Survey Research 2019-10-06

2019 K-Innovation ODA Program with Sri Lanka

2019 Policy Consultation on Supporting Improvement of Science, Technology and Innovation (STI) policy and Institutional Framework for Sri Lanka

STEPI SCIENCE AND TECHNOLOGY POLICY INSTITUTE

Ministry of Science,Technology and Research

NASTEC

2019 K-Innovation ODA Program with Sri Lanka

Title	2019 Policy Consultation on Supporting the Improvement of Science, Technology, and Innovation (STI) Policy and Institutional Framework for Sri Lanka
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In Cooperation with	Ministry of Science, Technology, and Research (MoSTR) of Sri Lanka National Science and Technology Commission (NASTEC)
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2019 Policy Consultation on Supporting the Improvement of Science, Technology, and Innovation (STI) Policy and Institutional Framework for Sri Lanka

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Executive Summary

Sri Lanka is a lower middle-income country with population of 21.2 million and per capita GDP of $3,946 as of 2019. Since the civil war ended in 2009, the GDP growth rate in Sri Lanka has averaged 5.88% from 2003 until 2017, reflecting a peace dividend and a commitment to reconstruction and growth. The economy is transitioning from what was previously a predominantly rural-based economy toward a more urbanized one oriented toward manufacturing and services.

The main focus of the policies and economic reforms as stated by the previous government of Sri Lanka was a knowledge-based social market economy. Likewise, the vision proposed by the current new government of President Gotabaya Rajapaksa is “a productive citizen, a happy family, a disciplined society, and a prosperous nation.” In this context, the Sri Lankan government has announced its intention to promote Science, Technology, and Innovation for the achievement of SDGs and pursue a technology-based society.

Sri Lanka has formulated various policies including the National Science and Technology Policy (2008), Science, Technology, and Innovation Strategy for Sri Lanka (2011) and the National Research and Development Framework (2016) for the development and utilization of science and technology. Nonetheless, the country still lacks implementable action plans that fit or change the political, social, and economic contexts of the country, according to the project concept paper submitted by the government of Sri Lanka.

After the successful training provided by STEPI to STI policy experts in Sri Lanka in 2018, the two-year policy consultation project started with generous funding from the government of the Republic of Korea in 2019. The training was aimed at improving the STI policy capacity of Sri Lankan STI policy makers and experts in order for them to gain deeper understanding and insights of STI policy and strategy development. It also helped government officials from various ministries and STI stakeholders obtain appropriate knowledge of policy analysis techniques and mechanisms for R&D commercialization. In the new project on policy consultation, the STEPI-NASTEC collaborative works have been designed to examine the STI development experiences of both countries and share know-how and knowledge of STI for economic and societal developments together.

As an advisory body to the Government of Sri Lanka on Science and Technology, the National Science and Technology Commission (NASTEC) requested that STEPI identify impediments to the effective implementation of major STI policies and develop incentive-based strategies such as action plan to eliminate or minimize such impediments during the 2019-2020 project. Thus, the STEPI-NASTEC project focused on the assessment of the overall national STI system in Sri Lanka to diagnose the current status of the STI system, governance including the current STI resources, and capabilities and challenges during the first year of the project. In 2020 as the second year of the project, experts from both countries will have opportunities to investigate the action plans of both countries and share methodological policy tools and skills to develop implementable action plans.

This report, which is the first output of the STEPI-NASTEC collaborative project, contains comparative studies on the national STI system, STI governance and major policy, and STI data mechanism of Korea and Sri Lanka. It is a truly collaborative analysis conducted by Korean experts, with great insights and critical information provided by STI policy stakeholders in Sri Lanka. Based on the study with policy recommendations listed in this report, the STEPI-NASTEC project is expected to bring about more fruitful outcomes, contributing to the sustainable bilateral ties between Korea and Sri Lanka and national STI development and growth in Sri Lanka.

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CHAPTER 1

Project Overview

2019 Policy Consultation on Supporting the Improvement of Science, Technology, and Innovation (STI) Policy and Institutional Framework for Sri Lanka

Chapter 1. Project Overview

1. Introduction

Sri Lanka has set, as its national vision, becoming an upper middle-income country by 2025 by transforming into the hub of the Indian Ocean with a knowledge-based, competitive social market economy. To do so, the country is attempting to harness Science, Technology, and Innovation to create the conditions that will realize economic growth.

In order to realize this vision of national development with sound STI capacity, it is necessary for the government to have its officials equipped with knowledge and expertise in establishing and implementing a national STI policy, its action plans, and an efficient STI system. In most cases, policy formulation and implementation in Sri Lanka are based on ad hoc approaches and intuition.

The National Science & Technology Commission (NASTEC) initiated the collaborative official development assistance (ODA) project in partnership with the Science and Technology Policy Institute (STEPI). In 2017, the first customized STI Policy training program on “Capacity Building in STI Policy Formulation and R&D Commercialization in Sri Lanka” was conducted in 2018 at Sri Lanka Institute of Development Administration (SLIDA). The training program seeks to support and strengthen the Science, Technology, and Innovation (STI) policy instrument in managing sound national R&D commercialization and innovation capability by accelerating the technology transfers for entrepreneurships through contribution to national economic growth. The expected means of delivery of the contents of this training program are descriptive course materials and presentations on various policy tools, R&D planning and evaluation techniques, and R&D commercialization approaches with the relevant case studies taken from Korea. A few people from Korea who are experts on the subject matters above have visited Sri Lanka to conduct this training program.

The implementation of three major recent policies, namely National S&T Policy (2008), Science, Technology, and Innovation Strategy for Sri Lanka (2011), and National Research and Development Framework (2016), is not satisfactory, and efforts to develop such policies were for naught. Worse, the much needed outputs and outcomes expected through the implementation of those policies, which were designed for the different developmental needs of the country, suffered heavily due to the non-implementation of such policies. This situation suggests the lack of implementable action plans that fit or change the practical situation (political, social, and economic) in the country. The major drawbacks of the system are the inadequate attention paid to economic gains in the formulation of action plans and the lack of proper legal framework to make the implementation compulsory. Introducing incentive-based strategies is an alternative to avoid the current drawbacks in the system. There may be other alternatives introduced to Sri Lanka based on Korea's experience.

2. Objectives

The objectives of the policy consultation are the development of comprehensive STI policy and action plan and formulation of a supportive institutional framework for the implementation of S&T policies.

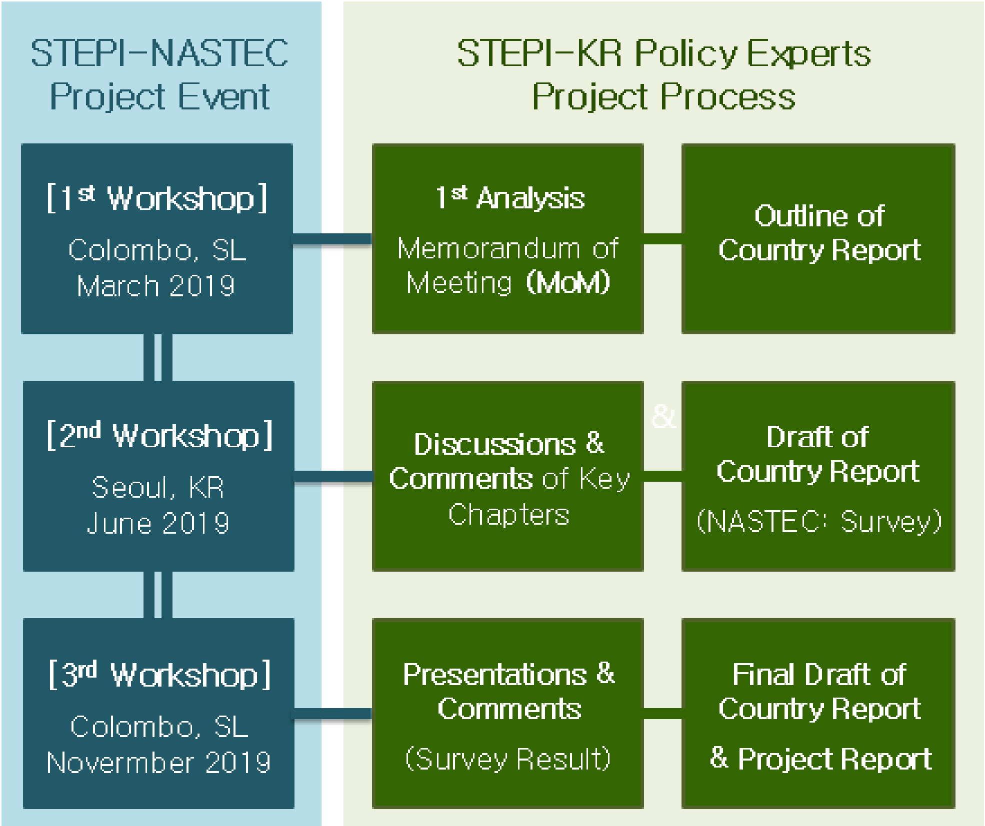
1) Analysis of the national STI system and governance with STI policy challenges and recommendations
2) Meetings and workshops (3 times in 2019)
3) Publication of country report to be entitled *Assessment of the National STI System in Sri Lanka*

3. Project Framework

The project aims to provide policy consultation to the Sri Lankan Government. STEPI is expected to provide a team of experts working jointly with a team of local experts composed of key stakeholders from government ministries, academe, public organizations, and private sector entities in order to develop the STI policy.

The main activities of the 2019 project are as follows: (1) assessment of the national STI system; (2) capacity building for STI policy; and (3) country report. The Project strongly recommends that the Sri Lankan participants maintain active discussions with Korean experts and draw implications and lessons from the lectures.

[Figure 1-1] Project Scheme



4. Project Team

4.1 Korea's Research Team

The research team from Korea is composed of two STEPI experts, a team leader Dr. Inkyoung Sun and a researcher Mr. Byung Woo Jeon, and three external experts: Prof. So Young Kim from the Korea Advanced Institute of Science & Technology (KAIST), Dr. Kwan Young Kim from the Green Technology Center (GCT) at the Korea Institute of Science & Technology (KIST), and Ms. Haengmi Kim from the Korea Institute of Science & Technology Evaluation and Planning (KISTEP).

[Table 1-1] Korea's Research Team

Name	Institution	Position
Dr. Inkyoung Sun	Science & Technology Policy Institute (STEPI)	Head of the Office of Development Cooperation
Mr. Byung Woo Jeon	Science & Technology Policy Institute (STEPI)	Researcher
Prof. So Young Kim	Korea Advanced Institute of Science & Technology (KAIST)	Professor & Head of the Graduate School of Science & Technology Policy (STP)
Dr. Kwan Young Kim	Green Technology Center (GCT), Korea Institute of Science & Technology (KIST)	Senior Researcher & Director of the Green Technology Partnership Initiative (GTPI)
Ms. Haengmi Kim	Korea Institute of Science & Technology Evaluation and Planning (KISTEP)	Associate Research Fellow

4.2 Sri Lanka's Research Team

NASTEC is responsible for this project in Sri Lanka. The local research team works in cooperation with the STEPI research team.

[Table 1-2] Sri Lanka's Research Team

Name	Institution	Position
Prof. Niranjanie Ratnayake	National Science & Technology Commission (NASTEC)	Chairperson
Prof. Jennifer Perera	National Science & Technology Commission (NASTEC)	Member
Mr. Nimal Ranamukhaarachchi	National Science & Technology Commission (NASTEC)	Member
Mrs. D. Nandanie Samarawichrama	Ministry of Science, Technology, and Research (MoSTR)	Additional Secretary (Administration & Finance)
Dr. Kalpa W. Samarakoon	National Science & Technology Commission (NASTEC)	Senior Scientist
Mr. Seyed Shahmy	National Science & Technology Commission (NASTEC)	Senior Scientist

5. Main Activities

5.1 Activity 1: Preparation of the Project

In the first months of 2019, the STEPI team received a project concept paper from NASTEC, which is requesting two-year policy consultation from STEPI. By communicating with NASTEC via several means including Skype meetings, both parties came to an understanding that the general goal of the project would be to find out the factors hindering the successful implementation of STI policy in Sri Lanka. The development of action plans to implement STI policies was suggested as one of the possible project activities to facilitate STI policy implementation during this two-year project.

5.2 Activity 2: Kick-off Workshop and Field Research

On March 25-29, 2019, the STEPI team (Dr. Chi Ung Song, Dr. Wangdong Kim, Dr. Inkyoung Sun, and Mr. Byung Woo Jeon) visited Colombo and held the Kick-off meeting with NASTEC and other major stakeholders in the STI policy community of Sri Lanka. The meeting aimed to introduce the project and to discuss the scope and expected outputs of the first year of the two-year project. Furthermore, the STEPI team made several visits to major STI entities in Sri Lanka including the Ministry of Science, Technology, and Research (MoSTR), Arthur C. Clarke Institute for Modern Technologies, Sri Lanka Institute of Nanotechnology, and University of Colombo. From all those field research and interviews with STI experts in Sri Lanka, valuable information and data were collected to establish sufficient grounds for the planning of the first year of the policy consultation project. Based on the agreements between STEPI and NASTEC experts on the scope of the first-year project, STEPI recruited three more Korean STI policy experts and developed studies on national STI system and governance, including the STI data mechanism of Korea, to share Korea's experiences and cases with the STI policy experts in Sri Lanka.

5.3 Activity 3: STEPI-NASTEC STI Policy Workshop in Korea

The five-member delegation from Sri Lanka was invited to the STEPI-NASTEC STI Policy Workshop in Seoul, Korea, where they participated in five-day intensive programs from June 24 to 29, 2019. The Sri Lankan delegation to the STEPI-NASTEC STI Policy Workshop in Korea consisted of two (2) commission members, a senior officer, and two scientists from NASTEC. The purpose of the “STEPI-NASTEC STI Policy Workshop” was to share the experiences of Korea and Sri Lanka in STI development and discuss the current major STI policy issues in both countries. Moreover, the workshop was expected to improve understanding of the current national STI system in Sri Lanka and develop strategies for more effective STI governance.

5.4 Activity 4: STEPI-NASTEC STI Policy Workshop in Sri Lanka

From November 18 to 22, 2019, the STEPI team consisting of Dr. Inkyoung Sun, Prof. So Young Kim, Dr. Kwan Young Kim, Ms. Haengmi Kim (via conference call), and Mr. Byung Woo Jeon visited Colombo to share the first version of their analysis on each subject of Sri Lanka’s STI policy. The main goal of the STEPI-NASTEC STI Policy Workshop in Sri Lanka is to get feedback from local experts on the Korean experts’ analysis and to discuss further the policy recommendations for NASTEC and MoSTR as to what to do to facilitate the successful implementation of STI policy in Sri Lanka. In addition, both STEPI and NASTEC delegations were encouraged to discuss the scope of the 2020 project in advance to prepare for an effective start of the second-year project.

5.5 Activity 5: Final Report

With the data and information collected from the workshops in both Korea and Sri Lanka, the research team wrote a final report. The contents of the report are composed of two parts: one is a project report that focuses on the STEPI-NASTEC project including its aims, process, and results; the other part is the experts’ studies on Sri Lanka’s STI policies, which deal with the national STI system, STI governance, and STI data mechanism in Sri Lanka, followed by policy recommendations. The main information and critical data sources of the analysis were generously contributed by local experts throughout the workshops in both countries.

6. Project Schedule

The entire schedule of the project is as follows:

[Table 1-3] 2019 Project Schedule

Activities	Jan. '19	Feb. '19	Mar. '19	Apr. '19	May '19	Jun. '19	Jul. '19	Aug. '19	Sep. '19	Oct. '19	Nov. '19	Dec. '19
Project Preparations												
Kick-off Meeting in SL												
Interim Report												
Preparation of the STEPI-NASTEC STI Policy Workshop in Korea												
STEPI-NASTEC STI Policy Workshop in Korea												
Country Report												
Preparation of the STEPI-NASTEC STI Policy Workshop in Korea												
STEPI-NASTEC STI Policy Workshop in Sri Lanka												
Final Report												

7. Project Outputs

STEPI provides the following deliverables:

- **Deliverable 1:** Revised project proposal, which was summarized in the MoM based on the first field research and kick-off meeting in Sri Lanka (March 2019)
- **Deliverable 2:** Interim report (June 2019)
- **Deliverable 3**: Program agenda for the STEPI-NASTEC STI policy workshop in Korea (June 2019)
- **Deliverable 4:** Presentations and training materials for the capacity-building workshop (June 2019)
- **Delivferable 5 :** Project report, which provides the summary of the project and the analysis of the STI system of Sri Lanka.

CHAPTER 2

Current Status of National Policy and Strategy in Sri Lanka

2019 Policy Consultation on Supporting the Improvement of Science, Technology, and Innovation (STI) Policy and Institutional Framework for Sri Lanka

Chapter 2. Current Status of National Policy and Strategy in Sri Lanka

1. Introduction

The Democratic Socialist Republic of Sri Lanka is a presidential republic, having gained its independence from the United Kingdom in 1948. After the 26-year-long civil war, Sri Lanka has finally set, as its national vision, becoming an upper middle-income country by 2025 by transforming into the hub of the Indian Ocean with a knowledge-based, competitive social market economy. In its vision, Science, Technology, and Innovation (STI) are one of the essential tools for the country to create the conditions that will realize economic growth.

Despite the significant demand for globally advanced technology and products and availability of relatively highly skilled human resources in Sri Lanka, the field of science and technology still has problems of insufficient STI resources and lack of a holistic STI system to support the country in moving forward as an upper-middle income country with global STI competitiveness. In particular, the lack of technology policies and strategies for the manufacturing sector is said to have led to little incentive for the private sector to enter and invest. Sri Lanka's IT literacy rate was a mere 27.5% in 2016, with only 15.1% of households having Internet access. The technology service sector has long been dominated by ICT, and there is little focus on promoting disruptive innovation technologies such as artificial intelligence (AI), data mining, and other high-quality technological services. The economy needs a shift toward innovative, knowledge-based business ventures.

[Table 2-1] Country Overview with Key Statistics

Official name	Democratic Socialist Republic of Sri Lanka
Capital[1)]	Sri Jayawardenepura Kotte (Administrative) Colombo (Commercial)
Population[1)]	21.67 million
Area[1)]	65,610 sq km (land: 64,630 sq km; water: 980 sq km)
Major languages[1)]	Sinhala, Tamil, English
Major religions[1)]	Buddhism, Hinduism, Islam, Christianity
Life expectancy[1)]	72 years (men); 78 years (women)
Poverty rate[1)]	3.1% (poor households based on the official poverty line)
Currency[1)]	Sri Lankan rupee
GDP[3)]	$86.566 billion (2019 est.)
GDP per capita[3)]	$3,946 (2019 est.)
GDP composition by sector[3)]	Agriculture (7.8%), industry (30.5%), services (61.7%)
Export partners[2)]	US 24.6%, UK 9%, India 5.8%, Singapore 4.5%, Germany 4.3%, Italy 4.3% (2017)
Export commodities[2)]	Textiles and apparel, tea and spices, rubber manufacture, precious stones, coconut products, fish
Import partners[2)]	India 22%, China 19.9%, Singapore 6.9%, UAE 5.7%, Japan 4.9% (2017)
Import commodities[2)]	Petroleum, textiles, machinery and transportation equipment, building materials, mineral products, foodstuff
Unemployment rate[1)]	4.4%

[1)] Source: Sri Lankan Statistics (2019)

[2)]Source: CIA World Factbook (2019)

[3)]Source: IMF World Economic Outlook Database (2019)

President Gotabaya RAJAPAKSA, who was newly elected on November 16, 2019, pointed out the relatively slow growth rate of GDP and per capita income from 2015 to 2018 and emphasized the important roles of technocrats and his plans for a “Technology-Based

Society (Smart Nation)” in his proposals for the Sri Lankan government (Rajapaksa, 2019).

This chapter introduces the major STI policy of the country including the STI plans proposed by the newly elected president and his new Sri Lankan government. It concludes with a short history of the bilateral STI cooperation between Sri Lanka and Korea in recent years.

2. Major STI Policies

In 1978, the first policy statement on S&T for the country was developed. Thirteen years later, in 1991, a presidential task force mandated the development of an expanded S&T policy. This was followed by the S&T Development Act passed by the Parliament in 1994. As stipulated in this Act, the National Commission on Science and Technology (NASTEC) was established in 1998 with the powers to function as a policy advisory body on S&T.

The earliest attempt to formulate an S&T policy in Sri Lanka was during the period 1950 – 1960 by the Ceylon Association for the Advancement of Science, the predecessor to the Sri Lanka Association for the Advancement of Science (SLAAS). In 1978, a 7-point S&T policy statement was developed by the National Science Council (NSC) in association with SLAAS. In 1986, a Presidential Task Force was appointed with the mandate of looking into all aspects of S&T particularly the implementation of the 7-point policy objectives developed by NSC. In 1991, this Task Force submitted a report recommending several projects and programs with a view to achieving the 7-point policy objectives. Based on this report, an S&T Development Bill was presented to the Parliament in 1994 and was unanimously passed as the Science and Technology Development Act No. 11 of 1994. This Act brought together the S&T institutions under the purview of the Ministry of Science and Technology. The Act also stipulated the establishment of the National Science and Technology Commission (NASTEC), which was mandated to develop policies and plans for the advancement of S&T and the application of S&T for national development. In 1996, prior to the establishment of NASTEC, the National Science Foundation (NSF) as the successor to NSC and the Natural Resources, Energy, and Science Authority (NARESA) developed ten policy elements.

National Science and Technology Policy (2008)

In 2007, NASTEC, which was established in 1998, initiated extensive consultations with the relevant stakeholders to develop a new S&T policy. The new policy was approved by the Cabinet of Ministers as the National Science and Technology Policy (NSTP). With its vision of "a prosperous nation of scientifically literate and innovative people, with a strong and stable economy based on highly developed scientific and technological capabilities," this policy dealt with two major aspects: the development of S&T in the country and the application of S&T for national development. The NSTP recommended 10 policy objectives (Table 2-2) as well as the relevant strategies for the realization of the objectives. The responsibility of implementing the NSTP was vested in the Ministry of Technology and Research (successor to the Ministry of Science and Technology) as per the NSTP. Thus, the ministry dealing with Science, Technology, and Research was identified as the executive arm of the NSTP.

[Table 2-2] 10 Policy Objectives of the National Science and Technology Policy (2008) in Sri Lanka

Policy Objective 1	Foster a Science, Technology, and Innovation culture that effectively reaches all citizens of the country
Policy Objective 2	Enhance Science and Technology capability for national development, make use of science and technology expertise in the national planning process, and strengthen governance and policy implementation mechanisms
Policy Objective 3	Build up and progressively expand and improve the resource base of scientists and technologists necessary to respond to the developmental needs of the country
Policy Objective 4	Promote basic, applied, and developmental research particularly in areas of national importance and priority
Policy Objective 5	Develop, or acquire and adapt, scientific knowledge and technologies for transfer to achieve the progressive modernization of all sectors and to enhance the country's competitiveness in the world economy
Policy Objective 6	Ensure the sustainable use of natural resources for development while protecting the environment

Policy Objective 7	Document, research on the scientific basis of, and promote indigenous knowledge-based technologies
Policy Objective 8	Develop a culture of innovation and Intellectual Property and ensure the protection of Intellectual Property Rights (IPR)
Policy Objective 9	Ensure the quality standards of Science and Technology Institutions, products, and services to achieve national and international recognition
Policy Objective 10	Promote the application of Science and Technology for human welfare, disaster management, adaptation to climate change, law enforcement, and defense to ensure human and national security

Source: National Science and Technology Policy (2008), p.ix.

In 2009, NASTEC developed a five-year (2011 – 2016) action plan for the implementation of NSTP following extensive consultations with all S&T institutions, scientists, technologists, academic community, and administrators. This plan was formulated considering the mandates of the S&T institutions coming under the purview of all ministries but was not implemented as well.

Science, Technology, and Innovation Strategy for Sri Lanka 2011-2015

Subsequently, the S&T Ministry, recognizing the important role of science, technology, and innovations as key to winning the economic war, developed the Science, Technology, and Innovation Strategy 2011 – 2015 (STIS) with a prioritized course of action based on the NSTP (COSTI, 2010). This strategic plan had four goals and a total of fourteen objectives (Table 2-3). All these objectives are in agreement either totally or partly with the NSTP, so the STIS could be considered a mechanism for implementing the NSTP. The implementation of STIS 2011 – 2015 came with a newly established Coordinating Secretariat for Science, Technology, and Innovation (COSTI) set up with considerable investment by the State.

[Table 2-3] Goals and Objectives of the Science, Technology, and Innovation Strategy for Sri Lanka 2011-2015

GOAL 1. Science, Technology, and Innovation for Economic Development	
Objective 1	Advanced Technology Initiative
Objective 2	Import replacement by strategic production and social activities
Objective 3	Techno-entrepreneurship Initiative
GOAL 2. A World-class National Research and Innovation Ecosystem	
Objective 1	S&T Governance
Objective 2	Attract, build, and retain Human Capital
Objective 3	Science and Technology infrastructure and services modernization initiative
Objective 4	Investment in R&D
Objective 5	International Partnerships
GOAL 3. Toward a Knowledge Society	
Objective 1	Science for All Initiative
Objective 2	Attract students at all levels to science
Objective 3	Technology, R&D, and innovation in industry and businesses
GOAL 4. Ensuring Sustainability	
Objective 1	Economic Sustainability
Objective 2	Environmental Sustainability
Objective 3	Social Sustainability

Source: Science, Technology, and Innovation Strategy for Sri Lanka 2011-2015 (2010), p. 9.

National Research and Development Framework (2016)

In 2016, the Ministry of Science, Technology, and Research and NASTEC formulated the National Research and Development Framework (NRDF) to align the activities of the S&T community with the national development goals toward a knowledge economy driven by Science, Technology, and Innovation. This plan, which was designed for a medium-term

R&D framework, identifies “ten focus areas that require immediate attention of the S&T community along with ten forms of interventions to address issues and problems (NRDP, 2016, p.5).”

The ten focus areas identified in the NRDF are: 1) Water; 2) Food, Agriculture, and Nutrition; 3) Health; 4) Shelter; 5) Environment; 6) Energy; 7) Minerals; 8) Apparel Industry; 9) ICT and Knowledge Service; and 10) Basic Science, Emerging Technologies, and Indigenous Knowledge. Meanwhile, the first five focus areas are proposed in order to address societal challenges and improve the societal well-being of the country, and the last five focus areas are selected with the aim of economic development.

The ten possible forms of interventions to foster the ten focus areas above are: 1) Policy Formulation; 2) Pure and Applied Research; 3) Promotion of Innovation; 4) Application of Nanotechnology; 5) Application of Biotechnology; 6) Application of Indigenous Knowledge; 7) Testing, Standardization, and Accreditation and Assurance of Intellectual Property Rights (IPR); 8) Capacity Building; 9) Application of Information Communication Technologies (ICT); and 10) Popularization. Along with the ten focus areas, the ten forms of interventions can be combined depending on an issue or a target; its 10 X 10 matrix presents a hundred possible approaches for policy action.

Technology and Digitalization Chapter in Vision 2025

In the Budget proposals for 2016, the Minister of Finance stated thus: “Our investment in Science, Technology, and Innovation has failed to keep up with the growth in GDP. Its impact is evident in the low percentage of hi-tech value addition to our manufactured exports (0.9 %) and poor contribution of patents and research-based services and industries to our economy. This has to change rapidly if our economy is to be led by innovation. We expect hi-tech manufactured exports to constitute at least 10% of our exports by 2020.” The Minister further said, “I propose setting up a National Innovation Center (NIC) at the Ministry of Science, Technology and Research, which will manage the Innovation Accelerator Fund set up as a revolving fund. It is proposed that Rs. 100 million be allocated as seed capital to this Center and another Rs. 3,000 million be provided as well within a period of 3 years .”

This is a most encouraging and significant development toward the promotion of STI activities, which can also be seen as the implementation of the second policy objective and the 1st strategy of the NSTP, which recommended the progressive increase of investment in S&T by up to 1.5% of GDP by year 2016. Inadequate investment in STI was one of the impediments to implementing the NSTP. The allocation of funds for specific STI activities in the 2016 Budget removes this impediment to some extent. It is now the responsibility of all stakeholders including the Ministry of Science, Technology, and Research, S&T institutions, and most importantly the scientists and technologists, along with S&T administrators as well as researchers in S&T, to make use of the allocation for ST&I with maximum determination for the development of the country.

STI Policy Proposals of Newly Elected President Gotabaya Rajapaksa

President Gotabaya Rajapaksa was elected on November 16, 2019, and a new administration started immediately after his victory in the presidential election. As the most promising presidential candidate, President Rajapaksa proposed the ten key policies (Table 2-4), one of which is “technology-based society.” Emphasizing that the country should integrate technological innovation with every sector in the 21st Century, he and his team proposed four programs: 1) Global Innovation Hub; 2) Citizen-Centric Digital Government; 3) Digitally Inclusive Sri Lanka; and 4) IT Entrepreneurship. In particular, the new president stressed the use of “Internet of Things (IoT), Artificial Intelligence (AI), Biotechnology, Robotics, Augmented Reality, Cloud Computing, Nanotechnology, and 3D Printing (Rajapaksa, 2019, p.50)” through the innovative activities of the Global Innovation Hub. Given the significance of the digital transformation of society, he also pointed out new digital infrastructure such as high-speed optical transmission system, high-speed 5G mobile broadband system, mobile payment system, or cross-border e-payment system. It is proposed that the number of software engineers and programmers be increased up to 300,000 by 2025, with the knowledge process outsourcing and business process outsourcing industry in the country to record trade profits of USD 3 billion by 2025 (Rajapaksa, 2019, p.51).

[Table 2-4] 10 Key Policies of President RAJAPAKSA

1	Priority to National Security
2	Friendly, Non-aligned, Foreign Policy
3	An Administration Free from Corruption
4	New Constitution that Fulfills the People's Wishes
5	Productive Citizenry and Vibrant Human Resources
6	People-Centric Economic Development
7	Technology-Based Society
8	Development of Physical Resources
9	Sustainable Environmental Management
10	Disciplined, Law-abiding, and Values-based Society

Source: Rajapaksa (2019), p.2

In his higher education policy proposals, the new president also puts high priority on the production of "smart technocrats." Given the current serious problems of brain drain, his proposal to increase higher education institutes — including new technical university colleges, "four institutes affiliated with the Ceylon German Technical Training Institute (CGTTI)" to be established (Rajapaksa, 2019, p.22) — shows his strong intention of creating an innovative culture within the country where globally competitive talents can be raised to work and having a highly paid, creative labor force.

3. International STI Cooperation

STI Agreements and MoU for International STI Cooperation[1]

According to the Ministry of Science, Technology, and Research, the country has maintained international cooperation in the field of STI with India, China, Thailand, Pakistan, Cuba, Russia, Iran, and South African through MoUs. The following is a list of international STI cooperation agreements of the Ministry of Science, Technology, and Research in Sri Lanka with other countries (as of June 2019).

[Table 2-5] International STI Cooperation of Sri Lanka

Country	MoU/ Agreement
China	MoU on co-establishing the China-Sri Lanka Joint Laboratory on Biotechnology MoU on Scientists' Exchange Program with China's Ministry of Science and Technology
Cuba	MoU on Science and Technology cooperation with Cuba's Ministry of Science, Technology, and Environment
India	Agreement with the Government of India in the field of Science and Technology
Iran	MoU with the Government of Iran on Science, Technology, and Innovation cooperation
Pakistan	MoU on cooperation in Science, Technology, and Innovation with Pakistan's Ministry of Science and Technology
Russia	MoU on Science and Technology cooperation with Russia's Ministry of Education and Science
Thailand	MoU on Scientific and Technological cooperation with Thailand's Ministry of Science and Technology
South Africa	MoU with the Government of South Africa on cooperation in the fields of Science and Technology

[1] This section is written based on the presentation of Madam Nandanie Samarawickrama, Additional Secretary of the Ministry of Science, Technology, and Research, during the 2019 STEPI-NASTEC STI Policy Workshop in Seoul in June 2019.

Country	MoU/ Agreement
In Progress	Discussions with Ecuador, Belarus, Latvia, New Zealand, Slovenia, Vietnam, Georgia, and Indonesia have been initiated for STI collaborations

Source: Samarawickrama (2019)

The following are programs on bilateral cooperation of the Ministry of Science, Technology, and Research in Sri Lanka:

- Indo-Sri Lanka joint research program
- India's scientific and research fellowship program
- Research program on the safe use of Chrysotile Asbestos
- CERN and CMS Collaboration
- NAM S&T Center
- BMISTEC - Finalized the Memorandum of Association (MOA) to establish the BMISTEC Technology Transfer Facility
- UN-CSTD STI Policy Review

Bilateral Relations Between Korea and Sri Lanka

The bilateral diplomatic ties between Korea and Sri Lanka started in 1977. The employment of Sri Lankans in Korea was first started in the early 1990s. Since then, the areas of employment have been gradually expanding; today, there are about 25,000 Sri Lankans in Korea. "Former President Rajapaksa made a state visit to Korea in 2012, after 17 years. The following year, Korean Prime Minister Hongwon Chung made an official visit to Sri Lanka for the first time (Daily FT, 2014)" in 2013.

The aid from Korea to Sri Lanka was roughly about USD 80 million per year, and most of the aid went to the improvement of water supply and road building in remote areas (Daily FT, 2014). In the education sector, the Korea International Cooperation Agency (KOICA) has implemented several aid programs to modernize and upgrade the facilities of technical colleges (i.e., Technical College at Gampaha and Kurunegala Technical College) and vocational training centers (i.e., Orugodawatta) and provided training programs for senior administrative officers at the Department of Technical Education and Training (Daily FT, 2018).

When it comes to STI bilateral cooperation between Korea and Sri Lanka, the first official cooperation was initiated by the agreement on Scientific and Technological Cooperation, which was signed on May 25, 1994 in Seoul. The Ministry of Science, ICT, and Future Planning of Korea, which was the counterpart ministry in Korea at that time, and the Ministry of Science, Technology, and Research were engaged in finding mutual areas of cooperation.

In 2017, NASTEC under Sri Lanka's Ministry of Science, Technology, and Research requested STEPI to provide a customized training program for STI stakeholders on STI policy development and R&D commercialization mechanisms by submitting a Project Concept Paper. The following year, a special workshop on capacity building in STI policy formulation and R&D commercialization commenced in Colombo in May and June with NASTEC. With the success of the workshop, STEPI and NASTEC have launched a two-year policy consultation project on the "Improvement of STI Policy Implementation and Institutional Framework" in 2019.

CHAPTER 3

Sharing Korea's Experiences and Analyzing STI System in Sri Lanka

2019 Policy Consultation on supporting improvement of Science, Technology, and Innovation (STI) policy and institutional for Sri Lanka

Chapter 3. Sharing Korea's Experiences and Analyzing STI System in Sri Lanka

1. National STI System

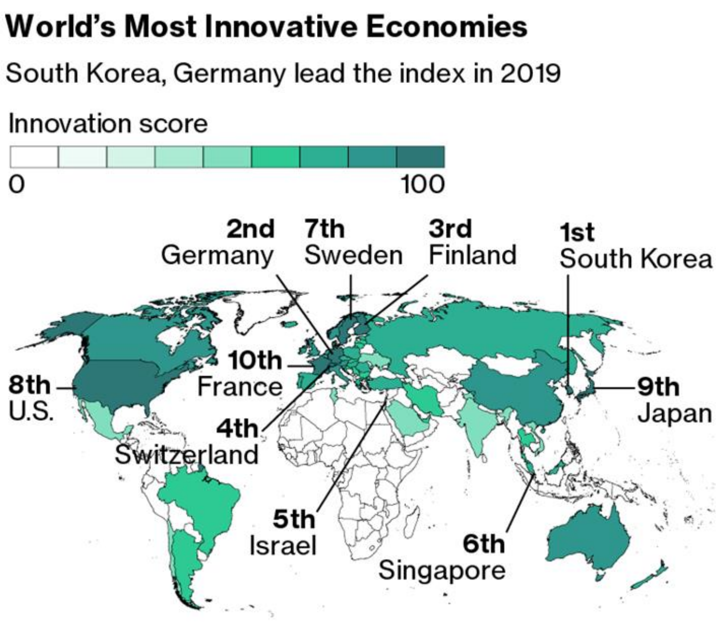
Prof. So Young Kim (KAIST)

1.1 National STI System of Korea

1.1.1 Why Korea to Benchmark?

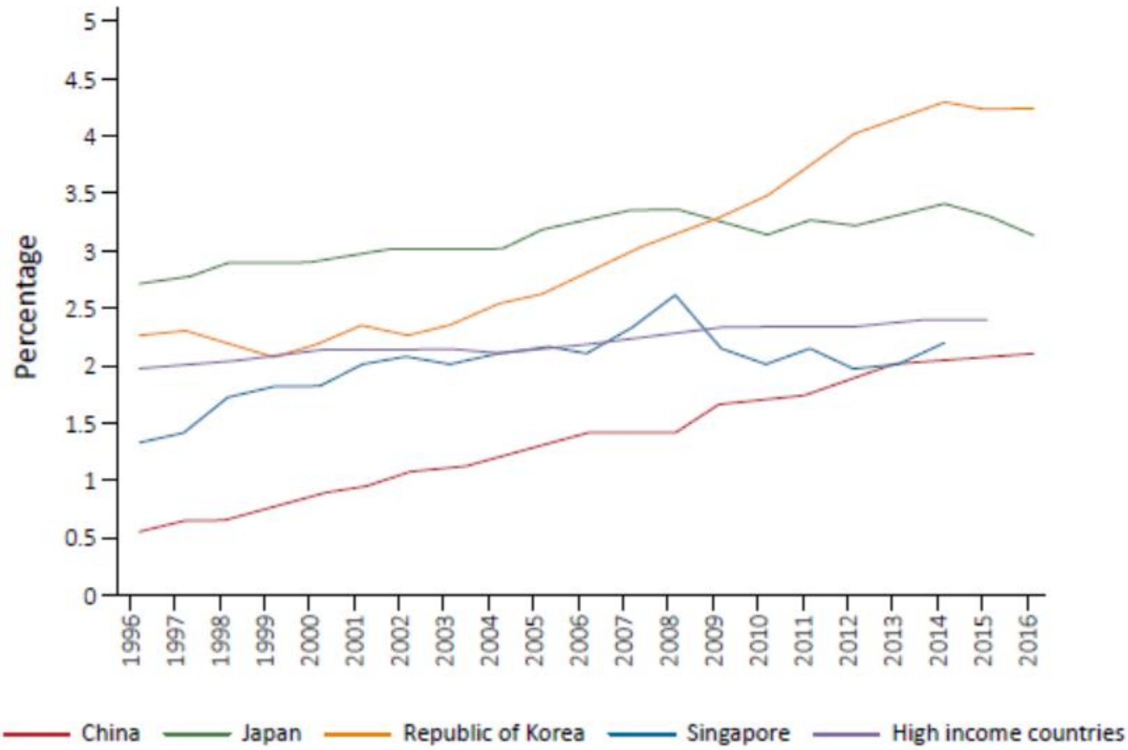
South Korea is touted as one of the most innovative countries that successfully transformed itself from a poor agricultural economy to a modern industrialized country. It has topped Bloomberg Innovation Index for the sixth straight year as the world's most innovative nation.

