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NATION RELIGION KING**



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Science, Technology & Innovation:
2020**

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Foreword

Science, Technology & Innovation (STI) are essential to achieving the objectives that Cambodia has set for her national development goals by 2030 and 2050. In my capacity as Senior Minister, Minister of Industry, Science, Technology & Innovation, I observe and agree that many developing nations with strong foundations in science and technology have shown effective growth and sustainable development. This sector should lay the foundation needed to address the challenges of Cambodia at the national, regional, and international levels. Under the supreme leadership and vision of **Samdech Akka Moha Sena Padei Techo HUN SEN**, Prime Minister of the Kingdom of Cambodia, the Ministry of Industry & Handicraft was reformed with an expanded mission. The new Ministry of Industry, Science, Technology & Innovation was created in March 2020. Additionally, the National Council of Science, Technology & Innovation was launched under the leadership of **Samdech Techo Prime Minister** as its Honorary Chairman. To further enhance its mission and policy formulation for a robust national ecosystem in Science, Technology & Innovation, an Advisory Board of Science, Technology & Innovation was also established to provide the necessary scientific and technological expertise to the Council. The first priority was to recruit talents with proper qualifications and expertise in various fields of Science, Technology & Innovation, to serve at the General Department of Science, Technology & Innovation and the National Institute of Science, Technology & Innovation. The quality of their contribution to the draft of this report is exemplary and remarkable considering their recent appointment to the ministry.

This report contains insightful information on the STI ecosystem in Cambodia that can inform policymakers, academics, private sectors, and development partners about the central pillar of STI for future industrial policy development. Considering the current status of STI in Cambodia, human resources, infrastructures, and funding are yet to be established. I strongly encourage relevant stakeholders to read and make full use of the information available in the report. The context-based analysis points out recommendations and ways forward to spur a robust national ecosystem and address challenges facing all dimensions of the STI sector. A thorough understanding of our current national STI ecosystem is essential to translate our 2030 and 2050 vision into a clear strategy to guide the healthy growth of our nascent industry, as well as our small and medium enterprises, while enabling their transformation to fit the needs of the incoming era of Industry 4.0.

I would like to take this opportunity to thank and congratulate the General Department of Science, Technology & Innovation and the National Institute of Science, Technology & Innovation for their wonderful contributions. This valuable report should be the compass to guide relevant ministries and institutions to implement their STI related policies more effectively. Effective policy implementation within a robust STI ecosystem will enable Cambodia to become an upper-middle-income country by 2030 and a high-income country by 2050. ✓

Phnom Penh, 03 August 2021

Senior Minister
Minister of Industry, Science, Technology
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List of abbreviations

ADB	: Asian Development Bank
AFD	: Agence Française de Développement
AI	: Artificial Intelligence
AMMST	: ASEAN Ministerial Meeting on Science and Technology
APASTI	: ASEAN Plan of Action on Science, Technology, and Innovation
APO	: Asian Productivities Organization
AR	: Augmented Reality
ASEAN	: Association of Southeast Asian Nations
AVI	: Asian Vision Institute
CBRDF	: Capacity Building, Research, and Development Fund
CDC	: The Council for the Development of Cambodia
CDRI	: Cambodia Development Resource Institute
COSTI	: Committee of Science, Technology, and Innovation
CSDGs	: Cambodia Sustainable Development Goals
EDF	: Entrepreneurship Development Fund
FDI	: Foreign Direct Investment
GDP	: Growth Domestic Product
GDSTI	: General Department of Science, Technology & Innovation
GDSMEH	: General Directorate Small and Medium Enterprises and Handicraft
ICT	: Information and Communication Technology
IDP	: Industrial Development Policy
INSEAD	: Institut Européen d'Administration des Affaires (European Institute for Business Administration)
GERD	: Gross Expenditure of Research and Development
KAS	: Khmer Agriculture Suite
KE	: Khmer Enterprise
MAFF	: Ministry of Agriculture, Forestry, and Fisheries
MCFA	: Ministry of Culture and Fine Arts
MEF	: Ministry of Economy and Finance
MISTI	: Ministry of Industry, Science, Technology & Innovation
MNCs	: Multi-National Companies
MoLVT	: Ministry of Labour and Vocational Training
MOC	: Ministry of Commerce
MoEYS	: Ministry of Education Youth and Sport
MoH	: Ministry of Health
MoI	: Ministry of Interior
MPTC	: Ministry of Posts and Telecommunications
NCSTI	: National Council of Science, Technology & Innovation
NSTC	: National Science and Technology Council
NEA	: National Employment Agency
NiDA	: National Information Communication Technology Development Authority
NISTI	: National Institute of Science, Technology & Innovation
OECD	: Organization for Economic Co-operation Development
PDR	: People's Democratic Republic
PPPs	: Public-Private Partnerships
R&D	: Research and Development
RGC	: Royal Government of Cambodia
SAAMBAT	: Sustainable Assets for Agriculture Markets, Business and Trade

SDGs	: Sustainable Development Goals
SDF	: Skill Development Fund
SMEs	: Small and Medium Enterprises
SPM	: Samdech Prime Minister
STEM	: Science, Technology, Engineering and Mathematics
STI	: Science, Technology and Innovation
TSC	: Techo Startup Centre
TVET	: Technical and Vocational Education Training
UILs	: University and Industry Linkages
UN	: United Nations
UNDP	: United Nations Development Programme
UNESCO	: United Nations Educational, Scientific and Cultural Organization
VR	: Virtual Reality
WIPO	: World Intellectual Property Organization

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1. Introduction

1.1 Background

The Royal Government of Cambodia (RGC) embraced the United Nations' 2030 Agenda for Sustainable Development and its associated 17 Sustainable Development Goals (SDGs) with a strong commitment to their achievement. The formal development process of the Cambodian SDGs (CSDGs) Framework was laid out with multiple rounds of consultations with relevant stakeholders, including policymakers, line ministries and agencies, development partners, and civil society organizations. The proposals on how the goals would be integrated within Cambodia's policy and delivery systems were taken into account. Then, CSDGs Framework 2016- 2030 adopted all 17 SDGs and added one additional goal, related to clearance of land mines and Explosive Remnants of War, reflecting the national priority of de-mining Cambodia's territory. This resulted in a final version comprising: 18 CSDGs, 88 nationally relevant targets, and 148 (global and locally defined) indicators including 96 national indicators. Taking into account the development pathway of most developed nations, it is obvious that the realization of the goals requires undoubtedly the integration of science, technology & innovation (STI) in the action lines. For instance, science is a need for water technology to clean water, promotion of alternative and clean energy sources, sustainable industries, and investment in research on scientific studies and innovation. The United Nations Committee for Development realizes accordingly that building up STI capabilities is a quick measure to achieve the goal of the 2030 agenda, eradication of poverty, sustainable growth, and sustainable development. For this reason, The United Nations Technology Bank for Least Developed Countries was established as an evidence to signify the importance of STI's role in achieving sustainable development.

