%
Vietnam	12,696	60,540	13,670	67.9%
Philippines	7,354	47,088	7,747	57.3%
Cambodia	1,064	10,905	1,258	88.8%
Brunei	879	2,373	747	48.9%
Laos	750	4,237	810	93.6%
Myanmar	558	1,651	663	60.8%

Source: Elsevier, SciVal Database

10.6.2 University ranking

Universities in Brunei are not included in the QS World University Rankings 2014.

10.6.3 Patents

Although Brunei has a patent application system, many applications are from overseas and there are only a few applications from Brunei itself. The number of international patent applications in the last 24 years is 12[34].

The number of patents applied by UBD in the 4 years from 2011 to 2014 was 28.

10.7 Foreign Relations

10.7.1 Japan

(1) ASEAN exchanges of the Institute of Advanced Energy, Kyoto University

The Institute of Advanced Energy, Kyoto University started exchanges with The Centre for Advanced

34 http://www.globalnote.jp/p-cotime/?dno=4240&c_code=96&post_no=5380

Material and Energy Sciences (CAMES), the University of Brunei Darussalam under the subject of "Renewable Energy and Low-Carbon Technology" on September 18, 2014.

(2) Solar energy generation experimental facility of Mitsubishi Corporation

Mitsubishi Corporation installed a solar power generation facility with a 1.2 million kWh production capability and conducts proving tests for renewable energy use. It is likely that efforts of Brunei toward a post-petroleum society will draw attention.

10.7.2 Other Foreign Countries

Basically, Brunei has an omnidirectional foreign policy and ASEAN countries are the top priority. Among ASEAN countries, Malaysia and Singapore are located a short distance away and the number of flights per day is around 5, which is relatively high. Brunei plays a role in promoting science and technology in ASEAN countries through participation in ASEAN COST, etc.

UK's Shell owns the mining rights to petroleum and natural gas, which comprises a majority of Brunei's GDP, and a small number of researchers, scientists and engineers are employed by the company.

On February 18, 2014, Brunei joined the International Atomic Energy Agency (IAEA), which made the country the 162th (latest) member.

On December 9, 2014, Park Geun-hye, the President of South Korea and King Hassanal Bolkiah of Brunei held a summit meeting and agreed to strengthen ties in areas such as infrastructure construction and agriculture.

10.8 Topics on Science and Technology

S&T policies in Brunei focus on energy, environment, information and communications, food safety and health. In order to become a country with self-sufficiency in its food supply, interesting measures have been taken in making agriculture a senary industry and certification of Halal Food.

10.8.1 Bio-Innovation Corridor (BIC)

In September 2013, the Agro-Technology Park opened near the international airport as a cluster for production-processing-distribution industry-based agricultural technologies. In March 2014, it changed the name to Bio-Innovation Corridor (BIC). In the future, it will be developed in three terms and multiple companies will create industrial clusters to implement farm work research, processing research and distribution research projects.

The facility is located near the international airport and government offices in the capital, Bandar Seri Begawan, which is beneficial for the export of agricultural products and domestic sales. The current size is about 500 ha, a majority of which is farmland. Processing factories of companies and research facilities are built in a part of the site. It is expected to expand about 10 times in scale in the future and become a village-based new town with 28,000 employees and 9,000 residents. A Chinese company will undertake the design and construction work.

10.8.2 S&T for the Halal Certificate system

For Muslims, not eating pork is an important rule. Food that does not contain any component of pig is called Halal (permissible). Food with a Halal Certificate is labeled with a certificate symbol and it is recognized as food that general Muslims can eat without any problems.

The standards of Halal are very strict and even food using a component from pigs as a catalytic agent is not permitted in the Halal Certificate standards.

Products with a Halal Certificate should comply with Halal not only in the components of products but also in the production line. For example, a Halal product must not be produced in the same factory that produces non-Halal Products. Although a manufacturing company may produce and sell non-Halal products as their own products, the production line must be separated from Halal products.

Ultimately, to know whether food contains pork components or not requires examination not only in the method of choosing materials and the method of handling production process but also research at a molecule level. As a result, scientific and technological research is required in order to analyze food components and the processing process in detail, not just pork. This has generated a new value for pursuing food safety beyond Islamic rules.

Tanaka Kikinzoku Kogyo developed a “simple pork detection kit” that detects pork components at a microgram level using a gold colloid (a gold particle in 60 nm size). This kit was patented in Japan and Brunei.

10.8.3 UBD-IBM Centre

University Brunei Darussalam (UBD) acquires an IBM Blue Gene supercomputer—the first of its kind in the ASEAN region. The Centre is currently focussing on collaborative research on these cutting-edge Smarter Planet modelling topics using high performance computing facilities installed at UBD.