[Figure 3-1] Country Rankings on Bloomberg Innovation Index 2019



In light of the indicators used for Bloomberg Innovation Index (e.g., R&D intensity, manufacturing value-added, productivity, high-tech density, tertiary efficiency, researcher concentration and patent activity), it is not surprising that South Korea ranks top on this index. South Korea's R&D expenditure as a percentage of GDP is the world's highest, and its manufacturing value-added is the world's second. The country also ranks within five on most other indicators.

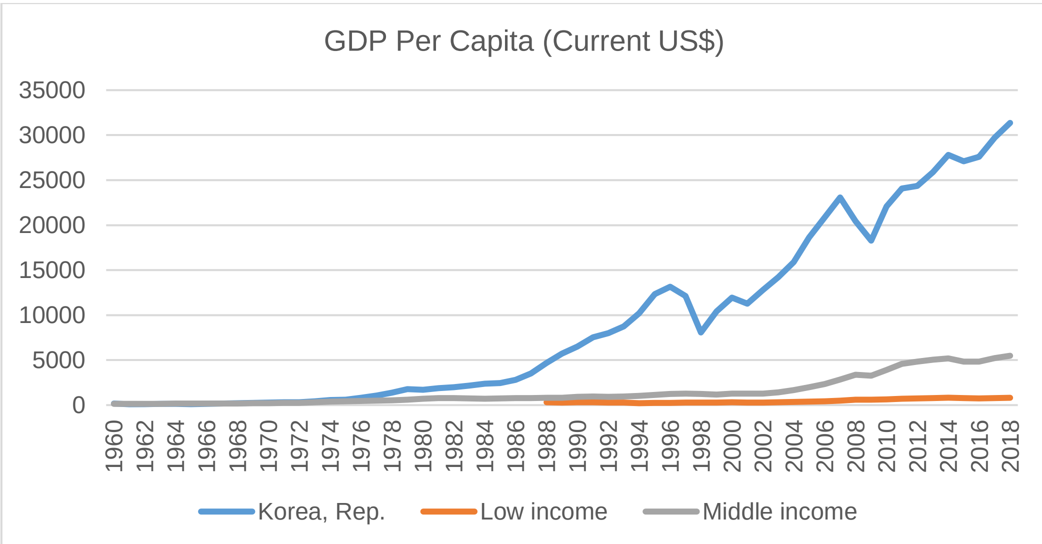
[Figure 3-2] Gross R&D Expenditure as % of GDP



Source: UN ESCAP (2018)

However, looking from the historical perspective, this achievement is miraculous. Arising from the ashes of the war (Korean War, 1950~53), South Koreafound itself one of the poorest countries in the world in the 1960s. Its per capita income was only $67 in 1953. Indeed, General Douglas MacArthur, the commander leading the UN Allied Forces during the Korean War, is said to remark that it would take at least 100 years to rebuild the country. Even after fifteen years, its per capita income remained as $94 in 1967, just one dollar less than Kenya's per capita income. The world average per capita income was then $462, five times higher than those of both countries. In 2017, just five decades after, however, Korea went ahead of other countries with its per capita income $29,743, far exceeding the world average per capita income of $10,741. Kenya's per capita income ($1,595), on the other hand, still lags far behind, which is common to many less-developed countries (LDCs).

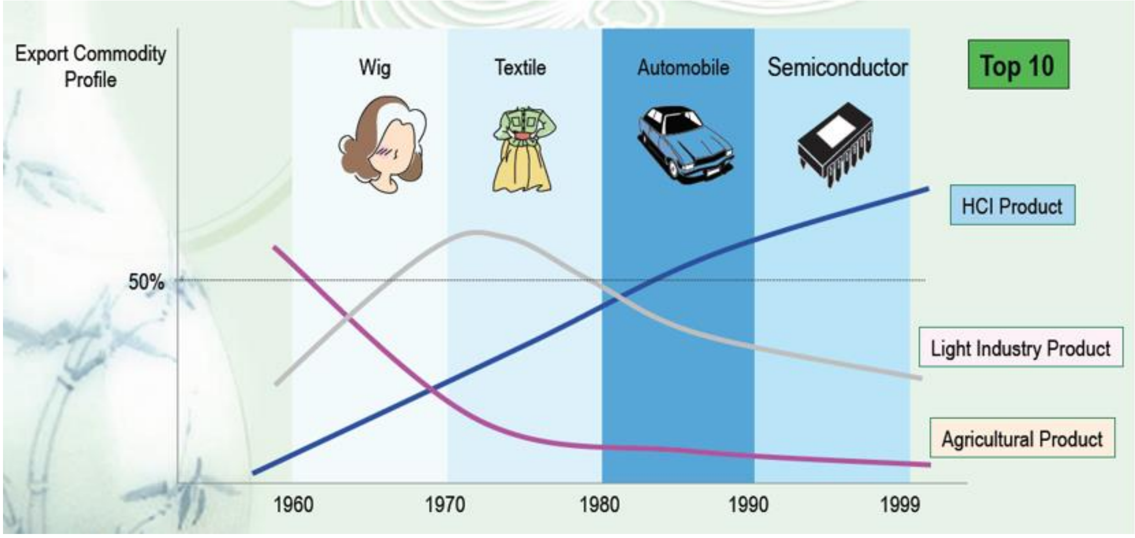
[Figure 3-3] GDP per Capita Growth of Korea, Low Income and Middle Income Countries in 1960~2018



Source: World Bank World Development Indicators (2019)

Much has been written about why South Korea made such an exceptional success in economic development (Amsden 1989; Haggard 1990; Wade 1990; Woo 1992; Woo-Cumings 1999). One of the critical factors commonly identified in these studies is the so-called heavy and chemical industrialization (HCI) drive initiated by the government.

[Figure 3-4] Major Export Products of Korea



Source: EDCF (2015)

HCI required massive investment in both capital and technology, which would only have been possible with substantial long-term planning of the government. Indeed, the Korean government introduced a series of the Five-Year Economic Development Plan from 1962 to modernize its economic structure. The Technology Development Plan was introduced in parallel with the Five-Year Development Plan, for the implementation of the latter was not impossible without upgrading technological capacity and the workforce with proper technological skills.

The next three decades have witnessed a dramatic change in many indicators of South Korea's economic performance, collectively named as the "Miracle of the Hand River," which culminated in South Korea's admission to OECD in 1996 that signaled the country's official recognition as a developed country. Many observers now consider South Korea's economic success as the best example of S&T-driven fast-track industrialization and modernization. Entering OECD Development Assistance Committee (DAC) in 2010, South Korea has become virtually the only country that succeeded in the transition from a recipient to a donner country. As this transition was underpinned by the remarkable growth of its capacity of Science, Technology, and Innovation (STI), numerous requests and efforts are being made these days to benchmark South Korean experience of building the national STI capacity.

1.1.2 What to Benchmark from Korea?

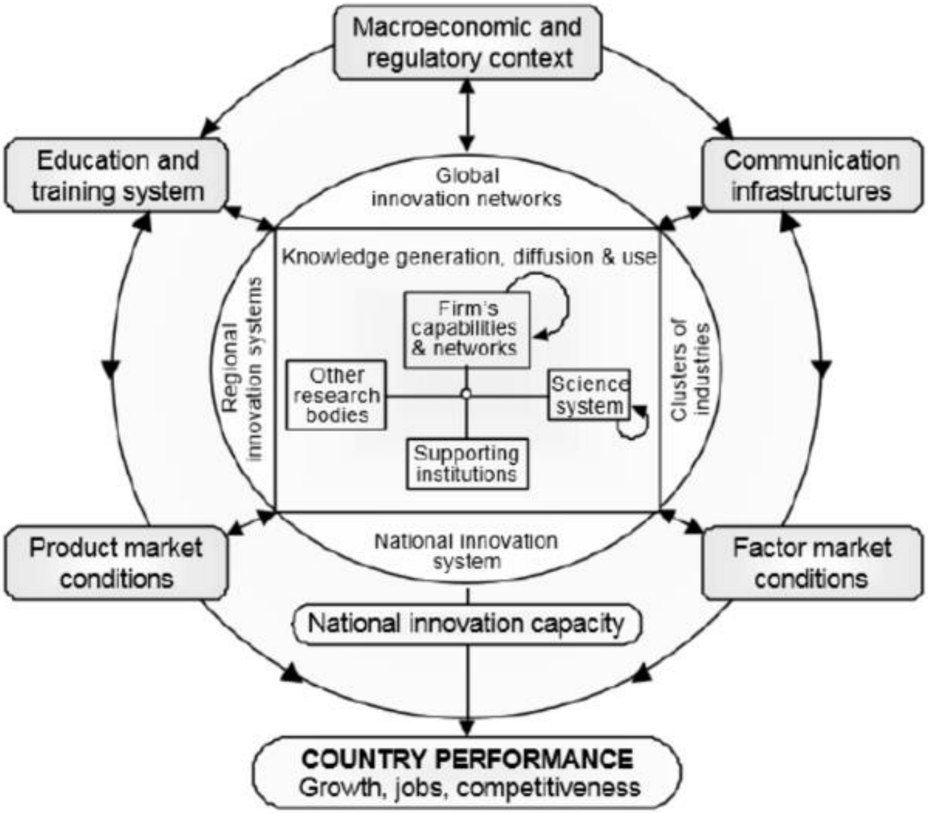
According to the vast literature on the national innovation system (NIS), STI capacity is not simply the result of research and development in S&T. In fact, the NIS literature has grown to understand the complexities and uncertainties in the evolution of STI of a given system of actors and institutions (Freeman 1987, Metcalfe 1995, Lundvall 1992, Patel & Pavitt 1994).

[Figure 3-5] Various Definitions of NIS

Network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies (Freeman 1987)	Elements and relationships interacting in the production, diffusion, and use of new and economically useful knowledge (Lundvall 1992)
National institutions, incentive structures and competencies that determine the rate and direction of technological learning (Patel & Pavitt 1994)	Set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies (Metcalfe 1995)

Of particular note is the complex feedback mechanisms and dynamic relations of innovation actors and institutions, as opposed to the so-called linear model of innovation that sketch STI process as a one-directional development from basic research to applied technology to innovation (Godin 2006). One of the best-known depictions of NIS clearly shows intricately linked sub-systems that comprise NIS as well as complex feedback loops of different components of each system (OECD 1999). What is notable is that STI capacity is a result of numerous factors interacting with one another and thus hardly reducible to R&D input or the existing stock of knowledge. That is, STI capacity-building requires a sincere appreciation of difficulties in coordinating different sections or segments of the system and negotiating among various actors with often conflicting interests.

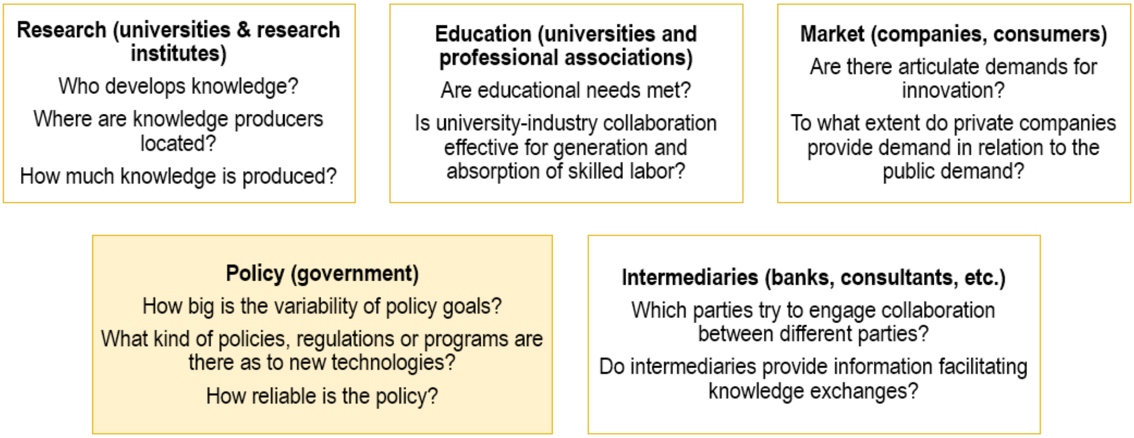
[Figure 3-6]OECD Framework for Management of NIS



Source: OECD (1999)

The NIS approach therefore helps to identify what to benchmark from South Korea's STI development with a realistic understanding of what can be applicable in a local context and what cannot. The following list of inquiries for each innovation actor posited in one of the recent NIS studies (Herkert et al. 2011) can help to sort out the questions to ask in learning about the NIS system of Korea and categorize the elements of benchmarking. The next section describes the national STI system focusing on the key actors within the public sector and the coordinating mechanism of national STI policy.

[Figure 3-7] Inquaries for Each NIS Actor

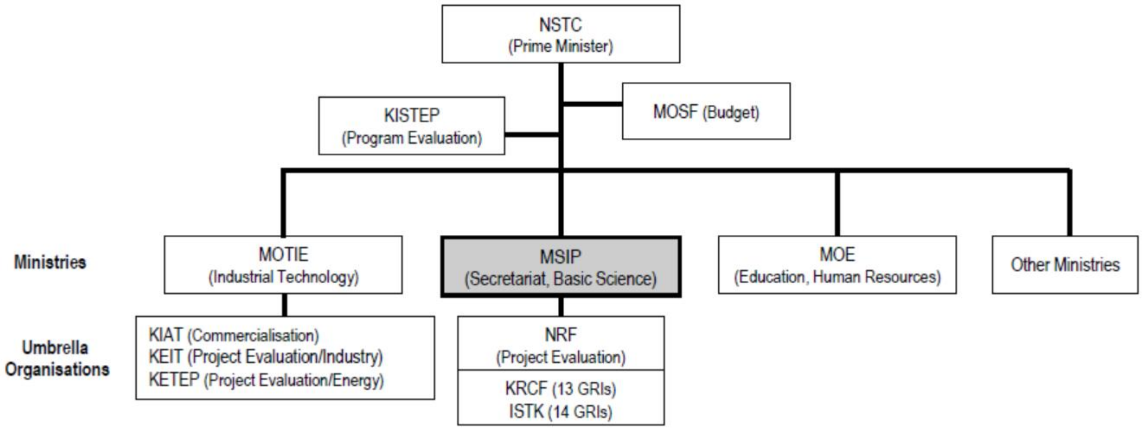


Source : Herkert et al. (2011)

1.1.3 Key NIS Actors and Mechanisms of S&T Coordination in Korea

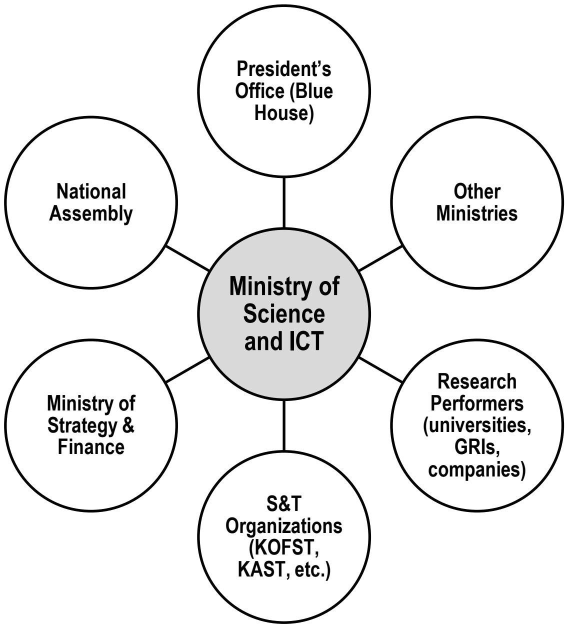
The most salient government actor of the Korean NIS is the Ministry of Science and ICT, MSIT (previously the Ministry of Science, Innovation, and Future Planning, MSIP).Some ministries – Ministry of Trade, Industry and Energy (MOTIE) and Ministry of Education (MOE) – take more significant roles than others in STI capacity-building in their tasks of industrial technology development and human resource management, but it is clearly MSIT that takes precedence over the matters of R&D.

[Figure 3-8] Government and Public Organizations Relevant to STI in Korea as of 2015



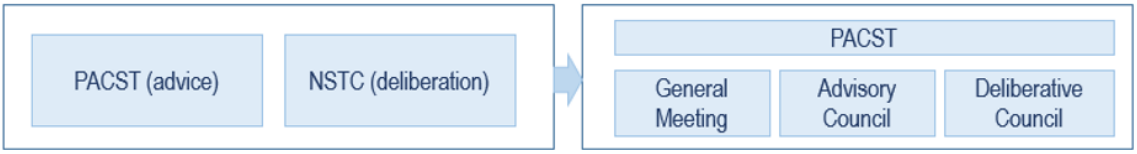
Major public-sector stakeholders of the national STI system of Korea are also formed around MSIT. Although The President's Office and the National Assembly are hierarchically located above MSIT, the actual process of S&T policy implementation – especially day-to-day operation and handling of S&T-related issues – is essentially undertaken by MSIT.

[Figure 3-9] Major Public-Sector Stakeholders of National STI System of Korea



What is interesting about MSIT is that while it is a ministry having S&T as its jurisdiction, it also has to review and evaluate R&D spread over multiple ministries. This dual role of MSIT gives rise to a tension in the coordination of national STI policy, which was part of the reason that the government has made sustained effort to create an institutional framework to coordinate multiple actors of STI within the government. The topmost organization in charge of national STI policy coordination is the Presidential Advisory Committee on Science and Technology (PACST), mandated to provide consultations for the President in regards to national S&T, strategies for S&T development and other directions for major STI policies. Before 2017, PACST was largely confined to the advisory role, but with the merger of the National S&T Council (NSTC) it has become a full-fledged organization taking the roles of advising and deliberation.

[Figure 3-10] 2017 Merger of PACST and NSTC



Now PACST is run on two groups. One is the Advisory Council comprised of civilian members together with the President as a chairperson, which runs three subcommittees on S&T infrastructure, S&T innovation, and S&T and society. The other one is the Deliberative Council that examines and determines more down-to-earth issues of STI, such as R&D funding allocation, R&D program planning, S&T workforce policy, and regional S&T policy.

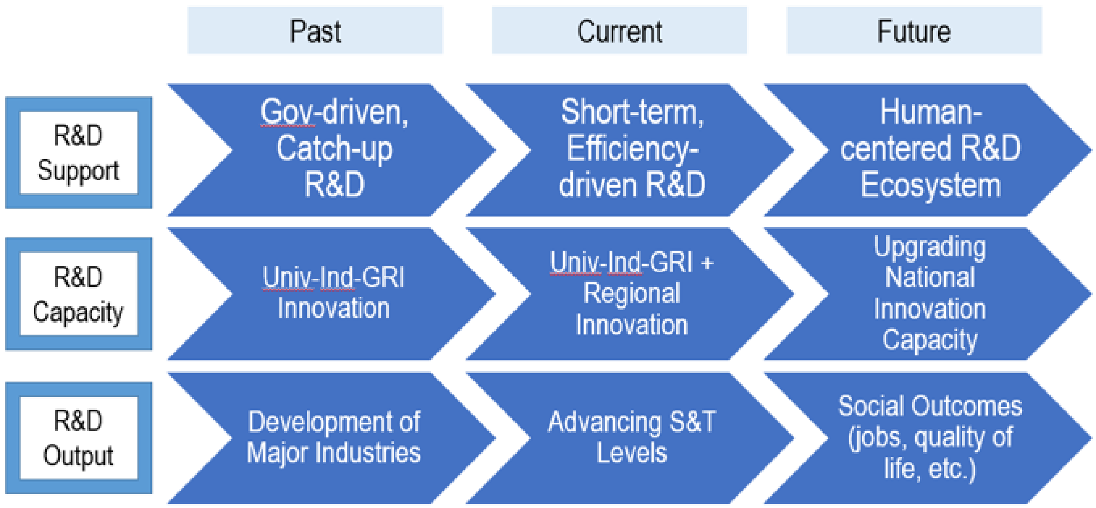
Most civilian members comprising PACST are prominent scientists and engineers, yet the composition of civilian members has changed significantly across the government. In particular, with the new administration in 2017 that took over the government after the impeachment of the previous president, some of PACST members are now replaced by younger and early-career researchers (even a graduate student from KAIST, South Korea's best-known S&T university).

Another notable change in the recent governmental coordination mechanisms is the revival of S&T Ministerial Roundtable in 2018. Two governments ago (i.e., during the RohMoohyun administration, 2003~08), this Roundtable was created to coordinate national R&D programs spread across government ministries and thereby strengthen the linkages among ministerial R&D programs. Presided by the Prime Minister and attended by all ministers of the ministries conducting R&D, the Roundtable develops government-wide strategies to implement R&D innovations cross-cutting the jurisdictions of multiple ministries. While the coordinating role of this Roundtable is apparently similar to that of the Deliberative Council of PCAST, what is distinctive about the Roundtable is that it is comprised of top-most officials of each ministry related to S&T and therefore has stronger implementation power.

In its effort to strengthen R&D innovation, the S&T Ministerial Roundtable presented a step-by-step blueprint for the future orientations of national R&D innovation through its National

R&D Innovation Plan announced in 2018.

[Figure 3-11] Step-by-Step Scheme of the National R&D Innovation Plan

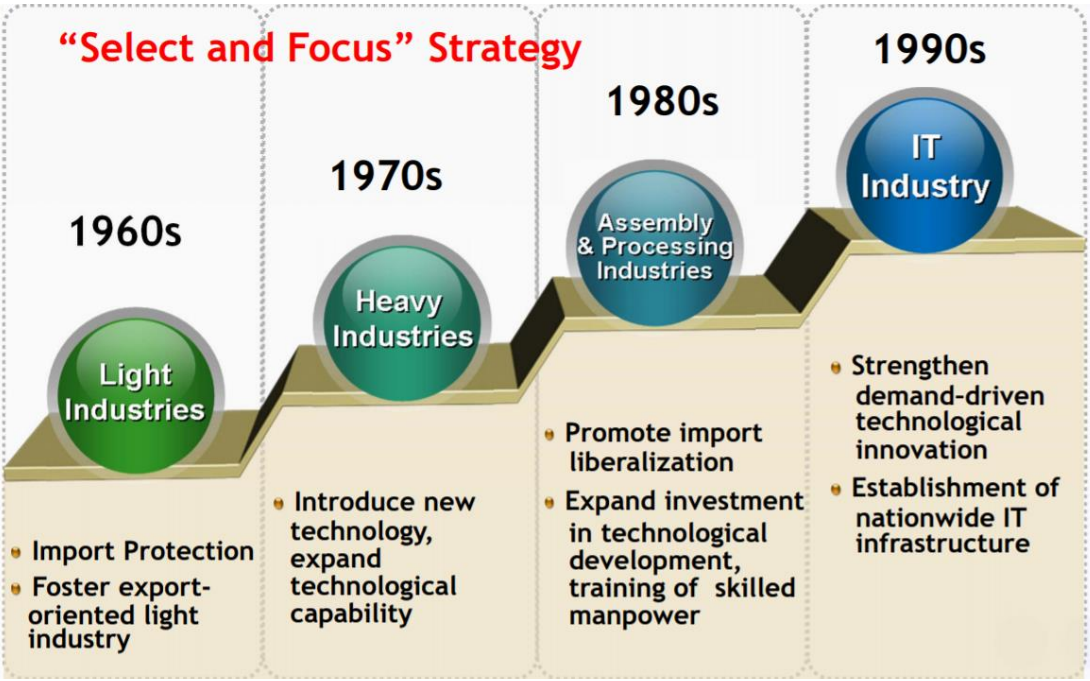


1.1.4 Challenges to the National STI System in Korea

Despite the extraordinary success of South Korea in its economic transformation backed by the development of indigenous STI capacity and sophisticated mechanisms of S&T coordination, several challenges remain for it to take off again to a more advanced system of STI.

One of such challenges is the effectiveness of the so-called "picking winners" strategy that has long characterized priority setting of the governmental R&D planning. This strategy has long been taken for granted, for South Korea faces lack of resources and therefore has to "select and focus" its limited resources on particular areas of priority. The question now arising among innovation scholars of the Korean S&T community is whether this strategy is still valid given that the private sector is becoming more vibrant and up-to-date with latest technological capacities. Since the existing coordination mechanisms of STI are mostly government-driven, it will be a big challenge for Korea to come up with an equally productive way to align and arrange innovation activities of the private sector with the supposedly national goals of innovation.

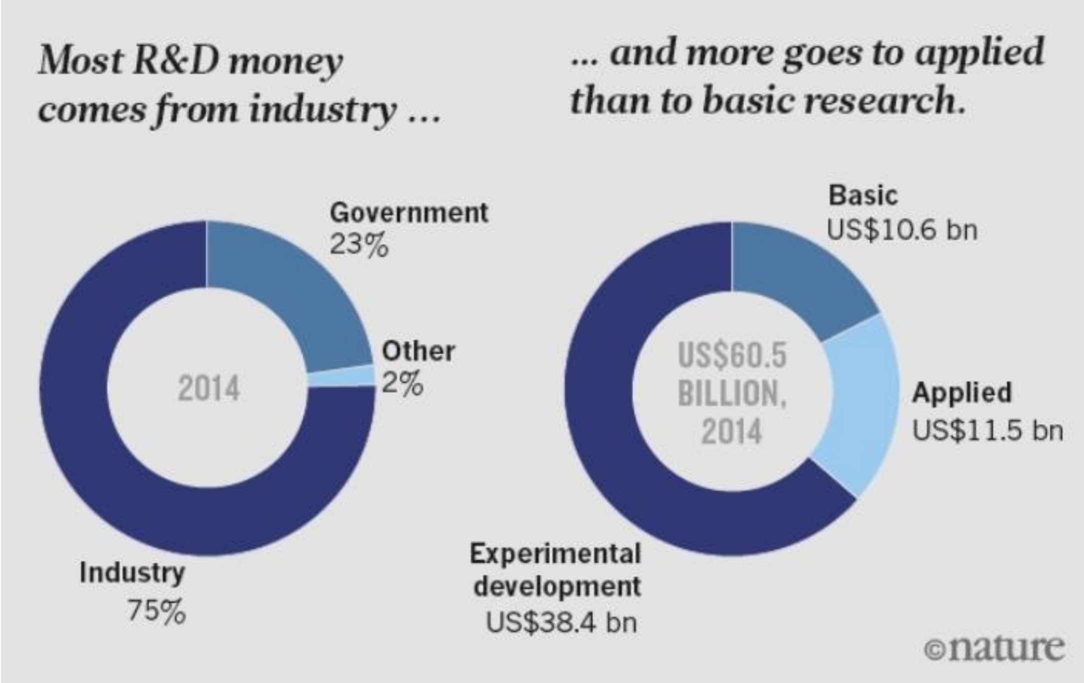
[Figure 3-12] "Select and Focus" Strategy of STI of Korea



Source : Jang (2018)

The next challenge is how to promote basic science capacity, given that much of the previous effort to support S&T is lop-sided to quick and easy development of applied technologies rather than building scientific bases of fundamental innovation. Indeed, one of the Nature commentaries published in 2016 pointed out the serious imbalance in Korea's R&D funding for basic vs. applied research. In a sense, the orientation of the existing STI system towards application should be historically understood, for South Korea facing the dilemma of "winning Nobel Prizes or winning markets" had to choose the latter (Kim & Leslie 1998). Yet with South Korea now taking the #1 position as the world's most innovative country, it is time to revisit this historical legacy of the national STI system.

[Figure 3-13] Application-oriented R&D Funding of Korea

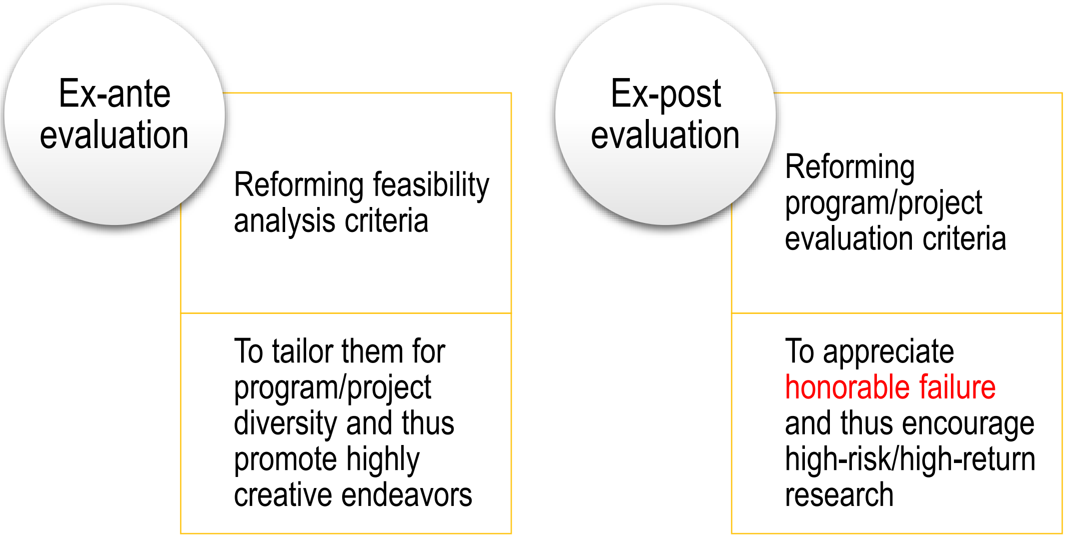


Source : Zastrow (2016)

Thirdly, while the coordination of STI seems to be working well with the S&T Ministerial Roundtable (at the ministerial level) and PCAST (at the top governmental level), the continuing fragmentation of funding agencies that distribute government R&D funding is a big problem that rank-and-file researchers are pointing out as one of the hurdles for quality-driven research. Almost every ministry doing R&D has its own funding agency, which has often led to redundant funding as well as inconsistent rules. Lately, the government has re-organized those ministerial funding agencies, which reduced the number of funding agencies from 19 to 12 and unified the R&D funding rules. Yet more effort is expected to come to increase the efficiency of R&D funding management of these agencies.

Finally, there have been calls to revisit the existing national R&D evaluation, for it is too much driven by quantitative performance so that innovations taking long time are hard to bear fruit under the current system of R&D. The government has recently introduced reforms in the way government-funded R&D programs or projects are selected (ex ante) and evaluated (ex post); for example, the so-called honorable failure policy was introduced in 2017 to exempt researchers pursuing highly challenging goals from future funding penalties if they fail to produce expected outcomes. However, it may take longer than expected for quality-driven evaluation to take root, for the quantity orientation of exams or tests is more or less culturally ingrained in Korean society. Then, the government would have to take more proactive measures to convert its existing system of STI review and R&D evaluation to a truly professional one that encourages high-risk and high-return research.

[Figure 3-14] Challenges to R&D Evalutaion in Korea

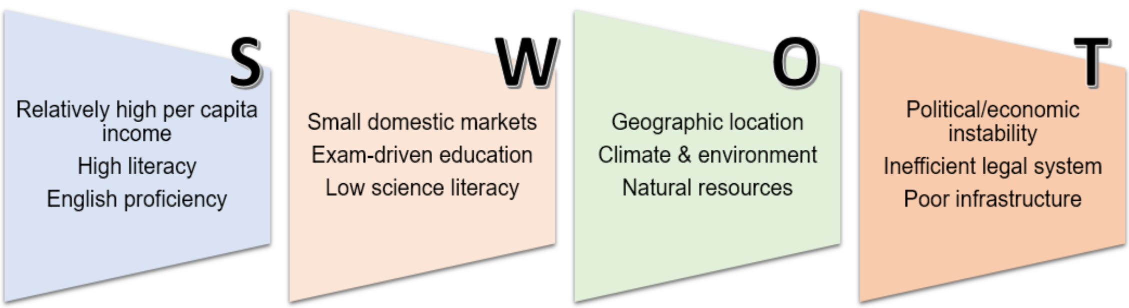


1.2 National STI System of Sri Lanka

1.2.1 Understanding the Socioeconomic Context

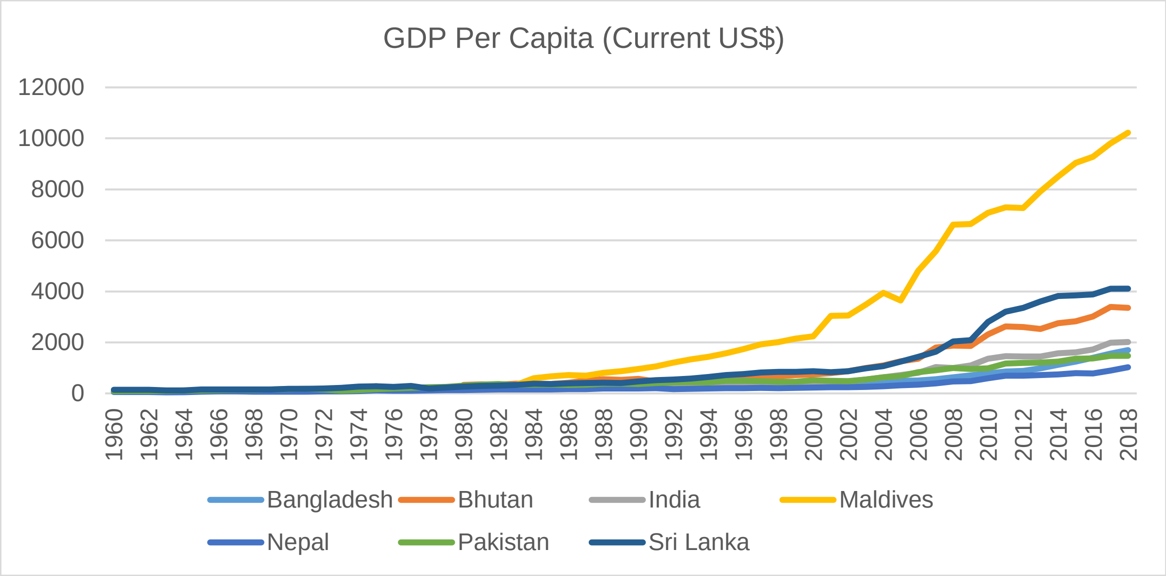
The national system of STI of any country needs a basic understanding of the socioeconomic context surrounding the actors and institutions that comprise its STI system. The following presents a SWOT analysis of Sri Lanka's socioeconomic conditions underpinning its STI system.

[Figure 3-15] Summary of SWOT Analysis of Sri Lankan Socioeconomic Conditions



First of all, Sri Lanka is a relatively wealthy country in the region where it is located. It is one of the two richest island countriesin South Asia. Although Maldives shows the highest level of per capita income in the region, it is a tiny countrydependent mostly on tourism. In contrast, Sri Lanka with the population of 2.2 million and significant natural resources aims to become a knowledge-based, export-oriented Indian Ocean hub.

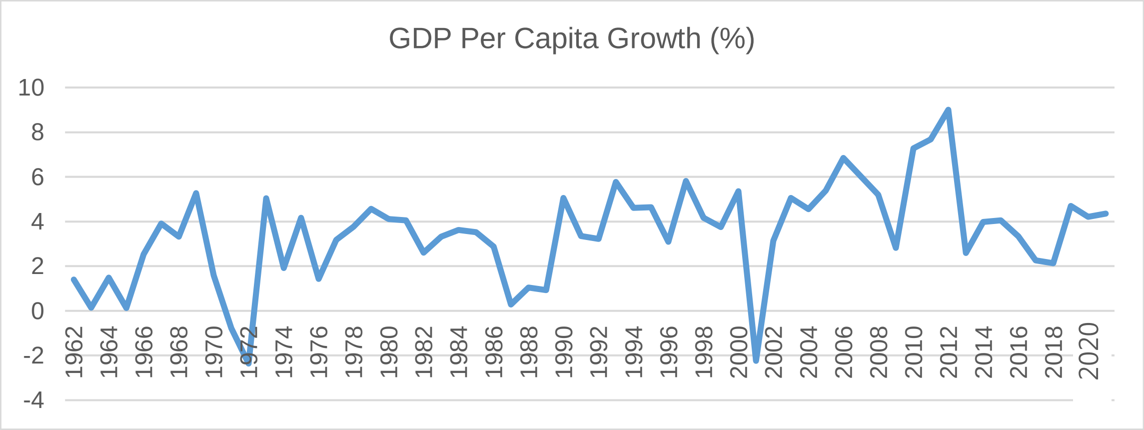
[Figure 3-16] GDP per Capita of South Asian Countries in 1960-2018



Source: World Bank World Development Indicators (2019)

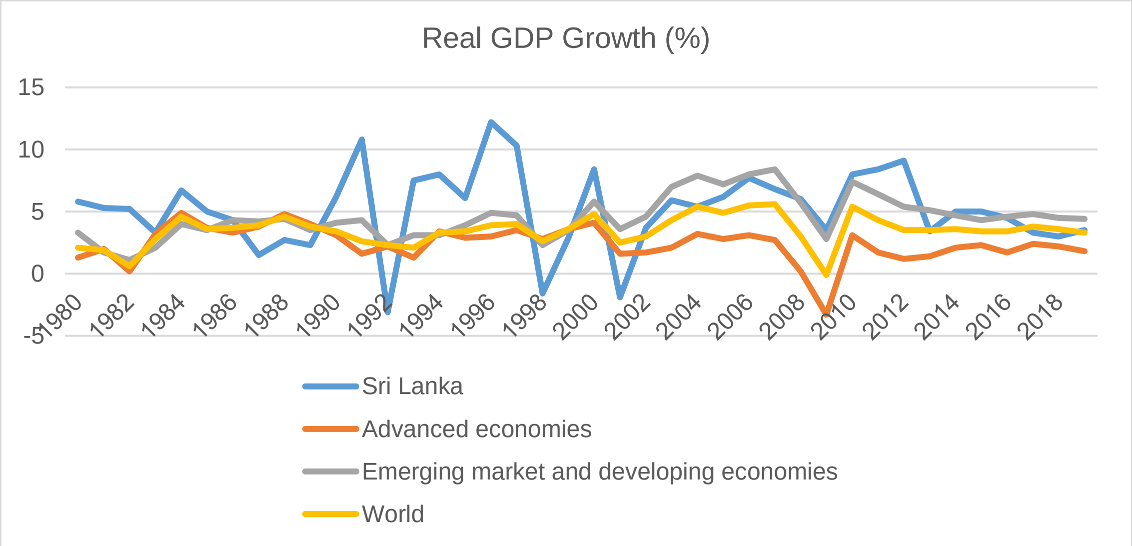
Sri Lanka experienced relatively high rates of per capita income growth in the early half of the 2010s (7~9% between 2010 and 2013) but recently the per capita income growth rate has slowed down to 2%. However, according to the IMF that agreed to extend its 2016 loan of $1.5 billion to Sri Lanka, real GDP growth of Sri Lanka is expected to improve about 3.5% this year.