In action, the overall reform efforts of the government in the past decade has yielded the country to have a robust economic growth with the average annual growth domestic product (GDP) of around 7% during the last decade, supported by a stable and low rate of consumer price inflation over the same period (APO, 2018). However, relying on foreign direct investment (FDI)-led growth from the labour-intensive industry can be no longer promising, because trade preferences that Cambodia has enjoyed are lessened along with increases in labour cost (Ehst et al., 2018). Also, the government acknowledges that the growth will not be inclusive and sustainable unless Cambodia shifts its economic structure from a low/ or unskilled labour in the labour-intensive industry to an economy with better labour productivity with skilled and knowledge-based workforce as an engine of growth (RGC, 2015). Industrial Development Policy (2015-2025) was laid out in the same year after having this initiative. Obviously, the core foundation of the policy is relying on high-skill human capital, especially the science and technology professionals. This is a primary contributor to the realization of the government's vision to become an upper-middle-income country by 2030 and a high-income country by 2050.

The Rectangular Strategy-Phase IV– the country's political development strategy – was adopted by the government of Cambodia of the Sixth Legislature of the National Assembly as the principal socio-economic policy agenda. It has four strategic goals: (1) maintaining sustainable economic growth of around 7% per year; (2) generating more and decent employment; (3) reducing poverty headcount to below 10%; and (4) enhancing capacity and governance of the public institutions (RGC, 2018). It is clearly seen that science and technology, including industry 4.0 and the digital

economy are among the principal key drivers, surely human resource development and economic diversification, in order to realize the vision of 2030 and 2050. As results, many strategic documents have been adopted with sound instigation of STI in their respective action plans. Some officially-referred documents are important to keep in mind, which include Industrial Development Policy (IDP) 2015-2025, Science, Technology, Engineering & Mathematics (STEM) Education Policy 2016, Small and Medium Enterprises (SMEs) development policy¹ 2017-2021, Technical and Vocational Education and Training (TVET) Policy 2017-2025, Modernized TVET Strategic Action Plan 2019-2023, Education Strategic Plan 2019-2023, Cambodian Higher Education Roadmap 2030 and Beyond, STI Policy 2020-2030, and Cambodia Digital Economy and Society Policy Framework 2021-2035. Science and technology are seen in principle to be the foundation to secure the achievement of each policy objective. The principal motivation of some important policies and their reflection on the science and technology perspective are highlighted as follows.

The IDP 2015-2025 has the vision to transform Cambodia's industrial structure to become more diversified with a skill-driven industry. It aims to achieve three targets: (1) increasing the share of industry to GDP to 30% by 2025, and that of manufacturing to 20% in 2025; (2) to diversify the export of goods by increasing the export of non-textile to reach 15% of all exports by 2025 while still promoting the export of processed agricultural products to reach 12% of all exports by 2025; and (3) Improving the official registration of SMEs to 80% to 90% in 2025 (RGC, 2015). In other words, this policy is designed to increase the value-added of some priority areas including agri-food processing, garment, pharmaceutical and medical equipment production, and construction materials, packaging equipment for export, furniture manufacturing, and industrial equipment. The policy reveals in medium-term the role of governmental bodies for inter-ministerial action. For instance, Ministry of Industry and Handicraft² have the mission to work other ministries to promote and encourage studies and research on STI as well as assessing the feasibility of government to invest in STI by linking research by talented researchers with priority areas of the development.

The SMEs development policy 2017-2021, which also draws on IDP and Rectangular Strategy phase IV, was prepared with a five-year implementation plan for the General Directorate Small and Medium Enterprises and Handicraft (GDSMEH). Two of its five strategic directions related to STI are to promote productivity, technology and innovation, and to promote entrepreneurship and human capital development for the micro, small and medium-sized enterprises in some particular sectors such as ICT service providers; agroindustry; food supply chains, and food safety in the supply chain (ADB, 2017).

Furthermore, National TVET Policy 2017-2025 which was officially approved by the government in June 2017 aims to help improve people's livelihood and enhance the country's human resources with relevant competencies and skills, working attitude, productivity and employability (RGC, 2017). To this end, this policy has four strategic goals: (1) to improve the quality of TVET supply which can meet the demand of the national and international labour market; (2) to further promote equitable access to TVET; (3) to encourage public-private partnership (PPPs) by mobilizing resources to support the financial sustainability of TVET system; and (4) to enhance governance

¹ So far, this policy has yet to be official.

² The current name is Ministry Industry, Science, Technology & Innovation (MISTI).

of the TVET system. The policy gives a strong focus on skill development for the worker to address new technology change as seen in the concise strategic action plan released in 2019.

Cambodian Higher Education Roadmap 2030 and Beyond provides educational direction for 2030, supporting the government to come into life the vision to become an upper-middle-income country by 2030 and a high-income country by 2050. In particular, the document aims to contribute to sustainable and inclusive development through economic diversification, and improvements in competitiveness and productivity by focusing on quality services and equitable access to affordable decent education, particularly TVET, and life-long learning that are expected to give youth better economic opportunities (MoEYS, 2019). Promoting STEM for new programs and educational institutions in higher education, curriculum reform in general education and teacher training reform are the focal agenda of the educational development plan. For instance, MoEYS has recently received a five-year Higher Education Improvement Project (HEIP) in 2019 with a total budget plan of 92.5 MUSD. The project aims to improve STEM education and research in higher education. There are four components including (1) improving teaching and learning capacity, (2) improving research in STEM and agriculture, (3) strengthening sectoral governance and project management, and (4) contingent emergency response.

In December 2019, the National Policy on STI 2020-2030 was adopted and approved by the Samdech Prime Minister (SPM) of the Kingdom of Cambodia. This long-term policy aims at strengthening the foundation and improving the environment for STI toward sustainable socio-economic development (Cambodia's vision 2050). The main strategic goals of this policy include human resource development in the framework of STI, and strengthening the STI ecosystem to upgrade the country's competitiveness in the industries and services (RGC, 2019a). At the same time, implementing this far-reaching policy requires systematic participation from all relevant government stakeholders, private sectors as well as development partners.