10.9 Summary

In an abundant economic environment like Brunei, people may think that the country has a low academic level because people’s self-motivation to work on science and technology and innovation are low. However, through online and on-site investigations, the author felt that there is the possibility for Brunei to show a dramatic qualitative change in 10 to 20 years. This can be estimated from the future vision of Brunei with the post-petroleum and natural gas era in mind, and also from a rapidly increasing science and technology budget and the situation regarding construction plans for the Bio-Innovation Corridor in the National Development Plan proceeding under the country’s vision. It is considered that this is a major reference to Japan, where there is concern about the negative aspects of the low birthrate and aging population.

References:

- 2012 Agricultural Statistics (handbook), Department of Agriculture and Agrifood, Ministry of Industry and Primary Resources (MIPR)
- Article “Support for proving test of solar power generation facilities that contribute to the development of Brunei,” Mitsubishi Corporation http://www.mitsubishicorp.com/jp/ja/ir/ar/2013/operations/energy/project.html
- Presentation of Brunei Research Council (stored by JST)
- Presentation of Brunei Economic Development Board (stored by JST)
- Presentation of University of Brunei Darussalam (stored by JST)
- Presentation of Brunei Institute of Technology (stored by JST)

See also:

- S&T related links (Ministries, Research Institutes and Universities)
- Brunei Economic Development Board http://www.bedb.com.bn/
- University of Brunei Darussalam http://www.ubd.edu.bn/
- Brunei Institute of Technology http://www.itb.edu.bn/
- Brunei Halal, Ministry of Industry and Primary Resources (MIPR) http://www.industry.gov.bn/index.php?option=com_content&view=article&id=81&Itemid=102

11. Myanmar

11.1 Outline

It has been 23 years since the democratic movement in 1988 was ended by the army coup d'état. Prime Minister Thein Sein said in his policy speech in June 2012 that he would like to triple per capita GDP by 2015, proceeding in peaceful stability with reforms in all areas, including politics, administration, and economy. Endowed with rich natural resources, and with a population over 50 million people, Myanmar is also highly evaluated for its good-quality cheap labor. Attracting attention as the “last frontier in Asia,” Myanmar is drawing attention from advanced countries including those in Europe and the US In order to build industry, it is urgently required to develop human resources which meet the needs of the industrial sector by establishing the basic policy on science and technology.

11.2 Current Socioeconomic Trends and Background

11.2.1 Basic Information

The official name of Myanmar is the Republic of the Union of Myanmar. Its capital is Naypyidaw (Transfer of the capital occurred in 2006.). The former capital Yangon is still the center of economic activities, with the main airport and part of government organizations still remaining there. With the area of 680,000m^2, its land is about 1.8 times larger than that of Japan. Of its population of 51.41 million people[35], Bamar people account for approximately 70%, with many other ethnic minorities living there as well. Located on the west side of the Indochina Peninsula, it occupies a strategic position in southeast Asia, bordering with China on the northeast, Laos on the east, Thailand on the southeast, Bangladesh on the west, and India on the northwest.

11.2.2 History

The colonial rule by the U.K., which started in the 19th century, lasted until 1948. In that year, Myanmar became independent as a sovereign state under the republic system, adopted the official name of the “Union of Burma,” and under Prime Minister U Nu, proceeded with nation building aiming to realize socialism based on democracy. While the state of affairs of the country was unstable, it became one of the most prosperous countries in Southeast Asia by exporting rice and so on. In 1952-1965, a total of 200 million dollars were provided as Japan’s postwar repatriations under the “Japan-Burma Repatriations and Economic Cooperation Agreement,” followed by 140 million dollars in the form of economic cooperation until 1977 under the quasi-repatriation agreement. However, the U Nu government was brought down by a military coup d’état by the Burmese army in 1962, the Revolutionary Council chaired by general Ne Win gained all the power and started a socialist government. Having changed its name to the “Socialist Republic of the Union of Burma” in 1974, the country became a military dictatorship and centralized politically, while adopting a socialist system economically through extreme nationalization. The economy continued deteriorating, impoverishing the people. It became internationally isolated, as people were strictly restricted in going abroad, at the same time entry of foreigners became severely controlled.

Under such conditions, a student movement aiming for democratization spread to the whole country in 1988. It was the time when world-wide détente and pro-democracy movements were gaining force, and in Burma as well, students-centered movements were spread from Rangoon to

[35] Interim announcement by the Myanmar’s Ministry of Immigration and Population in September 2014

local areas. However, a coup d'état by the Burmese army happened again, and pro-democracy movements were contained by the national army. The military government changed the national name from Burma to Myanmar in 1989. Later, having consistently criticized the military government from the position of human rights protection, European countries and the US imposed economic sanctions from 1997 which drove the country into a wall, however, pro-Myanmar countries such as China and Russia continued their support for the military government. While having not imposed economic sanctions, Japan suspended assistance. Myanmar did not come to an end immediately, as ASEAN, to which the country became a member of the same year, did not join economic sanctions either, but took the policy of encouraging democratization in the long run by stimulating the economic base and creating social stability through investment. Endowed with rich natural resources such as forest resources, natural gas, and jewelry, it was said to be acquiring enough foreign currencies to maintain military rule. However, there was a limit to economic policies under military rule, which was surely exacerbating the gaps in economic development with the neighboring Thailand; presumably as a result, they judged it necessary to democratize the country in order for European countries and the US to lift economic sanctions. Finally in 2011, they accomplished the transition to a civil government peacefully.