[Figure 3-17] Sri Lanka's GDP per Capita Growth



Source: Worled Bank World Development Indicators (2019)

[Figure 3-18] Real GDP Growth of Sri Lanka and Other Economics



Source: IMF (2019)

Sri Lanka has a highly literate population with the 96.3% of adult literacy, which is far above the world average. Although English is spoken by 1.8% of the population, it is widely used for official and commercial purposes.

While relatively high income levels, high literacy rates, and English proficiency provide favorable conditions for investment in and performance of STI, Sri Lanka suffers from notable weaknesses. It has a relatively small domestic market so that manufacturing and services requiring economy of scale and aiming global competitive advantage cannot grow only targeting the domestic market, which is indeed the main reason for its goal to transform itself into export-oriented economy by 2025 as declared in its Vision 2025.

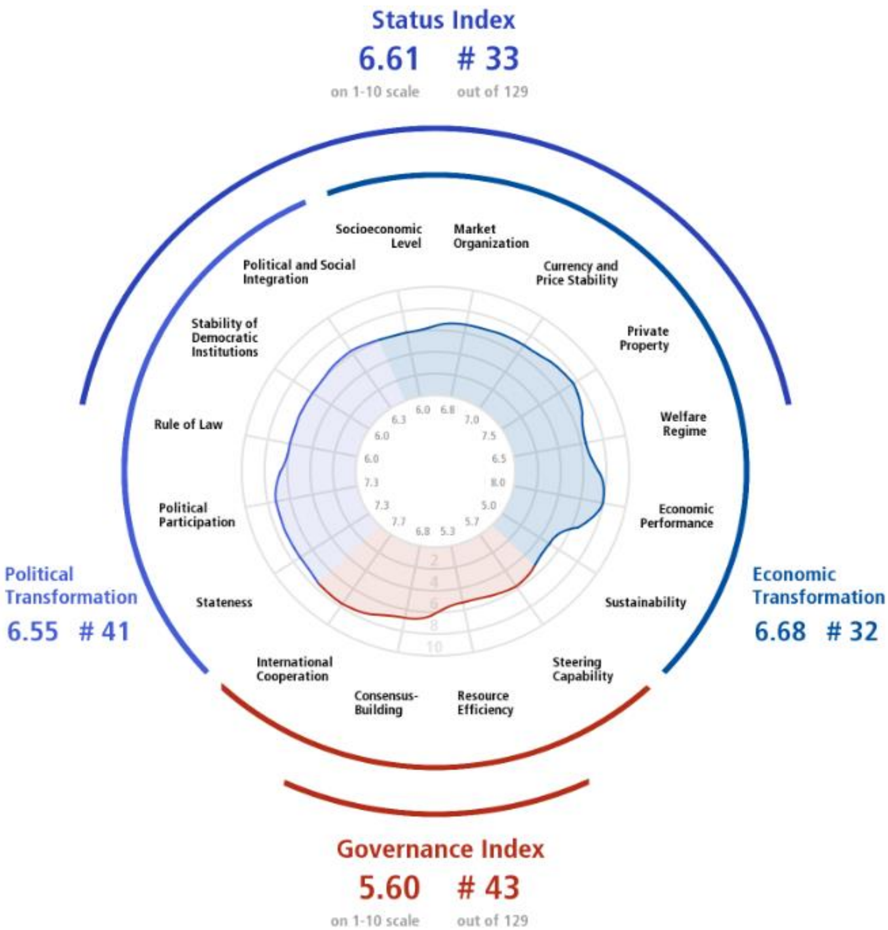
Despite the relatively high literacy rate, Sri Lanka's education system is largely driven by exams testing memories rather than programs promoting curiosity and creativity. Coupled with low science literacy rates, such exam-driven education exacerbates the recruitment of the best and brightest into science and engineering.

Yet there areopportunity factors characteristic of Sri Lanka's geographic and environmental conditions. Its geographic location together with deep harbors has made it a strategic place since the time of the ancient Silk Road. Sri Lanka is also abundant in natural resources such as limestone, graphite, mineral sands, etc.

As for threat factors, three problems stand out. First, although Sri Lanka's three-decade civil war ended in 2009, there still exist some pockets of instability. Second, its legal system is criticized for the lack of fairness and efficiency. Indeed, according to BTI Transformation Index by Bertelsmann Stiftung (a German non-profit foundation promoting entrepreneurship and future-oriented society), the political and legal dimensions (such as rule of law, stability of democratic transition, and political and social integration) turn out to be performing poorly compared to other sectors of Sri Lanka.

Lastly, deteriorating infrastructure poses serious challenges to Sri Lanka's development into a knowledge-based economy. In particular, although Sri Lanka has the highest road density in the region, its road and transport infrastructure, the very backbone of economic and social development, is poorly managed due to the lack of coordination and alignment among the relevant ministries and provincial councils.

[Figure 3-19] Sri Lanka's Rank on BTI Transformation Index



Source: Bertelsmann Stiftung (2018)

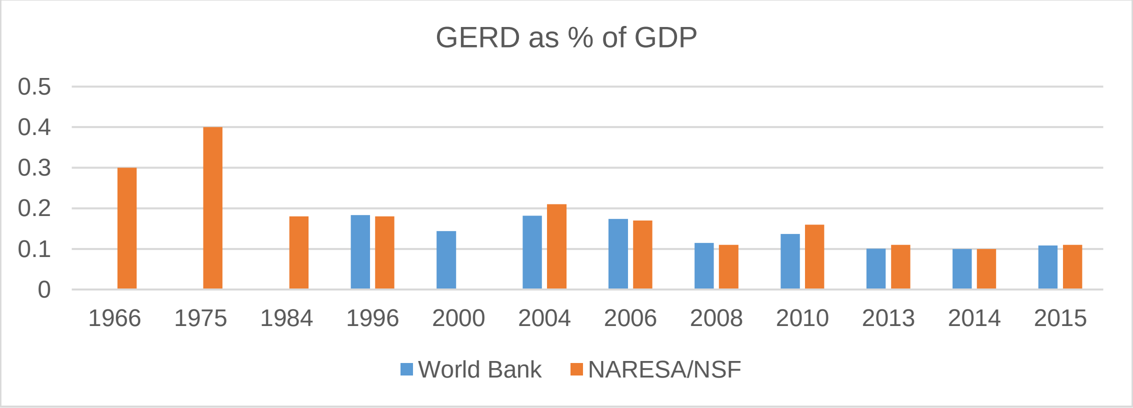
1.2.2 STI Performance of Sri Lanka

Poised to become an upper middle-income country with the strengths and opportunities described above yet facing a number of challenges to the upgrading of its socioeconomic systems due to structural weaknesses and threats, Sri Lanka is in great need to take full advantage of the potentials of science and technology. In particular, many of its Vision 2025 plans and initiatives (e.g., digitization, modernization of the plantation sector, new export-oriented trade policy) requiresubstantial indigenous STI capabilities. It is thus crucial to examine how Sri Lanka is performing in its STI sector in terms of input and output in order to gauge its current STI system and identify areas of major improvement.

a) S&T Input

Two of the most important inputs into S&T are funding and personnel.As for the funding, the data for gross R&D expenditure (GERD), the standard measure of national spending for S&T, is rather sparse and often inconsistent as the following figure shows. The World Bank's World Development Indicators list Sri Lanka's GERD data from 1996 but not all annual data are available. The National R&D Surveys of Sri Lanka, first undertaken in 1996 by NARESA and NSF since then, also contain limited data on GERD and show some discrepancy from the World Bank data. Yet what shows up in common is that GERD is quite small, remaining only at the rate of 0.1% of GDP. Even compared with other South and Southeastern Asian countries (India – 0.63%, Pakistan – 0.25% Thailand – 0.63%, for example), Sri Lanka's GERD is too small relative to its level of development. It should be noted that virtually all developed countries devote more than 1% of their GDP to R&D (US – 2.79%, UK – 1.70%, Germany – 2.88%, France – 2.23%) and especially those countries of historically successful economic transformation have spent more than 2% of their GDP for R&D (Japan – 3.28%, Republic of Korea – 4.23%, Singapore – 2.20%).

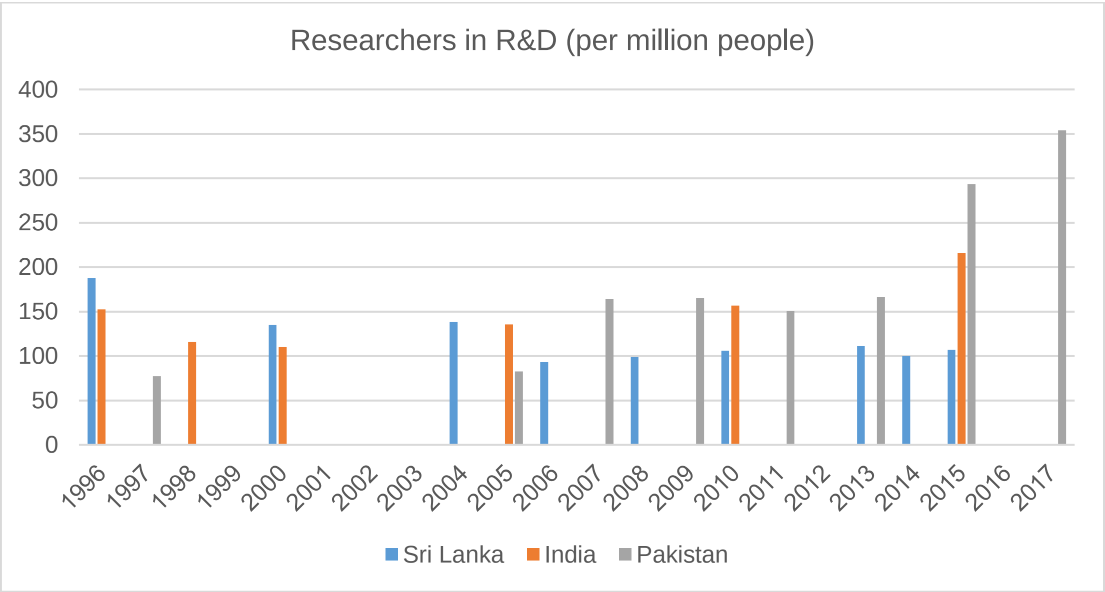
[Figure 3-20] Gross R&D Expenditure (GERD) as of % of GDP (World Bank vs. NARESA/NSF Estimates)



Source: World Bank (2019)

As for personnel, the number of researchers in R&D is lately showing stagnation in Sri Lanka, which is in notable contrast to two other Southern Asian countries that have seen a rise in the number of R&D researchers outpacing Sri Lanka in large margins. When compared to other Asian countries (China – 1,036, Japan – 5,231, Malaysia – 2,261, Republic of Korea – 7,097) as of 2015, the number of full-time equivalent (FTE) researchers per million people in Sri Lanka is only 106, which is extremely small.

[Figure 3-21] Researchers in R&D-Sri Lanka, India, and Pakistan

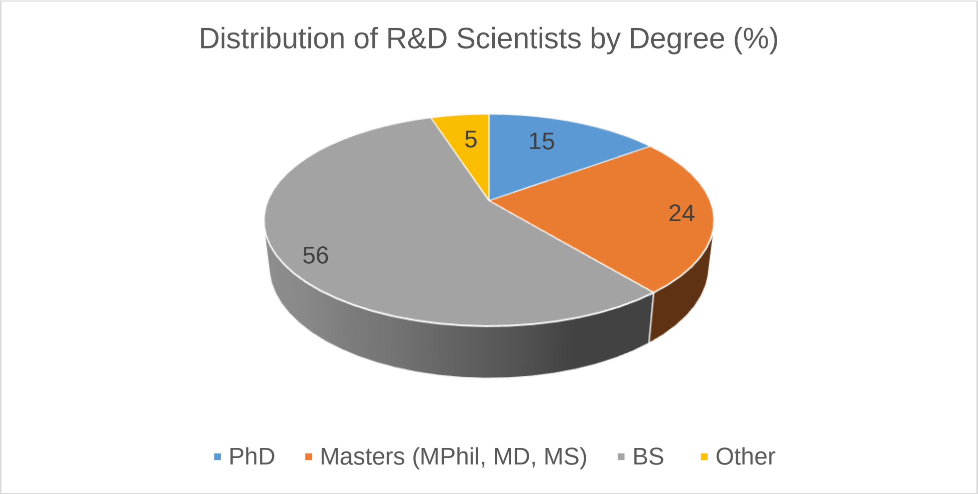


Source: World Bank (2019)

A close look at the composition of Sri Lankan scientists conducting R&D reveals that the bulk of R&D is performed by those with bachelor's or master's degrees. This poses a great challenge to the upgrading of Sri Lanka's STI system, for it is ultimately the researchers and scientists that would lead Sri Lanka's socioeconomic transformation by applying advanced knowledge and skills to various problems at hand that Sri Lankan society is facing.

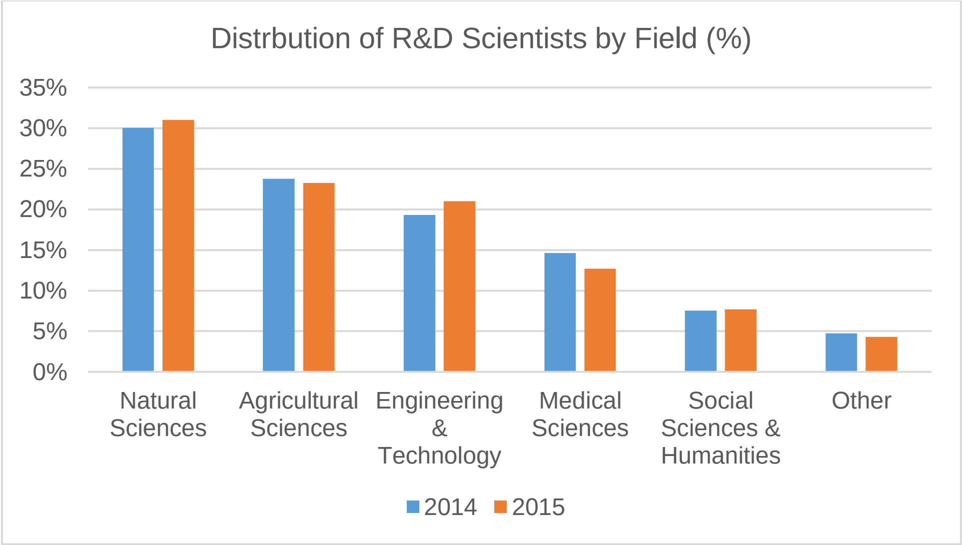
How these researchers and scientists are distributed across different fields is also an important indicator for strategic commitment of the national STI system. The data from the National R&D Surveys for two years of 2014 and 2015 show a slight increase (from 19% to 23%) in the share of R&D scientists of engineering or technology backgrounds, but natural scientists and agricultural scientists together take up a half of all R&D scientists. Given that many down-to-earth projects of various sectors require engineering problem-solving, there is a clearly urgent need for more engineers and experts of technological skills.

[Figure 3-22] R&D Scientists by Degree



Source: NSF (2015)

[Figure 3-23] R&D Scientists by Field

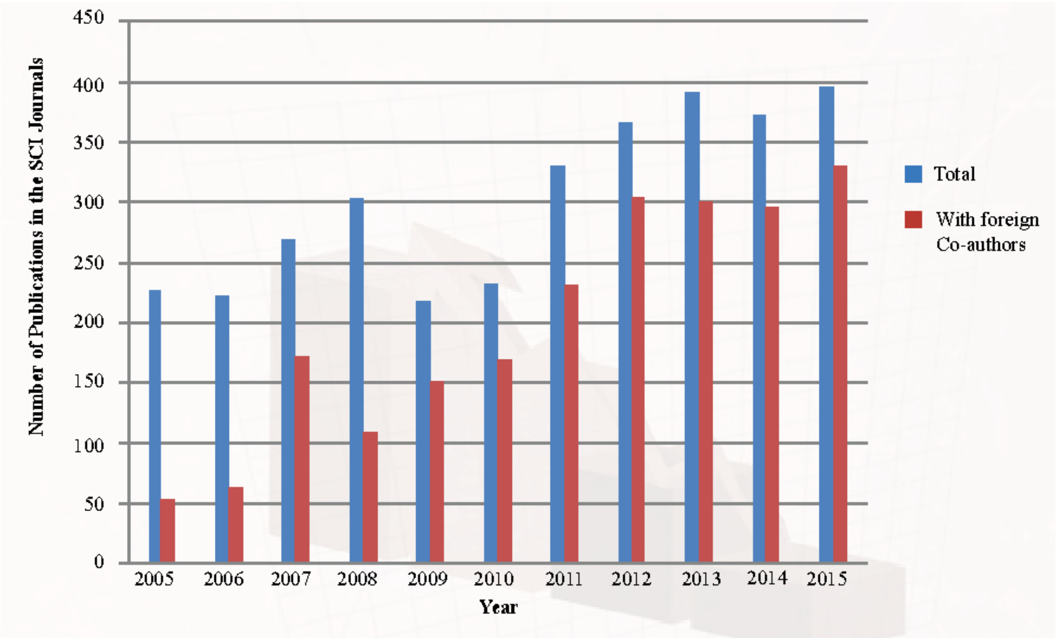


Source: NSF (2015)

b) S&T Output

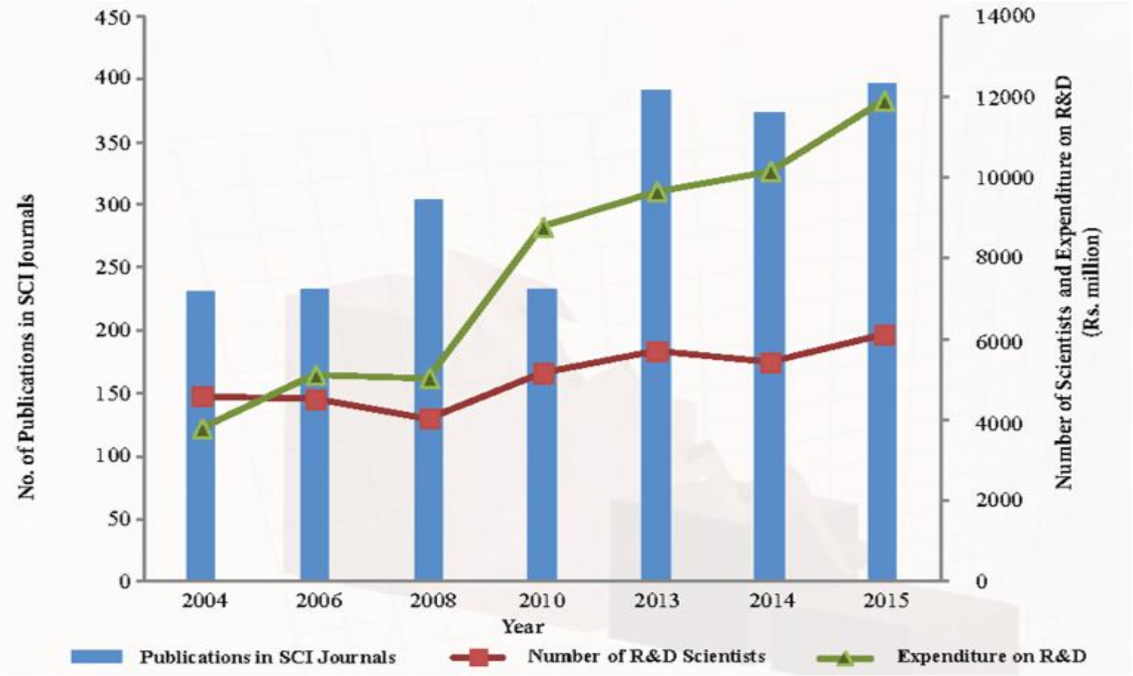
Turning to S&T output, two of the most common indicators are scientific papers and technological patents. SCI publications of Sri Lankan scientists shows generally an upward trend, though with a bit of slowdown in recent years. It is notable that this growth has been accompanied by the growth in publications co-authored with foreign scientists. When compared to the level of R&D expenditure and the number of scientists, the volume of SCI publications seems to be growing in tandem with the increase in funding and R&D personnel; yet the elasticity of the publication to R&D expenditure does not seem to be large, as seen in the period of 2013~15.

[Figure 3-24] Trends in SCI Journal Publications by Sri Lankan Scientists



Source: NSF (2015)

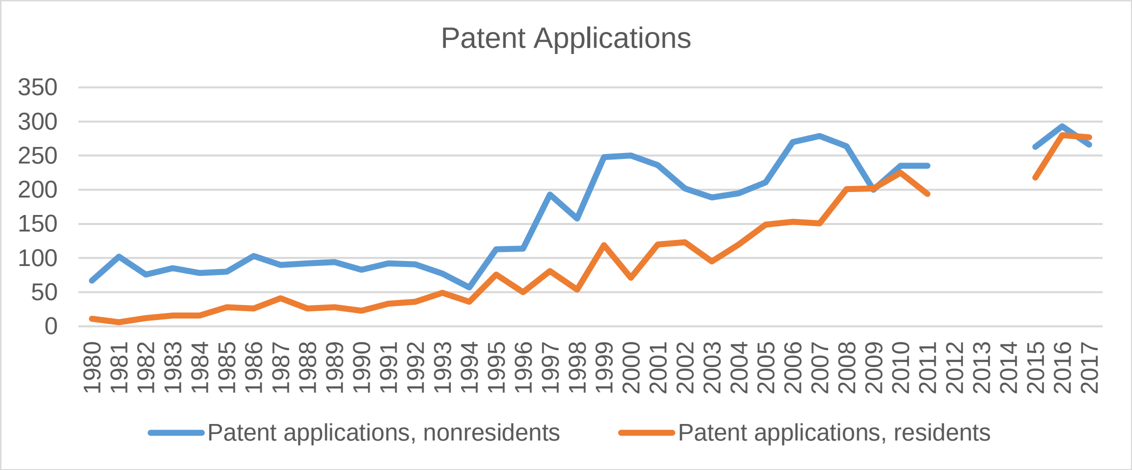
[Figure 3-25] Trends in SCI Journal Publications, R&D Expenditure and R&D Scientists



Source: NSF (2015)

As a form of intellectual property, a patent contains technical information of a given invention, and therefore the volume of patent activities is considered to be a critical indicator of technological progress. The World Bank data show a significant rise in patent applications by both non-residents and residents starting from the late 1990s. More recently, patent applications by residents have caught up with those by non-residents, implying more booming activities of indigenous technological inventions.

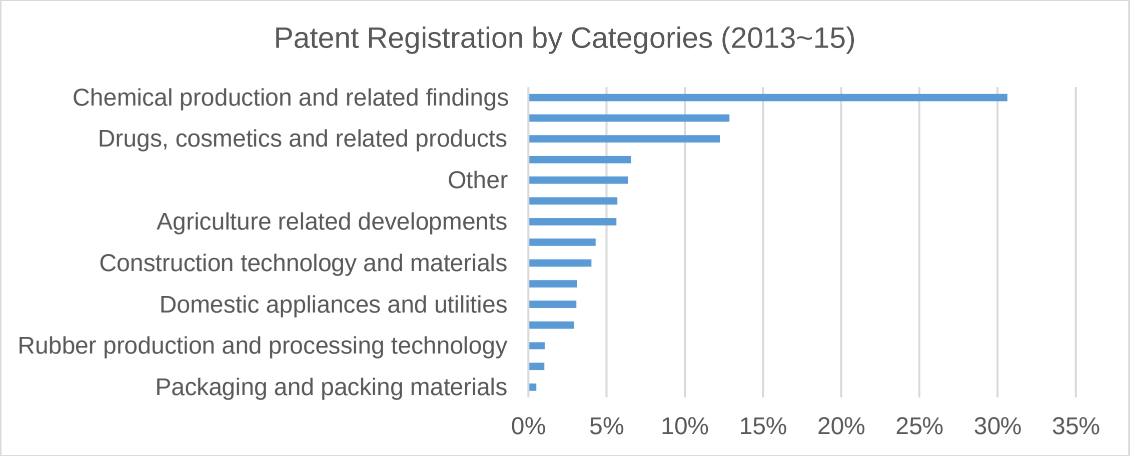
[Figure 3-26] Patent Applications in Sri Lanka \



Source : World Bank (2019)

Looking into the composition of patents registered during the years of 2013~2015, patents for chemical products turn out to take about 30.9% of the whole patent registration, followed by process technologies (12.9%) and drugs/cosmetics (12.1%). Patents related to ICT, agriculture, and energy saving also take about 5~6% of all patent registrations.

[Figure 3-27] Distribution of Patent Registered by Categories in Sri Lanka



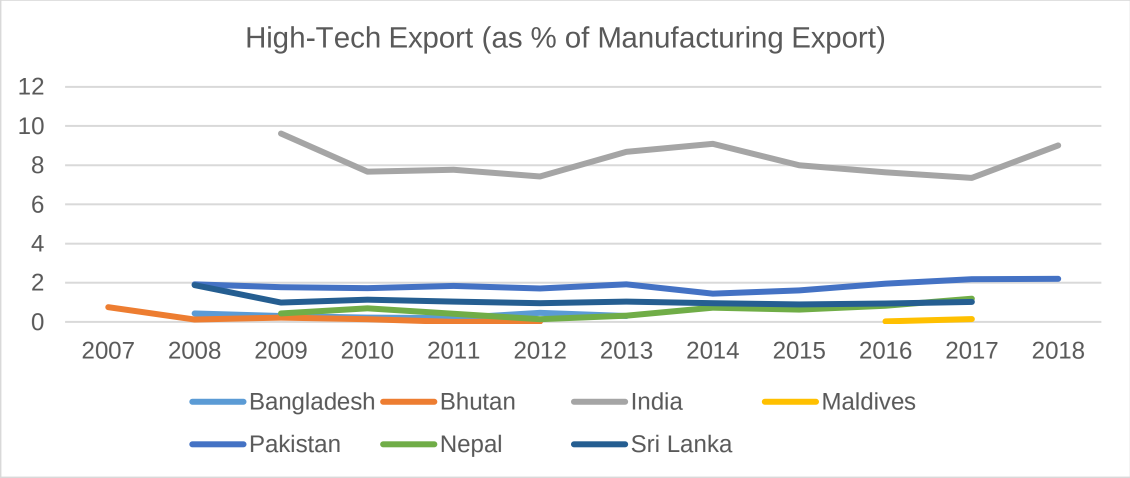
Source : NSF (2015)

If patents and papers represent the direct output of S&T activities, actual outcomes of S&T investment would come in the form of market products and services or social improvements.

One of the well-known indictors in this respect is the portion of high technology exports in manufacturing export. Indeed, much of S&T capacity is transformed into high-technology export in advanced countries, as seen in their large shares of high-technology export in manufacturing export (e.g., US – 22.9%, UK – 22.7%, France – 25.7%, Germany – 16.7%, Japan 18.4%, Korea – 31.1%, Singapore – 50.9%, on average between 2007 and 2017 according to the World Bank data).

It is thus important to check how Sri Lanka is performing in this regard. While Sri Lanka and Maldives have the highest per capita income in the region, India surpasses all the other South Asian countries in high-tech shares of manufacturing export, which ranges around 7~9%.Sri Lanka is also behind Pakistan, which exports around2% of manufacturing products as high technologyitems. Notably, India and Pakistan are the two countries in the region spending more of their GDP on R&D than Sri Lanka, which reaffirms a link between investment and outcome of national support for S&T.

[Figure 3-28] High-Technology Exports of South Asian Countries



Source : World Bank (2019)

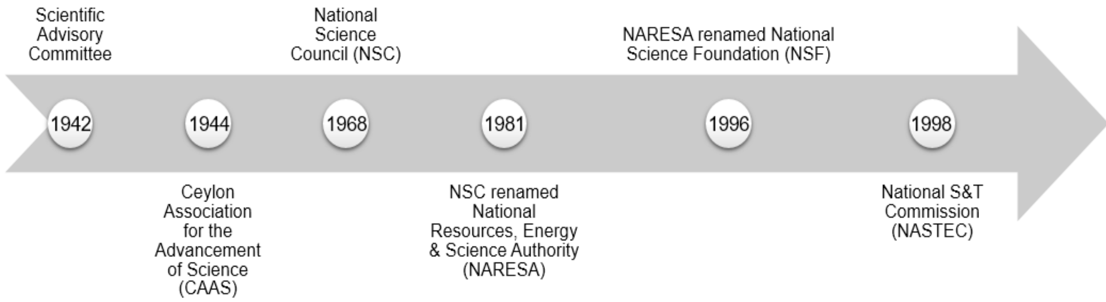
Another indicator implying S&T output is the performance of the country in product space. The more developed a country becomes, the greater portion of its exports would be occupied by high-tech products. In one of the rare analyses comparing product space changes over the three decades, the World Bank country report on Sri Lanka (2016) compares Sri Lanka and Thailand, finding very little change in major exports in the former despite the opportunities created by foreign direct investment and regional integration, which is in big contrast to Thailand that expanded significantly into electronics and machineries.

1.2.3 Key Actors of the National STI System

The national innovation system approach as previously reviewed gives due credit to complex and dynamic relationships of various innovation actors in the STI system. This section examines the key actors of the national STI system of Sri Lanka focusing on the government and public sector.

S&T related organizations of Sri Lanka date back to its colonial period. The Scientific Advisory Committee was formed in 1942 to advise the then Ministry of Industry and Commerce on the matters pertaining to industry and research. In recognition of the need for more systematic planning for S&T, Ceylon Association for the Advancement of Science (CAAS) was established with the responsibility to formulate and implement a national science policy. Succeeding this institution in the post-independence era was the National Science Council (NSC) created by the act of the Parliament in 1968, which was renamed as the National Resources, Energy and Science Authority (NARESA) in 1981. With the enactment of the Science and Technology Act of 1994, the latter was renamed as the National Science Foundation in 1996. The Act established another major institution of S&T, the National S&T Commission (NASTEC), which was officially launched in 1998.

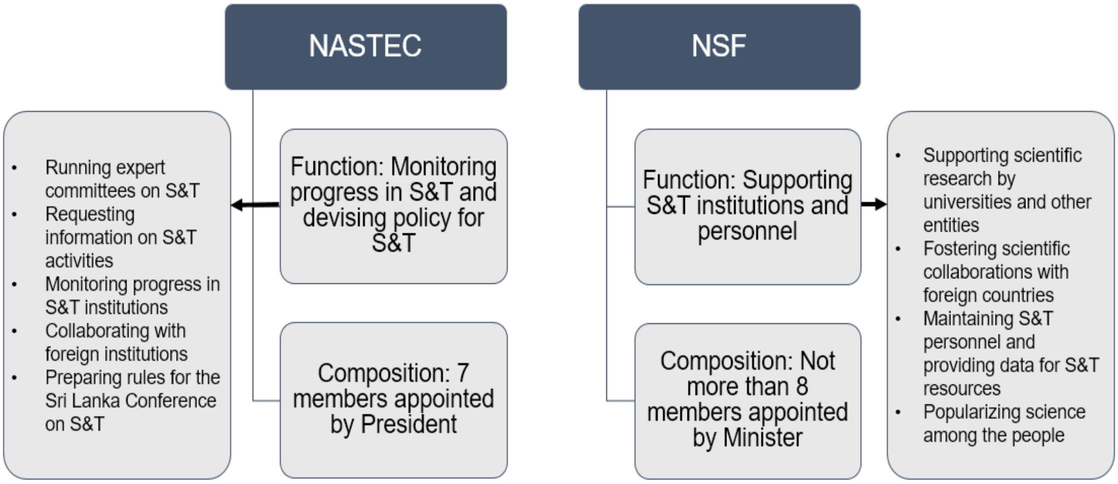
[Figure 3-29] Development of Major S&T Organizations in Sri Lanka Before 2000s



One of the unique features of Sri Lanka's STI system is that major S&T organizations were created from the S&TDevelopment Act of 1994, the framework act promoting and regulating its S&T system. In addition to NSF and NASTEC, three more organizations were built out of this Act – theCouncil for Information Technology of Sri Lanka (CINTEC), the Industrial, Technology Institute (ITI) and the Arthur C. Clarke Institute for Modern Technologies (ACCIMT). These organizations are of different nature from NSF and NASTEC, however, for they are research institutes conducting R&D themselves unlike NSF and NASTEC that are in charge of policy formulation and implementation in S&T and thus have no in-house research functions.

There are notable differences in the roles and expectations between NASTEC and NSF. NASTEC is an overarching institution concerned with general matters of S&T; as such, it is responsible to monitor the nation's progress in S&T and convene experts to assess the conditions of STI and recommend relevant policies. NSF is an institution specialized in the support of S&T by providing resources and opportunities for research and related networking such as research grants, exchange programs. Although NSF has its own role in S&T policy formulation of Sri Lanka by running the R&D survey and the Science, Technology Management Information System (STMIS), its main roles are essentially to facilitate S&T development through various means of funding and personnel support.

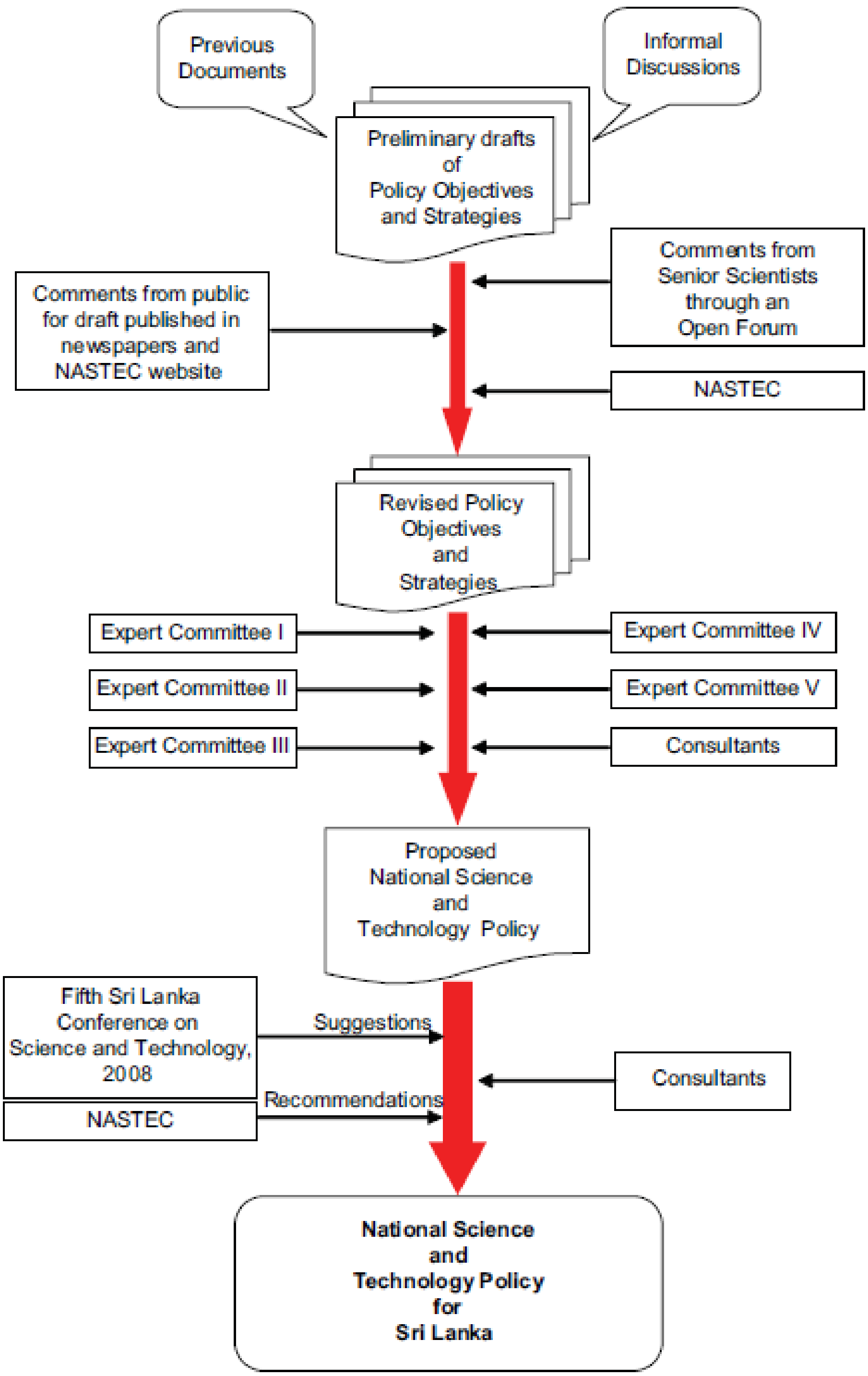
[Figure 3-30] Major Functions and Compositions of NASTEC and NSF



NASTEC mandated by the 1994 S&T Development Act to develop and implement national S&T policy in consultation with the S&T Ministry has been leading the nation's effort at STI policy formulation since its inception. NASTEC prepared the National S&T Policy (NSTP) comprised of ten elements and succeeded in obtaining its approval by the Parliament in 2009.