In an attempt to seize the opportunity and overcome threats from Industrial Revolution (IR) 4.0, the RGC formulated a policy framework for Cambodia's digital economy and society, which is a long-term policy framework. The ultimate goal of the policy formulation is to help foster technological advancement in automation, robotics, artificial intelligence, which are expected to employ in various sectors ranging from manufacturing to services (RGC, 2019a). Alongside the plan, it was suggested to have a requirement of a well-designed education system, on-the-job training for specialized fields, human resources planning, and cybersecurity (UNDP, 2019).

To realize results from the aforementioned policies and strategies, the government has designed various interventions to promote STI. And, they are mostly, but not limited to, associated with mentorship, technical assistance, training program, SMEs financing and digital transformation and promotional activities related to STI. Below are the main government interventions to nurture the ecosystem of STI in Cambodia.

According to Sub-decree 96, the Techo Startup Centre (TSC) was transformed into a public administrative institution on 06 July 2020 with a mission to nurture startups to grow into successful businesses by enhancing talents, entrepreneurship, and innovation capacities through the well-supported programs. These mandates directly complement the government strategy on mentorship, technical assistance, link to investment, link to talent, and specialized training program (RGC,

2020a). To achieve the mission, TSC has been involved in many different key activities. In terms of policy support, TSC also conducts policy research to support digital economy development in Cambodia. So far, TSC has conducted a study about the FinTech landscape in Cambodia, and soon TSC will also conduct a policy study related to the startup ecosystem and last-mile logistics in Cambodia. Aside from that, to support the startup ecosystem in Cambodia, TSC is also running the first accelerator program in Cambodia called “Reverse Innovation” to promote public-private partnerships (cooperates and startups). In the agriculture sector, TSC is working on digital technology and enterprise for rural value chains under the Sustainable Assets for Agriculture Markets, Business and Trade (SAAMBAT) project to create Khmer Agriculture Suite (KAS). KAS will help improve SMEs and startup productivity and serve as a platform to connect all stakeholders within the agricultural supply chain to provide buyers with information about agricultural products and suppliers with market demand. To ease and shorten the process of registering new businesses from a few months to 8 days, TSC also developed Online Business Registration running through Cambodia Data Exchange (CamDX), a unified yet decentralized data exchange layer between information systems that offers a standardized and secure way to provide and consume services.

To promote SMEs access to finance, the government released sub-decree 68 in 2019 to establish the SME Bank with an initial investment capital of about USD100 million (RGC, 2019b). The initiative aims to assist enterprises in agro-processing and SMEs that are linked to FDI, the tourism sector, and tech start-ups through the credit-guarantees schemes and concessional loans to qualified SMEs (RGC, 2019b). Even though the bank services are not limited to, it intends to increase access to credit among SMEs that find it difficult to access loans for their businesses from commercial banks and microfinance institutions (MFIs). New innovative industries or manufacturing ventures of higher value-added products and higher technological contents are among the top priorities of the bank.

Khmer Enterprise³ (KE) is created as an implementation unit of the Entrepreneurship Development Fund (EDF) to implement the support programs and directly work with business owners and entrepreneurial communities. KE aims to mobilize, invest, and manage resources, from all legitimate sources, to support the development of a vibrant entrepreneurial ecosystem and to provide financial and non-financial supports to related entrepreneurial ecosystem builders. Khmer Enterprise mission is to: (1) support entrepreneurship ecosystem building; (2) provide financial and non-financial support to startups and SMEs; (3) encourage local and international investors to invest in Cambodia entrepreneurship ecosystem; and (4) encourage and stimulate growth in prioritized sectors, particularly ICT.

Besides, the national context on STI development ecosystem, the regional platform has been a substantial driver for local change. For instance, at the 16th ASEAN Ministerial Meeting on science and technology (AMMST-16) in Vientiane, Lao PDR on 6 November 2015, the science & technology Ministers of the member states agreed that the ASEAN Plan of Action on Science, Technology, and Innovation (APASTI) 2016-2025⁴ shall be accompanied by an implementation plan. It includes the priorities; targets/deliverables; specific actions; timelines; indicators, to be

³ For more information, please to go <https://www.khmerenterprise.info/home>.

⁴ <https://asean.org/wp-content/uploads/2017/10/02-APASTI-2016-2025-Implementation-Plan-FINAL.pdf>

derived from the work plans of various Sub-Committees under the ASEAN Committee on Science Technology Innovation (COSTI). APASTI goals are to use ASEAN STI to address the grand challenges of the new millennium; ASEAN economic integration, public-private partnership, talent mobility, increased awareness of STI, the impact of STI, research & development collaboration, technology commercialization, entrepreneurship development, and network of centers of excellence.

However, the aforementioned policies and program interventions for STI have been quite fragmented or incoherent. By becoming increasingly aware of the importance of STI, the government opted to establish the Ministry of Industry, Science, Technology & Innovation (MISTI), being transformed from the former Ministry of Industry and Handicrafts (MIH) on April 06, 2020 via sub-decree No. 48 (RGC, 2020b). The newly established Ministry allows the government to mobilize the human resources in STI to cultivate and nurture for having a sound and inclusive development through good coordination among governmental players, academia, research institutions, private sectors, and development partners. The reallocation of National Council of Science, Technology & Innovation at MISTI through royal decree **នស/រកត/1020/1073** dated on 10 October 2020 indicates nationwide the role as coordinating body for STI. The details about the process of establishing MISTI are summarized and presented in Figure 1.

1.2 Purposes

This opening report aims at characterizing the most recent developments in Cambodia's STI development ecosystem, especially in terms of policy development, structure and performance. Specifically, this document will tailor the discussion on STI topics including existing practices of different institutions, human resources, legal frameworks, and some activities and results made by different stakeholders. The important reflection is constructed as fundamental inputs for STI policy formulation and implementation. The development prospect toward vision 2030 as upper-middle-income and 2050 as a high-income country is based upon the thorough positioning ourselves on STI planning and development. The information highlighted is useful to mainstream the significance of STI in the economic development of the country.

1.3 Approach

STI team, composed of different academic backgrounds and experiences, was assigned to produce this report content, which is elaborated based on desk review and descriptive approach using existing data from the official report by the government and development partners. Peer-reviewed journal articles are also utilized to enrich and validate the discussion. Series of group discussion among team members, and focus group discussion, were set and conducted to ensure a sufficient and balanced analysis with quality based on facts and evidences (See Appendix 1). This analysis of the STI development ecosystem in relation to manufacturing sector in Cambodia is made for the first time after the endorsement of MISTI on 26 March 2020.