11.2.3 Politics

The Constitution of the Republic of the Union of Myanmar (2008) has, as its basis, a republican system with a president as the head of state, and a federal system in which limited autonomy is given to ethnic minorities. Parliament is a bicameral system, consisting of the House of Nationalities (Upper House) and the House of Representatives (Lower House). However, 25% of seats at both chambers are reserved for military representatives who can be appointed by the national army, indicating the huge power the national army is still wielding. No government agencies are making policies; individual ministries and agencies have the characteristics of administrators of state-owned enterprises to the end. It has been 23 years since the pro-democracy movement in 1988 was ended by the army coup d'état. The power was transferred from the military government which lasted a long time until 2011 to the civil government of Thein Sein. Aung San Suu Kyi, the symbol of victims to the military dictatorship, was relieved from house arrest, and became a member of the federal parliament in the 2012 general elections. Nonetheless, as the new president Thein Sein was the No. 4 man in the former military government, there are strong views that the situation where many ministers are former army officers is still military rule which has only changed its form.

11.2.4 Ethnic groups, Languages and Religions

In 2014, a national census was taken for the first time in 31 years. While the population was estimated to be over 60 million people in 2012, it was actually about 50 million people and substantially revised downward. The ethnic composition is that Bamar people account for about 70%, followed by the ethnic minorities of the Shan people 9% and Karen people 7%. Rohingya people (accounting for about 0.02% of the population) who reside in western Rakhine State are Muslims, and incurred many refugees due to the persecution and purge under the military government. Even at the moment, the government treats Rohingya people as non-nationals, resulting in frequent clashes. Ninety percent of Myanmar's people believe in Buddhism.

The official language is the Burmese language. As for the name of the country, "Myanmar" has been used in Burmese since its independence in 1948, while the English name was "Burma." Later, the military government also changed the English name to "Myanmar" in 1989; whereas some European countries and the US continued to use "Burma" implying criticism against the military government; after the transfer to the civil government, however, "Myanmar" became uniformly used both in Burmese and English.

11.2.5 Education System

With the average literacy rate of over 90%, Myanmar had a high level of higher education until the 1990s. As the *terakoya* private school system is well developed even in local areas, the literacy rate is said to be high despite that children in poor families cannot go to school. The school system is composed of 5 years of elementary school, 3 years for junior high school, and 2 years for high school. Students who did well used to go on to faculties of medicine, dentistry, engineering, and information. Afterwards, however, very strict control was imposed on universities under military rule. The level of university education substantially dropped, as especially universities for science and technology were relocated to local areas because they would allegedly become breeding grounds for pro-democracy movements. This is said to be because pro-democracy movements in the late 1980s originated from medical and engineering universities.

11.2.6 Economy

The main industry is agriculture. However, its productivity is low, with mechanization of agriculture only starting recently. While the food self-sufficiency rate is high thanks to the warm climate, they are unable to engage in mass production of rice, the major product, because production for export is difficult due to the lack of standardization of crop varieties. Throughout the 2000s, the secondary industry was increasing its share in the GDP. The First Five Year Plan (2011-2015) set the target of decreasing the share of agriculture from 36.4% to 29.2%, while increasing the share of industry from 26% to 32.1%; going forward, industry is expected to become the largest industrial sector in Myanmar. However, while Myanmar’s GDP by industry showed double-digit growth in the 2000s according to the statistics, in reality, the coverage of the “industry” sector may have expanded—accompanying possible structural changes in industries—in order to show high growth. The new government has even listed, as a national target, collection of reliable statistical data. In addition, reform of the economic sector is actively promoted. The most notable is that transition was completed to the managed foreign exchange rate system based on market rates by solving the state of dual foreign exchange rates and abolishing official government rates in 2012. There used to be the difference of no less than 100 times between the official and market rates, which resulted in a system giving advantages to state owned enterprises managed by those related to the army. It can be seen as a major reform in order to encourage direct investment from overseas as well as establish a normal market economy.

Figure 11-1: Summary of Myanmar’s economy

	2011	2012	2013
Real GDP growth rate (%)	5.9	7.3	7.5
Nominal GDP per person (USD)	832	835	869
Unemployment rate (%)	4.02	4.02	4.02
Current account (USD)	1.182 million	2.438 million	2.751 billion

Source: The World Bank / JETRO World Trade Investment Report (2014)

The largest trading partner is China. Since the 1990s, while European countries and the US imposing economic sanctions, China has been actively providing economic cooperation, regarding Myanmar as occupying a geo-politically important position for the land route to the Indian Ocean. China leads direct investment to Myanmar on an accumulated basis, having made a particularly large amount of investment in the area of mining. For reference, foreign direct investment (approval basis) in FY2013 amounted to about 400 million dollars in total, led by Singapore, Korea, and Thailand in that order. As for the fields, manufacturing is the largest, followed by transportation/manufacturing, with the relationship with the neighboring Thailand deepening. Daily commodities are mostly imported from Thailand and China. Japan ranks 5th for export and 4th for import. It should be noted that the ageing of domestic workers is regarded as a problem, because workers are flowing out to Thailand due to vulnerable domestic industrial bases and unstable employment.