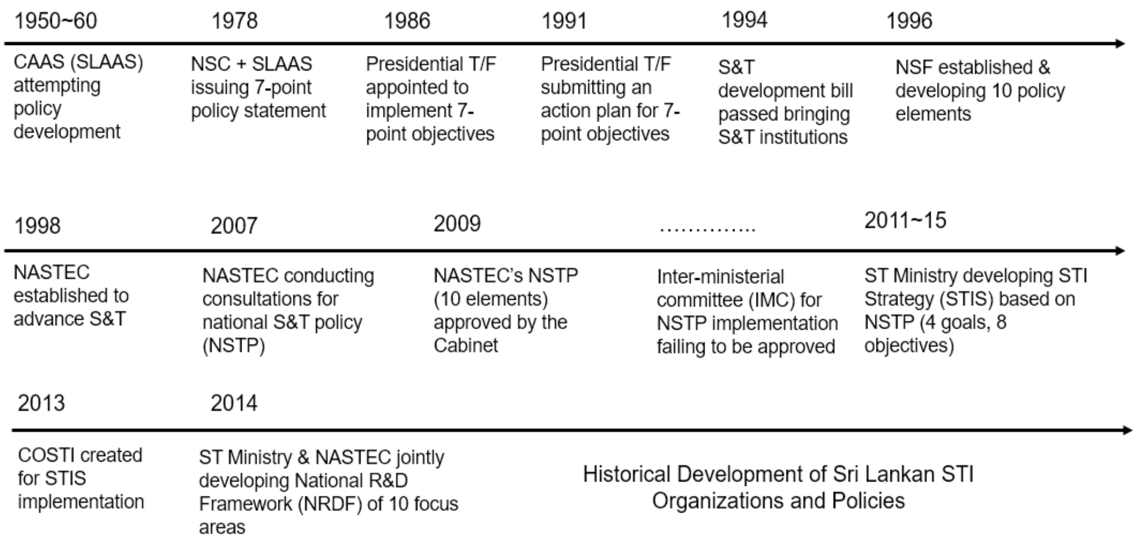
However, the next few years saw virtually no progress in its implementation due to the failure in inter-ministerial coordination to divide and define roles and responsibilities among relevant ministries. The S&T Ministry developed the Science, Technology, and Innovation Strategy (STIS) on its own from the NSTP, which contains four goals (STI innovation for economic development, creation of a world-class national research and innovation eco-system, transformation into a knowledge society, and promotion of sustainability) accompanied by eight objectives. A new organization, the Coordinating Secretariat for Science, Technology, and Innovation (COSTI), was created in 2013 to facilitate the coordination across the ministries for the implementation of STIS.

[Figure 3-31] NSTP Development Process



Source : NASTEC (2008)

[Figure 3-32]Historical Development of Sri Lanka's S&T Organizations and Policies



The latest development of national STI policy is the National R&D Framework (NRDF) developed by the Ministry of Science, Technology, and Research together with NASTECin 2014. NRDF addresses ten "Trust Technological Areas" for its strategic focus including water, health, energy, software & knowledge services, and basic sciences.

This overview of key public-sector actors of Sri Lanka's STI system reveals the historically complex relationships among S&T institutions in Sri Lanka with their genealogy contingent upon the evolution of STI at each time of major S&T policy announcements. When reviewed in relation with Sri Lanka's S&T performance of the previous sub-section, one might conjecture that much of the gap between what was planned in STI policy and what has been achieved in S&T has something to do with a rather inefficient and unclear coordination of innovation actors and poor incentives, despite the long history of Sri Lanka's effort to build S&T institutions. The next section then provides a comparative analysis of the two STI systems of Korea and Sri Lanka with the hope to derive insights and recommendations to upgrade Sri Lanka's STI system.

1.3 Comparisons and Insights

Before proceeding to the comparison, it must be noted that any comparison without taking a full account of structural and historical differences between the two countries would be only tentative and suggestive.The following presents the comparisons of the STI systems of the two countries focusing on three aspects.

1.3.1 Legal Framework

One of the first notable differences found in the legal framework of STI in the two countries is the sequence of S&T institutions and legalities defining them. In Korea, the S&T Basic Law, a framework actdelineating the government's responsibility for S&T, was enacted in 2001. There had been numerous acts legislatedon various activities of S&T before this Act such as Genetic Engineering Act (1993), Engineering & Energy Innovation Act (1995, now renamed as Industry Technology Promotion Act). Therefore, the framework act emerged after many years of legal effort to promote various areas of S&T in Korea, and its content mainly reflects the scope of S&T activities that the government has promoted since the time of heavy chemical industrialization and collective consensus evolved through the history of S&T promotion.

In contrast, Sri Lanka's framework act for S&T – the1994 S&T Development Act – introduced much earlier than in Korea, appears to have been imposed from the top rather than emerging out of long-held effort and experience of S&T promotion. The S&T Development Act begins with the descriptions of major S&T institutions, which is also different from Korea's S&T Basic Law devoted mostly to the stipulation of missions and tasks of the whole STI system of the country.

In order for the Act to be more than a legal document, there must be enforcement mechanisms in place so that relevant stakeholders of the STI system align their interests and behavior with desirable actions as envisioned in the Act.

1.3.2 R&D Challenges

Now spending the largest share of GDP to R&D, Korea is facing what is called the Korean R&D Paradox (denoting the gap between large R&D investment and low rates of R&D commercialization). Despite international ranking data, Korean citizens are now vocal about concrete benefits delivered to them through S&T investment. The Korean R&D Paradox is essentially the call to increase efficiency in R&D investment and upgrade its R&D structure (for example, through greater support for basic sciences and strategic recalibration of its long-held "select and focus" strategy).

For Sri Lanka, the problem is its extremely low level of investment in R&D as the cross-national data suggest clearly that it lags behind even countries of lower per capita income. Although the Sri Lankan government planned to increase R&D funding up to 1.5% of GDP by 2016, it did not materialize. Given such budget constraints, it will be all the more important to select target areas of S&T expenditure, which may mean revisiting its priorities of funding across different areas for strategic focusing. In particular, S&T-driven transformation into a knowledge economy needs much stronger focus on engineering and technology than has been given so far.

It is true that large R&D spending does not necessarily lead to large R&D output (as often lamented in the form of the Swedish Paradox or the Korean Paradox), yet too small investment is still a problem.

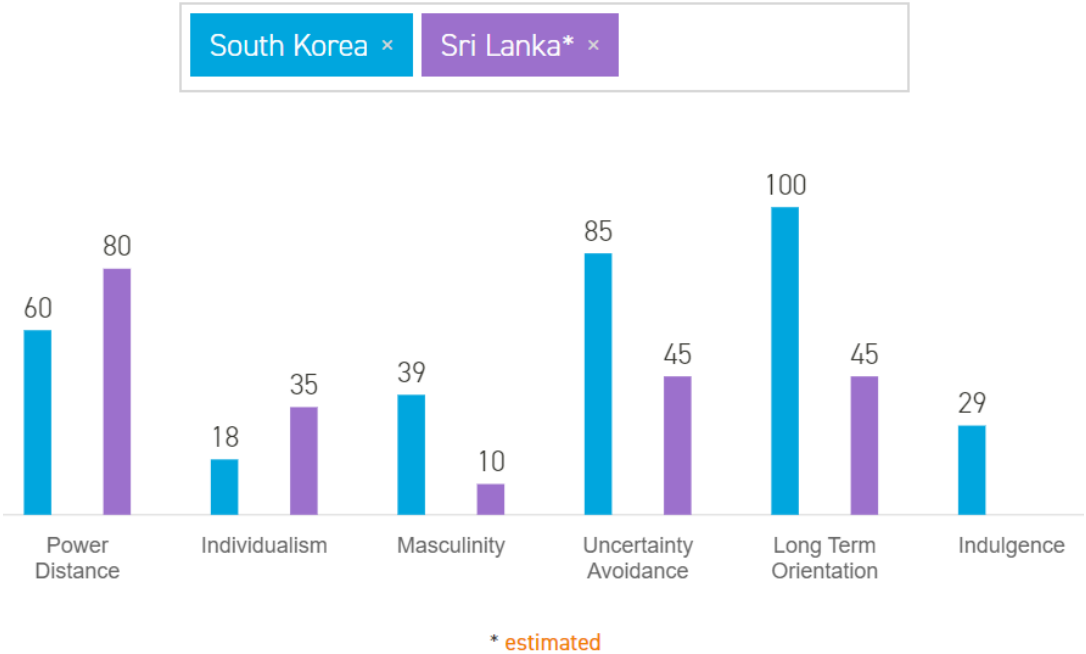
[Figure 3-33] Swedish and Korean Paradoxes of R&D Investment

Swedish Paradox	Korean Paradox
R&D expenditures high (with strong basic sciences) but insufficient economic results (esp., high-tech exports)	High levels of R&D investment not leading to actual commercialization of technologies spun off from universities/government research institutes

Why is R&D investment so low in Sri Lanka? There may be multiple factors – political, economic, social, or cultural reasons – to consider. Is it because its political leadership is less committed to S&T? Is it because of the government budget constraints, stagnant economy or due to even more fundamental structure of the economy? What about citizens? Are they less literate in science or less supportive of S&T? As for cultural factors, Hofstede's cross-cultural data show Sri Lanka to be low on long-term orientation but also low on uncertainty avoidance in comparison to Korea.

Hofstede Insights provides survey data results comparing national cultures and values based on six dimensions identified in Hofstede's cultural dimensions theory. Two of these dimensions – long-term orientation and uncertainty avoidance – are considered to have close relationships to cultural attitudes promoting innovation and entrepreneurship. On the scale of 0~100, Koreans turn out to hold strong long-term orientation on average, while Sri Lanka's long-term orientation score is only half of the Korean score. As S&T is comprised of inherently future-driven activities requiring long-term perspective, one may conjecture that this low score has something to do with Sri Lanka's low investment in R&D. Yet there is good news, for Sri Lanka turns out to be more adventurous in the sense of lower avoidance of uncertainty, which bodes well for future increase in R&D investment for high-risk high-return projects.

[Figure 3-34] Cultural Orientations – South Korea vs. Sri Lanka



Source : Hofstede Insights (2019)

1.3.3 Coordination Mechanism

One of the lamentable problems in the STI policy formulation of Sri Lanka is the failure to implement the National S&T Policy crafted through extensive consultations with experts and stakeholders. As is known, poor coordination among relevant ministries and agencies was part of the causes for this failure.

Korea had also experienced similar failures in the early years of STI development. It was largely because R&D by nature is spread across multiple ministries, although S&T is the main jurisdiction of the Ministry of Science and Technology. The latest integration of the Presidential Advisory Committee on Science and Technology (PACST) and the National S&T Council (NSTC) is the result of many years of trials and errors in establishing an effective mechanism of coordination in the nation's ever-growing community of S&T actors and activities. Though there still is room for improvement to set up clear demarcation of roles and responsibilities (R&R) of different S&T institutions, strong consensus has emerged among key ministries and public sector stakeholders for the honoring of R&D and accountability based on R&D of S&T institutions, which is the very foundation of successful multi-agent, inter-ministerial coordination.

On the other hand, there exists some ambiguity in the major S&T institutions about their R&Rs in Sri Lanka, despite the mandates set up in the 1994 Act. In particular, the roles of advising for higher-level decision making on S&T vs. deliberation on S&T issues seem to remain unclear in existing organizations. Also, the tasks of nationwide funding allocation vs. specific funding distribution appear to be overlapping in NRC and NSF. All this indicates an imperative to demarcate proper roles and responsibilities of major S&T organizations with equally clear mechanisms of enforcement of their mandates.

Again, these comparisons must be taken with usual caveats for political, economic, social and cultural conditions resulting in current STI performance of the two countries. More in-depth analyses of the national STI system of the two countries incorporating historical and contemporary factors would generate richer insights for mutually beneficial lessons to upgrade their national STI systems.

1.4 Recommendations

This final section closes the chapter with a few recommendations for Sri Lanka's STI system. The first and foremost recommendation is to make full use of "science for science policy (SOSP)." It is crucial to utilize science to analyze and improve S&T policy. As for R&D investment, what is important is not to just increase GERD. While Vision 2025 set the goal to increase GERD to 1.5% of GDP by 2016, it not only failed to achieve the change but the goal itself remains wishful thinking.

What is important is in fact to find out an optimal level of GERD in consideration of Sri Lanka's socioeconomic conditions. This requires a rigorous analysis of the budget situation to derive a realistic estimate of what can be achieved in the medium term. In this regard, NASTEC can commission social scientists to undertake scientific assessments of the announced goals in S&T policy. Once such assessments are made, the government must back up them with concreate steps with a three-year or five-year medium-term plan setting yearly targets to achieve long-term goals.

SOSP is also needed for the effort at the optimal distribution of S&T workforce. Obviously, the creation of "technology-based society" and the achievement of desirable goals such as UN SDGs require extensive technological capabilities, more effort must be made to find out the right size of the workforce of engineering and technology. Yet, just increasing the engineering workforce without the rigorous analysis of workforce demand may backfire from the oversupply of low-quality engineers. One might ask, for example, if the increase of "software engineers and programrs to 300,000 by 2025" in the new president's election platform feasible (Rajapaksa 2019). If so, what would it take?

Another recommendation is to negotiate and adapt among key STI stakeholders for better coordination of STI policies and organizations. For such negotiations, it must be understood among the interested parties that roles and responsibilities (R&Rs) of governmental STI organizations are not fixed forever; rather R&Rs evolve and get redefined along with changing policy environments. One of the ways to promote coordination among different entities engaged in STI policy is to test out pilot projects for mutual learning in order to collaborate with other innovation actors and manage potential conflicts on the road to achieving a common goal. Some of the examples for piloting include: (i) designing a cross-ministry or a cross-agency project on a cross-cutting issue (e.g., smart agriculture), (ii) building a technology roadmap for a particular technology domain, which inherently involves multiple stakeholders, and (iii) conducting technology assessment/foresight for emerging technologies.

Finally, for the enforcement problem, serious effort must put in to create right incentives. Policies and plans don't last without a proper incentive structure. Incentives are critical, as they signal rewards for taking right courses of action. Yet they are not necessarily material or pecuniary (e.g. cash bonus vs. tenure promotion for top journal publication). In this regard, evaluation for performance is equally critical, as policy improvement is only possible with timely and accurate feedback. Effective evaluation requires that sufficient training of advanced methods and tools for policy evaluation be provided for STI professionals.

2. National STI Governance and Policy

Dr. Kwan Young Kim (GTC, KIST)

The STI governance and policy of a nation is a critical factor in determininghow the country pursues its development across a multitude of aspects such as socialdomains, the economy, and sustainability. Given the significance of governance and policymaking withinacountry, especially for countries that are categorized as developing nations as in the case of Sri Lanka, it is vital to study how governance and policiesare planned and executed by developed nations such as Korea. Therefore, this report describes a comparative study that was conducted to identify certain factors that hinderthe STI governance and policy implementation of Sri Lanka and proposes recommendationsdrawn from effective practices that were observed in Korea.

2.1 National STI Governance Structure of Korea

To understand what are considered as ideal examples of STI governance and policy for a developing country, this section will discuss the STI governance and policy of Korea. Having set Korea as an ideal example for STI governance and policy in this comparative study, this subsection will analyse each process from planning to monitoring, evaluation, and innovation of R&D commercialization.

Overall, the STI governance planning of Korea is divided into three phases,witheach phase havingdistinct reasons and challenges. Yun-seok & Jae-sung (2009) divided the phases as the phase of imitation (duplicative imitation), the phase of internalisation and innovation (creative imitation), and the phase of mature innovation.

[Figure 3-33] Economic Development Goal and STI Focus

Economic development goal	**STI policy focus**	**Main source of technology and mode of technology acquisition**		
		Foreign Mature technology	**Foreign precommercial technology**	**Domestic R&D**
Realization of an innovation-based economy 2000s-	Nurturing creativity			Creative R&D Creative HRD Innovation
Structural transformation: Hi-tech based industries 1980s/90s-2000s	Promotion of RG&E for technological catching-up		Creation of new value-added by FT + indigenous R&D: Creative imitation	
Industrialisation: LM-tech based industries 1960s-80s/90s	Promotion of technology learning	Learning by doing: Duplicative imitation; simple RD&E		
		Transition completed	Transition underway	

Source : KSP(2017)

2.1.1 Planning of STI in Korea

a) Phase of imitation (duplicative imitation).

Imitation, also known as the outward-looking technology strategy, was the first phase that was introduced in the STI planning of Korea. In this initial phase, which took place during the 1960s to 1970s, Korea's STI policy was in the mode of supporting foreign technology acquisition to facilitate industrialisation (Kim, 2019). The technology absorption process was supported by the establishment of the Korea Institute of Science and Technology (KIST) followed by the formation of the Ministry of Science and ICT (MSIT), which enabled technology learning and adaptation (OECD, 2014).

b) Phase of internalisation and innovation (creative imitation).

About adecade after the first phase, Korea was confident enough to undergo a major structural transformation by moving on to the second phase: internalisation and innovation. In this phase, which took place in the 1980s and 1990s, Korea began to establish new international laws in trade and technology while also incentivising local private companies to promote Korean R&D and innovation (KSP, 2017).

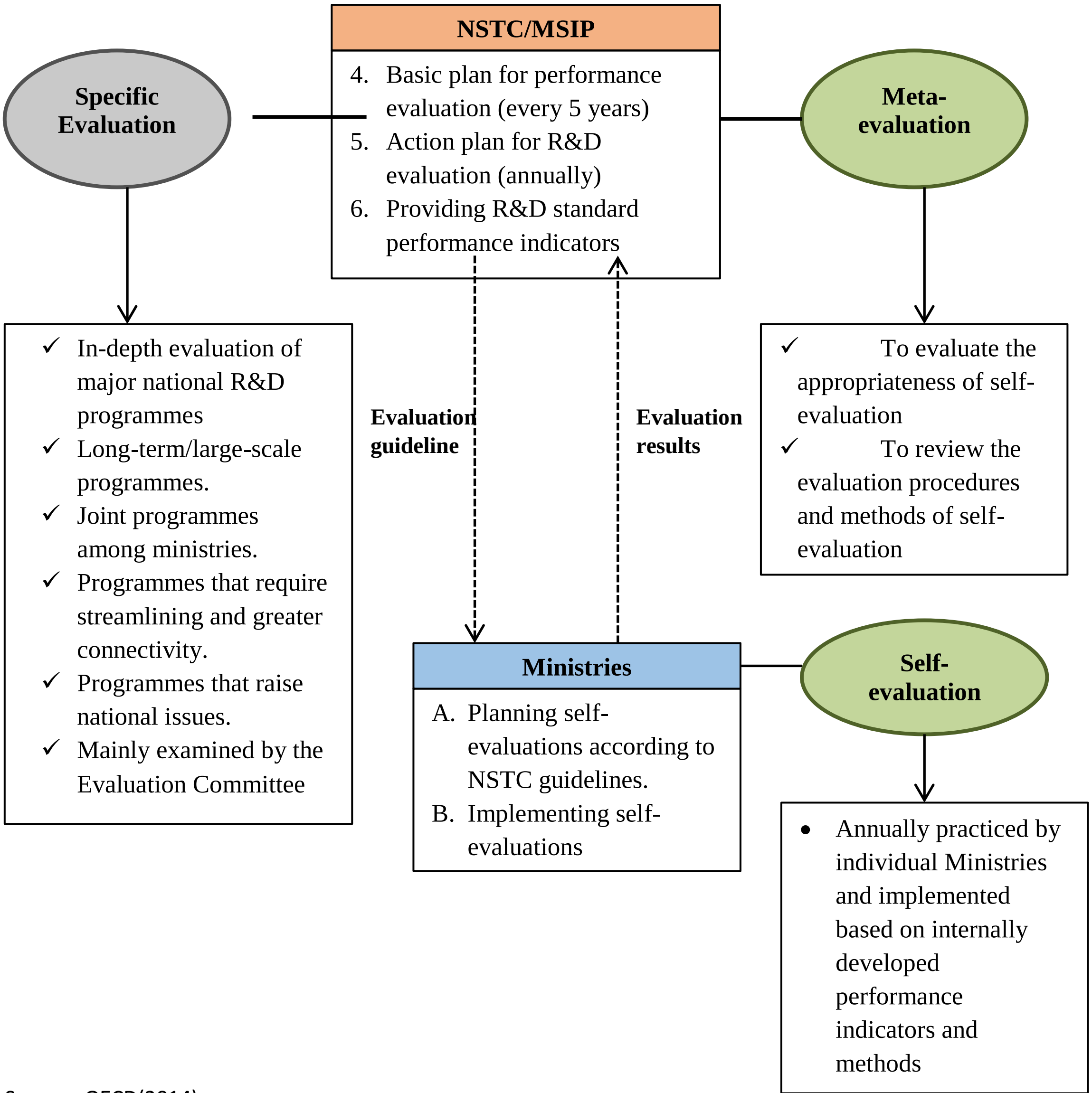
c) Phase of mature innovation (creative R&D innovation).

The most recent phase of mature innovation, which began in the early 2000s, was considered to be unique compared to the previous twophases. In this phase, STI policies were reorganized to strengthen domestic R&D and innovation. To execute this form of planning, government and industry-university research centers have worked together to advance Korea's competitiveness in terms ofinnovation capabilities and innovation systems (UN ESCAP, 2018).

2.1.2 Monitoring & Evaluation.

To ensure that the plansare being adhered to, the government of Korea assigned institutions to monitor and evaluatethe national innovation agenda. In general, the monitoring and evaluation tasks were divided into two approaches: (1) self-evaluations conducted by each ministry that operates and manages R&D, which are followed by meta-evaluations by MSIT, and (2) specific in-depth assessments by MSIT (KSP, 2017). Even though MSIT has the responsibility of specifically evaluating programs, not all programs require MSIT specific in-depth evaluation. Focused evaluations by MSITare only conducted when a program requires a large budget, spans across an extensive period of time, involvesinter-ministerial or inter-program coordination, or requires particular attention in relation to certain major socio-economic issues (OECD, 2014).

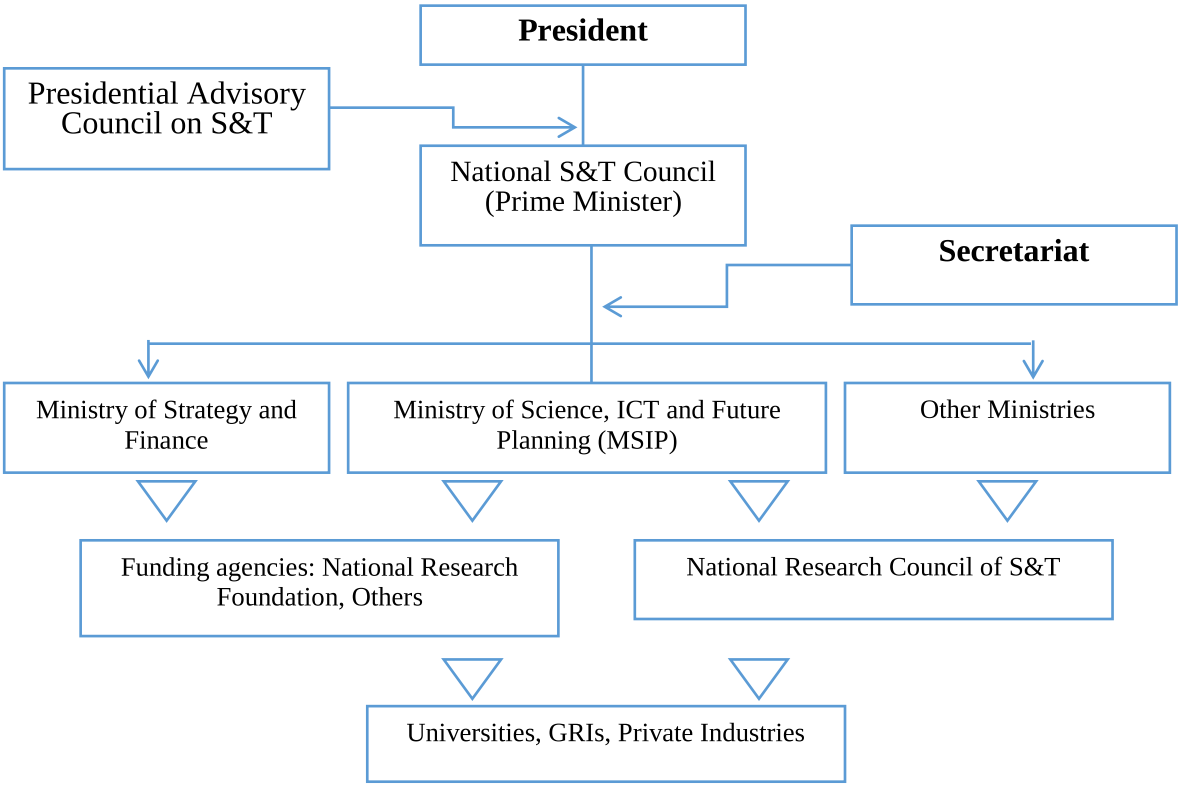
[Figure 3-34] Korea R&D Program Evaluation System



Source : OECD(2014)

Whereas Figure 3-34 describes how MSITconducts evaluations, Figure 3-35 illustrates the organizational structure of the Korean government. From Figure 3-35, it can be seen that MSIP operates directly under the Prime Minister. This structure shows that the current Korean STI policy is dominated by a top-down R&D approach (KSP, 2017).

[Figure 3-35] Organizational Structure of STI Policy



Source : KSP (2017)

2.2 National STI Policy of Korea

2.2.1 KoreanSTI policy (Five-year basic plan, action plan, program)

a) Five-year Economic Development Plan (1971 - 1996).

To understand how Korea achievedits success in STI, it is necessary to understand the chronological order of its STI governance and policy. With a desolate economy based on agriculture prior to 1960, South Korea faced the same challenges of present day developing countries until the introduction of outward orientation between 1961 to 1979 (Kim, 1991). As forementioned in the previous section, Korea learned and imitated foreign advanced technology (Lee & Kim, 2009). To support this manoeuvre, Korea developed several five-year economic development plans that spanned from 1962 to 1996 (OECD, 2014).

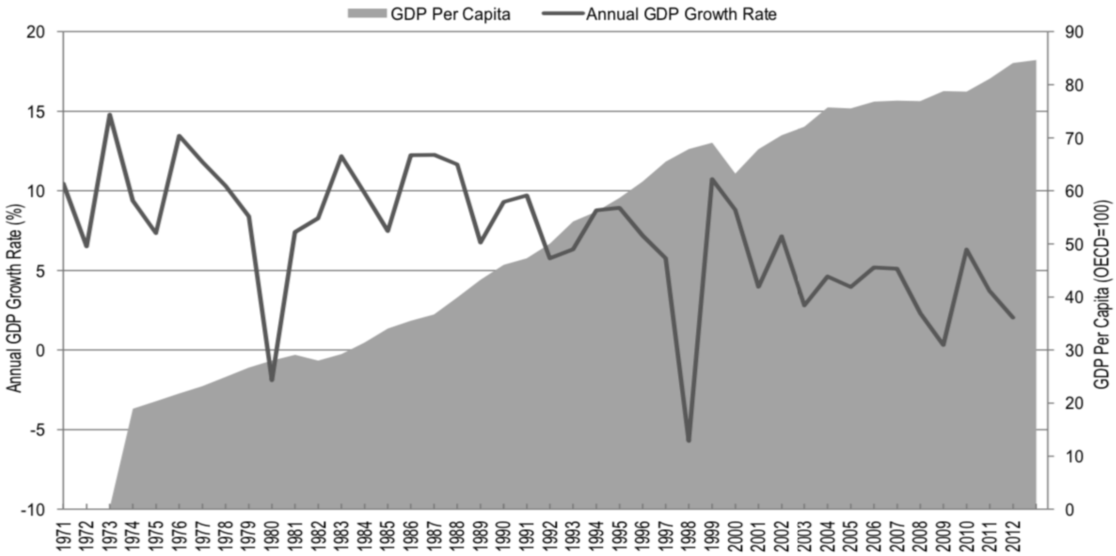
[Figure 3-36] Korea's five-year economic development plans, 1962 - 1996

Five-year economic development plan	Principal objectives
1st (1962-66)	Building domestic light industries: textiles, etc.
	Infrastructure development: power plants
2nd (1967-72)	Building key domestic heavy and chemical industries (HCI): steel, machinery, chemicals, shipbuilding, etc.
	Infrastructure development: Gyeongbu expressway (Seoul-Busan)
3rd (1972-76)	Industrial restructuring:
	Building heavy and chemical industries (industrial complexes)
4th (1977-81)	Industrial restructuring:
	Strengthening heavy and chemical industries (building the foundations for technological capabilities)
5th (1982-86)	Economic stabilisation:
	Industrial competitiveness by opening and rationalising the economy
6th (1987-91)	Regulatory reforms
	Supporting high-tech industries
	Building high-tech and innovative capabilities
7th (1992-96)	Revitalising the economy
	Establishing a basis for balanced development of industrial sectors and companies

Source : OECD (2014)

After the introduction of an outward-looking technology strategy and the specific five-year development plans, the national economy sky-rocketed. Korea was able to produce results through the effectiveness of consistent STI policy and Korea's strategic mode of dispensing resources based on worthiness and economic returns (KSP, 2017). National planning supported by the five-year economic development plans proved to be effective, as shown by the continuous positive GDP growth since its introduction in 1962 until the government ceased the plans in 1996 to develop a new Vision 2025 in 1999 (OECD, 2014). Based on an OECD report in 2014, Vision 2025 has brought about a fundamental shift as Korea changed its strategy from short-term development to a long-term market-based innovation strategy.

[Figure 3-37] Korea's GDP per capita and annual GDP growth rate, 1971 - 2012



Source : OECD (2014)

b) Korea STI Policy Action Plan

As we can see from the development of STI policy since the phase of imitation to the current mature innovation, Korea required a solid action plan to facilitate continuous progress. This section will take a closer look at how Korea successfully shifted from one phase to another through changes in STI policy.

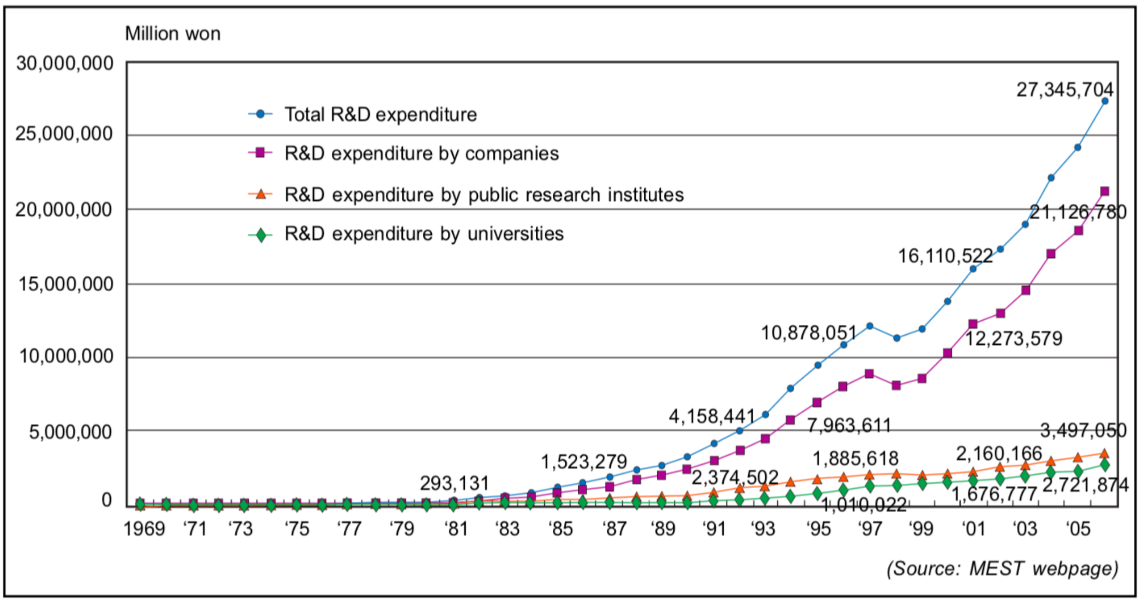
- **From the imitation phase to the internalisation phase**

Korea established the right action plan to support technology learning and acquisition from the early phase to the second phase. Not only did Korea take the opportunity and promote Original Equipment Manufacturing (OEM), which later became Original Design Manufacturing (ODM), but Korea also performed manageable imitative reverse engineering for basic products such as the vacuum tube and AM radios (Kim, 2019). The experience of diving into the manufacturing industry gave Korea theadvantage of being able to learn and absorb technology, which in turn madereverse engineering possible. During this transition, Korea was showing signs of a phase-shift from imitation to internalisation.

■ From the internalisation phase to mature innovation

The last phase-shift process from internalisation to mature innovation is amajor breakthrough. This is due to the fact that a multitude of players were required atthe national scale to successfully achieve Korea's STI mission of becoming a mature innovator. To enable this transition, the STI policy was designed to restrict the Forgin Direct Investment (FDI) and foreign licensing, forcing Korea, particularly its private companies, to explore, locate and choose a non-FDI channel as part of their technology acquisition strategy in identifying the best path to grow their business (KSP, 2017). The data from (Lee, 2010) below shows that companies in Korea had the highest spending in R&D even compared toother research institutionssuch as public research centers and universities. The STI policy based on the non-FDI approach seemed to be highly effective in boosting R&D activities in the country.

[Figure 3-38] Trend of R&D expenditure by R&D performers



Source : Lee (2010)

■ Behind Korea's STI Successful Program

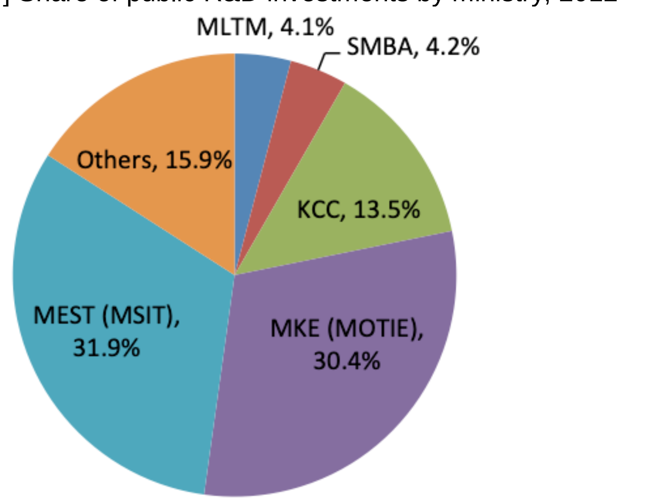
To understand how Korea was able to make outstanding progress inits national STI strategy, this section point outs several distinct factors behind the success.

Effective national-level coordination

Many may be aware of Korea' stability to conduct effective coordination atthe national level. This was the catalyst behind Korea'ssuccessful STI policy implementation. UN ESCAP (2018) states that Korea has developed multiple sector-specific policies through the (inter-ministerial) coordination of high-level presidential committees. Therefore, this section will expand upon this aspect to understand the level of coordination that was implemented.

Technology and innovation policy in Korea is shaped by several ministries that are involved in different rolessuch as formulation, implementation, and evaluation. OECD (2014) explains that the Korean Institute of Science and Technology Evaluation and Planning (KISTEP) conducts planning and evaluation, the National Research Foundation (NRF) supports MSIP for R&D performance management for government research institutes, and the Korea Institute for Advancement of Technology (KIAT) assists in commercialising industrial technology under the coordination of the Ministry of Trade, Industry and Energy (MOTIE). Furthermore, in 2012, MSIP (formerly known as MEST, and currently MSIT) and MOTIE (formerly known as MKE) accounted for the majority of R&D spending with 31.9% and 30.4%, respectively.

[Figure 3-39] Share of public R&D investments by ministry, 2012

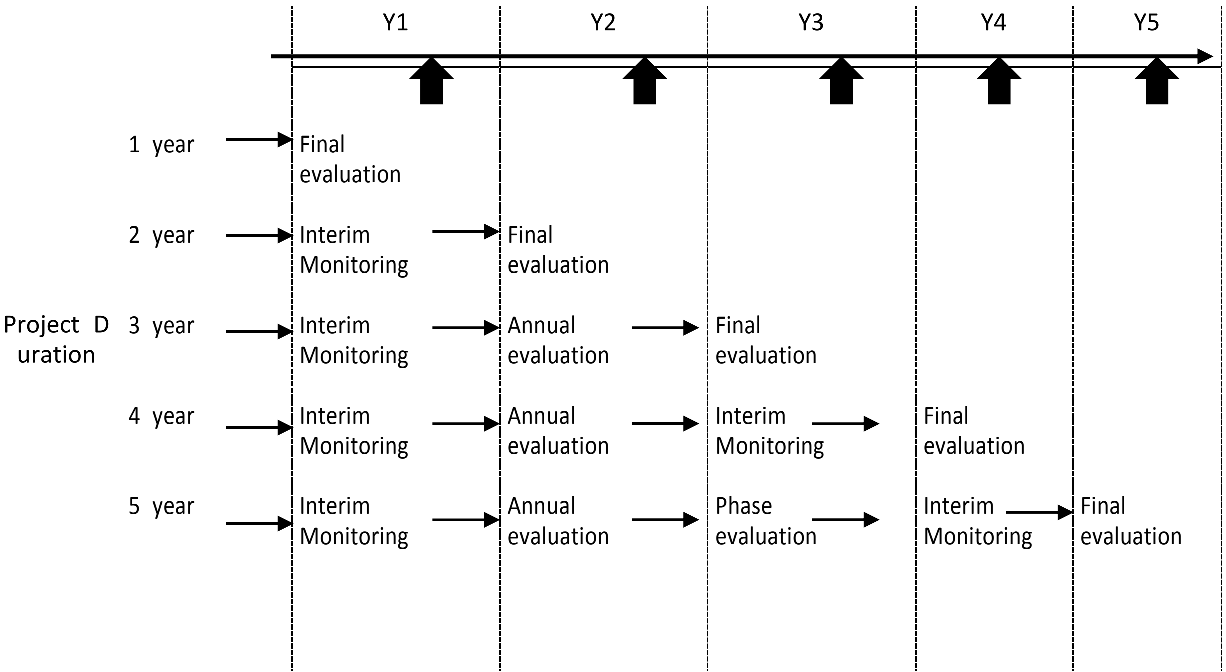


Source : OECD(2014)

Clear measurement guidelines

As aforementioned in the previous section, Korea implemented an STI policy that has proven to be effective. Although many programs could result in economic return,many others could fail during the implementation process. To gauge which R&D programs are promising and which programs should be halted, the Korean government has its own method of measuring STI policy implementation.