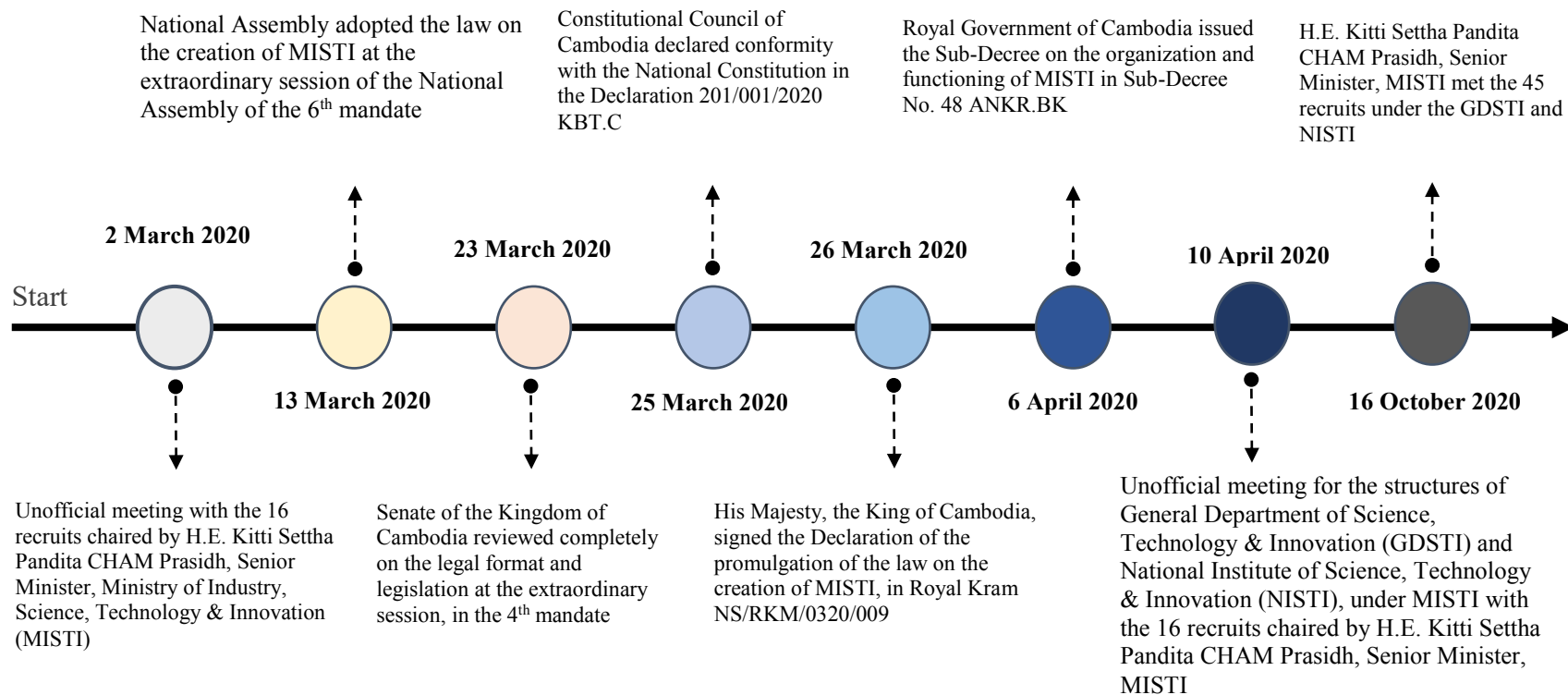


Figure 1: Background Events of Ministry of Industry, Science, Technology & Innovation

2. STI Ecosystem

2.1 Funding and Finance

R&D Funding

What does R&D mean?

According to Organization for Economic Co-operation Development (OECD, 2016), Research and Development (R&D) has been categorized into three types: (1) basic research, (2) applied research and (3) experimental development. Basic research aims at creating new knowledge with no specific applications in view. Applied research is devoted to creating new knowledge with specific applications in mind. Experimental development focuses on developing new products (i.e., both goods and services) or processes.

Why R&D funding is important for Cambodia?

Cambodia has undergone a significant transition for more than 20 years and reached a lower-middle-income status in 2015 (APO, 2018). With regards to income status transition, Cambodia has two consecutive visions of becoming an upper-middle-income country by 2030 and a high-income country in 2050. The visions would inevitably require that Cambodia transforms itself into a knowledge-based society for economic development. The knowledge-based economy relies on innovation (Savrul & Incekara, 2015). Innovation itself depends on knowledge creation and utilization produced by R&D activities. This is why countries around the world have been investing in R&D activities (Nair et al., 2020; Olaoye et al., 2020; Sokolov-Mladenović et al., 2016). Evidence indicates R&D activities yield innovation in the forms of new products and processes (Whitehouse, 1995). New products may improve the quality of life, whereas new processes may enable firms to reduce production costs and become more competitive. Indeed, increasing productivity is the key to higher living standards and stronger economic growth, which is in line with Cambodia's 2030 and 2050 visions. Therefore, R&D funding promotes innovation and is an important contribution to Cambodia's journey towards 2030 and 2050 visions.

What is Cambodian R&D funding level?

The relevance of STI in achieving 2030 & 2050 visions has consistently been mentioned in important government documents. Examples of these documents include Cambodia Industrial Development Policy for 2015-2025 (RGC, 2015); Rectangular Strategy Phase IV for 2018-2023 (RGC, 2018); and National Policy on Science, Technology and Innovation for 2020-2030 (RGC, 2019). Despite such a strong emphasis, national budget allocation for R&D activities has yet to be stated in those documents. On the contrary, there have been some figures reported in various sources about R&D expenditure in Cambodia. Letter N^o 80 ស.ជ.ន. ជ.ស dated on 26 January 2017 from Cabinet of Minister agreed to allocate 0.1% and 0.4% of GDP for 2020 and 2025, respectively (OCM, 2017). According to UNESCO Institute of Statistics (UNESCO, 2015), the gross expenditure of R&D in Cambodia was only 0.12% of GDP in 2015. In a piece of Phnom Penh Post news on 15 March 2018 (Spiess, 2018), SPM promised Cambodia would increase S&T funding level to 0.20% of GDP by 2020, 1.0% by 2025, and 1.50% by 2030. However, R&D allocation has not seen in practice for measurable purposes.

What is R&D funding level in comparison with other countries?

The R&D funding level of Cambodia in 2015 together with those of other ASEAN nations are shown in Figure 2, plotted based on data from the UNESCO Institute of Statistics (UNESCO, 2020). It should be noted that data from Brunei, Indonesia, Lao, and Myanmar are not available

from the source. Among those nations with R&D expenditure reported, Cambodia had the lowest expenditure on R&D. Singapore and Malaysia were the two top spenders in the ASEAN region. Cambodian R&D level (0.12%) was still more than three times lower than the average of the lower-middle-income country group (0.43%), and six times lower than the average of the ASEAN nations in 2015 (See Appendix 2). This indicates that we must allocate more R&D budget as soon as possible if it aims to exploit STI as a means of economic growth.