Figure 11-2: Major trade partners of Myanmar (2013) (Unit: million dollars)

	Export	**Import**
No. 1	Thailand (38.4%) (4,306)	China (29.8%) (4,105)
No. 2	China (26.0%) (2,911)	Singapore (21.2%) (2,910)
No. 3	India (10.2%) (1,144)	Thailand (10.0%) (1,377)

Source: JETRO World Trade Investment Report (2014)

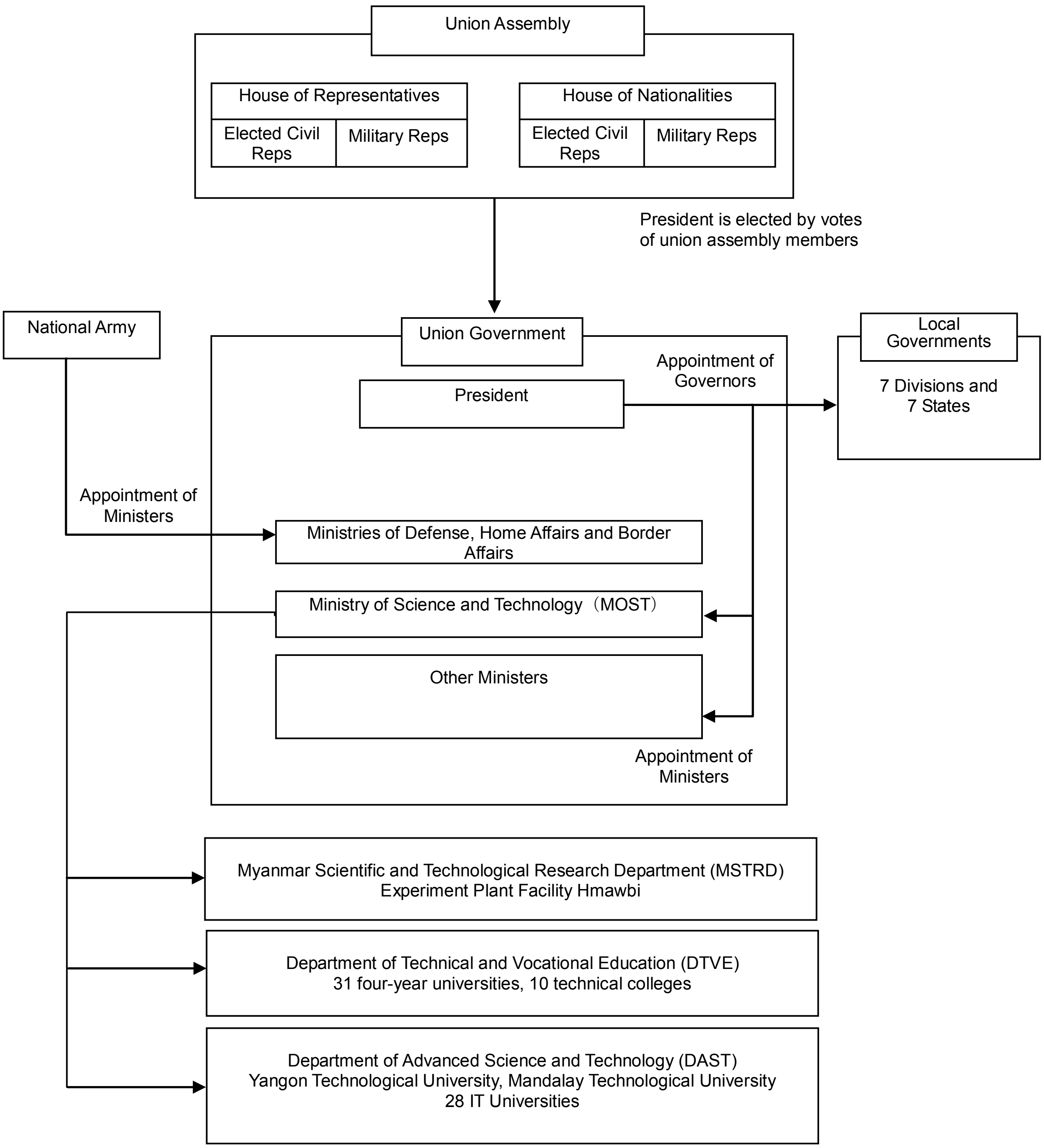
Regarding energy, while deposits of natural gas, oil, and rare metals have been confirmed, mining development is left to foreign capital, with mining rights given in long-term contracts. As a result, related businesses such as refining have not been developed, contributing little to development of the country, despite the rich endowment of natural resources.