[Figure 3-40] Interim Evaluation Methods by Project Duration



Source : KSP (2017)

Depending on the duration of the project, interim evaluations are conducted once or more to assess whether an R&D project should be continued or halted (KSP, 2017). By using this approach, Korea is able to cut unnecessary funding for projects that do not offer any progress to the Korea STI policy and national strategy. In addition, Korea practices the quantitative measurement approach, which will be discussed further in the recommendation section to reduce any redundancies in the content of this report.

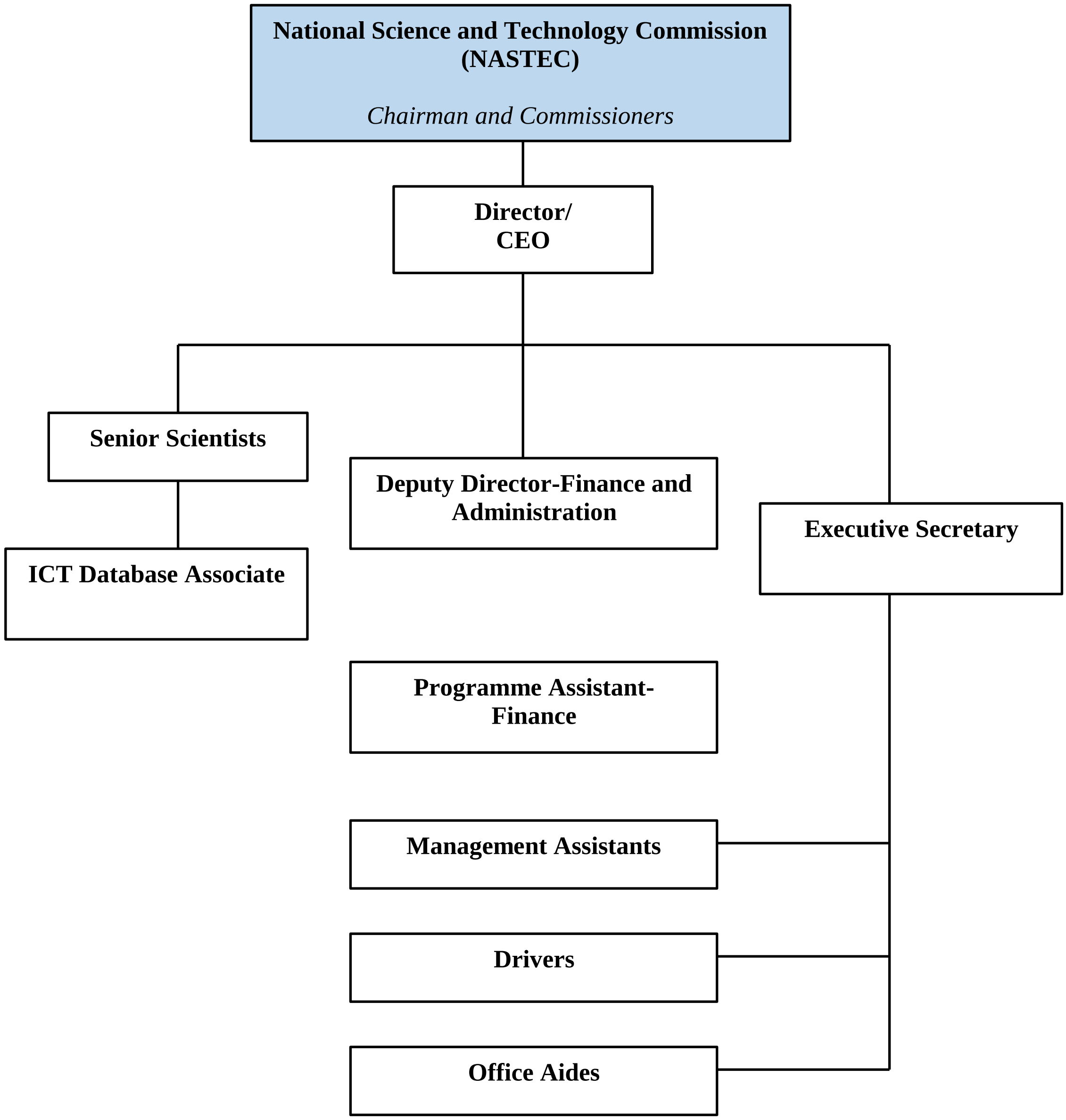
2.3 STI Governance and Policy of Sri Lanka

Sri Lanka, which is categorized as a developing country, can learn the effective STI governance practices of Korea as an example through this report, for several reasons. Firstly, as forementioned in the previous section, Korea has been highly successful in developing its STI policy. Korea has an evaluation body, MSIP (currently MSIT), that conducts meta-analysis and specific analyses of Korea’s R&D and innovation agenda. Secondly, in contrast to Korea, Sri Lanka does not have a clear monitoring and evaluation process to develop its STI policy. Having set an example in the beginning of this report, to better understand the second part, this section will provide an overview of Sri Lanka’s STI policy.

2.3.1 Governance Structure of Sri Lanka’s STI Policy

Where as Korea’s STI policy was established by multiple ministries led by NSTC, which is directed by the Prime Minister, Sri Lanka’s STI policy was established by the National Science and Technology Commission (NASTEC) in 1998 through an extensive development process (NASTEC, 2008). In contrast to Korea, in which smooth coordination was possible as its policymaking body was directly led by the Prime Minister, NASTEC is an organisation placed just under the ministrial level and led by a Chairman and Commissioners, as described in the figure below. More precisely, NASTEC exists within the Ministry of Science and Technology and is outside the influence of other ministries (The Panel of The UN Commission of S&T For Development, 2007).

[Figure 3-41] NASTEC Organisational Structure (NASTEC Annual Report, 2016)



Source : NASTEC Annual Report(2016)

2.3.2 Sri Lankan Institutional Involvement in Developing STI Policy

Unlike the Korean approach,which consistently involvesthe same ministries such as MOSF, MSIP(currently MSIT), and MOTIE (OECD, 2014), Sri Lanka practises a different approach, which may be a factor in why its national R&D and innovation agenda could not be achieved effectively or efficiently. One example related to this was when it formulated a five-year plan to support the NSTP. Despite making this plan in 2009, NASTEC does not work closely with other ministries, and in contrast it workswith various institutions and practitioners such as S&T bodies, academic communities, as well as scientists and technology experts(Ratnasiri, 2015). After trying this bottom-up approach, NASTEC has since been attempting a new approach. In 2014, NASTEC partneredwith its parent institution, the Ministry of Technology and Research, to develop the 2015-2020 investment framework to coordinate nationwide S&T institutions to follow the STI-based economy agenda (Ratnasiri, 2015). These two are among several examples that could be described in this report to emphasize Sri Lanka's lack of focus on a single approach among its various options;in this case, Sri Lanka's preferences of using bottom-up or top-down approaches.

2.3.3 Challenges in STI Policy and Governance in Sri Lanka

In this report, the challenges faced by Sri Lanka in terms of STI policy and governance will be examined in the Recommendation section, in the subsection of Identification of factors hindering effective STI policy implementation in Sri Lanka. This was done to reduce possible redundanciesor repeating content between two similar sections.

2.4 Review ofSri Lanka'sMajor STI Policies and Strategies

2.4.1 National Science and Technology Policy (1995)

The first initiation of STI policy development started in 1995. In the past, according to Samarakoon (2019, p.20), a team named the Presidential Task Force formed S&T policies, which resulted in seven major policies based on the ideas of human capital building, scientific knowledge and technology sourcing, development and utilization of technology, science and technology coordination at the national level, science and technology diffusion and promotion, and the creation of mechanismsfor objective-related fund generation.

Although the policies appear to be thorough as a single grand plan, the supporting action plan was established far behind schedule in the late 2000s. Only in 2009 did Sri Lanka, through NASTEC and the Ministry of Science, Technology and Research, begin developing a five-year plan to implement the S&T policiesestablished in 1995 (Ratnasiri, 2015).

2.4.2 National S&T Policy (2008)

In 2008, NASTEC developedseveral strategiesfor its National Science and Technology Policy. Among the tenmajor policies with many supporting strategies, there is one STI policy inSri Lankathat is especially similar to the experiences of Korea: Policy 5, the Technology Transfer policy. The objective of this policy,according to NASTEC (2008, p.30), is technology transfer, whichis then followed by the 5-b Strategy that details some challenges and initiatives related to this strategy. Having taken a closer look at this policy, it is clear that the 5-b technology transfer strategy isinconsistent with its proposed strategy and initiative. The strategy encourages industries and R&D institutions to concentrate on high-tech innovation, technology transfer, and commercialization. However, there are challenges as it isdifficult to understand the needs of the industry. The proposed initiative may be a better alternative tojoint ventures with foreign commercial organisations. The high reliance on FDI or cooperationwith foreign companies may not be the ultimate solution if the objective of the policy is to truly encourage concentrating on high-tech innovation, technology transfer, and commercialisation. Similar to what was discussed earlier in the Korea STI policy section, which will also be discussed again in the Recommendation section, non-FDI channel technology transfers would pay off despite requiring additional time to be implemented.

2.4.3 Science, Technology, and Innovation Strategy for Sri Lanka (2011)

In this report, there is one part in particular that NASTEC should reconsider reviewingto ensure the success of the national agenda, which is the individual top-down approach by one ministry that does not involveother ministries. This will be further discussed in the Recommendation section.

The Minister of Science and Research stated in the Science, Technology, and Innovation Strategy that the Ministry of Technology and Research is responsible for undertaking an accelerated program by establishing centres of excellence through partnerships with state research institutes, universities, and the private sector (Vitarana, 2010). STI policy and strategy executions on national plans should be conducted by focusing on cross-ministerial collaboration. As stated in the aforementioned report, Sri Lanka's technology initiative may be advanced through a single ministry working independently. However, the effectivenessof such an approach is questionable. Even more questions are raised, such as who performs the tasks, how the tasksareconducted, and how often evaluationsare conducted on the national strategy.

2.4.4 National Research and Development Framework (2016)

In 2016, a new Minister of Science, Technology and Research was appointed, but the approach taken remained the same with non-inter-ministerial coordination. On the other hand, it seemed that NASTEC had chosen a more bottom-up approach in developing their framework. The Minister of Science, Technology and Research explains that National Research Development Framework is a product of an uphill struggle by the National Science and Technology Commission (NASTEC) and the policy formulation division of the Ministry of Science, Technology and Research.

2.4.5 "Technology and Digitalization" Chapter of the Vision 2025 (2017)

A year following the introduction of the National Research and Development Framework, the government issued its Vision 2025 plan, which addresses a variety of subjects, including technology and digitalization. Upon reading all of the chapters, the technology and digitalization strategy seems promising. However, it may be better for the government of Sri Lanka to provide additional details. For example, the first technology and digitalization strategy development in the Vision 2025 states that the government will have a plan of action, yet it does not explain in further detail how the government plans to allow foreign technology transfers to Sri Lanka. In regard to this, if Sri Lanka truly hopes to move up the technological ladder, the Vision 2025 should share the current national status in terms of technology transfer and elucidate the nation's plan regarding this matter. The meaning of 'transfer of appropriate foreign technologies into Sri Lanka' should be further explained on whether it will come from FDI or non-FDI channels. By mentioning the nation's current status and specific plansin terms of technology transfers, Sri Lanka could undergo a smooth transition to move up the technological ladder as it has planned, similar to the example set by Korea.

2.4.6 Innovation and Entrepreneurship Strategy of Sri Lanka 2018-2022

Good signs of positive change could be seen from the Sri Lanka 2018-2022 Innovation and Entrepreneurship Strategy. The national innovation and entrepreneurship agenda appears to be building upon the Vision 2025 plan, with many stakeholders ranging from government institutions (inter-ministerial), the private sector, and university experts. Some points to be highlighted in this grand strategy include: "The government has a high reliance on FDI for knowledge transfer, as mentioned in the Operational Objective 1.4. (I&E Strategy, 2018)"

Even though some objectives have clearlyset target goals, many operational objectives had no clear numerical measurements. Anexample of a good objective from the document is the Operational Objective 3.1, "which aims for a specific increase of 0.8% in gross expenditure on R&D by a specific deadline: the end of 2022 (I&E Strategy 2018, p.20)." By setting such quantitative goals, the responsible or concernedministry(ies) can conduct precise measurements to more easily navigate and progress their performance towards the national strategic goal.

Whereas some objectives have set quantitative measurable goals, certain objectives were left questionable in terms of how to measure its success. An example of an objective that would be difficult to measure is "Operational Objective 2.2 related to government plans to improve access to finance for growth and innovation by incentivizing private sector investments (I&E Strategy 2018, p.17)." In this objective, it is unclear how much incentive will be offered to the private sector and how the government will measure the degree of improvement regarding access to finance, assuming that it is improving. In this case, the evaluation of progress wouldbe confusing as there was no initial quantitative target that was set fromthe beginning. The first word 'improve', which is more qualitative in nature, should be converted into a quantitative target to make it more measurable, similar towhat Korea has done. This issue will be discussed again in the Recommendation section with additional suggestions.

2.4.7 National Export Strategy of Sri Lanka (2018-2022)

In adifferent agenda from STI, Sri Lanka developed the Sri Lanka 2018-2022 National Export Strategy (NES) through its Ministry of Development Strategies and International Trade (MoDSIT) and the Sri Lanka Export Development Board (EDB) with the help of the European Union (EU). NES was developed using both top-down and bottom-up approaches, and was developed with the involvement ofseveral government institutions such as government ministries, with the exception of the Ministry of Science, Technology and Research (NES, 2018). Thiswas rather disappointing as the Ministry of Science, Technology and Research has an R&D focus in several industries through NASTEC that could help Sri Lanka in boosting its export income.

The National Research and Development Framework 2016 has ten focus points, one of which isthe apparel industry. This industrywas chosen as the apparel industry in Sri Lanka is the largest employment contributor with 300,000 direct employeesand 600,000 indirect employees. In addition, clothing is a major national export commodity that contributes 38% of total export earnings (NRDF, 2016). The R&D strategy developed by NASTEC for the apparel industry would have been included in the NES in supporting national export income if the Ministry of Science, Technology and Research was involved in the NES core team or other committee positions. As a result of this poor coordination, the apparel industry, despite being a NASTEC R&D focus, was not included in the six NES focus sectors listed below (NES, 2018).

[Figure 3-42] NES Focus Sectors

Focus sectors	Type of industry	Growth trend
IT-BPM	Services	Mature
Wellness tourism	Services	Emerging
Spices and concentrates	Agriculture	Mature
Boating industry	Manufacturing	Visionary
Processed foods and beverages	Agriculture	Emerging
Electrical and electronic components (EEC)	Manufacturing	Visionary

Source : NES (2018)

2.4.8 Vision 2025

Continuing on from the discussion started in the chapter of Technology and Digitalization, this section will analyze whether inter-ministerial or centralized coordination is present in general to realize the Vision 2025. The terminology ‘Ministries’ is mentioned in only two instances in the Vision 2025(p.23 & p.47). The first instance involved the acknowledgement of the poor ministerial coordination and the second instance was related the Ministry of Power and Renewable Energy was mentioned in relation to thenational production of sustainable clean energy.

This discussion is brought to the surface as there was little to no inter-ministerial coordination mentioned by the government of Sri Lanka to realise the Vision 2025, based on the national document. With all due respect to the Sri Lankan government, which may have coordinated with all of its ministries through verbal or written communication, in large-scale STI national agendas like Vision 2025, the government should have specified in writing which ministries will be responsible for which strategies. Lack of government ministry coordination will result in non optimal performance, as described in the forementioned 6th strategy (Vision 2025, 2017). By proclaiming a clear mandate, any potential redundancies and the possible inefficiencies of the ministries can be minimized to achieve optimal national performance.

2.4.9 Impedimentsin Sri Lankan STI Policy Implementation

The factors hindering Sri Lanka's STI policy will be discussed to conclude the second chapter of this report. At least two factors were identified as major causes that have been hindering STI policy implementation in Sri Lanka.

2.4.9.1 Lack of national-level coordination

As mentioned and explained in the previous subsections onthe National Research and Development Framework 2016, the National Export Strategy of Sri Lanka 2018-2022, and the Vision 2025, Sri Lanka lacks effective coordination among its ministries to successfully implement STI policy. To briefly summarizethe details, the lack of coordination stems from:

Poor STI-related government support, especially with no existing and well-established institution to coordinate the planning, distribute the responsibilities, monitor the implementation, and evaluate the program. There wereproposed coordinating bodies, namely COSTI (Coordinating Secretariat for Science, Technology, and Innovation) and NSTICAMS (National Science, Technology & Innovation Coordination and Monitoring System)(Vitarana, 2013). However, there havebeen no signs of effective coordination in STI policy. The two institutions appear to be redundantin practice as they have the same responsibilities atslightly different authority levels.

An unclear mandate across government ministries that are capable ofadvancingSTI implementation and development (e.g., the case of NASTEC's NRDF and NES 2018-2022 not including the apparel industry as an export focus sector). This challenge was addressed in 2008 by NASTEC(2008, p.21), which stated that there is an absence of an institutional mechanism at the national level to command and harmonize S&T policy execution and linked development programs across all of the relevant sectors of the government. Although the problem has been acknowledged, a solution has yet tobe introduced.

2.4.9.2 Institution to commercialize STI remains unknown

As an addendum to the second point regarding the lack of national coordination, there is also little evidence indicating that Sri Lanka has designated a specific institution to commercialize the nation's STI. This may become a contributing reason as to why researchers in the R&D sector of Sri Lanka unaware of market demands.

2.4.9.3 Poor progress monitoring and program evaluation

In addition to the minimal coordination, there are few sources on how Sri Lanka conducts its STI policy monitoring and evaluation. Again, this issue was addressed in 2008 by NASTEC on the same page as the previous issue of lack of coordination, where it explained that S&T governance requires periodic appraisals and improvements in effectiveness (NASTEC 2008, p.21.)

Institutions in the country have become aware of the problem. However, the higher government authorities have yet to provide their full support to tackle the challenges that hinders the STI policy implementation progress. The issue of the 'need for periodic reviews' is critical andjust as important as coordination. However, in contrast to COSTI, which was formed by the government in 2013 as a plan to improve coordination among institutions involved with STI policy implementation, the issue of monitoring and evaluation has yet to be solved. This is a major task the government must work to resolve.

2.5 STI Governance &Policy Recommendations for Sri Lanka

As the title suggests, this part will contain relevant recommendations for Sri Lanka's STI policy based on Korean literature review, which was conducted in a previous section.

2.5.1 Reinventing NASTEC Governance Structure and Responsibility

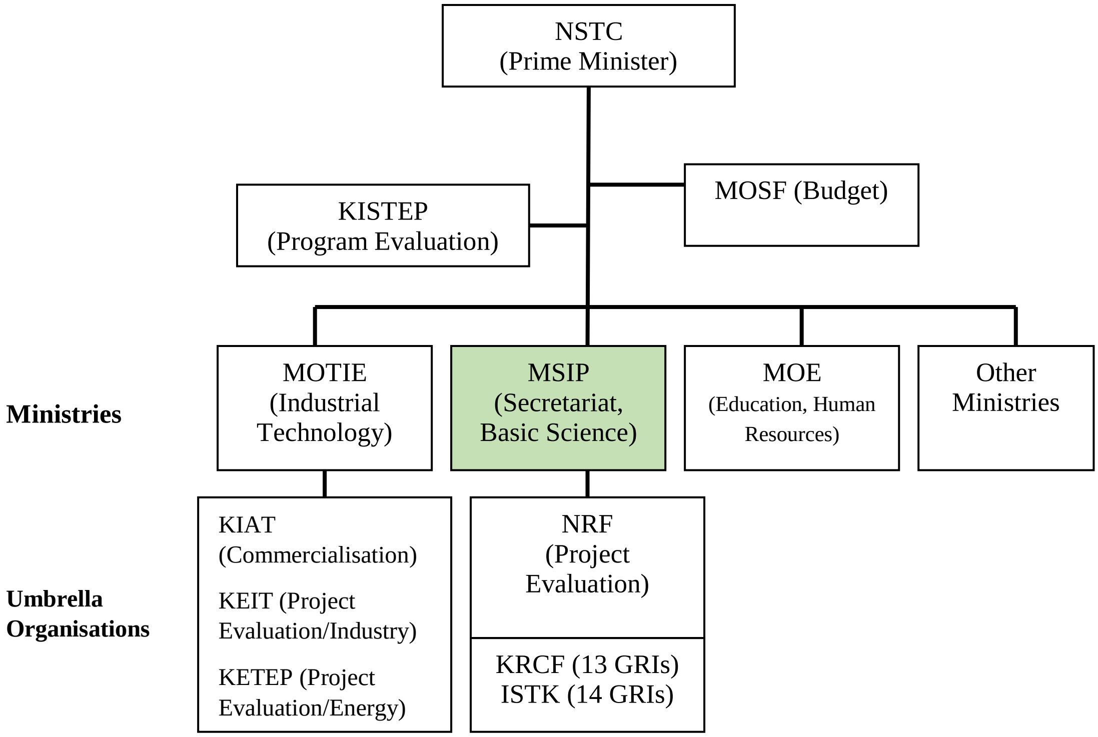
As stated several times in the previous section on Sri Lankan STI Governance, Sri Lanka's main problem that impedes STI policy implementation is the governance structure itself. It is clear that the main factor contributing to the ineffectiveness of STI implementation is the lack of coordination, which is an issue that stems from the STI governance structure. NASTEC, which is placed under the Ministry of Science and Technology, has no authority to coordinate Sri Lankan ministerial bodies, especially the Ministry of Industry, which is believed to be linked to STI commercialisation given no institution in Sri Lanka is specifically dedicated for this purpose (The Panel of The UN Commission of S&T For Development, 2007). As in the case of Korea, such a commission to develop and coordinate STI policy should be led directly by the Prime Minister (KSP, 2017). Therefore, for the first recommendation, this report recommends Sri Lanka to restructure NASTEC governance by moving it up as an independent body that does not belong to any specific Sri Lankan Ministry.

By focusing on this restructuring process, while simultaneously adding the role of a coordinating body, NASTEC will have the capacity to organiseinter-ministerial coordination between multiple institutions involved with STI implementation. As modest or poor STI performance growth is known to be caused by insufficient coordination of trade strategies, industrial policies, environmental criteria, and education focus(UNCTAD STI Capacity Development Course, 2017), this means that taking this recommendation into account would also help Sri Lanka in boosting its STI implementation performance. The result may not be felt instantly as it requires some time to take effect; however, with inter-ministerial coordination, NASTEC could help Sri Lanka in developing its national science and technology to become more effective and efficient.

2.5.2 Forming or Assigning an Institution for STI Commercialisation.

Even though NASTEC, through its Objective 5, has encouraged industries and R&D institutions to commercializescience and technology (NASTEC, 2008, p.10), Sri Lanka has no institution delegated to promote and commercialise its national STI. STI commercialisation policies, which are supported by a specific institution that is designated with thetask of commercializing S&T, presumably results in better commercialization compared to simple encouragement. Therefore, as a second recommendation, this report suggests that Sri Lanka should form a new institution with a focus on STI commercialization. Forming a specialized government -institution that handles STI commercialisation in anexisting ministry could also be an option as the institution may have intersecting interests between national industry commercialisation and the national STI agenda. A possible choice could be the Ministry of Industry and Commerce. Regardless of whether a new institution is formed or the responsibility is assigned to an existing body, an STI commercialization institution is expected to make significant contributionsin taking advantage of many future opportunities. For example, public research commercialisation has the potential to go beyond patent and licensing through various activities such as public-private research collaboration, contractual research, faculty consulting, and student entrepreneurship (OECD, 2015).

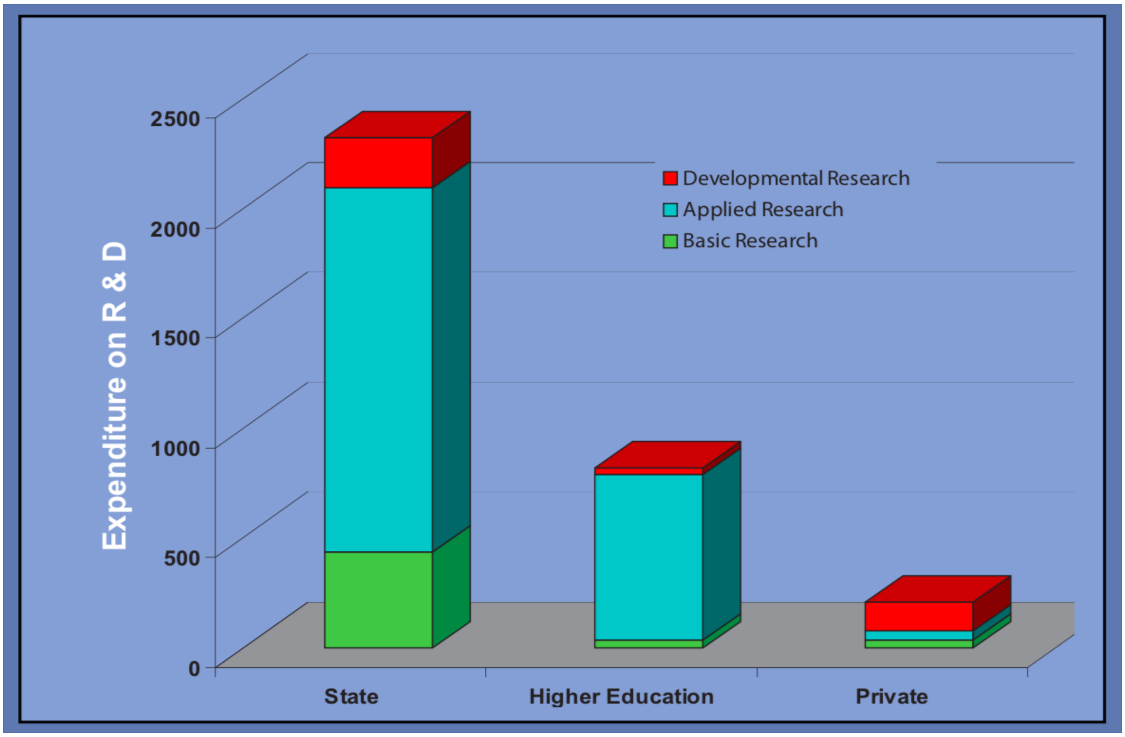
[Figure 3-43] Technology and innovation system in Korea, 2013.



Source : OECD (2014)

With regardto commercialisation, Sri Lanka should look at the best practicesthat have been practiced by Republic of Korea. For example, a partnership was formed with a different ministry(in this case, MOTIE) to develop a body (KIAT) that strives to understand the market demand across various industries and to commercialise the national R&D program (OECD, 2014). By developing this new institution in adifferent ministry, not only does it promote inter-ministerial coordination, but it also increases the effectiveness of STI policy implementation. This is possible as the R&D industry plays an important role in boosting STI implementation performance. This may also be the reason why Korea invests almost the same percentage of its R&D budget into the R&D industry of MOTIE (30.4%) as it invests into MSIP (31.9%) (OECD, 2014). For comparison, the figure below illustrates the R&D spending of Sri Lanka (Vitarana, 2010).

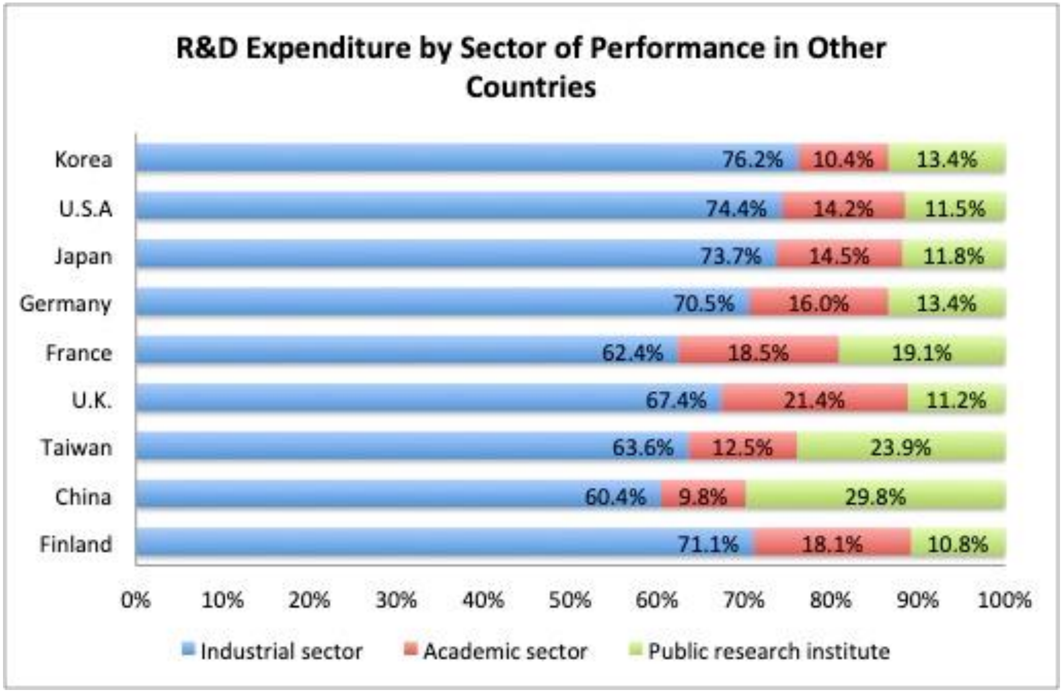
[Figure 3-44] Sri Lankan R&D expenditure by R&D performer in 2004



Source : Vitarana(2010)

To support the recommendation, the Sri Lankan government should also invest in its STI commercialization institution to aid in balancing public-private research cooperation. By doing so, the implementation of STI policy in Sri Lanka is expected to improve in terms of performance.

[Figure 3-45] R&D expenditure of Other countries by R&D performer



Source : Vitarana(2010)

2.5.3 Establishing and Strengthening STI-Policy Measurement Strategy

Firstly, the Sri Lankan government should be clear and specific, to the extent of specifying the body that will be in charge of conducting STI measurements, which include monitoring and evaluation. Following the example set by Korea, a country that has been successful in implementing STI policy, the coordinating and evaluation body should be the same. In this case, COSTI will not only have theauthority to coordinate, but also have the authority to monitor and evaluate national R&D programs.

Secondly, Sri Lanka is advised to set a concise intermediate indicator to track programs during progress monitoring and program evaluation. The example from the best practices of Korea that were described in the literature review involves conducting an interim evaluation and setting a quantitative measurement approach. To explain more in detail, this recommendation is important for Sri Lanka to consider for several reasons. First, the choice of indicator is vital in defining success and for measuring the impact of policy design (Cust, 2008). Unlike Korea,which concisely conducts measurements, Sri Lanka seems to lack measurable indicators for its objectivesto track the progress and status related to STI program implementation. An example of this was described in the Innovation and Entrepreneurship Strategy of Sri Lanka 2018-2022 section. The figure below illustrates an example from Korea that highlight how the ideal practice of measurement should be conducted.

[Figure 3-46] Brief Summary of Ex-post R&D Project Evaluation

<table>
<tr><td>Objectives</td><td colspan="3">• Success/Failure decision by examining the level of achievements of a project's goal</td></tr>
<tr><td rowspan="7">Methods & Criteria</td><td>Item</td><td>Contents & Description</td><td></td></tr>
<tr><td rowspan="2">Level of Goal Achievement</td><td>Achievement of detailed performance goals
<table>
<tr><th>Performance index</th><th>weight</th><th>goal</th><th>achievement</th><th>ratio</th><th>score</th></tr>
<tr><td>Index #1</td><td>0.4</td><td>100</td><td>80</td><td>80%</td><td>32</td></tr>
<tr><td>Index #2</td><td>0.6</td><td>150</td><td>180</td><td>100%</td><td>60</td></tr>
<tr><td>Sub total</td><td></td><td></td><td></td><td></td><td>92</td></tr>
</table>
<u>Example</u></td><td>Quantitative</td></tr>
<tr><td>• Appropriateness of project implementation methods
– Investigate actual implementation against initial planning</td><td rowspan="5">Quantitative</td></tr>
<tr><td rowspan="2">Superiority of R&D Result</td><td>• Quality of R&D result</td></tr>
<tr><td>• Superiority of quantitative R&D outputs
– Patents, papers, licensing and commercial application, etc.</td></tr>
<tr><td rowspan="2">Appropriateness of R&D result utilization plan</td><td>• Appropriateness (specific, clear, feasible,….) of commercial utilization plan</td></tr>
<tr><td>• Scientific, socio-economic impacts</td></tr>
<tr><td>Result Uti lization</td><td colspan="3">Incentive (excellent performers get an additional score (max 5%) in the next project) & Disincentive (poor performers cannot participate or get scores deducted (max 5%) in the next project)</td></tr>
</table>

Source : KSP(2017)

Korea uses comprehensive measurements to assess its national R&D perform ance following aguideline from MSIP (currently MSIT), which includes quantitative target setting as an S&T strategy for its interim evaluation (KSP, 2017). By using a numerical target, Korea is able to conduct interim evaluations as foremention ed in the previous subsection on ‘Clear Measurement Guidelines’. As such, it is highly recommended for Sri Lanka to set more quantitative indicators for its pr ogram objectives related to STI policy implementation, especially for the purpos e of monitoringthe progress of its R&D program. This is in line with what Cust (2008) explained, in that indicators support in setting alink between economic an d non-economic measurement, speeding up the cost and benefit analysis of an aspect being assessed. By taking this recommendation into consideration, this a uthors hopes that Sri Lanka’s STI policy and implementation could be further d eveloped in a successful direction.

3. STI Data Mechanism

Ms. Haengmi Kim (KISTEP)

3.1 The Advent of the Data Economy Era

Society of the 21st century considers vast amounts of data produced through the foundations of IT technology as a key factor for industrial development and innovation. As such, the world seeks to create new industrial and economic values from data. Data is the basic unit for the knowledge pyramid. In other words, although data is only a piece of information at the point in which it is createdor generated, data can evolve into information and further into knowledge by combining with other types of data. In addition, data can be given a new meaning over time or can be newly interpreted according to different perspectives.

In 2011, David Newman referred to this social phenomenon as the "Data Economy"in a Gartner Report(David, 2011). The Korea Information Society Agency definesa data economy as an economy that creates innovative businesses and services, with all data flowing freely and being easily utilized, serving as a catalyst for the development of other industries. In addition, data is used as a resource for services and is recognized as a new type of capital that can lead to industrial development and innovative growth, similar to financial capital or raw materials (NIA, 2018). As the quantity of data becomes immeasurable with the widespread use of smart devices, IoT, and SNS in recent years, the management and utilization of such tremendous amounts of data has become an indicator of both corporate and national competitiveness.

Corporations play a pivotal role in the data economy, expanding their revenue from consumers by simultaneously processing and utilizing data to develop new types of value (products and services) to provide to their consumers. Google's search engine takes up 88.2% of the global search engine market, and it is used to generate revenue from advertising and other search data. Apple stores user data from devices such as Apple smartphones, tablets, and smartwatchesinto the cloud to provide app services (NIA, 2018).

At a national level, governments strive to manage and use data to realize public welfare, optimize existing services, and implement additionally public/administrative services by analyzing data generated from existing public services. In addition to nurturing highly educated or skilled professionals to meet the social needs for data analysis, governments also work to reform relevant institutions to encourage the production, sharing, and utilization of data, which contributes to additional public value.

As such, in the current era of data economy, it is imperative to build systemsto convey systematic data governance (people, processes, technologies, policies, etc.) that encompassesthe standardization, management, utilization, and proliferation of data.

3.2 Data Management of National Science&Technology

In the data economy era, data capital is a resource directly linked to the national economy, especially since scientific technology data is a matter related to national capabilities in science and technology. Certain types of scientific technology data may be an indicator that can be used to evaluate national competitiveness.

Cheng (Cheng, 2006) defines scientific data as data obtained as a result of scientific and technological activities, including data from tools and sensors as well as data obtained from experiments and analyses. Kang Hee-Jong (Kang, 2012) refers to data collected and managed by the government or public institutions through research, surveys, or reports using public funds as public data, and data obtained from scientific and technological activities as scientific data.