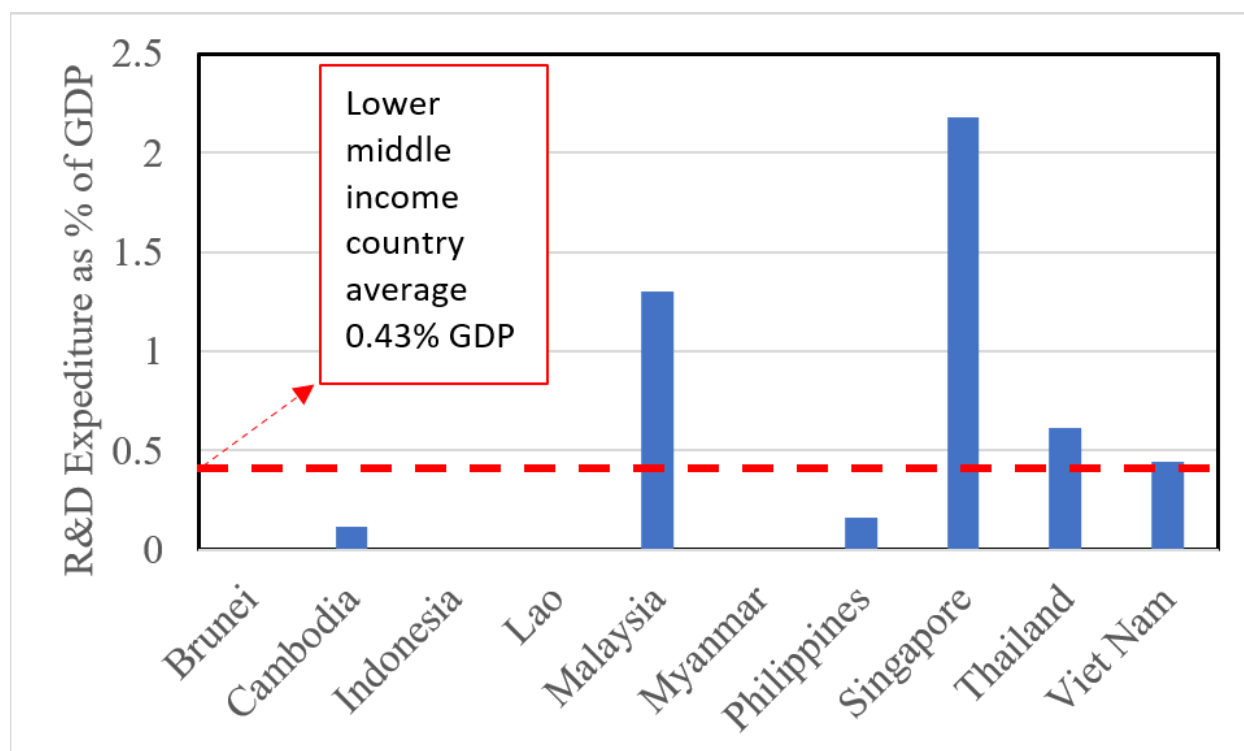


Figure 2: R&D expenditure of ASEAN countries in 2015. Data from Brunei, Indonesia, Lao and Myanmar are not available. (Source: UNESCO Institute of Statistics.)

Human Resources

Cambodia is supplied with adequate flexibility of work; however, the workforce here in Cambodia is considered predominantly as unskilled to middle-skilled workers ranging from agro-industries to the construction industry. As technological and innovative change, and what's more, intensity increment, there is a developing interest for a versatile labour force with both psychological and noncognitive aptitudes. To solve the issue, the Royal Government of Cambodia decided to establish Cambodia's national TVET policy 2017 - 2025. The TVET 2017 - 2025 policy goals are to promote public-private partnerships and mobilize resources from stakeholders to support TVET (ADB, 2018).

It is understood that a well-educated workforce will thrive on the country's economy and prosperity. The education level of citizens within each country is very important for both government and private sectors, especially the workforce within the field of science, technology, and innovation. This is because specialized workers are very important for each country to be able to adapt to the rapidly changing scientific and technological requirements within the labour market. Figure 3 shows the survey results on the educational attainment of the Cambodian labour force ages 15 to 64 in 2015. Only 5.4% of them (both genders) received high-level technical training or post-secondary education. A small increase of 1.4% is seen when those of upper secondary qualification is added to this percentage (MoP, 2016). The low level of labour force being able to complete their educational attainment can be driven by the

lack of understanding of the importance of science, technology, and innovation. This shortage can be seen among individuals, parents, and the community.

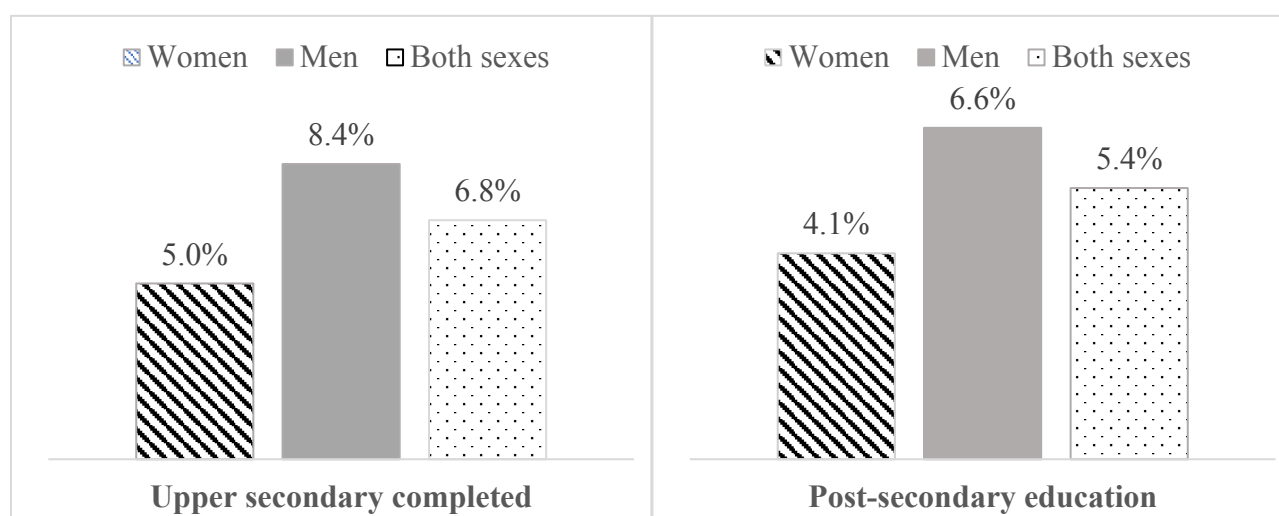


Figure 3: Percentage of Educational Attainment of the Labour Force Ages 15-64, 2015