11.3 Science and Technology Policy

11.3.1 S&T Related organizations

Science and technology policies are implemented by the Ministry of Science and Technology (MOST). However, it is said that Myanmar's ministries and agencies are generally not in charge of formulating policies but are merely managing and operating state-owned enterprises and organizations under them. While President Thein Sein has clearly stated the importance of science and technology, the country remains at the level typical of developing countries in that priority is given to resolution of social problems such as overcoming of poverty and development of infrastructure for agriculture. While MOST is in charge of management of intellectual properties as well, there is no policy as to how to protect them.

Figure 11-3: Governmental Organization Chart Related to S&T in Myanmar



Myanmar

11.3.2 Policy and Trends in S&T

The basic law is the Science and Technology Development Law, which was legislated in 1994 after nullifying the Union of Burma Applied Research Institute (UBARI) Act, legislated in 1954. It clearly states to contribute to National Economic Development Plans, designating MOST as the ministry in charge. However, the basic policy for science and technology was in preparation as of the fall of 2014. Without the basic policy, the Law cannot be said to be implemented in accordance to a consistent strategy, as evidenced that individual ministries have an organization for research and development on their own etc.

The following are priority areas of science and technology linked to National Economic Development Plans:

- Agriculture, forestry, and livestock industry (especially biotechnology)
- Source and other materials
- Water quality preservation, and development of the water supply and sewage systems
- Information and communication
- Building construction and transportation
- Renewable energy
- Medicine and drug development

Draft revised Law was under discussion in the Assembly in 2014.

11.4 Promotion Bodies of Science and Technology

As of 2014, under the control of the Department of Advanced Science and Technology (DAST) of the MOST, there were 2 national technological universities in the country (Yangon and Mandalay), and 28 IT universities, while under the Department of Technical and Vocational Education (DTVE), 31 four-year engineering universities and 10 technical colleges. Practical education is not sufficiently given, because they are mainly teaching theories by classroom lectures. Accordingly, the Myanmar Computer Federation (MCF) has opened courses at IT universities, aiming to develop IT human resources. MCF is receiving grants from the Japanese Ministry of Economy, Trade and Industry (METI). METI plans to establish an educational institution to teach manufacturing, having in mind as a model the Thai-Nichi Institute of Technology which was established in Thailand in 2007.

11.4.1 Ministry of Science and Technology (MOST)

It was functioning as the Central Research Organization (CRO) under the UBARI Act; the name was changed to the Myanmar Scientific and Technological Research Department (MSTRD) after the implementation of the Science and Technology Development Law in 1994; MSTRD was absorbed by the MOST which was established in 1996; and it remains so today. The following are 6 departments under the MOST:

- Myanmar Scientific and Technological Research Department (MSTRD)
- Department of Technical and Vocational Education (DTVE)
- Department of Advanced Science and Technology (DAST)
- Department of Atomic Energy (DAE)
- Department of Technology Promotion and Coordination (DTPC)

・ Materials Science and Materials Engineering Research Department

The main role of the MOST is to develop human resources as well as establish the education and research environment. As for the annual budget, it has 8 million dollars in total (2013), with the basic budget of 6 million dollars and the multi-year block budget of 2 million dollars for annual equivalent (2013). It is about 96 million yen, converted at the exchange rate of 120 yen/dollar. The investment in research and development is no more than 1% of GDP, which is an extremely small figure, and no comparison to those of advanced countries and emerging economies.

11.4.2 Experiment Plant Facility Hmawbi

The experiment plant facility Hmawbi was constructed in 1976, with the support of the United Nations Industrial Development Organization (UNIDO) and the Indian government. In 1998, it was transferred under the control of the-then Ministry of Industry No. 1 to that of MSTRD. In addition to research and development, it is implementing test production as well. It has several facilities, including a steel plant, insecticide-manufacturing experiment plant, and paper-manufacturing plant.

11.4.3 Yangon Technological University (YTU)

Established in the 19th century, it is a traditional university with a long history. The name changed from Government Technical Institute (GTI/1895-) to Engineering Department of Rangoon University (1946-), to Burma Institute of Technology (BIT/1961), to Rangoon Institute of Technology (RIT/1963-), and to Yangon Institute of Technology (YIT/1990-), before changing to the current Yangon Technological University (YTU/1998-). With the start of the Ph.D. (engineering) program in 1997, reform of the YTU curricula has been implemented in accordance to the national plan and reform plan following the transfer to civil government. Being a university under MOST's direct jurisdiction, it is managed in accordance to Education and Internationalization of human resources to support the industrialization of the country, which is the purpose of government's educational reform. However, there is no specific roadmap for the reform of university. While it had been a graduate school, it started undergraduate education in 2011. As for the career of graduates, about 20% of them join government organizations including research institutions, while the remaining 80% go abroad or work for private companies. Currently, nevertheless, the needs of the market are not matched by development of human resources. Accordingly, it has now started creating programs to enable job training and internship, by requesting cooperation from NGOs. Moreover, having organized a student service center in 2014, it is accumulating data on the careers of graduates etc., in order to grasp the movements of students after graduation and implement training seminars after graduation.