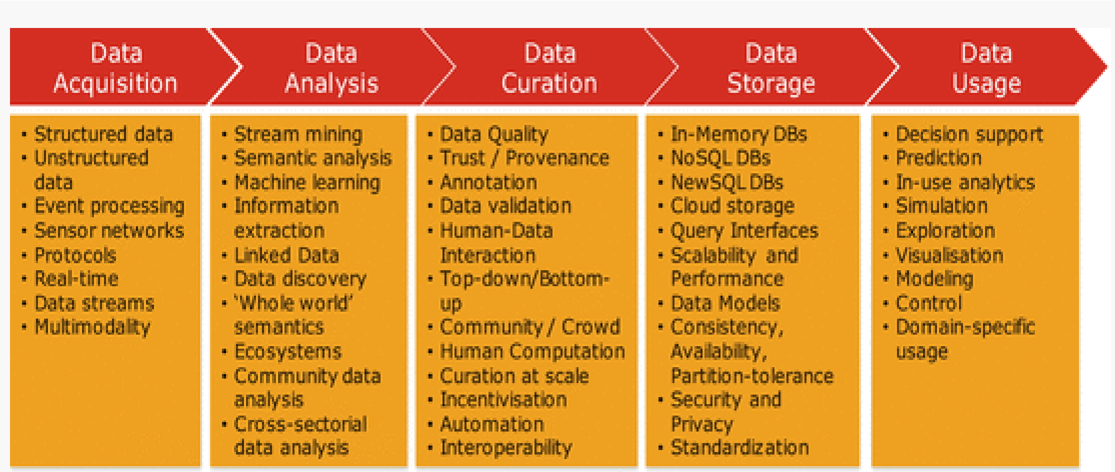
McKinsey Consulting (McKinsey Global Institue, 2011) predicted in 2011 that, in addition to businesses, governments will have the opportunity to increase efficiency and the value of investments through data to overcome public funding restraints or limitations. Given the social contribution of public data, the impact of scientific data related to innovation on society and the industry is by and large related to national science and technology capabilities. Therefore, major countries are in the process of systematically implementing policy processes to establish data management strategies at the national level.

In the 1950s, the United States of America established the National Science Foundation, laying the groundwork for the exchange of scientific data between domestic and foreign scientists. In 2006, the Interagency Working Group on Digital Data (ISWGDD) was formed under the National Science and Technology Council (NSTC) to provide public access to data generated by federal agencies in order to manage scientific data at the national level and to provide a model for the control and management of scientific data (Yoon, 2016).

In Europe, each country is pushing for scientific data management policies. Germany established and operates a platform called the eSciDoc system to store, process, publish, and distribute all scientific data that is generated in the process of research, including research results, preliminary research documents, experimental data, pre-prints, and study data. The United Kingdom collects, manages, and maintains data through the Joint Information Systems Committee and the Digital Curation Centre. Australia has also continually invested in this field for a decade from 1997 to 2017, and in the process, established the Australian National Data Service and the Australian Research Collaboration Service to build a data management system (Yoon, 2013).

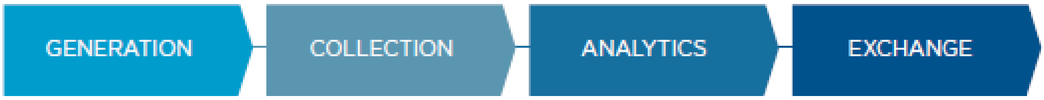
The overall purpose of managing scientific data is to identify a basis for strategic decision-making from aggregated data, and to effectively utilize and create new value as public assets. To create value from data, we need to consider how the data can be used at each step and the types of output that can be obtained (Edward, 2016). This approach can be cultivated through the data value chain. Although there are no formalized models, the data value chain is composed of a life cycle: data production → data collection and processing → data analysis → data distribution/use. In each stage, new forms of value are added through the market relationship between supply and demand.

[Figure 3-47] Data Value Chain by Edward Curry



Source : Edward (2016)

[Figure 3-48] Data Value Chain by GSMA Report



Source : GSMA (2018)

*GSMA: a trade body that represents the interests of mobile network operators worldwide

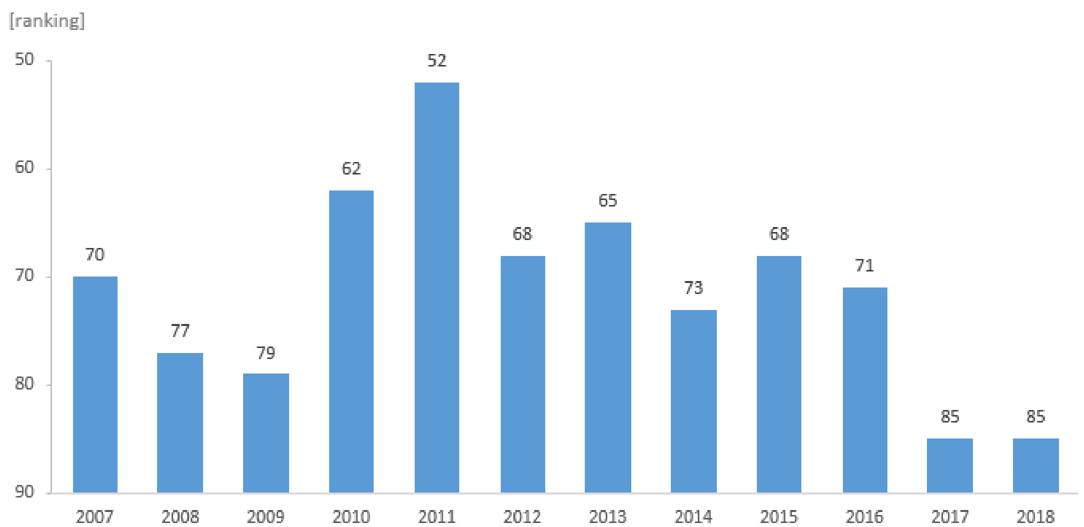
3.3 Sri Lanka's Science and Technology Levelsin terms of Data

Sri Lanka, which had been a colony of other countries for over 400 years, was finally able to become an independent country in 1948. Sri Lanka has traditionally consisted of an agriculture-centric economy through tea exports. Many efforts are being made in all areas such as the economy, diplomatic relations, public policy/service infrastructure, and science and technology etc. to lead the country from an agricultural-oriented economy towards a knowledge-based society.

The World Economic Forum (WEF) defines national competitiveness as "policy/institutional and other factors that enable sustainable economic growth and long-term prosperity." Under this definition, the WEF discusses major and emerging worldwide economic/social issues every year. This is based on a comprehensive analysis of important factors that lead to productivity and competitiveness with concepts related to structural factors that stimulate economic activity in a country. In this regard, the WEF annually releases national competitiveness indices in line with their evaluation system.

According to the 2018 WEF National Competitiveness Report, Sri Lanka's national competitiveness ranks 85th among 140 countries.In terms of national competitiveness rankings over the past five years, although the total number of countries being assessed varies each year, Sri Lanka’s rank fluctuatesbetween the 68thand 85th ranks. The rankings over the years was found to be distributed over relatively large range.

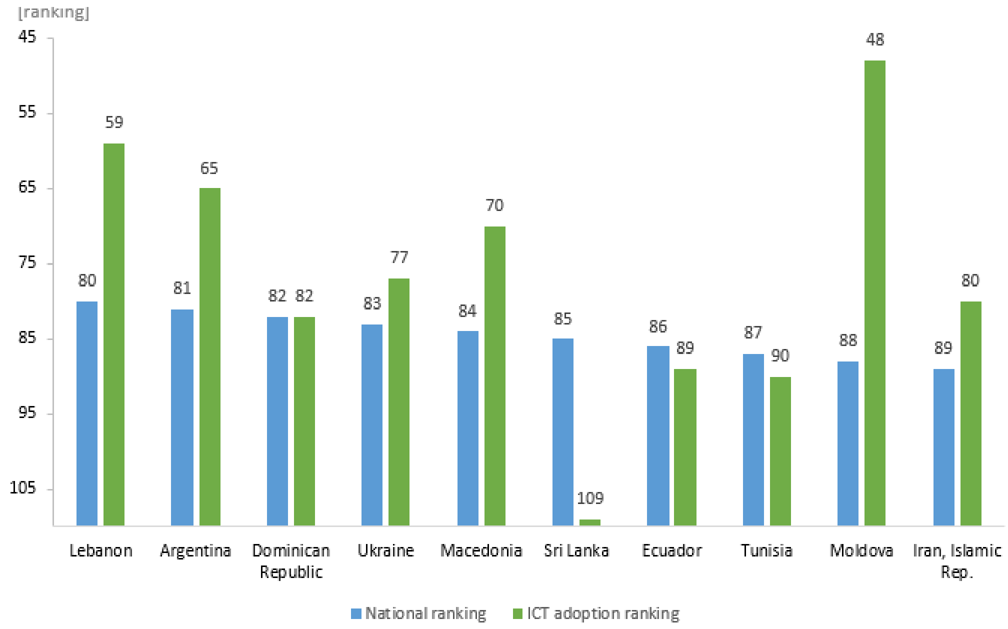
[Figure 3-49] Ranking Trend of Sri Lanka’sCompetitiveness



In terms of science & technology, “Health(5th pillar)” in the human resources sector (human resources in terms of more productive people with healthier physical and mental skills), Sri Lanka ranks 46th with 86.9 points.In the field of education and technology (education implies skills and competence; a population with higher levels of education is more productive as it has the collective ability to create new knowledge and applications and the ability to enable rapid task performance and knowledge transfer), Sri Lanka ranks 70th with 62 points.

In addition, Sri Lanka ranks 109th in terms of ICT penetration (the spread of information and communication technologies: the environment sector). The ICT penetration identifies the degree, which the national institutional environment is able to adapt to the era of the Fourth Industrial Revolution. This is the third lowest ranking achieved by Sri Lanka among all indicators, after the product market (129th) and the labor market (117th).

[Figure 3-50] ICT Adoption and Capacity Ranking



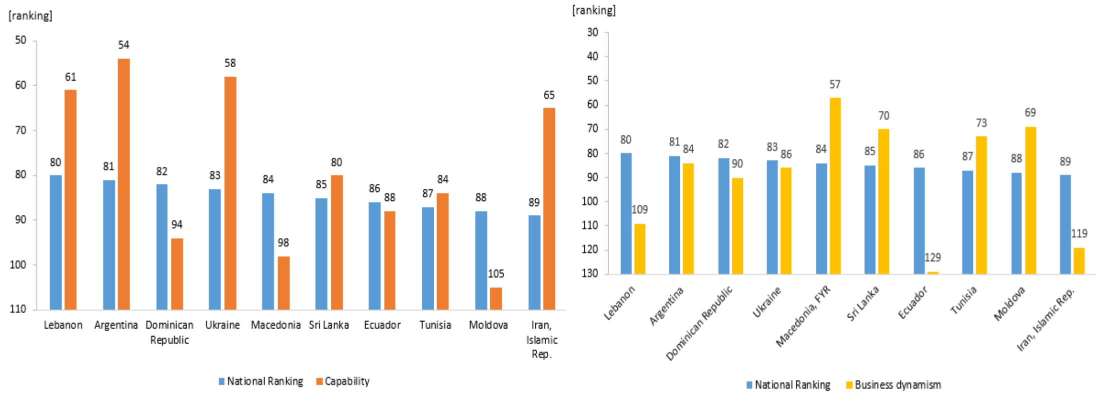
If we look at the ICT penetration rankings of the countries that ranked between 80th and 90th in national competitiveness (which is similar to Sri Lanka), we can see that the level of ICT penetration of the other countries in this range are at a similar level. Moldova, which ranks 88th in national competitiveness, is particularly notable as it ranks 48th in ICT penetration, higher than its overall national competitiveness.

In an agricultural-oriented economy such as in Sri Lanka, the ICT penetration ranking index is especially important, as ICT technology can be used to achieve an advanced agricultural economy, which involves ICT applications such as smart farms.

In corporate dynamism (the ability of the private sector to create new technologies and adopt new ways of organizing tasks through changes, risks, new business models, and a culture that accommodates administrative rules that enable companies to enter and exit the market), which is an indicator that can gauge the level of science &technology, Sri Lanka ranks 70th, indicating that there is a dynamic corporate culture in preparation of the growth in national competitiveness. In addition, Sri Lanka ranks 80th in the innovation field (the quantity and quality of official research and development; the degree to which cooperation is promoted within a country: connectivity, creativity, diversity, and the ability to transform ideas into new products and services).

These science and technology indicators provide an objective means of knowing the capabilities of a country. Therefore, it is recommended to use these indicators in the process of planning and promoting policies of creating an ecosystem for science and technology innovation.

[Figure 3-51] Capacity and Business Dynamics rankings



In addition to the WEF national competitiveness indexes, there is the Global Innovation Index (GII), which is jointly published by IMD of Switzerland, Cornell University of the U.S., INSEAD of France, and the World Intellectual Property Organization (WIPO). Additionally, the European Commission's Corporate Industry Bureau presents an annual European Innovation Scoreboard. As indicators of science, technology, and innovation that are published by different institutions are set up with different perspectives, a comprehensive review will help in understanding the current situation of a nation in the individual fields of politics, economy, society, culture, law, and education. These indicators may be invaluable in the future development of each sector by comparing countries with similar social levels and systems.

3.3.1 Data generation by Sri Lanka's major institute of science and technology

The creation of scientific and technology data begins with a researcher. Research notes, experimental notes,and reference literature utilized by researchers fall within the broad scope of scientific and technological data. If aresearch is initiated with sponsoring from a specific institution (government or corporate), the information of the sponsoring agency (research funding, field, contract period, etc.) would also form an important axis inscientific and technology data collection.

The data held by individual researchers and sponsoring organizations cannot create economic value in itself, as it is not accessible to anyone and is not always available for other purposes. However, if this data is organized/refined using a certain standard and managed in an accessible area that can be used by everyone, it is ready to be reborn as new economic value.

In this chapter, we will review the current status of Sri Lanka's major scientific and technological institutions in terms of data generation, management, and disclosure.

3.3.1.1 National Science Foundation

a) Features and procedures of the support program

Sri Lanka's NSF operates a comprehensive support system that spans across various areas, including education, infrastructure, and research support to promote Sri Lanka's science and technology. NSF's mission is not only to support specific research in the scientific field, but also to support programs such as cost support for attending overseas academic conferences, operating in multinational companies or institutions, and participating in training programs to strengthen capabilities for specific purposes, which is the most important resource for solving economic and social problems.

The overseas education program is an important program for fostering long-term human resources that provides opportunities to be exposed to global S&T environments and issues and opportunities to learn and acquire technologies and know-how through experience by cooperating with leading overseas research institutes. Furthermore, continuous exchange with overseas institutions provides additional opportunities to raise Sri Lanka's prominence in the international community.

[Figure 3-52] Grants Scheme by NSF

South Korea's R&D is conducted by all of its ministries. Under the wing of the Ministry of Science and ICT is the National Research Foundation (NRF), which executes and manages the major projects of the Ministry of Science and ICT.

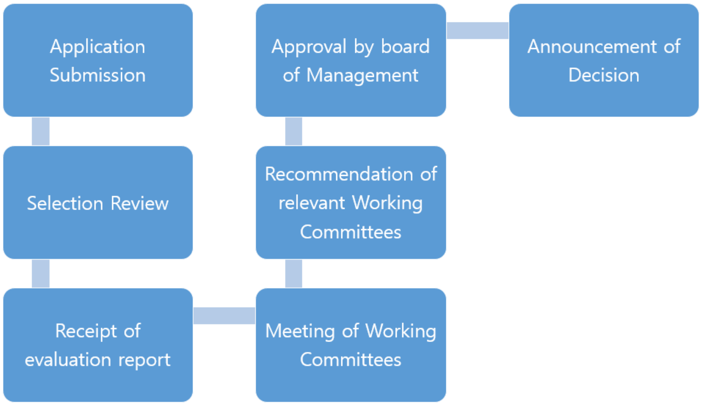
South Korea's NRF mainly supports basic research-oriented research programs such as individual research, group research, and the fostering of next-generation researchers. Although in-depth comparisons are required to fully understand each supporting program, in general, there is a difference between the programs of Sri Lanka and the Republic of Korea. Whereas Sri Lanka's NSF has separate programs to support overseas academic and educational institutions in addition to research support, the research support program of Korea's NRF is supportive to cover the costs of receiving training domestically and overseas within the research project funding budget.

In addition, the NRF research support program of Korea supports the operation of academic institutes to promote research activities in Korea. This program covers a portion of the costs of publishing academic journals (publishing online journals), supports the hosting of academic conferences, and covers the costs required to build a database. Additionally, the program seeks to lay the groundwork for domestic researchers to interact with each other domestically and boost research through these exchanges. The results of the research contribute to the exchange through an official route of scientific communication. As a result of such efforts, Korea was able to build the Korea Citation Index DB, which is provided as a global platform that serves SCIE journals and is free to use for anyone in the world. Therefore, this R&D program became one of the best practices of R&D project support.

NSF of Sri Lanka operates STIMS (Science Technology Information Management System), which is both a research proposal submission system and a PMS (Performance Management System). It also appears to possess the project data so that it can respond to external data requests once a proposal is selected. In this respect, the proposal submission system (STIMS) is the first step in producing government R&D data. Data collected through a research support system continuously evolves: once a proposal is selected to receive funding, it leads to new data through connections with other data; if a proposal is not selected, its data growth is halted and preserved in that status. Although the growth of individual data may end at this stage, additional insight can be obtained by searching for patterns such as areas of accumulated individual data, researchers, institutions, subject matter, or technology formats from different perspectives. These forms of insight cannot be obtained from evolving data in combination with heterogeneous data after selection. In other words, the utilization of data depends not only on the collection and accumulation of data, but also on how it is managed and analyzed.

Research project support and selection procedures do not differ drastically by country or institution in terms of overall procedure. However, the areas of support and the criteria of selection differ according to the situation and interests of each country.

[Figure 3-53] NSF Proposal Grant Process



The research project support system of Korea does not only deal with accepting proposals for projects, but it is linked to internal project management systems and the database programs of researchers.

The NRF proposal acceptance system strives to manage research content, contract periods, project participants, and the project implementation stage in a seamless manner. However, as the objectives of the various managing departments are not homogenous, related systems are established under each department based on the use and purpose of each managing department. As such, there are practical difficulties in perfect linking the various systems. Therefore, the important consideration in designing a data collection and management system is how to design it in a connected manner that follows a single flow. System planners and developers should keep this in mind during the planning stage to ensure any data can be linked between systems whether or not it is managed in the visible menu of the system. This means the system should be established with the flexibility to be able to adjust data from anywhere. This requires in-depth discussions with the relevant stakeholders, who need to be responsible for each system at the different departments. If the system of one department changes, the departments that use the linked data should be notified of the changes in the data/menu etc. to be constantly up to date during the process.

b) Sri Lanka Science, Technology & Innovation Statistics Handbook

This report was published by the Science and Technology Policy Research Division (STPRD) of NSF that collects data and produces statistics based on the International Statistical Methodology for Science and Technology (2007) and the OECD Frascati Manual (2002) presented by UNESCO.

The report examines the status of R&D for four types of entities, and consists of at-a-glance indicators of R&D investment in all countries of the world in terms of economics rather than specifically government R&D.

1) Higher Education sector (State and Private)-full coverage.
2) State S&T sector that includes Research Institutions, S&T Service-providing Institutions–full coverage.
3) Business Enterprises–250 institutions were selected for the survey considering the size of the establishment, the degree of the institution's R&D activity and the institute's contribution to the national economy. All major industries that

conducted a substantial amount of R&D were included in the sample as per the guidance of the Department of Census and Statistics.

4) Private Non-Profit Institutions (PNP)–all institutions that were involved in activities related to S&T were covered

Data collected through the aforementioned four types of entitiesare sub-divided into four areas (R&D investment, science and technology research personnel, innovation indicators, and socioeconomic indicators) to provide R&D-related statistics. Refer to Appendix 1 for sub-dimensions of the statistics.

The Sri Lanka Science, Technology & Innovation Statistics Handbook has major three advantages as statistics.

First, it is easy to compare international levels of different countries as the same standards are used to calculate scientific and technology statistics according to the guides of OECD and UNSECO. Second, the data is reliable as it utilizes a mix of published data by international statistics organizations and directly collected data. Third, by utilizing statistical data from international organizations and external organizations, the tasks involved in collection, analysis, and reporting can be streamlined.

Whereas the handbook has such advantages, it is limited in identifying the micro-characteristics of Sri Lanka's national science and technology as it provides the comprehensive perspectives of statistics when comparing different countries. Another limitation is the time difference between data collection and data publishing and use as the handbook refers international statistics, which are usually 1~2 years old.

3.3.1.2 National Science & Technology Commission (NASTEC)

In order to carry out R&D under the initiative of the government, it is necessary for organizations with a mission to plan and select support research programs as well as evaluate and disseminate the research results. Sri Lanka operates research support agencies such as NSF under the Ministry of Science and Technology. In addition, Sri Lanka has a policy advisory body in the National Science & Technology Commission (NASTEC), which plans the development of Sri Lanka's science and technology and whose main mission is to make policy proposals. NASTEC not only discusses key issues in Sri Lanka's science and technology but also advises the government in determining the implications of new policies and links them to national policies. Another main role of NASCTEC is to measure the performance of 45 research institutions.

c) Science and Technology Status Report of Sri Lanka

This report comprises of an analysis of the statistical results of NASTEC's survey on 45 science and technology research institutes and is divided into five research areas based on the OECD R&D classification system. The research fields are grouped into five sections like the below.

① Natural Sciences
② Engineering Technology
③ Medical and Health Sciences
④ Agricultural & Veterinary Sciences
⑤ Other

The data collection process of the Science and Technology Status Reportis conducted by hand (paper format). This is the only information that is gathered for this proposal, which means there are limitations in identifying specific indicators and the collection path for theScience and Technology Status Report.

However, there are several known weaknesses of carrying out paper surveys. The biggest challenge occurs during the data collection and management stage. The questionnaires may be distributed through existing mailing addresses or e-mails. However, if the collected data is not an electronic file, or if it is an electronic file but is not in a format that is appropriate for immediate statistical analysis, the data must be cleaned and refined into an appropriate form for analysis after collection. For example, if an EM file is received in the Word format, or if a reply is sent as a printed copy, the collector must re-enter or modify the file into a statistical output form, such as a Microsoft Excel file. Only with such preceding efforts can a paper survey be initiated to produce statistics. If the organization continues to conduct paper surveys going forward, it is imperative to find an efficient process to complete this step quickly. Otherwise, systemization should be considered from a long-term perspective.

The value of data in an electronic file remains even after the completion of a statistics report. As data is formed with new values by accumulation, it is necessary to implement the digitized file as a DB to create statistics reports. This DB has the advantage of being able to be used for specific-purpose data analysis in the future. Furthermore, it can serve as a good source for information service planning when building an integrated platform for science and technology.

3.3.1.3 Coordinating Secretariat for Science, Technology, and Innovation (COSTI)

The Coordinating Secretariat for Science, Technology, and Innovation, which is set up within the Ministry of Science and Technology, provides online multidisciplinary indicators of Sri Lanka's science and technology through an online platform. COSTI servesthe role of a coordinator in areas where inter-ministerial or public-private cooperation is required for national development.

a) Sri Lanka Innovation Dashboard

COSTI operates the online service known as the Sri Lanka Innovation Dashboard. Although the data collection path and method of this web was not confirmed during the writing of this proposal, this online service is an interactive scientific and technological statistics system that consists of four menus: Innovation Eco System, Four Dashboard Views, Current Status of the System, and Search.

[Figure 3-53] COSTI Main Screen

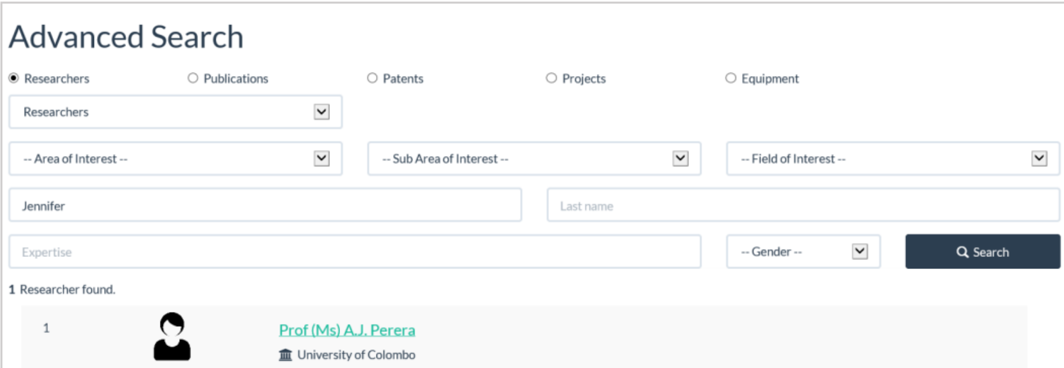
① The Innovation Ecosystem provides components such as Publications, People, Position, Partnerships, Places, Patents, Financing, and the National Research Repository.

② The Four Dashboard View consists of the General Dashboard, which provides general information (organizations, publications, cooperative situations) about researchers and participants; Academic & Research, which provides the distribution of researchers by type of organization; Decision Makers, which provides information on national scientific innovation capabilities (Global Innovation Index); and the Dashboard, which helps organize new businesses.

③ The Current Status of the System provides researchers, papers, patents, partnerships, inventors, as well as GII rankings and scores.

Users can use this website after creating an individual account and can construct a personalized dashboard that consists of their personal interests. Recently, the Search function was added, allowing users to search for researchers, papers, patents, assignments, and facility equipment use. The search provides the data underlying the aforementioned scientific and technology statistics of Sri Lanka, and the Sri Lanka Innovation Dashboard is an information service platform that, unlike the Handbook and Status Report, provides raw statistical data. As the Sri Lanka Innovation Dashboard is an online information service, it has the advantages of timeliness and scalability compared to existing statistical reports in that it can create new menus, add search services, and be frequently updated each time new data is added.

[Figure 3-54] Search Field and Search Result



[Figure 3-55] Detailed Search Result (Researcher)

The Customized Dashboard service of the Sri Lanka Innovation Dashboard is an innovative service that provides a customizable menu based on the user's purpose or interests, as users' information needs differ according to their tasks and roles. For this reason, this dashboard is qualified to beused as an integrated science and technology statistics information service platform.

In Korea, the Ministry of Science and Technology does not directly plan or operate statistical online services. Instead, a separate agency supportsthe Ministry of Science and Technology in such tasks. Sri Lanka, on the other hand, is unique in that statistical online services are directly operated by the Ministry of Science and Technology.

3.4 Suggestion for Sri Lanka's Integrated Platform of Science and Technology

3.4.1 Direction of the Sri Lanka Science and Technology Data Management System

NSF, NASTEC, and COSTI, the organizations that manage science and technology data under the Sri Lanka Ministry of Science and Technology, produce data on science and technology R&D according to their respective missions. Some data comes from direct surveys, while other data are statistics from international organizations and other statistical surveys. These three organizations handle different types of R&D data, the publishing of cycles and forms, and R&D data management and delivery according to their individual missions.

NSF identifies researcher information (such as degree and past benefits), the type of support (research summary, benefits, etc.), contracted projects/programs, and performance results through STIMS. By accumulating and monitoring these aspects for each project, demographic information, information for overseas academic societies, and research area can be identified and analyzed. In addition, by linking research project information with the PMS, the progress details of research projects and achievements can be continuously tracked.

The limitation of NSF is that STIMS appears to serve as both a research support system and a project management system in its current form. We believe that the segmentation of the proposal system and the project management system helps in structuring the details and the output of government R&D investments.

In addition, NSF's Statistical Handbook is an international standard for science and technology statistics, which is useful for understanding the status of Sri Lanka's science and technology R&D (investments, manpower, supporting entities, etc.) at the macro level. However, given that government-funded R&D accounts for 60% of Sri Lanka's total R&D

investment, there is a lack of micro-analysis for government R&D execution. This is an aspect that needs to be improved upon.

NASTEC is a science and technology policy advisory organization that periodically prepares reports covering Sri Lanka's science and technology status and studies developments through periodic surveys of 45 research institutes in the country.

The evaluation of the research institutes is divided into two general sectors: the management sector and the research sector. In the management sector, the evaluation looks at how well an organization has identified and carried out the tasks that are appropriate to its mission, as well as how effectively the workforce is managed. In the research sector, the evaluation assesses how much scientific and technology output has been created and disseminated, the degree of expertise that has been accumulated in each field of research, and the amount of cooperation that was engaged.

[Figure 3-57] Institute Evaluation Schema

This research institute assessment process requires several considerations for the assessment system (category, division, indicator, etc.) depending on the purpose and characteristics of the research institute being assessed. In addition, each system should be reviewed annually to facilitate collection, but the assessment indicators should be organized in a manner that derives policy implications or acts as a basis for decision-making.

The comprehensive and systematic management of the data collected and submitted for this evaluation and the results of the evaluation become a resource for the continuous monitoring of the status of R&D utilization of an institution. This can be used to set up the long-term or short-term vision of an institution that is open to change. Furthermore, by regularly evaluating government-funded laboratories, the government can use these laboratories as frontier players to lead national innovation systems and develop science and technology capabilities.

As the major task of NASTEC involves policy advice, the assessment of research institutes had better to be processed in more developed manner which can save times to efforts, while NASTEC spends more time to use and analyze the results of servey for advisory purposes. In addition, the results should be embedded with a system and service as open data through an integrated information service platform.

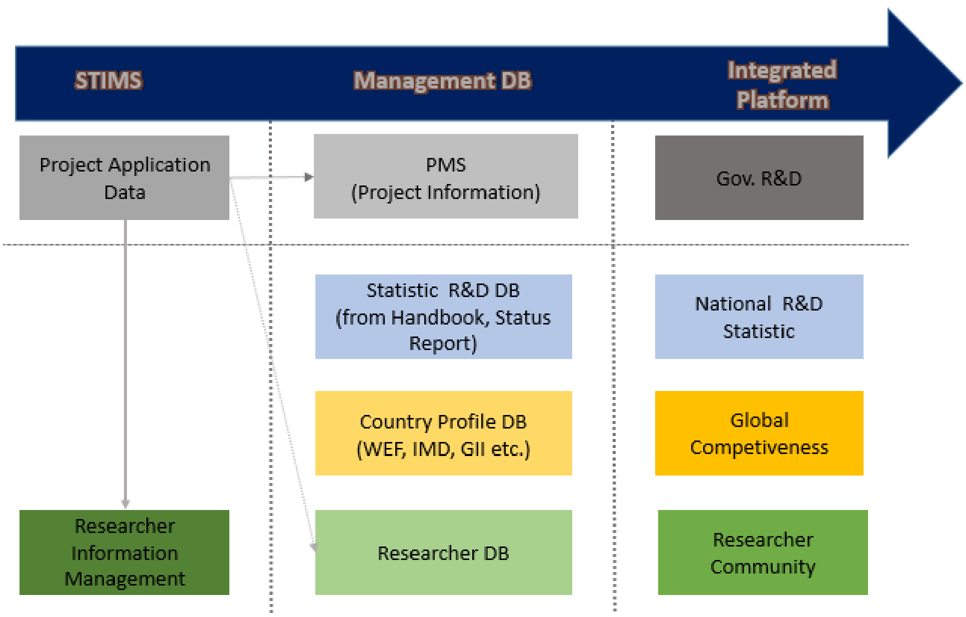
Lastly, the Sri Lanka Innovation Dashboard, which is operated within the Ministry of Science and Technology, is expected to be used as an integrated platform for science and technology statistics that provides interactive online services. Therefore, it is recommended to modify the current COSTI first-level menu to cover all S&T data, including government R&D, other R&D, and science and technology innovation data.

In summary, we propose the following directions for the establishment of an R&D data value chain for the Ministry of Science and Technology of Sri Lanka.

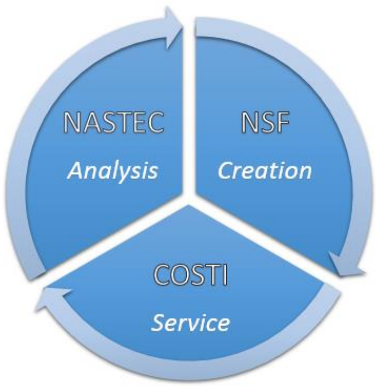
① The roles of NSF, NASTEC, and COSTI should be divided into collection, management, analysis, and services based on the R&D data value chain (creation – refinement & management - analysis – utilization), and each organization should perform the corresponding data roles. In other words, NSF oversees research project support and the management of projects and outputs, NASTEC serves as a policy advisory-centered body (data analysis), and COSTI operates an integrated platform for science and technology information services.

② To establish an R&D data value chain, each organization should build the necessary systems. NSF should promote advanced STIMS, PMS module implementation, and advanced DBs. NASTEC should set up the necessary system required to analyze the statistical and support data for decision-making. However, if NASTEC continues to conduct research institute evaluations, it is also essential to establish a system to conduct the survey itself, or NASTEC should consider a procedure to implement an electronic system for the data to provide online services by implementing DBs from survey data. Lastly, COSTI should provide online information services to store/manage data produced through government R&D by being assigned the role of a repository. At the same time, the Sri Lanka Innovation Dashboard should be modified into an integrated platform that provides comprehensive information on science and technology R&D in addition to a community feature in which researchers can find scientific technology information both domestically and overseas as well as other researchers for collaboration. This is vital as the method, scope, and content of service provision may vary depending on who uses the platform. From this perspective, it is proposed that the current first-level menu is modified to be more comprehensive and logical to better support researchers, policy planners, and government officials in the first development phrase.

[Figure 3-57] Sri Lanka S&T Data Mechanism



[Figure 3-58] Role by Organization



The detailed items, implementation methods, flows, etc. are dependent on the type ofdata that is collected and how is should be configured. Therefore, once the roles of the three organization are defined according to the data value chain roles, each system and platform should be designed to seamlessly link data, and be configurable in a manner that reflects the user's pattern to achieve the user's goal.

3.4.2 Development of an Integrated Platform for the Science and TechnologyData Mechanism

The first phase in establishing an integrated platform for the Sri Lankan science and technology data mechanism involvesconstructing an overall frame of the platform and building the basic contents and DB.The second phase involves buildinga statistics DB other than government R&D, and the third phase involves implementing the integrated platform. This means that the first and second phases must be achieved before the platform is complete. In addition, segmentation by process within the phasesis also important to achieve a step-by-step pathway for the integrated platform.

① Integrated Platform Phase 1: Constructing the entire framework and establishing a basic DB

The integrated platform is divided into four domains. The first domain is government R&D. The second domain, named "National Statistics", combines the national statistics of NSF's Statistical Handbook and the NASTEC Status Report other than R&D funding information. The third domain, named "Global Competitiveness", provides the main content of Sri Lanka's Country Profile as analyzed in various global competitiveness reports such as GII, IMD, and WEF. For the final domain, it is proposed that the fourth domain covers the researcher community or corporate R&D information. However, the actual menu decision can be made by the relevant authorities and decision-makers through consultation.

In the first phase of the integrated platform, the menus for each domain should be finalized and the contents (data composition, data display, convenience functions, etc.) under each menu should be detailed. However, as the contents of all the menus cannot be completed at the same time, the goal of this phase is to establish at least one menu for each domain.

During the first phase, the PMS and the researcher database should be upgraded at the same time to proceed into the second phase.

② Integration Platform Phase 2: Enhanced content optimization

As a phase to enhance the content, all sub-menus and contents under each first-level menu should be completed. In particular, the Global Competitiveness menu allows for the monitoring of national competitiveness indicators as well as scientific and technological competitiveness indicators such as IMD, WEF, and GII. In addition, visualization should be added to enable users to trace the annual global rankings of Sri Lanka's indicators and observe the changes at a single glance.

③ Integration Platform Phase 3: Completion of basic content and additional services

Domain 4is suggested to be a section on researchers (such as a community) or corporate R&D information. However, data collection for corporate R&D data would be difficult as some data may be related to trade secrets that cannot be open to the public. Thus, the planner of the integrated platform should engage in discussions with other R&D stakeholders to decide upon the appropriate contents for Domain 4. The main purpose of the current dashboard is to extract and utilize the data, and so it is configured in a one-way manner. However, an enhanced active menu that encourages research collaboration among domestic researchers by enabling the exchange of project information under Domain 4 is proposed for the integrated platform. This is the motivation for suggesting the researcher menu. To organize a researcher community menu, it is recommended to have interviews and hold meetings with researchers to better understand their needs and expectations.

3.4.3 Considerations for the implementation of an integrated platform

Data implemented into the integrated platform can be stored and managed in a single management DB, but government R&D data (STIMS, researchers, 45 research institutions, etc.) of Sri Lanka appears to be already managed separately. Among them, it is recommended to first upgrade the PMS.

3.4.3.1 PMS Implementation

The project data can be collected, managed, or even serviced from the integrated platform. Interestingly, STIMS appears to function as both a research proposal submission system and a PMS system. As the current STIMS system does not appear to be completely separated, the separation of the two modules is the first task that should be completed. This will help in operating the entire systematic R&D cycles going forward. However, the modules should be linked with certain information, otherwise each DB cannot be automatically linked, which means manual work is required. An example key value to link the two systems would be a unique control number for each project. Once a proposal is submitted, a unique project number is assigned to it. This number is used as a key value between the PMS and the proposal submission system. This allows anyone to search and extract project outlines (contract content, subject, research participants, and institution) from the project management system with the assigned number. To further develop the current STIMS, internal discussion is recommended to discuss how the research project support module should be separated from STIMS and what additional information should be included to capture the status of a project to its conclusion. In this chapter, we will discuss the considerations of implementing the PMS.

When implementing a PMS, the second task to undertake is to check how much of the R&D budget is spent by unit. In addition, one needs to consider which units (common and minimum units to capture R&D budget segmentation) can be used to collect execution details.

In South Korea, R&D units within ministries are divided into the Program and Project levels. A program unit is divided into three stages, and the lowest program unit is composed of a project unit. Once execution details are collected annually according to the designated unit (project unit in South Korea), the total aggregated project funds in the execution details equals to 98~100% of the initial R&D budget. Therefore, the annual R&D budget of each ministry can be comprehensively identified. Using this information, it is possible to know who conducted the research, the type of research that was conducted, and the amount of funds that was spent.