TVET is mainly funded by government expenditure, foreign donors, and the private sector. According to the Agence Française de Développement (AFD), Cambodia TVET is not sufficiently funded compared to the neighboring countries (Christine, 2019). Recently, ADB has provided a loan of nearly a hundred million USD to start a project on the “Skill for Competitiveness Project” for TVET improvement through the Ministry of Labour and Vocational Training (MoLVT). Upgrading skills to colleges and universities through the improvement of science & technology laboratories at some higher education institutions and vocational schools are being made to cope with future demand by manufacturing sectors (ADB, 2018). It is noticed that ADB has played an essential role in promoting skilled labour forces. At the same time, the HEIP project with 92.5 million USD has recently been implemented through MoYES for STEM improvement in the higher education sector. This World Bank loan aims to address high-skill human resources through science & technology research and development. On the other hand, research and development for technology in telecommunication and ICT have been also undertaken by Capacity Building, Research, and Development Fund (CBRDF) through the Ministry of Post and Telecommunication (MPTC). Initiative action has started since 2017. Several million USD has been yearly made to serve some years actions adopted by the council of the fund.

In order to allocate resources from stakeholders, RGC through MEF has decided to set up some schemes to support STI related activities such as SME Bank, TSC, KE, and Skill Development Fund (ADB, 2018). For instance, the Skill Development Fund (SDF) is designed as a channel for receiving foreign funds or any funds that are outside the normal government budgetary channels for developing productive skills. The goal is to raise the quantity of workers' productivity, competitiveness, and incomes of enterprises and individuals within the field of science, technology, and innovation as well as other fields by helping train and supply them with needed skills. (Christine, 2019). SDF is a co-financing grant by the RGC with an annual grant of \$5 million and a \$9.6 million grant from the Asian Development Bank (ADB) (Kruy, 2020).

Overall assessment on Funding and Finance investment on STI is limited comparing to other neighboring countries and it is much further than other emerged developing countries like Israel, South Korea, China, and Japan. It also indicated the fragmented allocation and management of resources. Hence, a strong coordination body to synergize the activities with a

concise management framework of monitoring and evaluation with well-designed accountability finance allocation is strongly recommended.

2.2 Infrastructure

Infrastructure is usually described as the public service such as roads, electricity supplies, sewerages, laboratory facilities, research centers, phone lines, water pipes, and so on. In the early 20th century, a more generic definition of infrastructure is the network of assets system where its components will be maintained by the replacement and refurbishment.

STI infrastructures are the basic system that supports and drives the ecosystem of STI. Infrastructure is the form of a wide variety of infra-technologies, and associated standards are essential to conducting R&D and controlling production processes for quality and yield and finally to execute market transactions for complex products (Tasse, 2008). The education point of view is seen to get good attention in the last several years. For instance, the higher education development project (HEIP) as well as TVET improvement has been implemented. Some potential higher education institutions having STEM nature are chosen for the HEIP project. Those includes Royal University of Phnom Penh, Institute of Technology of Cambodia, Royal University of Agriculture, National University of Battambang, and Svay Rieng University, while the TVET improvement project is implemented mainly by TVET schools under MoLVT. The HEIP project of MoEYS puts substantial emphasis on some favorable drivers. Few points could be highlighted including connection of secondary schools to universities for increasing student interest in STEM, incentivizing university researchers, and establishment of center of excellence.

Appropriate institutions and frameworks for the emergence of new technology-based economy needs to be in place. With the goal to transform the economy, RGC has realized the role of STI in economic growth. The initiative of infrastructure has been created with a concrete duty and functions. Indeed, MISTI has just been transformed from the Ministry of Industry and Handicrafts in time of pandemic due to the need for socio-economic development in Cambodia. Moreover, MISTI also has just become the national body responsible for the National Council of Science, Technology, & Innovation (NCSTI) which was formed on 10 October 2020.

With the NCSTI newly established at MISTI, it is necessary the body must play a substantial role in coordinating the relevant ministries and institutions to work together for a common goal of STI as a tool for the sustainable growth of Cambodia in terms of economy, society, and environment. Additionally, it is important to have a supporting infrastructure, laying out mechanisms allowing good interaction/engagement between government, private sectors, and academia.

The role of existing and newly created STI infrastructure components and their roles are described in Table 1. This table will give a short description of the body that is the key player of each main activity of the STI ecosystem.

Table 1: STI Infrastructure in Cambodia

STI domain	Authorization	Establishment	Coordination	Implementation
SCIENCE AND STI EDUCATION				
Science landscaping and access to publications	NCSTI	MoEYS, MoLVT, MoH, MAFF, MISTI, CDRI, AVI	MoEYS, MISTI	MoEYS, CDRI
Support to scientists or R&D activities	NCSTI	MoEYS, MISTI, MAFF, MEF, MoH	NCSTI, MEF	MoEYS, MISTI, MAFF, MoH, Private research centers and companies
STEM education and TVET	NCSTI	MoEYS, MoLVT, MAFF, MoH, MISTI, MPTC	MoEYS, MoLVT	MoEYS, MoLVT, MAFF, MoH, MPTC, Private Institutions
TECHNOLOGY				
Technology-intensive infrastructure	NCSTI	MISTI, MoEYS, MAFF, MPTC	NCSTI, MEF	MISTI, MoEYS, MAFF, MPTC, relevant ministries/companies
Industry-scale technologies	NCSTI	MISTI, CDC	MISTI	MoEYS, Industries
Small-scale technology	NCSTI	MISTI	MISTI	MoEYS, Companies
eGovernment, ICT in public administration	NCSTI	MEF, MPTC, MISTI, MEF	NCSTI, MEF, MPTC	MPTC, MISTI, MEF
INNOVATION				
Innovation policy and ecosystem	NCSTI	MISTI	NCSTI, MISTI	MISTI, MoEYS, MAFF, MPTC
Specific innovation support systems	NCSTI	MISTI, MoEYS, MAFF, MPTC	NCSTI, MISTI	MISTI, MoEYS, MAFF, MPTC
Social or inclusive innovation	NCSTI	MISTI	MISTI	MISTI

Source: Authors' compilation based on documents of RGC

2.3 Regulation framework

A regulation framework such as policy and legal process on STI in the context of Cambodia is far from coordination and can actually be found in different places like different ministries and institutions. However, the newly established MISTI in late March 2020 is going to be the only one government agency that is granted full authority by RGC to coordinate, lead and manage all STI related work, policies, regulations and legal framework (OCM, 2020a). Subsequently, sub-decree No. 48 ANKr.BK. dated on 6 April 2020 on the Organizing and Functioning of the MISTI where it provides jurisdiction of the MISTI to fulfill its mission as the RGC's servant (RGC, 2020b). The sub-decree creates two significant institutions such as General Directorate of Science Technology & Innovation (GDSTI) and National Institute of Science, Technology & Innovation (NISTI). These two organizations are the specialized ones to organize and prepare the STI policy, create the road map, draft laws and regulations related to the STI. The GDSTI has a mission to organize and manage discovery with technology in order to serve technology development in the fields of industry to promote artificial intellectual, robotics, and automation, and promote technology affairs such as smart, artificial intelligence, air-space technology and air-space information, and eco-innovation (RGC, 2020b).