Students of YTU number 8,000 (2007) for the undergraduate and graduate schools combined, with a 1:1 ratio for male and female students; for staff, the ratio is even higher for females at 80%. While the budget has been increasing, with the current year seeing the ratio of 200% to last year's, salaries for researchers and university professors cannot be seen as enough, as even professors are receiving only about 200 US dollars/month. The following are 12 departments, with approximately 240 teachers:

・ Department of Civil Engineering
・ Department of Mechanical Engineering
・ Department of Electrical Power Engineering
・ Department of Electronic Engineering

- Department of Information Technology
- Department of Mechatronic Engineering
- Department of Chemical Engineering
- Department of Textile Engineering
- Department of Mining Engineering
- Department of Petroleum Engineering
- Department of Metallurgical Engineering and Materials Science
- Department of Architecture

11.5 Input Index of Science and Technology[36]

11.5.1 R&D Expenditure

Gross expenditure on R&D (GERD) in Myanmar is about 8.35 million dollars, and 0.16% of GDP (2002). Compared to Japan's GERD of about 150 billion dollars (2011), it is extremely small in size for Myanmar.

It is a serious problem for the development of S&T in Myanmar that the absolute amount for R&D is stunningly small. They have almost no industries, nor have abilities for R&D. Moreover, since there are no accurate data on S&T, understanding of the current situation has to be acquired through on-site surveys and interviews with staff in charge at ministries and agencies.

11.5.2 The number of researchers

Based on the data as of 2002, the number of researchers in Myanmar is 4,725 (HC) and 837 (FTE). Looking at the number of researchers per 1,000 labor force, the size of researchers in Malaysia is 0.18 researchers (HC) and 0.03 (FTE).

It is at a very low level even in the ASEAN region, following Laos and Cambodia. It is partly because that the absolute number of students entering universities is small; in addition, with the low salaries for researchers, few students choose to become researchers as a career path after graduating from universities (graduate schools). As excellent students are directly receiving overseas grants, entering foreign universities, and finding jobs there; it has become a big issue for the promotion of research and development to develop and secure outstanding human resources.

11.6 Output Index of Science and Technology

11.6.1 Science Research Papers

Based on the indexes of the research analysis tool SciVal by Elsevier, comparison was made between Japan and the 10 ASEAN countries for such items as the number of research papers, citation counts, and the number of authors (see figure 11-4).

The number of papers in Myanmar is extremely small, along with Brunei and Laos. It shows that they fall far short of high-quality papers by Singapore, which is outstanding among the ASEAN countries.

36 UNESCO Institute for Statistics

Figure 11-4: Comparison of Selected Countries by Number of Science Paper

Item / Country	Number of Papers	Number of Citations	Number of Authors	International Co-Authorship
Japan	648,938	3,534,908	599,167	23.6%
Malaysia	93,406	292,001	76,671	31.3%
Singapore	80,680	701,014	48,757	51.5%
Thailand	53,334	257,150	48,585	37.4%
Indonesia	15,728	58,632	17,247	55.0%
Vietnam	12,696	60,540	13,670	67.9%
Philippines	7,354	47,088	7,747	57.3%
Cambodia	1,064	10,905	1,258	88.8%
Brunei	879	2,373	747	48.9%
Laos	750	4,237	810	93.6%
Myanmar	558	1,651	663	60.8%

Source: Elsevier, SciVal Database

11.6.2 University ranking

Despite having been graduate school universities, Yangon Technological University and Mandalay Technological University are not active in research. Other universities are not at the level to conduct scientific research either; and therefore, they have no way but to focus on education at the moment. However, it cannot be said that they are developing human resources to meet the demand of the industry, either. As a result, no university ranks high in the international ranking of universities. There is no university within the top 700 in the QS World University Ranking 2014.

11.6.3 Patent

There are no statistics in Myanmar for the registered number of patent ownership declarations; according to one estimate, it is said to be about 50-200 per year in 2000 and after. While the Ministry of Science and Technology (MOST) is the relevant ministry for the registration of property rights, there was no registration department established as of 2013[37]. Furthermore, there is no patent law or trademark law in Myanmar; development of legislation for protecting rights is an issue for the future.