Once the prerequisites for PMS implementation (obtaining the annual R&D budget of each ministry and designating a collection unit) have been resolved, the current project status of management, the project type, the relevant regulations, and the opinions of the researchers should be investigated for organizations that carry out and support project management. Once an agreement (contract) is signed for a project, the project contents can be acquired from the agreement to be embedded into the PMS. As the current PMS is not capable of conveying all project data, it should be supplemented or upgraded with the contents of agreements using common data types by each organization. In addition, a diagnosis process should be performed on the current PMS system to help people recognize the necessity of upgrading the PMS. Through this process, project management organizations can better understand what regulations are required to collect/manage/service R&D-related information. Setting up relevant legal foundations makes it easier to efficiently perform R&D data collection and management. In addition, all of the information, opinions, and data obtained during this investigation process are useful in the process of building an integrated platform in addition to PMS. Further recommendations for the PMS implementation stage are as follows.

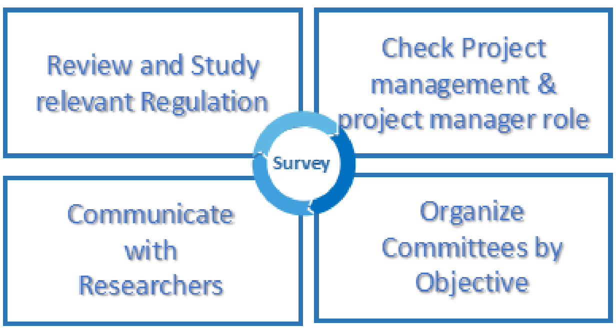
① Reviewing relevant regulations: It is necessary to verify whether there is a grounded regulation or not for the entire cycle of a project (from public offering-selection-assessment-management-publishing output). If there are no regulations, reviews should be conducted to determine which statements are needed and each stage to collect information and to modify current statements for the future. In particular, it is important to include regulations regarding the “data collection” process as this is the cornerstone for all government R&D data.

② Checking the project management procedures and the role of the project manager: This step evaluates what should be included in the project contract (agreement) in terms of the current project life cycle (proposal submission-selection-assessment-management), and identifies the areas that should be supplemented in current project management activities. In particular, the role of project managers in the project performance cycle should be considered. The role of the project manager in terms of creating relevant regulations is clearly defined with a responsibility in project management operations. Discussions on this topic are the most important axis in PMS design.

③ Communicating with researchers: Topics from researchers are highly extensive and all opinions should be categorized. Although there are a wide variety of opinions on subjects such as R&D support procedures, the amount of R&D support and duration, etc., opinions should be collected and reflected in a limited manner in platform services. Others must be shared with the related managers at each stage to advance to the following stage in the life cycle.

④ Organizing working committees: As it is not possible for a single team to implement regulations, determine the task management status, and fulfill the manager role of checking at the same time, it is necessary to form a sub-committee to present comprehensive plans and opinions exclusively for each topic. This should be also stated in the regulations.

[Figure 3-59] Investigaion for PMS implementation



One key consideration is related to those who work on the project. Before building a PMS, everyone involved in the platform project must have the same level of information at each stage of statistical collection, management, calculation, and distribution to ensure a smooth process. The first meeting should check the level of information regarding the R&D statistics of each participant, sharing the information they know to adjust each participant's information level. If the information, knowledge, and experiences between the participants are not uniform, these gaps may appear during the middle of the process and cause delays or distort the project direction. For this reason, it is crucial to share all information between the participants in the first meeting. This report presents a sample checklist of questions (Appendix 2) that a third party can use while reading the Sri Lanka Science and Technology Statistics Report and Services.

It is important to define the concept and range of the R&D data collection unit (same as the R&D data support unit), if it currently does not exist. The PMS framework should be created with the established concept and linked to the other DBs (such as the researchers DB).In addition, the performance collection should be performed on this unit as well. The R&D data collection unit should also be considered for all cases from the other ministries for future system migration.

The following is a list of sample considerations for R&D data collection. Therefore, at minimum, these considerations should be discussed and mutually agreed upon to the fullest extent possible.

[R&D data collection]

① What information is collected when collecting execution details of the R&D projects?

② Is the information effectively collected from the current project contract (agreement)?

③ What are the policy motivations to encourage researchers to submit projects and performance data?

④ To what extent will information be collected about the project performance agency and the project participating agency? Is a management code necessary for the management of the project performance agency and the project participants?

⑤ Is there a unique management code for research programs and projects within the ministries? If so, how can these be managed and what improvements can be made?

⑥ After the project agreement is in agreement and a DB is formed, how often will the execution details be collected? When will the details be collected?

⑦ What are the outputs by project type?

⑧ What can be done if it can be categorized as common output types?

⑨ Who should input the data into the system? Is it possible for anyone who participates in the research or only the principal investigator?

⑩ Should data be continuously updated in the system, or should it be updated at a certain period?

3.4.3.2 Researcher DB linkage and upgrade

Researchers participating in projects supported by the NSF are required to first be registered with the STIMS DB, which meansthere is an existing DB of research-specific identification numbers (codes). Given this fact,it is assumed the researcher information of the STMIS DB can be utilized through the Scientist Search feature of the STI Dashboard.

Before upgrading the researcher DB, it is recommended to check how muchinformation regarding each researcher's performance, affiliation, results, major co-researchers, co-researchers, R&D participation status, and role by project are covered in the existing DB. Through this process, the scope of information disclosure of the platform can be determined regarding whether or not it is allowable to be presented in the STI Dashboard.

The study of science and technology fundamentally begins with a researcher. Collaboration between researchers can contribute to the exchange of mutual knowledge, skills, and other expertise. In this sense, researcher information (including information on activities) is a key material in scientific technology data management that cannot be overlooked. Analysis and tracking of researchers will have important implications not only in terms of fostering the advancement of science and technology, but also in terms of boosting research itself.

3.4.3.3 Implementing the integrated platform

Whereas NSF collects and establishes R&D information, COSTI has a different mission in providing information via the web. As such, the system operates differently at each end. In conjunction with the different systems, it is important to differentiate between agency personnel that generate data and those who service the data to clarify the scope of their respective roles. The process of sending and receiving data is done automatically, but if the data is not properly maintained during the transaction, it can give rise to service errors. Therefore, the persons in charge at each system must sufficiently communicate during the data inspection and service process. In particular, confirmations need to be made with the service representative when adding new data to ensure the data is processed and published correctly. Representatives should plan data collection while being aware of the conditions and rules that will allow for smooth services within the system. If the data is added without prior communication between the involved parties, it may be necessary to modify the platform structure to be able to serve the data during the post-processing phase. Therefore, prior communication is definitely recommended to save post-effects and time.

In order to address these issues, the organizations that oversee data generation and provide services should consider the formation of a committee to discuss relevant data cycles from collection to services. The chairman of this committee should be from the Ministry of Science and Technology to steer the integrated platform in the desired direction.

The following are examples that should be considered when operating the integrated platform service based on the above premise. The examples can be modified and implemented through a comprehensive outreach process.

① It is important to consider whether COSTI should implement and manage the DBs directly at COSTI's end or whether these tasks should be assigned to organizations that collect and calculate the data. If the DBs are implemented at the organizations, COSTI also needs to operate an integrated service DB that manages all received data from the initial collectors.

▶If COSTI directly manages the data for each of the four domains of data collection, it does not need to setup another data curation process with the received data at their end.

② The structure and hierarchy of the data should be considered for each domain. Government

R&D data and global competitiveness data are different types of data with different hierarchies. As such, the data structure for each domain can differ. In this case, the user experience of the web may be inferior; therefore, user behavior should be fully considered when structuring the services.

③ Lastly, the service functions (search, download, print, save, etc.) that are provided in each screen should be configured based on user patterns to enable the use of data based on navigation flows and icons according to the purpose of the user's data.

We reviewed the main details of the upgrades that were implemented forthe PMS and the researcher DB, which is a necessary prerequisite for the implementation of the integrated platform. In addition, we reviewed the considerations regarding the information service implementation.

As Sri Lanka has different social and cultural background to Korea, it's not necessary for the system to be implemented in the same manner as in Korea. If restrictions occur during the implementation process due to differences in organizational and social culture to Korea, it is necessary to go through a deliberate process to adjust the suggestions to the actual situation with the understanding of the original purpose.

3.5 Conclusion and Limitations

Significant trial and error was involved in the process of creating, managing, distributing, and spreading data for the Korean information service for national R&D projects, which has been managed and operated for over a decade since 2008. The considerations presented in this paper are based on the lessons learned from solving various problems (e.g., the lack of thorough initial planning, unexpected system errors, conflicts among staff) under the assumption that South Korea would re-design the integrated platform.

Three major agencies within the Ministry of Science and Technology currently produce and publish statistics that are directly or indirectly related to Sri Lanka's science and technology and government R&D through papers or online services. However, we believe that there is still a lack of a pre-periodic management system that can generate utility value for the R&D

data. In particular, it is important to understand how the national budget is being utilized for the development of science and technology. However, the three Sri Lankan agencies does not provide details regarding government R&D information.

Therefore, the roles of the aforementioned three agencies should be reset according to the collection-analysis-utilization cycle in line with the mission of the three agencies. For the collection of government R&D data, we propose the separation of the research support system and the project management system in addition to upgrades for the researcher database.

In order to provide data that are generated and managed by various organizations through a single integrated platform, cooperation and communication is necessary between the organizations that collect and manage the data. Through this communication, the basic DB, which becomes the backbone of government R&D data, should be designed in a systematic and compatible manner, taking into account the long-term development direction of the integrated platform. This will minimize the problems caused by technical conflicts during the operation of the integrated platform.

This study was limited in obtaining detailed and whole information on the data collection route, collection method, usage period, and operation method of the nationwide R&D data survey that is conducted by the Ministry of Science and Technology of Sri Lanka. For this reason, the proposed integrated platform has a stronger function as repository that first focuses on storing raw data and providing information services according to data generation.

In the future, with more widespread understanding of the need to utilize an integrated platform through interviews, in addition to greater amounts of information on the overall government R&D data collection process, its management status, and additional R&D data, we hope the details regarding the platform implementation proposed in this report can be developed further.

For further reference to the Korean case, an outline of the R&D data mechanism of the Korean Government can be found in Appendix 3.

[Appendix 1]

The Sri Lanka Science, Technology & Innovation Statistics Handbook is composed of the following standards.

Financial Resources for Research and Development

① Gross Expenditure on R&D (GERD) in Sri Lanka 1966-2015

② Gross Expenditure on R&D (GERD) in Selected Countries

③ National Gross Investment on R&D by Source of Funding 2015

④ National Gross Investment on R&D for Different Sectors by Source of Funding in 2015

⑤ Trends in Gross Expenditure on R&D (GERD) by Source of Funding as a Percentage of GDP 2008-2015

⑥ Trends in National Investment on R&D by Source of Funding 2008-2015

⑦ National Gross Expenditure on R&D (GERD) by Sector of Performance 2015

⑧ Trends in National Expenditure by Sectors of Performance 2010-2015

⑨ Percentage of Gross Expenditure on R&D (GERD) by Source of Funding in Selected Countries

⑩ National R&D Expenditure by Nature of Research Activity 2015

⑪ National R&D Expenditure by Nature of Research Activity 2013-2015

⑫ Percentage of GERD by the Type of R&D Activity in Selected Countries

⑬ National R&D Expenditure of Different Sectors by Discipline 2015

⑭ National R&D Expenditure by Discipline 2008-2015

Human Resources in Science and Technology

① Distribution of R&D Scientists (Headcount) by Sector 2014-2015

② Number of R&D Scientists (Headcount) by Discipline and Gender 2014-2015

③ Educational Qualifications of R&D Scientists 2015

④ Distribution of R&D Scientists Full Time Equivalent (FTE) by Sector 2015

⑤ Distribution of R&D Scientists of Full Time Equivalent (FTE) by Discipline 2015

⑥ Educational Qualifications of Full Time Equivalent (FTE) Scientists 2015

⑦ Number of R&D Scientists (Headcount) by Age and Sex 2015

⑧ Number of R&D Scientists in Selected Countries

⑨ World Statistics of Researchers by Formal Qualification & Sex (Headcount)

⑩ Science and Technology Personnel (STP) by Category 2015

⑪ Distribution of Science and Technology Personnel (STP) by Sector 2013-2015

⑫ Distribution of Scientists and Technologists (in R&D and S&T Services) by Discipline 2015

Performance Indicators for Science and Technology

① Number of Patents Locally Applied and Registered During 2000-2015

② Number of Industrial Design Locally Applied and Registered During the Period of 2000-2015

③ Distribution of Patents Registered According to Classification 2013-2015

④ Patent Applications in Selected Countries 2013-2015

⑤ Main Fields of Publications in the SCI Journals 2013-2015

⑥ Knowledge Disseminations During 2015

⑦ Science & Technology Postgraduate Output 2013-2015

Innovation Indicators

① R&D Expenditure by Different Industrial Categories 2015

② Percentage of Total Revenue that came from the Sale of Products & Services by Industries Involved in R&D 2016-2015

③ Industries Involved in R&D in 2006-2015

④ Number of Innovations Developed by Business Enterprises in 2015

⑤ Number of Innovations Developed by the Government Sector (R&D) Institutions in 2015

⑥ Number of Innovations Developed by the Higher Education Sector in 2015

⑦ High-Technology Exports (Current US$) in Selected Countries 2013-2015

⑧ Involvement of Industrial Sector with Other Institutions in Conducting R&D and Innovation Activities 2006-2015

⑨ Countries where Sri Lankan Business Enterprises Acquired their Technologies during 2008-2015

⑩ Methodologies Used by Industries (%) to Protect their Intellectual Property Rights (IPR) during 2006-2015

Key Socio-Economic Indicators

① Demographic Indicators of Sri Lanka 2014-2015

② Demographic Indicators of SAARC Countries

③ Social Indicators of SAARC Countries

④ Economic Indicators on National Output and Expenditure

⑤ Composition of Exports 2014-2015

⑥ Composition of Imports by Major Categories 2014-2015

⑦ Realized Investments in the Board of Investment (BOI) Enterprises 2014-2015

⑧ Education Indicators in General Education

⑨ Number of Government Schools 2015

⑩ Number of Students Studying Science at the G.C.E. Advance Level in Government Schools 2015

⑪ Health Service Indicators of Public Sector 2012-2015

⑫ Key Indicators in Infrastructure Development in Public Communication Sector 2013-2015

⑬ Performance of Power and Energy Sector 2014-2015

[Appendix 2]

I. R&D project support and management

1. Overall

1) Are all national R&D projects managed by the NSF in Sri Lanka? Or do the ministries work independently?

① If NSF covers all R&D programs in Sri Lanka, are you aware of all related information like the annual R&D amount, the number of projects, and the program list and types?

② If the NSF does not cover all programs, which ministries other than the S&T ministry carry out R&D projects?

- Are R&D programs selected and executed at the same time through the same process? Or does it differ from ministry to ministry?

2) Are there regulations and systems that can manage the R&D programs of ministries in an integrated manner?

3) How is Sri Lanka’s R&D program structured? (i.e., what R&D program units are supported or managed)

① How does the R&D support program proceed from bottom-up and top-down? Does it depend on the type of support?

② Is there a defined concept in terms of project management in the R&D environment?

③ How many years is a project period? What are the criteria if this period varies for each project?

4) Sri Lanka hopes to establish a science and technology monitoring portal that can be used to make policy decisions. What was the motivation for this?

5) Should the portal service still be limited to the scope of government R&D? Should all of Sri Lanka's science and technology be included as a whole?

2. STIMS (proposal submission & project management system)

1) Does the selected project have an agreement (contract) procedure, or is the agreement replaced by notifying the selected project?

2) If a proposal is selected, how will the funding amount for the project be decided? (is the R&D funding amount by project fixed according to the R&D field, or is it decided by the advisory committee with consideration of the amount submitted by the researcher?)

3) Is this system connected to the project management system that contains the performance details/results of the selected projects?

※ The project management system manages all contract project details. This system also collects, records, and manages the performance produced by each project.

※Thus, the research proposal system, which is used to accept proposals, can be part of the project management system, or it can be linked to the project management system via a separate module.

4) Is NSF's STIMS (proposal submission system) a project proposal system for all ministries or is it only supported by the S&T ministry?
   ① If STIMS only supports the S&T ministry, is there a system like STIMS in other ministries?

3. Collection of R&D execution and output

1) Is there gathered information on the number of projects and how each are carried out? Or is this a plan for the future?
   ① Is it collected by a ministry unit (i.e., by the ministry that approves research projects) or is it managed by only one organization once it is approved?
   ② If identified by each ministry, do you plan to incorporate it? Do you plan to keep it separate from the decision-making process?
2) Does each department produce a statistical survey report that analyzes the status of government R&D by project, by output etc.?
   ① If so, what data are collected/analyzed? If not, why is this the case?
3) The contents of the project agreement are expected to differ depending on the type of project (supporting participation in overseas academic societies, supporting scientific research, supporting equipment/facilities, etc.). Is there a national standard form, or are the projects independently developed?
4) Are expected output goals set in the project agreement or project outline for future work?
5) Does each R&D project/task have its own management number, so it can be distinguished without overlap across all departments?
6) Are the types of outputs collected by each NST defined? Or is it possible for researchers to choose autonomously (do the output types depend on the type of program?)?

7) In Sri Lanka, which performance indicators do the R&D output place more weight on?

① Papers (journals), patents (technical), economic/social performance

② What other types of outputs are there?

4. ETC

1) If raw data or statistical data on the government R&D program of your country are needed, how can one obtain such information?

2) Who are the main users of science and technology statistics?

3) In what ways are the data used? (for what purposes?)

5. Researcher DB

1) Once registered with STIMS, an ID is assigned. Is this ID available as a unique identification code in all departments or only available within the registered ministry?

2) How and where is this DB currently being used? Is the information provided by the Scientist Search on the STI Dashboard sourced from the researcher DB of STIMS?

II. R&D Data Statistics

1. Statistical Handbook

1) Based on the utilization of data for 2008, 2010, 2013, 2014, and 2015, the latest reports were published annually and the lead time is estimated to be about two years. What is the official release cycle?

2) How many years and months does it take to collect, manage, and analyze data?

3) How are the domestic statistics provided by the statistical Handbook published by NSF collected? Online or Paper Survey?

① Is it carried out by the person in charge of the organization? Is this task outsourced?

② How many personnel are involved in this work (regardless of whether a separate agency exists)?

③ How long after a questionnaire is distributed are the answer sheets collected?

④ How long does it take to receive a questionnaire and process the data, and how much time is required to publish a statistics book?

4) Is the Statistical Handbook data the same every year? Are there modifications?

① If there are regular modifications, what procedures are used to implement the modifications?

5) Is the final product a report? Is it a statistical book or another type of report?

6) After the final publication, how are the statistics managed?

① After the publication of statistical books, are the raw data organized/managed to a level that can be published/distributed as electronic file?

7) What are the difficulties in collecting, managing, and analyzing the data?

2. Sri Lanka Innovation Dashboard by COSTI

1) Through which process is the data collected?

2) How is the website data updated? How often does this take place?

3) What was the implementation process/flow during the initial setup? (How do you decide who gathers the information or makes a DB?)

4) How long did the initial implementation take?

3. Sri Lanka Science, Technology Status Report by NASTEC

1) How does the research institution distribute, aggregate, and organize the questionnaires for the evaluation?

2) Are 45 organizations evaluated each year, or are there cycles by agency? What data are included in the survey and evaluation regarding an institution's performance?

3) How much time is required to produce statistical output from electronic data?

4) How often do you publish?

① What are the difficulties in collecting, managing, and analyzing the data?

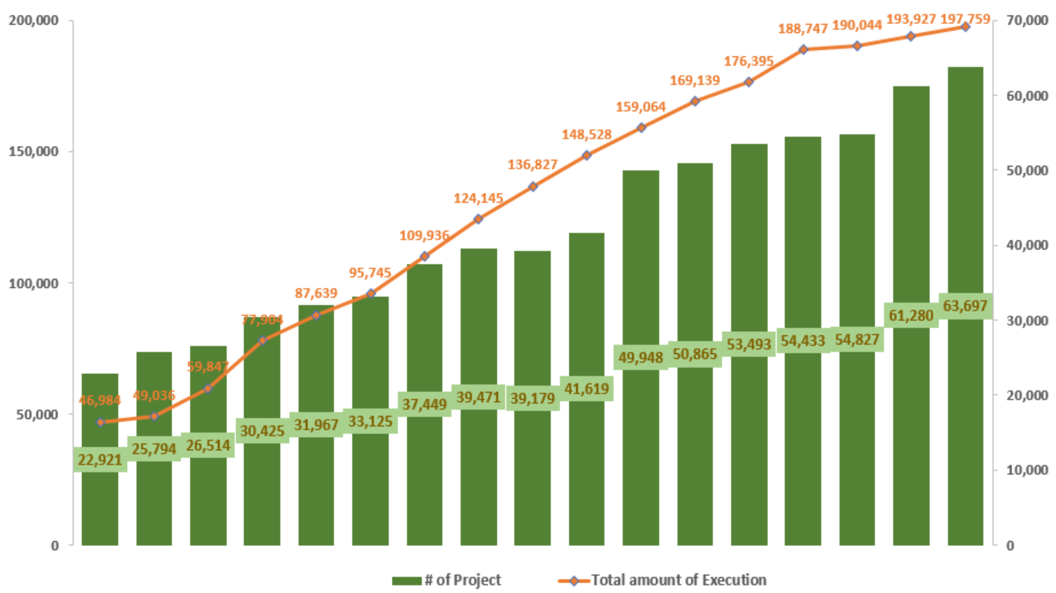
[Appendix 3] R&D Data Mechanism of the Korean Government

Korea initiated its government R&D support project in 1982 and has collected details on the government R&D enforcement conducted across all ministries in a unified manner since 1999. This provides a means of seeing how each ministry utilizes its budget and how success is achieved through its endeavors.

R&D budgets are classified by year. The amount and output of supported projects are also surveyed according to the year of occurrence. However, R&D output must be recorded with project information to be able to identify which projects contribute R&D output. This is one method of linking R&D investment and R&D output.

A total of 63,697 R&D projects were carried out in 2018. The R&D details and output generated in 2018 are the result of a steady increase in R&D investment over the past decade. Although the growth in R&D investment has slowed down in recent years, the R&D budget is expected to increase in 2020 to strengthen competitiveness in the field of materials and components technology.

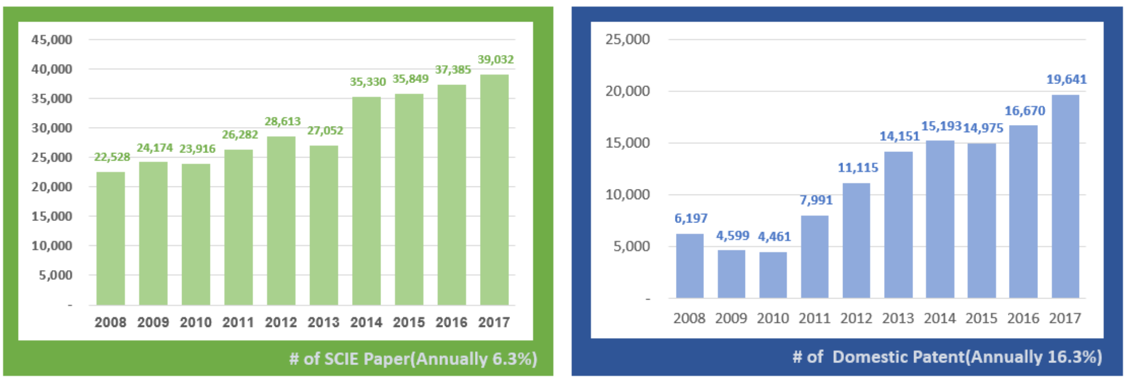
[Figure 3-60] 2002-2018 R&D Execution in Korea



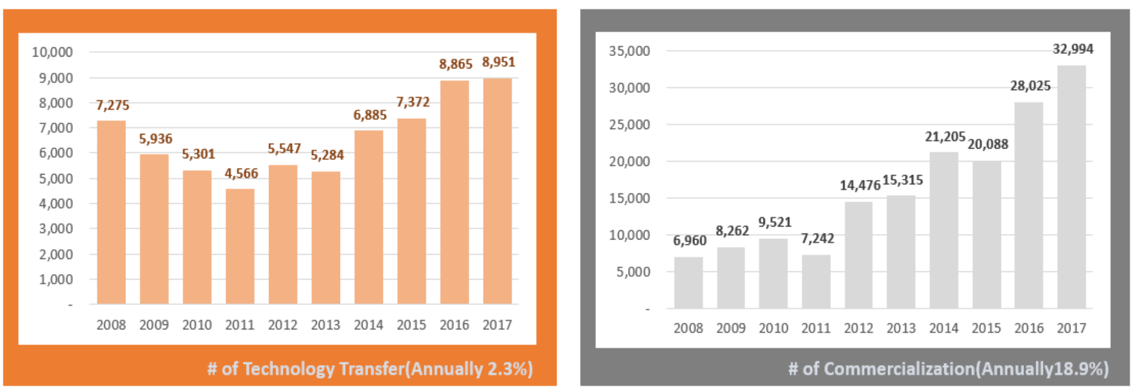
Surveys of the execution details of R&D support began in 1999, but a survey of R&D outputs was conducted as a trial between 2005 and 2006. The official survey was first conducted in 2007. Initially, 15 output types were recognized and collected. As a collection standard, Korea collected/investigated common outputs between departments (papers, patents, technology costs, commercialization, human resource development, educational support, etc.)

For detailed collection such as collection methods and calculation methods of each performance type, KISTEP (Korea Institute of S&T Evaluation and Planning) conducts two to three consultative meetings with R&D project management agencies each year to improve the procedures and standards for collection and verification.

[Figure 3-61] Trend of SCIE Papers and Patents



[Figure 3-62] R&D Outputs by Year and Type

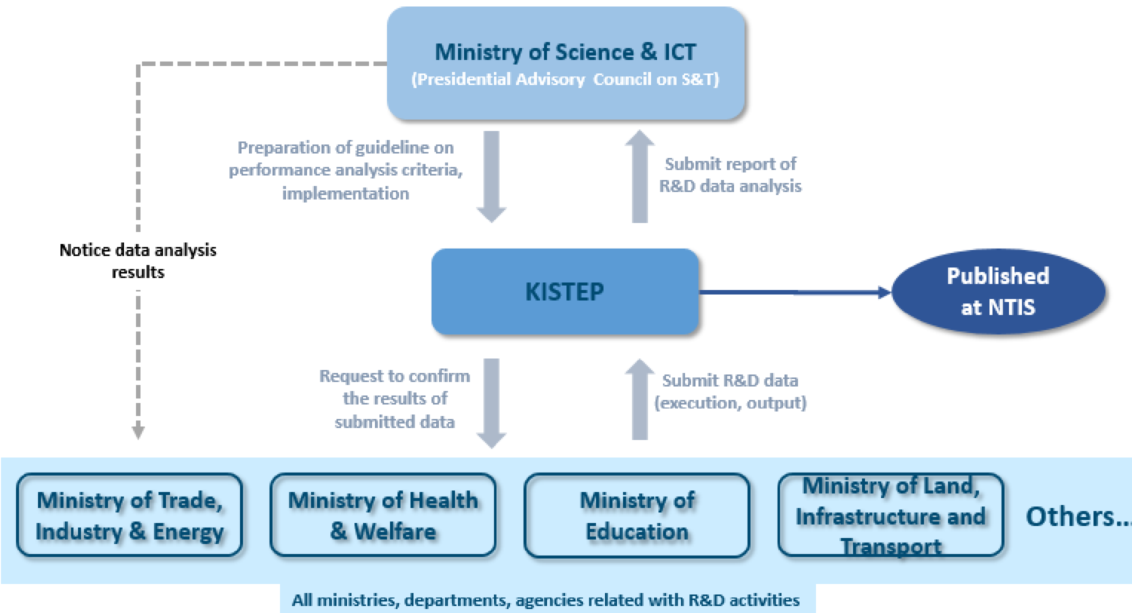


1. The Collection of R&D Data by the Korean Government

The Ministry of Science and ICT investigates the domestic R&D execution of all government ministries. KISTEP, which is under the Ministry of Science and ICT, utilizes the Standard Information Management System (SIMS) module within the National Technology Information Service (NTIS) system to store records of R&D execution and performance data through the collection process.

In addition, organizations established under each department that conduct R&D projects are determined according to the joint regulations of national R&D projects and the laws of each ministry (selection, execution, and management based on legal grounds).

[Figure 3-63] Systematic Schema of R&D Execution and Result Survey



The SIMS systems can receive data in conjunction with the project management systems (PMS) of each ministry, or the businesses/projects of agencies if there is no available PMS that can directly import data through the web page using Microsoft Excel file formats. The execution details do not have issues in collection as it is inherited from the overall project agreement, but the output data cannot be traced without manual inputs into the system. For this reason, a data input briefing is held in November every year.

The input briefing presentation offers guides on the changing collection and verification procedures such as newly collected data, change in collected data, and verification criteria. In addition, the involved parties are encouraged to import the correct information to prevent potential issues and the needs for manuals.
The collected information is used to evaluate R&D projects and serves as a basic reference for R&D budget allocation. In particular, a certain degree of obligation is given to R&D output data collection. If the data is not imported, then some outputs may be missed in the annual project evaluation.

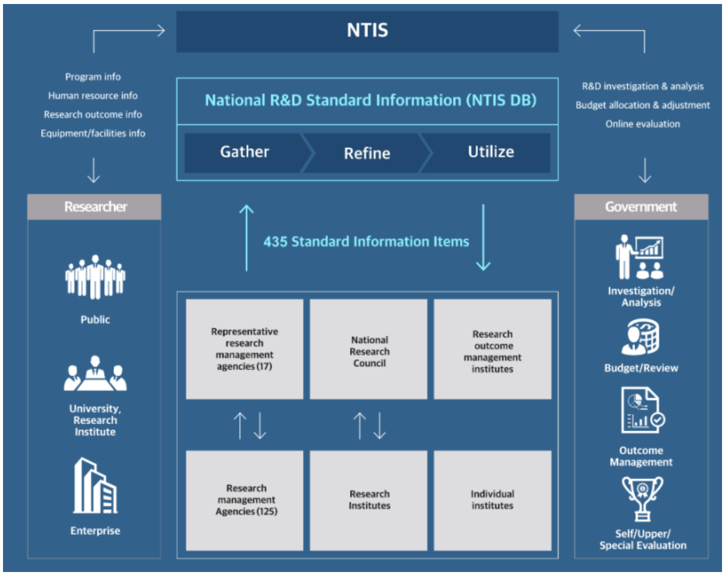
The collected data are verified through a six- to ten-month verification process and the main statistics are published as reports and statistics tables. Statistical data of the published reports are provided through the integrated platform to enable any user to analyze the data for any purpose. The statistics service is determined by the inspection personnel for data. As the statistics are related to the data collected by project unit, the fixed data is linked to the information of each project, and statistics can be viewed according to project information and output information in the statistical analysis menu. In addition, accurate scheduling is essential due to the fact that the time at which the previous year's data is finalized overlaps with the collection period of new R&D output data.

As mentioned in a previous section, Korea has separate institutions for collecting R&D data and providing services. Due to the different roles of the institutions, data extraction issues in the system, missing data, and rule errors are frequent occurrences when publishing confirmed data during the stages of data collection, verification, confirmation, and publication. Problems arise due to different interpretations and solutions for data collection and management, and the duties of platform personnel who provide services or generate data vary depending on the circumstances. Therefore, significant effort is made to foster communication between the project managers and the institutions.

2. The R&D Data Integration Platform Service of Korea

Korean Ministry of Science and ICT prepared the First Basic Plan for Research and Development Activities (2006-2010) in 2006 to enhance the efficiency of government R&D projects by exploring/promoting the basic direction in addition to various projects to promote the management/utilization of government R&D projects. The basic strategies of this plan included establishing a comprehensive management system for research outputs, promoting research outputs and utilization, and establishing a research performance and management/utilization infrastructure. One of the promotion strategies of this plan was the implementation of an information system that comprehensively collects/manages research outputs and provides them for convenient use by consumers. The National Science and Technology Information Service (NTIS) implementation plan was prepared in 2007 and services were first provided to the public in early 2008.

[Figure 3-64] NTIS Service Concept



Currently, NTIS consists of entire cycle R&D information, project and output information, researcher information, data utilization, and R&D Plus. Submenus are included for each menu and various statistics, including R&D statistics, are provided in the data utilization menu. The statistics provided by the Data Utilization menu provide raw data such as survey statistics, national R&D statistics, various competitiveness statistics, and OECD statistics. This menu also provides raw data in the Microsoft Excel format so that users can easily perform desired analyses and be provided with a pivot tool for statistics. Currently, only information that can be disclosed/opened are provided. As the collection demand for detailed data increases, opinions on the inspection and demand for collection are regularly gathered. Furthermore, a service satisfaction survey is conducted on a regular basis according to user level (e.g., related institutions and individual users). In addition, annual competitions are held using data provided by the platform to improve convenience and availability every year.

Through such efforts, the government strives to promote science and technology in a multitude of fields. For developing countries, NTIS is a benchmark that provides useful know-how in managing scientific & technological data and information services. One example of a nation that uses NTIS as a benchmark is Costa Rica, which it started in 2018. NTIS continuously communicates with people and organizations related to the overall life cycle of national R&D data and strives to realize information services by integrating various technologies suitable for the ICT environment.

CHAPTER 4

Capacity Development Process

2019 Policy Consultation on Supporting the Improvement of Science, Technology, and Innovation (STI) Policy and Institutional Framework for Sri Lanka

Chapter 4. Capacity Development Process

1. Kick-off Workshop and Field Research

1.1 Introduction

1.1.1 Objectives

The objective of this workshop was to introduce team members from two partner institutions—STEPI and NASTEC—and to discuss the detailed schedule and scope of the 2019 Project. Following the kick-off meeting, the STEPI team conducted field research on Sri Lanka's STI policy and governance and interviewed several STI stakeholders in Sri Lanka.

1.1.2 Korea's Research Team

[Table 4-1] Korea's Research Team

Name	Organization	Position & Area of Expertise	Contact Information
Chi Ung Song	STEPI	Vice President	cusong@stepi.re.kr
Wangdong Kim	STEPI	Chief Director of the Division of Global Innovation Strategy	wangdkim@stepi.re.kr
Inkyoung Sun	STEPI	Head of Development Cooperation Research	isun@stepi.re.kr
Byung Woo Jeon	STEPI	Researcher/ Project Coordinator	bwjeon@stepi.re.kr

1.1.3 Sri Lankan Delegation

[Table 4-2] Sri Lankan Delegation

Organization	Name	Position
Ministry of Science, Technology, and Research (MSTR)	Chinthaka S. Lokuhetti	Secretary
	Nazeema Ahamed	Director
Ministry of Megapolis and Western Development	Rahula Senanayake	Deputy Project Director
	U.G. Ratnasiri	Additional Secretary
Coordinating Secretariat for Science, Technology, and Innovation (COSTI)	Navodi Wickramasinghe	Deputy Project Manager
Arthur C. Clarke Institute for Modern Technologies (ACCIMT)	Shiran A. Welikala	Senior Deputy Director
Sri Lanka Institute of Nanotechnology (SLINTEC) Coordinating Secretariat	Harin de Silva Wijeyeratne	Chief Executive Officer
	Dulain Senarath Yapa	Executive Business Development
National Science Foundation (NSF)	Prof. Ananda Jayawardane	Director General
	J.G. Shantha Siri	Head
	Wasantha Anuruddha	Head
National Science and Technology Commission (NASTEC)	Dr. Kalpa Samarkoon	Senior Scientist
	Mr. Seyed Shahmy	Senior Scientist
National Intellectual Property Office of Sri Lanka (NIPO)	Nissansala Abhagamwan	Assistant Director
National Research Council of Sri Lanka (NRC)	Ms. Manisha Rajakse	CEO
Sri Lanka Inventors' Commission (SLIC)	Mr. A. Nmahnama	Head
University of Colombo	Prof. K.R. Ranjith Mahanama	Dean, Faculty of Science

1.1.4 Schedule

[Table 4-3] Workshop Schedule

TIME	EVENT	REMARKS
Monday, March 25, 2019		
22:40 -	Departure from Incheon Int'l Airport	Flight #: KE473
Tuesday, March 26, 2019		
04:30 - 07:00	Arrival at Colombo Airport, Sri Lanka Airport → Hotel	
07:00 - 11:30	Hotel Check-in & Break	Hotel: OZO Hotel
11:30 – 12:30	Lunch	
13:00 – 14:30	STEPI-NASTEC Workshop (Kick-off Meeting at NSF auditorium)	Introduction by each of the institutions for 10 min [NASTEC/NSF/NRC/NIPO/SLIC]& STI Policy in Sri Lanka [STEPI] Introductions to: - STI Policy in Korea (Dr. Song) - STEPI STI ODA Program (Dr. Kim) - 2019 STEPI-NASTEC Project (Dr. Sun)
16:00 - 17:00	* Meeting Ministry of Science, Technology, and Research	[MOSTR] chaired by the MOSTR Secretary [STEPI] Introductions to: - STEPI Korea (Dr. Song) - STEPI STI ODA Program (Dr. Kim) - 2019 STEPI-NASTEC Project (Dr. Sun)
Wednesday, March 27, 2019		
9:30 - 11:30	Arthur C. Clarke Institute for Modern Technologies (ACCIMT), Moratuwa	* Site visit/Interview/Meeting
11:30 - 13:00	University of Moratuwa /Innovation and Entrepreneurship	* Site visit/Interview/Meeting

TIME	EVENT	REMARKS
	Incubation center (Mora Ventures)	
13:00 - 14:00	Lunch	
15:00 - 16:30	Sri Lanka Institute of Nanotechnology (SLINTEC)	* Site visit/Interview/Meeting
17:30 - 18:00	KOICA Office in Sri Lanka	* Meeting
Thursday, March 28, 2019		
09:00 - 10:00	University of Colombo/Science and Technology Cell	* Meeting
10:00 - 11:00	STEPI Researcher Discussion	* Meeting at NASTEC
11:00 - 12:00	STEPI-NASTEC Wrap-up	* Meeting: Finalize the scope and schedule of the 2019 project
12:00 - 13:30	Lunch & Hotel Check-out	
13:30 - 15:00	Embassy of Korea in Sri Lanka	* Meeting Ms. Mi-Kyung Kim
15:00 - 16:30	→ Airport	
19:00 -	Departure from Colombo Airport	Flight #: KE474
Friday, March 29, 2019		
- 06:10	Arrival at Incheon Int'l Airport	

1.2 Kick-off Workshop and Field Research

From March 25 to 29, 2019, the STEPI team—Dr. Chi Ung Song, Dr. Wang Dong Kim, Dr. Inkyoung Sun, and Mr. Byung Woo Jeon—visited Colombo and conducted the Kick-off Workshop. The aim of this workshop was to introduce the project and to set the project output. Furthermore, the STEPI team visited and interviewed the Ministry of Science, Technology, and Research (MoSTR), science institutions including Arthur C. Clarke Institute for Modern Technologies and Sri Lanka Institute of Nanotechnology, and Science and Technology Cell at University of Colombo. It was a very fruitful to collect essential information on Sri Lanka's science and technology governance and system.