Meanwhile, the NISTI is an institute being mainly responsible for research and development of STI, in addition to providing capacity building on technology and innovation to serve intersections such as industrial revolution 4.0 and other next industrial generations, and promoting and encouraging research on artificial intelligence, robotics, and automation. The NISTI collaborates research on industrial technology (Agri-industry, food, and bio-medical) and electronic industry (software and hardware), and organizes and operates the laboratories, scientific research, and development of technology (RGC, 2020b).

Prior to the establishment of MISTI, there was an establishment of the National science and Technology council (NSTC) on 8 August 2014 (OCM, 2014). NSTC has its secretariat under the management of Ministry of Planning, and this National Council is chaired by Samdech Hun Sen, the Prime Minister. The NSTC is served in the Royal Government of Cambodia on Science and Technology drafted policy review and approval, promotion of policy implementation, production of strategic plan, master plan, action plan, development of programs for ST, and so on and so forth. NSTC has adopted the 10-year National Action Plan of science & technology for 2020-2030 (RGC, 2019).

Because the NSTC focuses only on science and technology, on 10th October 2020, the NSTC was converted to NCSTI through Royal Decree No.RS/RKT/1020/1073 where it serves the functioning of the Government on STI development by reviewing, approving, and promoting the policy implementation, creating the strategic plan, master plan, action plan, and developing program for STI. Also, it coordinates the STI leading tasks of Inter-Ministries and Institutions; mobilizes financial, technical, and human resources to support institutions and organizations working on STI development; and sets principles for human resources development in STI. Samdech Prime Minister is the honorary Chair of NCSTI, and Minister of MISTI is the Chair. NCSTI consists of thirty government institutions including other mainline ministries such as MoP, MoH, MME, MAFF, MoYES, MPTC, and others. The NCSTI has its own secretariat to assist and support the council members in order to collect information and data, and organize the event of the council (RGC, 2020c).

National Policy on STI: the NSTC adopted the national policy on STI for 2020-2030, which focuses on developing and strengthening adequate STI human resources with a balance in gender and professional ethics. Additionally, it focuses on enabling prominent STI human resources to perform leading tasks and establishing filtering and promoting mechanisms in order to create an enabling environment for national STI human resources to perform their full potentials (RGC, 2019). NSTC enables national research and development in an efficient and effective way focusing on the adaptation of acquired technologies to the local context and enhancing capacity to absorb foreign technologies. Through this policy, the government will draft and adopt laws related to STI such as laws concerning to basic framework of STI development, and other important legislation to strengthen governance of, promote, and stimulate STI development. The government's will is underway forward; however, it is noted that in 2014, the NSTC created its National Master Plan for 2014-2020 by aiming to draft and adopt at least seven laws such as the law on the composition of the committee and operation of the Cambodian S&T Council; law on the cultivation, use and treatment of S&T manpower; law on the installation and operation of government funds for S&T promotion, law on the establishment and operation of R&D institute; law on implementation and management of national R&D projects; law on cooperative development between industry, academia, and research institutes; and law on the establishment and operation of an S&T information center, etc. (NSTC, 2014). In 2020, the law on the establishment of MISTI has been adopted. The rest of that, it has not revealed the concern regulations and laws.

National Policy on ICT in 2020 is MPTC's document which focuses on setting up the policy framework, coordination framework and institutional arrangement for telecommunication, and ICT development. It also enhances business, investment environment, provides interlock measure and specific invention as need in the telecommunication, and ICT sectors. Under this policy, MPTC also targets to make a secure ICT system avoiding hackers who make troublesomeness of banking system in private sectors, and government's system operation. In addition, MPTC will push to organize and adopt the broadband policy, radio telecommunication policy, policy on universe global service and other policies concerning ICT as needed. MPTC collaborated with MOC to draft the e-commerce law and relevant sub-decrees. Those regulations have been adopted by the national assembly and government (MPTC, 2020).

Under the support of KOICA, the Cambodian ICT Master Plan for 2014-2020 has been created. It focused on empowering people, ensuring connectivity, enhancing capabilities, enriching e-services. Human resource building and e-awareness were a very important part that was stated in the Master Plan because it is a catalysis for industrial growth in the country. Promoting of telecommunication industry through opening the market and enhancing the internet service base, and having a plan to secure a national satellite and build up submarine cable are the main points (KOICA, 2014). Enhancing capacity focuses on the ICT industry, ICT standard, and research and development where it targets to be ownership of and to be enrolled into the global ICT ecosystem; to build the human resource capacity and competitiveness via research and development. The master plan also focuses on enriching e-Service, which addresses to e-government service, e-public service, and e-economic service. E-service has been implemented by the government and private sectors such as e-visa, e-banking, e-payment and so on. In order to navigate master plan to reach its goal, they have never forgotten to setup the legal framework to secure their drive. The following laws were mentioned in the Master Plan in 2014: National ICT policy by NiDA (MPTC), Telecommunications Law by MPTC, e-Commerce Law by MoC, Radio Communication Law by MPTC, Law on the Copyrights and Related Rights by MoC, MoI, and MCFA, and Cybercrime Law by National Information Communication Technology Development Authority (NiDA). It is observed that those laws have been adopted, except only Radio communication law, and Cybercrime law whose draft was pending at MPTC.

E-commerce Law in Cambodia. In late November 2019, the Electronic Commerce Law (E-Commerce Law) has been promulgated by the king (OCM, 2019). The law aims to provide confidence to the public for electronic use and communication; it manages and controls electronic commerce within Cambodia, and abroad. It also creates authenticity in business transactions and civil relations through electronics. E-commerce law is required in modern technology to track whether the transaction, business, or contract has been created. In order to secure the electronic transaction, the law provides MPTC with authority to manage and control secure proceeding of electronic notification and electronic signature. The law also recognizes electronic signature for establishing the contract of the parties where it is similar to Digital Signature. However, a digital signature is required to register at MPTC. The RGC issued Sub-Decree No.246 on Digital Signatures in 2017 where it is an electronic message certifying the digital signatory and verifying the authentication of such electronic message signed by the digital signatory.