11.7 Foreign Relations

11.7.1 Japan

Immediately after the end of the World War II, Japan, in a severe food situation, imported a large amount of rice from Burma, despite the occupation and anti-Japanese movements during the war. Furthermore, after negotiations which started in 1952, postwar reparations were implemented—changing the name to economic cooperation later—from 1955 to 1977. Using them as a foothold, Japan has provided Official Development Assistance (ODA) for a long time since the 1960s; accordingly, the economic relationship between Japan and Myanmar has never been weak. Even under the military government, while European countries and the US were imposing economic sanctions, Japan continued providing assistance, although reducing the amount of ODA to about one-fifth. Nevertheless, in the area of science and technology, active cooperation has not been seen very much, including personnel exchanges.

[37] Myanmar Intellectual Property Report – JETRO www.jetro.go.jp/world/asia/mm/ip/pdf/laws_mm.pdf

(1) Co-authorship of scientific articles with Japan

In terms of co-authorship for scientific papers, however, Myanmar does not rank within the top 10 for major co-authorship countries for Japan in all individual fields of chemistry, materials science, physics and space science, computer science and mathematics, engineering, environmentology/ecology and global science, clinical medicine and psychiatry/psychology, basic life science, according to the data (1999-2001 and 2009-2011) in the “Benchmarking Scientific Research 2012” by the National Institute of Science and Technology Policy (NISTEP) of the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

(2) Cooperation with Japan Science and Technology Agency (JST)

JST has been conducting joint researches with Myanmar through the following programs: SATREPS and e-ASIA JRP.

・ Science and Technology Research Partnership for Sustainable Development (SATREPS)

SATREPS is a Japanese governmental program that promotes international joint research. The program is structured as collaboration between JST, which provides competitive research funds for S&T projects, and the Japan International Cooperation Agency (JICA), which provides ODA. Based on the needs of developing countries, the program aims to address global issues and lead to research outcomes of practical benefits to both local and global society.

1 SATREPS projects have been already funded in Myanmar as follows.

Japanese leading institution	Myanmar institutions	Agendas
University of Tokyo	- Yangon Technological University (YTU) - Mandalay Technological University (MTU) and others	Development of Comprehensive Disaster Resilience System and Collaboration Platform in Myanmar

・ e-ASIA Joint Research Program (e-ASIA JRP)

The e-ASIA JRP was officially launched in June 2012. It has been formulating and supporting international joint research projects in the East Asian Region on the multilateral basis as well as promoting researchers interaction through workshops, etc. The projects will be selected through open Call for Proposals. The Secretariat office is located in the building of NSTDA at the Thailand Science Park (TSP).

The e-ASIA JRP has currently 16 member organizations from 12 countries, consisting of Japan, Cambodia, Indonesia, Laos, Malaysia, Myanmar, New Zealand, the Philippines, Thailand, the US, Vietnam and Russia (as of June 2015). Ministries, agencies or other public/governmental bodies that provide research funds, might be a member organization of the e-ASIA JPR. From the Japanese side, MEXT, JST and the Japan Agency for Medical Research and Development (AMED) have been participating to support research projects.

In respect to Myanmar-related projects, 1 joint research projects in the field of “Health research” have been carried out.

(3) Support for engineering education by the Japan International Cooperation Agency (JICA)

JICA has been providing support since 2013, aiming to improve the quality of teachers and students, while strengthening the networks between Japanese universities and 2 major engineering universities under the Ministry of Science and Technology (Yangon Technological University and Mandalay Technological University). Although there are high expectations for engineering personnel in Myanmar to create industries, and moreover, the industry is demanding personnel who are talented and can be used in practice, the needs of the industry are not sufficiently met under the current circumstances. Accordingly, we will implement joint research, provide equipment, and support acquisition of funds for researches, in order to improve the abilities of both universities for research. Moreover, we will revise curricula and expand opportunities for intern programs in cooperation with Japanese companies to strengthen departments; and promote the introduction of the PDCA cycle for management of education programs. Furthermore, we will implement improvement of organizations/systems for practical education as well as education methods. The period of cooperation is until 2018.

11.7.2 Other Foreign Countries

While relationships for economic cooperation with China and Thailand are strong, there is no outstanding cooperation in science and technology at the moment. Recently in 2010, the country agreed with India on information sharing as well as cooperation in science and technology, receiving investments and loans from India mainly for infrastructure.

11.8 Topics on Science and Technology

11.8.1 Strengthening the Field of Agriculture

Through the eras of the socialist to military rule, rice was an important crop, and was sometimes forced to be grown under the plan, by methods such as not allowing the planting of crops other than rice during the rainy season in the farm land classified as paddy fields in order to improve the self-sufficiency rate of rice. Whereas nearly 70% of the population resides in villages, most farmers are living a poor life partly due to such historical background. It is an urgent task from the viewpoint of solving the poverty problem as well to develop the agricultural sector by improving the productivity of agriculture.

Among them, top priority should be given to modernization of agriculture. Research at the level of genes is promoted for mass production of rice. As centers for research, there is Yezin Agricultural University (YAU), besides the research institute under MOST. Here, it is cooperating with Israel which is conducting the most advanced research in this field worldwide, has created a system for overseas study with scholarships, and is learning technology. In addition to that, at the Institute of Agriculture under MOST, research is in progress on banana in the fields of bio-agriculture and tissue culture. At the moment, it is difficult for the country to conduct its own research and development in both fields; it is at the stage to be given technologies and learn from other countries.