1.2.1 1st Day – Kick-off Workshop

a) Introduction to STEPI's ODA Program

Dr. Wang Dong Kim (head of the STI ODA Project) introduced STEPI's work since 2013. He mentioned that the previous experiences of the ODA program were reflected to the contents of the program in 2019. In order to enhance the quality of the program, meetings, interviews, and discussions were organized with other ODA experts. As a result, suggestions were made to the program based on the development stage of partner countries, which starts from the national-level STI policy vision and plan to detailed action program like national technology roadmap, STI park establishment, and technology transfer and so on.

b) Introduction to the STEPI-NASTEC Program

Dr. Inkyoung Sun (Sri Lanka Project Manager) introduced the general project concept. She mentioned the two goals for 2019-2020: first, identify the impediments to the effective implementation of S&T policies; second, develop (incentive-based) strategies—action plan and/or instiutional framework—to eliminate or minimize such impediments. In addition, she aimed to listen to the current STI-related situation from Sri Lanka.

c) Introduction to National Science & Technology Commission (NASTEC)

It was established under the Science and Technology Development Act ('94), has been in operation since 1998, and is now an organization under the Ministry of Science, Technology, and Research. It is mainly an advisory body of government on science and technology research and related policies.

d) Introduction to National Science Foundation (NSF)

NSF is a government-funded organization under the Ministry of Science and Technology, established in 1998 under Article 11 of the 1994 Science and Technology Act. It is the successor to the Sri Lanka Resources, Energy, and Science Council (NARESA), which also succeeds the National Science Council (NSC) established in 1968.

e) Introduction to National Research Council (NRC)

NRC is a government-funded organization founded in 1999 to fund Sri Lankan public sector scientists. Its major work is to promote the government's research on science and technology to help build an active science and technology community.

f) Introduction to National Intellectual Property Office (NIPO)

NIPO was founded in 2003 under the Intellectual Property Act and is responsible for the administrative work of the intellectual property system in Sri Lanka. Its major work is to manage intellectual property including trademark registration, patents, industrial design, and registration.

g) Introduction to Sri Lanka Inventors Commission (SLIC)

SLIC is a statutory body established in terms of the Sri Lanka Inventors Incentives Act No. 53 of 1979. The principal objective of setting up of the SLIC is to promote inventiveness of the nation by providing technical, financial and legal assistance.

h) Meeting with the Secretary of Science, Technology, and Research

The STEPI team held a meeting with Mr. Chinthaka S. Lokuhetti (Secretary of Science, Technology, and Research). Dr. Kalpa and Dr. Sun explained the 2019-2020 program. Mr. Chinthaka S. Lokuhetti showed great interest in the program and talked about Sri Lanka's science and technology data, which have not been well-organized and managed by Sri Lankan institutions. He also emphasized the need for an organization devoted to the national science and technology innovation coordination and monitoring system.

1.2.2 2nd Day - Field Research

a) Arthur C. Clarke Institute for Modern Technologies (ACCIMT) Interview

Shiran A. Welikala (Senior Deputy Director) introduced the Arthur C. Clarke Institute for Modern Technologies (ACCIMT). According to him, Sri Lanka has the technology to use in the domestic market, but there is no market for the use of their technology. The most recent technology transfer case was early 2000s (transportation system development), since at that time there have been no cases of technology transfer. He emphasized that there is a technology, but no platform for technology transfer. The Sri Lankan government needs to participate actively in open platform for institutions. Moreover, he mentioned that there are currently 30 researchers (zero PhD researchers), and the government needs to continue funding to attract high-quality human resources.

b) Ministry of Megapolis and Western Development Meeting

Rahula Senanayake (Deputy Director) introduced the Tech City Project by the Megapolis and Western Development Department. He requested the cooperation of STEPI for Tech City led by the Sri Lankan government. Moreover, he requested active cooperation from STEPI because they have no experience with Tech City governance, operations, and policy guidelines. The STEPI team mentioned a case of operating and planning a project similar to Tech City. STEPI may suggest the strategy and direction of industry-university cooperation.

c) Sri Lanka Institute of Nanotechnology (SLINTEC) Interview

Harin de Silva Wijeyeratne (CEO) introduced the Sri Lanka Institute of Nanotechnology. According to him, technology development through nanotechnology is in progress, but there is difficulty in securing stable financial resources. He also said that there are several projects undertaken by the research institution, but most of the funding sources come from the private sector. Moreover, he explained that the private sector invests in specific research fields (healthcare and resources), but the amount of investment in other research areas is significantly smaller. He emphasized the need to secure financial support at the national level.

1.2.3 3rd Day - Field Research

a) University of Sri Lanka – Science and Technology Cell Interview

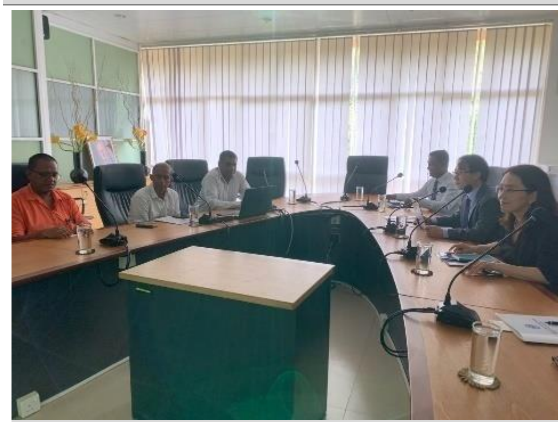
Dr. M.N. Kaumal (CEO) introduced the Science and Technology Cell of the University of Colombo and the actual research conducted by the university lab and research result connected to commercialization. In particular, collaborating students and faculty from the University of Colombo are working together on the project. In the case of the Cell, they are preparing sustainable funding sources through patents and commercialization. Nonetheless, Dr. M.N. Kaumal mentioned difficulties such as lack of detailed laws and regulations on patents and intellectual property rights.

[Figure 4-1] Kick-off Workshop and Field Research

STEPI-NASTEC Kick-off Meeting – March 26

Meeting with the Secretary of Science, Technology, and Research – March 26

Arthur C. Clarke Institute for Modern Technologies (ACCIMT) Interview – March 27



Ministry of Megapolis and Western Development Meeting – March 27

Sri Lanka Institute of Nanotechnology (SLINTEC) Interview – March 27

Science and Technology Cell Interview – March 28

2. STEPI-NASTEC STI Policy Workshop in Korea

2.1 Introduction

2.1.1 Objectives

To share the experiences of Korea and Sri Lanka in STI development and discuss current major STI policy issues in both countries

To improve understanding of the current national STI system in Sri Lanka and to develop strategies for more effective STI governance

- Presentations on the STI system and governance
- Workshops for the collective drafting of Chapters 3-5 of the country report

2.1.2 Korea's Research Team

[Table 4-4] Korea's Research Team

Name	Institution	Position
Dr. Inkyoung Sun	Science & Technology Policy Institute (STEPI)	Head of the Office of Development Cooperation
Mr. Byung Woo Jeon	Science & Technology Policy Institute (STEPI)	Researcher
Prof. So Young Kim	Korea Advanced Institute of Science & Technology (KAIST)	Professor Head of the Graduate School of Science & Technology Policy (STP)
Dr. Kwan Young Kim	Green Technology Center (GCT), Korea Institute of Science & Technology (KIST)	Senior Researcher Director of the Green Technology Partnership Initiative (GTPI)
Ms. Haengmi Kim	Korea Institute of Science & Technology Evaluation and Planning (KISTEP)	Associate Research Fellow

2.1.3 Sri Lanka's Research Team

[Table 4-5] Sri Lanka's Research Team

Name	Institution	Position
Prof. Jeniffer Perera	National Science & Technology Commission (NASTEC)	Member
Mr. Nimal Ranamukhaarachchi	National Science & Technology Commission (NASTEC)	Member
Mrs. D. Nandanie Samarawichrama	Ministry of Science, Technology and Research (MoSTR)	Additional Secretary (Administration & Finance)
Dr. Kalpa W. Samarakoon	National Science & Technology Commission (NASTEC)	Senior Scientist
Mr. Seyed Shahmy	National Science & Technology Commission (NASTEC)	Senior Scientist

2.1.4 Schedule

[Table 4-6] Schedule

Time	Event	Remarks
Monday, June 24, 2019		
-07:00	Arrival at Incheon Int'l Airport (ICN)	Flight #: KE474 Departure from Colombo: 19:00, June 23
07:00-09:00	To Hotel and check-in	Shilla Stay Gwanghwamun
13:00-14:00	Lunch	
14:00-15:00	Orientation	Dr. Inkyoung Sun & Mr. Byung Woo Jeon STEPI
15:00-16:30	[Seminar] STI Development in Korea: from Nation-building to Innovation	[Presenter] Dr. Inkyoung Sun Associate Research Fellow, STEPI
16:30-18:00	[Seminar] Introduction to Sri Lanka (Ch.2)	[Presenter] Mr. Nimal Ranamukhaarachchi

Time	Event	Remarks
Tuesday, June 25, 2019		
09:00-09:30	STEPI-NASTEC Meeting	
09:30-11:30	[Seminar] STI Data Mechanism: from Creation, Management to Application in Korea	[Presenter] Ms. Haengmi Kim Associate Research Fellow Korea Institute of S&T Evaluation and Planning (KISTEP)
11:30-13:30	Lunch	
13:30-15:30	[Seminar] STI Data Mechanism: from Creation, Management to Application in Sri Lanka	[Presenter] Mr. Seyed Shahmy
15:30-18:00	[Workshop] STI Data Mechanism (Ch.5)	All participants are expected to discuss and work together on a chapter on “STI Data Mechanism” in the country report.
Wednesday, June 26, 2019		
09:00-09:30	STEPI-NASTEC Meeting	
09:30-11:30	[Seminar] National STI System in Korea	[Presenter] Prof. So Young Kim Chair of the Graduate School of Science & Technology Policy Korea Advanced Institute of Science & Technology (KAIST)
11:30-13:30	Lunch	
13:30-15:30	[Seminar] National STI System in Sri Lanka	[Presenter] Prof. Jeniffer Perera
15:30-18:00	[Workshop] National STI System (Ch.3)	All participants are expected to discuss and work together on a chapter on “National STI System” in the country report
Thursday, June 27, 2019		
09:00-09:30	STEPI-NASTEC Meeting	
09:30-11:30	[Seminar] STI Governance and Policy in Korea	[Presenter] Dr. Kwanyoung Kim Director of the Green Technology Partnership Initiative (GTPI)

Time	Event	Remarks
		Senior Researcher, Green Technology Center (GCT), Korea Institute of Science & Technology (KIST)
11:30-13:30	Lunch	
13:30-15:30	[Seminar] STI Governance and Policy in Sri Lanka	[Presenter] Dr. Kalpa W. Samarakoon
15:30-18:00	[Workshop] STI Governance and Policy (Ch.4)	All participants are expected to discuss and work together on a chapter on “STI Governance and Policy” in the country report.
Friday, June 28, 2019		
09:00-12:00	[Field Visit] Korea Institute of Science & Technology (KIST)	https://www.kist.re.kr/
12:00-13:00	Lunch	
13:30-15:00	[Field Visit] Samsung d’light	https://www.samsungdlight.com/global/gate.html
16:00-18:00	[Field Visit] SK Telecom T.um	https://tum.sktelecom.com/eng/main.do
Saturday, June 29, 2019		
09:00-10:00	[Seminar] STI International Cooperation of Sri Lanka (Ch.6)	[Presenter] Mrs. D. Nandanie Samarawichrama
10:00-12:00	[Workshop]	Collective work of all participants on updating STI data and STI governance analysis, to be included in the country report
12:00-13:00	Hotel Check-out & Lunch	
13:00-17:00	Wrap-up Meeting	Feedback, suggestions & next steps
17:00-19:00	Dinner	
19:00-21:00	To Airport	
23:50-	Departure from Incheon Int’l Airport	Flight #: KE 474 Arrival in Colombo: 04:30+1

2.2 STEPI-NASTEC STI Policy Workshop in Korea

From June 24 to 29, 2019, the Sri Lankan delegation consisting of commission members, a senior officer, and two scientists from NASTEC attended the STEPI-NASTEC STI Policy Workshop in Korea. The purpose of the STEPI-NASTEC STI Policy Workshop was to share the experiences of Korea and Sri Lanka in STI development and discuss the current major STI policy issues in both countries. Moreover, the workshop aimed to improve understanding of the current national STI system in Sri Lanka and develop strategies for more effective STI governance.

2.2.1 Lecture

a) Orientation of the STEPI-NASTEC STI Policy Workshop in Korea

Dr. Sun introduced the goals of the STEPI-NASTEC STI Policy Workshop in Korea and the overall curriculum of the workshop.

b) STI Development in Korea: from Nation-building to Innovation – Dr. Inkyoung Sun

For the case of the energy sector, Dr. Sun explained how the energy sector in Korea started and developed gradually together with the industry, related STI capabilities, and national policies over the past five decades. While there was no single bullet to boost industrial development and gain global competitiveness in the energy sector, her presentation focused more on the evolutionary combination of policy, STI, and industry to reflect the changing sectoral ecosystem.

c) New Southern Policy of the Moon Administration in Korea – Mr. Byung Woo Jeon

South Korea's New Southern Policy was declared by President Moon Jae-in at the 2017 Korea-Indonesia Business Forum. A new Southern Policy can proceed based on 3P (People, Prosperity, Peace). A new Southern Policy is mainly focused on the ASEAN (Association of

Southeast Asian Nations) region. The vision of the new Southern Policy is to be consistent with the new Northern Policy to envision new economic guidance on the Korean peninsula. Many international development projects have been discussed in Sri Lanka since 2017, although the new Southern Policy of Sri Lanka does not include them.

d) STI Data Mechanism: from Creation, Management to Application in Korea – Ms. Haengmi Kim

Ms. Haengmi Kim introduced the general contents of Korea's national R&D program and its definition, history, and rationale. Korea's national R&D program played a leading role in the Korean economy, starting with the change of strategy and sector by period from 1960 to 2000. In particular, as R&D programs increased, interest in the research and management of R&D data grew. Korea's national R&D projects should be investigated, analyzed, and evaluated to prevent overlapping investments by sharing R&D information among ministries and to integrate the DB of R&D projects of all ministries to support R&D policy revision (National Science and Technology Knowledge Information service). She also demonstrated how the National Technology Information System (NTIS) is actually operated and how R&D information is entered and disclosed.

e) National Innovation System of Korea – Prof. So Young Kim

Prof. So Young Kim introduced the history of science and technology in Korea and emphasized their importance by comparing the results of science and technology in 1962 and 2018. She explained the need for a National Innovation System (NIS) in the development of science and technology and defined NIS as the components and relationships that enable new and useful knowledge production and dissemination activities of science and technology innovation within the scope of the state. The core components of NIS consist of actors of S&T innovation and networks, infrastructure, and governance that facilitate the linkage between them. NIS in Korea has been changing in three stages from the 1960s to the present.

f) Science, Technology, and Innovation Governance and Policy in Korea: Structure and Strategy - Dr. Kwanyoung Kim

Comprehensive STI policies and strategies by themselves are not enabling the creation of STI policy structure with the concept of the STI development program of Sri Lanka. Both the structure of STI's infrastructure and framework and strategies of STI's inter-ministerial cooperation for implementation are needed with concrete conceptualization.

In other words, action plans for the implementation of STI policies are needed, particularly performance monitoring and evaluation and assessment including the socio-economic impact on the progressive outputs. Evaluation and monitoring as well as assessment of progressive results and performance advent should be developed by two tracks of methodologies such as qualitative and quantitative approaches.

For the evaluation and monitoring of progressive results and performance advent, factors such as relevance, efficiency, effectiveness, impact or outcomes, and sustainability can be utilized. The development of definition and evaluation indicators of the five factors (relevance, efficiency, effectiveness, impact or outcomes, sustainability) is definitely necessary with the concept of the program design matrix.

g) Sri Lanka's Science and Technology Innovation System Thematic (Chapter) Collaborative Analysis and Draft Session

The collaborative analysis and draft session mainly focused on three chapters: (1) Science and Technology System; (2) Science and Technology Policy and Governance; and (3) Science and Technology Data from Creation, Management to Application.

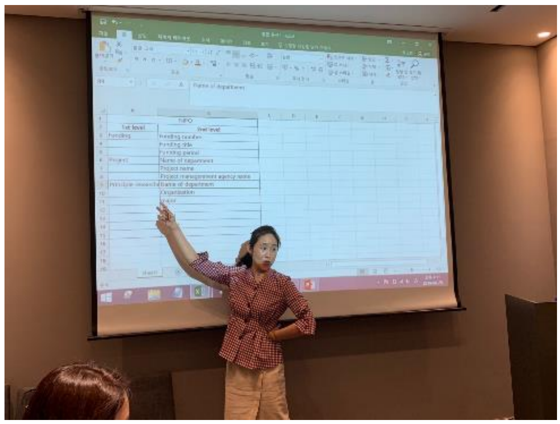
[Table 4-7] Assessment of the National STI System in Sri Lanka

CHAPTER 1. INTRODUCTION
Dr. Inkyoung Sun
CHAPTER 2. COUNTRY OVERVIEW
Mr. Byung Woo Jeon
CHAPTER 3. NATIONAL STI SYSTEM
Prof. So Young Kim
CHAPTER 4. STI GOVERNANCE AND POLICY: STRUCTURE & STRATEGY
Dr. Kwan Young Kim
CHAPTER 5. STI DATA MECHANISM: FROM CREATION, MANAGEMENT TO APPLICATION
Dr. Haengmi Kim
CHAPTER 6. INTERNATIONAL STI COOPERATION
Mr. Byung Woo Jeon
CHAPTER 7. CONCLUSION
Dr. Inkyoung Sun

[Figure 4-2] STEPI-NASTEC STI Policy Workshop in Korea

STEPI-NASTEC Workshop Orientation - Dr. Inkyoung Sun (June 24)

STI Data Mechanism: From Creation, Management to Application in Korea - Ms. Haengmi Kim (June 25)



National Innovation System of Korea – Prof. So Young Kim (June 26)

Science, Technology, and Innovation Governance and Policy in Korea: Structure and Strategy - Dr. Kwan Young Kim (June 27)

[Field Visit] Korea Institute of Science & Technology (KIST) - June 28

[Field Visit] Samsung d'light - June 28

[Field Visit] SK Telecom T.um - June 28	
	

3. STEPI-NASTEC STI Policy Workshop in Sri Lanka

3.1 Introduction

3.1.1 Objectives

From November 18 to 22, 2019, the STEPI team (Dr. Inkyoung Sun, Prof. So Young Kim, Dr. Kwan Young Kim, Ms. Haengmi Kim, and Mr. Byung Woo Jeon) visited Colombo and conducted the STEPI-NASTEC STI Policy Workshop in Sri Lanka. The aim of this workshop was to finalize the country report and to discuss the 2020 project scope and goal.

3.1.2 Korea's Research Team

[Table 4-8] Korea's Research Team

Name	Institution	Position
Dr. Inkyoung Sun	Science & Technology Policy Institute (STEPI)	Head of the Office of Development Cooperation
Mr. Byung Woo Jeon	Science & Technology Policy Institute (STEPI)	Researcher
Prof. So Young Kim	Korea Advanced Institute of Science & Technology (KAIST)	Professor Head of the Graduate School of Science & Technology Policy (STP)
Dr. Kwan Young Kim	Green Technology Center (GCT), Korea Institute of Science & Technology (KIST)	Senior Researcher Director of the Green Technology Partnership Initiative (GTPI)
Ms. Haengmi Kim	Korea Institute of Science & Technology Evaluation and Planning (KISTEP)	Associate Research Fellow

3.1.3 Sri Lanka's Research Team

[Table 4-9] Sri Lanka's Research Team

Name	Institution	Position
Prof. Niranjanie Ratnayake	National Science & Technology Commission (NASTEC)	Chairperson
Mrs. D. Nandanie Samarawichrama	Ministry of Science, Technology, and Research (MoSTR)	Additional Secretary (Administration & Finance)
Dr. Kalpa W. Samarakoon	National Science & Technology Commission (NASTEC)	Senior Scientist
Mr. Seyed Shahmy	National Science & Technology Commission (NASTEC)	Senior Scientist

Besides research team members, about 30 STI policy experts in Sri Lanka participated in the workshop.

3.1.4 Schedule

[Table 4-10] Schedule

Time	Event	Remarks
Monday, November 18, 2019		
23:50-	Departure from ICN	Flight #: KE0473
Tuesday, November 19, 2019		
-04:30	Arrival in CMB	
04:30-11:30	From Airport to Hotel & Early Check-in	Mövenpick Hotel Colombo
11:30-13:30	Lunch	
13:30-15:30	STEPI-NASTEC Meeting	Meeting with the new chairperson of NASTEC and board members Project progress check-up
15:30-18:00	STEPI Preparation Meeting	
Wednesday, November 20, 2019		
09:30-09:45	Welcome Remarks	Prof. Niranjanie Ratnayake (NASTEC Chairperson)

Time	Event	Remarks
09:45-10:00	Opening Remarks	Dr. Inkyoung Sun Project Manager & Associate Research Fellow, STEPI
10:00-11:00	Keynote Speech: Major STI policy issues in the current administration and future STI policy plans	Mr. Chinthaka S. Lokuhetti Secretary of the Ministry of Science, Technology, and Research
11:00-12:00	[Presentation] National STI System in Korea	Prof. So Young Kim Chair of the Graduate School of Science & Technology Policy Korea Advanced Institute of Science & Technology (KAIST)
12:00-14:00	Lunch	
14:00-15:00	[Presentation] STI Governance and Policy in Korea: Structure and Strategy	Dr. Kwanyoung Kim Director of the Green Technology Partnership Initiative (GTPI) & Senior Researcher, Green Technology Center (GCT), Korea Institute of Science & Technology (KIST)
15:00-16:00	Discussions	
16:00-17:00	[Presentation] STI Data Mechanism: From Creation, Management to Application in Korea	Ms. Haengmi Kim Associate Research Fellow Korea Institute of S&T Evaluation and Planning (KISTEP)
Thursday, November 21, 2019		
10:00-12:00	STEPI-NASTEC Wrap-up Meeting	
12:00-14:00	Lunch	
14:00-15:00	Visit to KOICA office in Colombo, Sri Lanka	
15:00-16:00	Visit to the Korean Embassy in Colombo, Sri Lanka	
16:00-19:00	Dinner & Transportation to Airport	
19:00-	Departure from CMB	Flight #: KE0474
Friday, November 22, 2019		
-07:00	Arrival in ICN	

3.2 STEPI-NASTEC STI Policy Workshop in Sri Lanka

a) National Innovation System of Korea – Prof. So Young Kim

Prof. So Young Kim introduced the history of science and technology in Korea and emphasized their importance by comparing the results of science and technology in 1962 and 2018. She explained the need for a National Innovation System (NIS) in the development of science and technology and defined NIS as the components and relationships that enable new and useful knowledge production and dissemination activities of science and technology innovation within the scope of the state. The core components of NIS consist of actors of S&T innovation and networks, infrastructure, and governance that facilitate the linkage between them. NIS in Korea has been changing in three stages from the 1960s to the present.

She also mentioned about when setting policy objectives for S&T investment, social outcomes (e.g., SDGs) are as important as economic outcomes. The S&T-driven development experience of South Korea may be half a success in this sense, for it mostly focused on economic performance. Sri Lanka can chart a different journey for more inclusive development of S&T.

She pointed out while inter-ministerial coordination is important to avoid duplicative effort, it is almost a perennial challenge to derive specific ways (workable solutions) to coordinate the design and implementation of S&T policy among different S&T organizations. Moreover, a new agency (National Innovation Agency) is just created under the Prime Minister (or President?) and post-election uncertainties, the recommendation to elevate NASTEC to the Prime Minister-level organization may create another confusion over coordination.

She addressed that a right size of R&D spending differs by country, yet the current level (0.1% of GDP) in Sri Lanka is very low. Effort must be taken to assess the optimal size of R&D expenditure given Sri Lanka's socioeconomic conditions. It takes a scientific analysis of a wide array of structural factors affecting R&D spending to provide a basis for the realistic target for Sri Lanka's optimal R&D spending.

b) Science, Technology, and Innovation Governance and Policy in Korea: Structure and Strategy - Dr. Kwanyoung Kim

Comprehensive STI policies and strategies by themselves are not enabling the creation of STI policy structure with the concept of the STI development program of Sri Lanka. Both the structure of STI's infrastructure and framework and strategies of STI's inter-ministerial cooperation for implementation are needed with concrete conceptualization.

In other words, action plans for the implementation of STI policies are needed, particularly performance monitoring and evaluation and assessment including the socio-economic impact on the progressive outputs. Evaluation and monitoring as well as assessment of progressive results and performance advent should be developed by two tracks of methodologies such as qualitative and quantitative approaches.

He pointed out Korea uses comprehensive measurements to assess its national R&D performance following a guideline from Ministry S&T strategy for its interim evaluation. By using a numerical target, Korea is able to conduct interim evaluations as aforementioned in the previous subsection on clear measurement guidelines. As such, it is highly recommended for Sri Lanka to set more quantitative indicators for its programme objectives related to STI policy implementation, especially for the purpose of monitoring the progress of its R&D programme.

He mentioned NASTEC also would be needed for highly-coordinated organization for under the Presidential office control and monitoring relating organization of STI in Sri Lanka as organization for inter-ministerial coordination whose roles and responsibilities for coordinating the design and implementation of S&T policy among different S&T organizations.

Moreover, he talked about Monitoring and evaluation for STI is needed for not only financial and technological impact for economic development and growth but also socially outcomes for sustainable growth linked with civil society and people. The terminology, Assessment instead of Evaluation is needed for the measurement for social impact of STI.

c) STI Data Mechanism: From Creation, Management to Application in Korea – Ms. Haengmi Kim

Ms. Haengmi Kim introduced the general contents of Korea's national R&D program and its definition, history, and rationale. Korea's national R&D program played a leading role in the Korean economy, starting with the change of strategy and sector by period from 1960 to 2000. In particular, as R&D programs increased, interest in research and management of R&D data grew.

She suggested for Sri Lank's intergrated plateform of science and technology. First, the roles of NSF, NASTEC, and COSTI should be divided into collection, management, analysis, and services based on the R&D data value chain (creation – refinement & management - analysis – utilization), and each organization should perform the corresponding data roles. In other words, NSF oversees research project support and the management of projects and outputs, NASTEC serves as a policy advisory-centered body (data analysis), and COSTI operates an integrated platform for science and technology information services.

Seoncd, to establish an R&D data value chain, each organization should build the necessary systems. NSF should promote advanced STIMS, PMS module implementation, and advanced DBs. NASTEC should set up the necessary system required to analyze the statistical and support data for decision-making. Also NASTEC needs to improve overall process of research institute evaluations from collection stage. To do it, it is also essential to establish a system to conduct the survey itself and to refine, and to support data upload to online web service platfrom.

Lastly, COSTI is recommend to provide online information services to store and manage data produced through government R&D by being assigned the role of a repository. At the same time, the Sri Lanka Innovation Dashboard might be modified into an integrated platform that provides comprehensive information on science and technology R&D in addition to a community feature in which researchers can find scientific technology information both domestically and overseas as well as other researchers for collaboration.

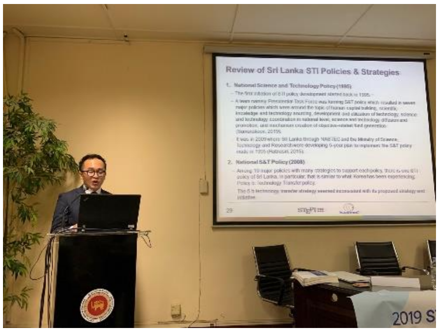
[Figure 4-3] STEPI-NASTEC STI Policy Workshop in Sri Lanka

STEPI-NASTEC Meeting – Nov 19

STEPI-NASTEC Workshop Opening Ceremony, Opening Remark – Nov 20

National Innovation System of Korea – Prof. So Young Kim (Nov. 20)

Science, Technology, and Innovation Governance and Policy in Korea: Structure and Strategy - Dr. Kwan Young Kim (Nov.20)



Q&A Sesseion (Nov.20)

Wrap-Up Meeting (Nov.21)

CHAPTER 5

Conclusion

2019 Policy Consultation on Supporting the Improvement of Science, Technology, and Innovation (STI) Policy and Institutional Framework for Sri Lanka

Chapter 5. Conclusion

1. Policy Recommandations

In order to foster the effective implementation of major STI policies and strategies of Sri Lanka, the STEPI-NASTEC team conducted collaborative examinations on three topics — national STI system, STI governance, and STI data mechanism — during the first year of the two-year policy consultation project to identify STI policy issues to be considered in advance. Policy recommandations are provided by the Korean experts in three topics as below.

In the first topic of the national STI system, four issues were raised for primary consideration by policymakers in Sri Lanka.

■ Localization issue

- The South Korean development experience is such an exceptional success story that it is hard to replicate in different socioeconomic and political contexts. What can we do, or how can we apply the recommendations in consideration of Sri Lanka's existing conditions?
- A general framework of analysis is good for cross-national comparison, but it requires detailed analysis of the local context to generate specific courses of action.

- Incentive Issue
  - It is critical for private companies to increase their R&D spending in order to raise the overall national investment in S&T. How can we motivate the private sector to invest in R&D?
  - The public sector already applied performance-based evaluation, but its effectiveness is quite limited. How can we incentivize public sector employees for better performance?
- R&D Type/Distribution Issue
  - (Social vs. Economic) When setting policy objectives for S&T investment, the social outcomes (e.g., SDGs) are as important as the economic outcomes. The S&T-driven development experience of South Korea may be half a success in this sense, since it mostly focused on economic performance. Sri Lanka can chart a different path for the more inclusive development of S&T.
  - (Basic vs. Applied) In addition to very low levels of R&D investment, the funding for basic research is extremely small in Sri Lanka. How can we balance R&D investment between basic and applied research?
- Coordination Issue
  - While inter-ministerial coordination is important to avoid duplicated effort, it is almost a perennial challenge to derive specific ways (workable solutions) to coordinate the design and implementation of S&T policy among different S&T organizations.

The following recommendations are suggested for the improvement of the national STI system in Sri Lanka:

- S&T Investment
  - The right size of R&D spending differs by country, yet the current level (0.1% of GDP) is very low. Effort must be made to assess the optimal size of R&D expenditure given Sri Lanka's socioeconomic conditions.

- It requires scientific analysis of a wide array of structural factors affecting R&D spending to provide a basis for the realistic target for Sri Lanka's optimal R&D spending.

■ S&T Workforce

- Since the transformation into a technology-based society and achievement of desirable national goals require extensive indigenous technological capabilities, the current size of the engineering workforce needs to be increased.
- The optimal size of the engineering workforce must be derived through a rigorous analysis of the current and future industrial demands for engineers; a simple increase of engineers will result in the oversupply of low-quality engineers.

■ Inter-ministerial/Inter-agency Coordination S&T Investment

- The role and responsibilities of S&T organizations need to be redefined and adapted in light of changing policy environments.
- Pilot projects can help increase mutual understanding and learning for collaboration across S&T-related ministries or agencies such as:
  - Cross-ministry or cross-agency project on cross-cutting issues (e.g., smart agriculture)
  - Technology roadmap project for a particular technology domain
  - Technology assessment or foresight project for a particular emerging technology

■ Evaluation

- Evaluation of performance is critical for policy implementation that requires timely and accurate feedback.
- Sufficient training on the methods and tools for R&D evaluation must be provided for both researchers and managers of S&T programs and projects.

When it comes to national STI policy governance, the following four issues are addressed for the improvement of STI governance that eventually leads to effective policy implementation:

- Performance Measurement Methodology Issue: Korea uses comprehensive measurements to assess its national R&D performance following a guideline from the Ministry on S&T strategy for its interim evaluation. By using a numerical target, Korea is able to conduct interim evaluations as mentioned in the previous subsection on clear measurement guidelines. As such, Sri Lanka is strongly advised to set more quantitative indicators for its program objectives related to STI policy implementation, especially for the purpose of monitoring the progress of its R&D program.
- Measurement Issue for the Social Impact of STI: Monitoring and evaluation for STI are needed for not only the financial and technological impacts for economic development and growth but also social outcomes for sustainable growth linked with civil society and people. Assessment instead of Evaluation is needed for the measurement of social impact of STI.
- Research-oriented University Issue: UST is one of the research-oriented universities located in Daedeok Research Complex in Daejeon, Korea. The 25 GRIs are heavily involved in utilizing their research fellows as professors for teaching and researching with researchers in their own GRIs as well as in UST.

In response to the above three issues addressed in the topic of STI governance, the following recommendations are suggested for NASTEC and MoSTR in Sri Lanka:

- Establishing and Strengthening the STI Policy Measurement Strategy: The Sri Lankan government should be clear and specific, to the extent of specifying the body that will be in charge of conducting STI measurement QAs. Sri Lanka is also advised to set a concise intermediate indicator to track programs during the process of monitoring and program evaluation. This recommendation has related evidence described in the 2018-2022 Innovation and Entrepreneurship Strategy of Sri Lanka.
- Forming or Assigning an Institution for STI Commercialization: The Sri Lankan government should also invest in its STI commercialization institution to aid in balancing public-private research cooperation. By doing so, the implementation of STI policy in Sri Lanka is expected to improve in terms of STI performance; Sri Lanka’s STI commercialization institution is also expected to make significant contributions in taking advantage of many future opportunities.

- Governance of Periodic Policy Review: An agency or an institute with high-level government authority is needed to provide its full support in tackling the challenges hindering the STI policy implementation. The issue of the "need for periodic review" is critical and as important as coordination and performance monitoring and evaluation.

In the specific topic of STI data mechanism, four issues are elaborated for further consideration for effective overall STI policy implementation: clear institutional role in the R&D data value chain, improvement of STI data management system, regulations, and working groups.

- Reflect the R&D data value chain role to each mission or duty of S&T key organizations: NSF for data collection, NASTEC for data analysis, and COSTI for data dissemination. Since the evaluation of 45 research institutions is one of the core functions of NASTEC, it is suggested that the current paper-based survey process be enhanced (like system survey) in terms of R&D data creations/use, as evaluation generates valuable information to monitor the R&D environment and its demanding tasks to convert paper data into electronic data for use and analysis as continuously usable information.
- Develop or improve the related management system under each organization by linking or integrating data between different organizations. Multiple options to improve the system are available: 1) data integration, which means new schema setup or thesaurus creation, etc.; 2) system integration, which means new system deployment or linking of the current system by modifying the current structure. Decisions can be made based on budget, timeline, current DB structure, and skill to implement the system.
- Review and set up related regulations in order to instill a sense of responsibility and duty in each of the key players. Otherwise, data can be neither managed well nor collected from different organizations. Regulations should cover personnel, projects, systems, and data itself under the R&D mechanism.
- Organize working groups by topics to be established as a priority. Working groups should have a hierarchical structure for decision making or to coordinate issues between different interest groups. There is a need to leverage all of the information

on the topics through the exchange and verification of information among committee members so as not to lose direction in the process.

The table below summarizes the policy recommendations to foster effective STI policy implementation in Sri Lanka. Each recommendation is grouped into a 4x3 matrix, based on its topic and suggested timeline.

[Table 5-1] Policy Recommendations in Summary

	Short-term	**Mid-term**	**Long-term**
S&T Investment	- Scientific analysis of structural factors affecting R&D spending to provide realistic target for optimal R&D spending	- Incentives for the private sector to increase R&D investment - Balancing R&D investment between basic and applied research	
Human Resources	- Increase of current size of engineering workforce - Analysis of current and future industrial demands for engineers	- Incentives for better performance of public sector employees	
Coordination	- Pilots in cross-ministry or agency project on cutting issues, tech roadmaps, or tech assessment - Data integration or linkage of DB - Inter-ministerial coordination to avoid duplicated effort	- Strengthening the function of STI commercialization by public-private research partnership - Division of labor in STI data mechanism (NSF-NASTEC-COSTI) - Automation of survey for NASTEC's institutional evaluation - Institution for STI commercialization	- Comprehensive STI data system
Evaluation	- Training on methods and tools for R&D evaluation - STI Measurement (indicators) for monitoring and evaluation - Periodic reviews	- Measurements of both social and economic outcomes	- Annual evaluation system covering all elements of research personnel, project, institutions, etc.

2. Expected Project Schedule (2020)

Considering both Sri Lanka's current challenges and policy recommendations proposed by the STEPI team, the 2020 project is expected to develop a couple of pilot action plans reflecting those challenges and recommendations in specific technology domains. In order to bring about effective outcomes of the STEPI-NASTEC collaboration and nurture the bilateral ties to make them more sustainable in the future, the following activities are suggested for the year 2020:

[Figure 5-1] Suggested Schedule and Activities and 2020 Project

- Expanding training sessions to provide STI policy tools and methods necessary for the establishment of an innovation ecosystem in Sri Lanka
- Developing STI action plans for selective STI domains as a pilot that can be a model for developing action plans for other STI domain policies
- Sharing national experiences in and knowledge of STI action planning in both countries
- Strengthening bilateral relations between Korea and Sri Lanka by providing networking and rigorous discussions among STI stakeholders in both countries
- Ensuring mutual responsibility for the collaborative project

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