11.8.2 Securing Energy for Promotion of Industries

Despite being endowed with natural resources such as natural gas and oil, power failures are happening, becoming a hindrance to the creation of industries including manufacturing. In the eras of socialist and military rule, construction of dams for water power generation was actively promoted. However, domestic electric power shortage happened as a result of transmitting and selling electricity to the neighboring China, India, and Thailand in the pursuit of foreign currencies. The track record of supply is 1,500 kW against the estimated demand of 2,300 kW in 2012 after the transfer to civil government. It has a huge problem in the supply of the absolute amount of electric power. While several projects for construction of electric power station are under way, prospects for improvement are uncertain in the situation where demand for consumer use is also rising. Research is in progress on renewable energies, including wind power, water power, solar power, and biomass. Consumer use of nuclear power is also targeted. However, while it is one of the targets to conduct research on nuclear engineering within the country and develop engineers, rather than importing the technology as it is, experts are in extremely short supply at the moment. The only department of nuclear engineering exists at the Mandalay Technological University (MTU).

11.9 Summary

After about 3 years since the transition to civil government, the country is finally starting to develop legislation and formulate policies as a democratic state. For the time being, science and technology are deemed necessary to eradicate poverty in local areas which depend on low-productivity agriculture as well as to reduce its gap with cities where industries are developing. However, there is a mountain of issues even for agriculture which is regarded as a priority by the government. With fertile land centered in the delta region, it used to be the largest exporter of rice in the world, but declined after the 1960s. An estimate by the United States Department of Agriculture (USDA) shows a concern that balance of supply and demand is tight for rice despite its status as a staple food; and if this low-productivity rice growing continues rice could become a crop to be imported. In order to solve issues in the field of agriculture, first of all, it is essential to develop infrastructure, focusing on irrigation facilities. Next, it has become necessary to improve weak breeding and fertilizer. Furthermore, it should make it possible to appropriately formulate policies by raising the reliability of statistics. There need to be reforms of the nationalized agricultural land system of the socialist era which still remains in the current agricultural policy of Myanmar, and planned production which remains in practice. In addition, it is urgently required to secure stable electric power to support industries. With the loss of electric power during transmission and distribution said to be 30%, electric power generation is not the only issue. Despite being endowed with natural resources, the country does not have enough technology and capital to develop them; as a result, gas fields and water power stations are developed by Chinese and Thai capital through the acquisition of mining rights, and produced electricity and gas are sent to China and Thailand, respectively. Statistics are also very rudimentary, and cannot be the basis for formulating industrial policy. The government is not very capable of collecting taxes, nor does it understand taxation on permanent establishment very well. Since it is not so structured to benefit the treasurer when there is direct investment by foreign capital, investment is insufficient for science and technology, education, and social infrastructure, leading to a vicious cycle of draining out young talented people from the country. In other words, we think that the largest and the most important issue is to develop a national policy promotion organization to achieve national targets, and to establish a system to develop human resources to bear such responsibilities. There is not much time left before the imminent ASEAN economic integration. If things are left as they are, the country could be fixed in a position of something like a subcontracting factory for Thailand and Malaysia etc. It is important to develop its own industries, modeled after Thailand which has become able to deal with complex production, beyond simple light industry (Cutting/Making/Packing: CMP), in a short period of time. From that perspective, it is urgently needed to develop a higher education system with a clear definition of necessary human resources required by the industry.

If Japan is to contribute to this country, it should make recommendations for industrial policy and human resource development policy by formulating a Japan-Myanmar joint initiative, just like the Japan-Vietnam Joint Initiative, which is said to be a success in Vietnam.

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- Yangon Technological University (YTU) http://ytu.edu.mm/
- Myanmar Computer Federation http://www.mcfmyanmar.org/

Abbreviations:

UBARI Act: Union of Myanmar Applied Research Institute Act (1954)
MOST: Ministry of Science and Technology
MSTRD: Myanmar Scientific and Technological Research Department
DTVE: Department of Technical and Vocational Education
DAST: Department of Advanced Science and Technology
DAE: Department of Atomic Energy
DTPC: Department of Technology Promotion and Coordination
YTU: Yangon Technological University
MTU: Mandalay Technological University
YAU: Yezin Agricultural University

Conclusion

This report was developed by the fellows of the Overseas Research Unit that belongs to the Center for Research and Development Strategy (CRDS), an internal organ of the Japan Science and Technology Agency (JST). The authors of all chapters are listed below. Osamu KOBATASHI is an employee of JST but is also the Director-General of the Singapore Office, and does not belong to CRDS. Besides the fellows listed below, Takehito HIGUCHI of the Overseas Research Unit helped develop the data of Vietnam and edited figures in all chapters.

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