Law on Telecommunication has been promulgated in December 2015 and it stipulated to ensure the utilization of infrastructure, networking, service, and provision of effective, safe,

quality, reliable, and affordable telecommunication responses to the needs of social and economic development; ensure participatory and encouragement of private sectors in the telecommunication field, and the lawful and effective competition; and ensure to protect users and to enhance the mobilization of national revenue. This law provides the authority to the Ministry of Posts and Telecommunications to control and manage all networks of telecommunication and internet services. It has also established functions and duties of the Telecommunication Regulator of Cambodia; classification and types of permits, certificates, and licenses; control and utilization of infrastructure and networks; and provide the capacity building, and research development (OCM, 2015).

Law on the Patents, Utility Model Certificates, and Industrial Designs have been promulgated in January 2003 where it protects granted patents and utility model certificates and for being registered in Cambodia, which follows this Law and the Patent Cooperation Treaty. The law aims to motivate innovation, and scientific and technological research and development; to promote domestic and external business and investment; to promote technology transfer to the country in order to facilitate industrial activities and economic development; and to provide protection for rights of industrial ownership and to combat the infringement thereof, as well as illegal business practices. The term, “patent” means the title granted to protect an invention; and the term, “invention” means an idea of an inventor that permits in practice the solution to a specific problem in the field of technology. This law is very important to protect the utility model on any invention that is new and applicability of industries and may be, or may relate to, a product or process. Tech incubators who created any new model of technology for industries are protected by this law (OCM, 2003). This law is also related to the laws on trademark and copyrights. The Trademark Law covers the protection of trademarks and service marks, when an objection to registration may be made, and the prior given when there has been a previous registration in another country, among other things. The trademark owners have been protected by the law, as well as their right to assign, transfer, and license their trademarks to third persons. The owner of the trademark can seek civil and administrative remedies. Law on copyrights is to provide the rights of the authorship, and the right related thereon concerning works and the protection of cultural products, performance, phonogram, and the transmission of a broadcasting organization to secure just and legitimate exploitation of those cultural products, and thereby contribute to the development of culture (OCM, 2003).

Taking into consideration the fast change of technologies in the context of the fourth industrial revolution it is a fact that MISTI is the coordinating body to facilitate STI ecosystem development in the countries. Furthermore, NCSTI is a national institution with full authority in facilitating and regulating the framework. It should be noted that several legal documents are to be produced in the future once accounting the TOR of each MISTI as well as NCSTI. For instance, the prioritized sectors are to be endorsed nation-wide with a well-designed supporting system of legal frameworks. At the same time, the legal support system must be up to date once the fast change of technologies is being employed at the market with the uncertainty of consequences of pros and cons. Thus, a favorable legal framework must be in place such as technology transfer, artificial intelligence (AI) ethics, FinTech Law, digital technology and implementation guideline, and others.

2.4 Competencies and Skills

Cambodia is transforming and modernizing the industrial structure from a labour intensive to a skill-based one. As stated in the rectangular strategy phase IV (2018-2023) and Cambodia's IDP (2015-2025), the RGC has emphasized that growth, employment, equity and efficiency

are one of the objectives in Cambodia's economic and social development planning. It also links the Cambodian industry and economy with the global value chain and integrates them into regional production networks. Cambodia has currently depended on labour-intensive manufacturing and low skilled service sectors to support its growth. Once the country develops towards an industrial market economy, more sophisticated production processes and high-skilled labour forces are required to sustain its rapid growth and to compete in the global markets.

However, the relationship between education and vocational training, and industrial policies remain limited. The government has launched key employment and human development policies, including the national employment policy (2015-2025) and the national technical and vocational education and training policy (2017-2025) in order to enhance skills and human resources development to meet the country's development. Therefore, if Cambodia is committed to transform a higher value-added economy, building human capital that can program new technology in the higher value-added sectors is one of the key success factors. The identification of the higher value-added sectors is very important specifically, responding to the needs of industry revolution 4.0 in Cambodia. In addition, Cambodia's growth has been largely driven by four main sectors, including garment manufacturing, tourism, construction, and agriculture. However, the long-term sustainability of growth will depend on the country's ability to move beyond these sectors, which in turn will require different skills from its work forces. It provides a more stable foundation for further industrial development and diversification. According to the NEA survey in 2017, ICT, finance and insurance, health, and education sectors experienced the higher demand in 2017 compared to 2016. It was expected to have a continued high demand for both 2018 and 2019. Moreover, the survey results show the highest proportion of establishments planning to introduce new services, products, or technologies, and to attain new markets in the future are in the education sectors, and finance and insurance.

Despite improvements in the education system, including educational hardware and software over the past two decades, many constraints on the learning environment and quality of teaching need to be considered. Indeed, Cambodia is facing a shortage of skilled human resources even for low and medium-skill intensive industries. Research on measuring human capital between 1990 to 2016 reveals that Cambodia education has accelerated slower than some countries in the globe and some countries in ASEAN region (Lim et al., 2018). There is a rising gap between the skills supply and demand that industries and businesses need. Concerns over skill gaps and skill mismatch are the persistent challenges by RGC (Madhur, 2014). According to the World Bank (2012), 73% of employers report that university graduates do not have the right skills for the jobs for which they are applying. There are about 22% of the foreign companies in Cambodia, which acknowledged skills as a severe constraint on their business. Therefore, to enhance the effectiveness of the education strategies and policies, there will be of a merit in pursuing a set of complementary measures that ensure students are prepared from the early primary school, continuous review and update of the curriculum, continuous improvement of the teaching pedagogy, enhanced digital skills as well as the skills in the 21st century. Specifically, one of the priorities should be given to better enhancement of the Cambodian workers' current skill sets as well as preparing for the future skill demands given the pace of the country's demographic shift. Indeed, the 21st Century skills are 12 abilities that today's students need to succeed in their future careers in the IR 4.0, including (1) critical thinking, (2) creativity, (3) collaboration, (4) communication, (5) information literacy, (6) media literacy, (7) technology literacy, (8) flexibility, (9) leadership, (10) initiative, (11) productivity, and (12) social skills (Chu, S. et al., 2016). These skills will help students to keep

up with the lightning-pace of today's modern markets. Specially, these skills are essential in the age of the internet of things (IOT). Figure 4 shows the skills in the 21st century.

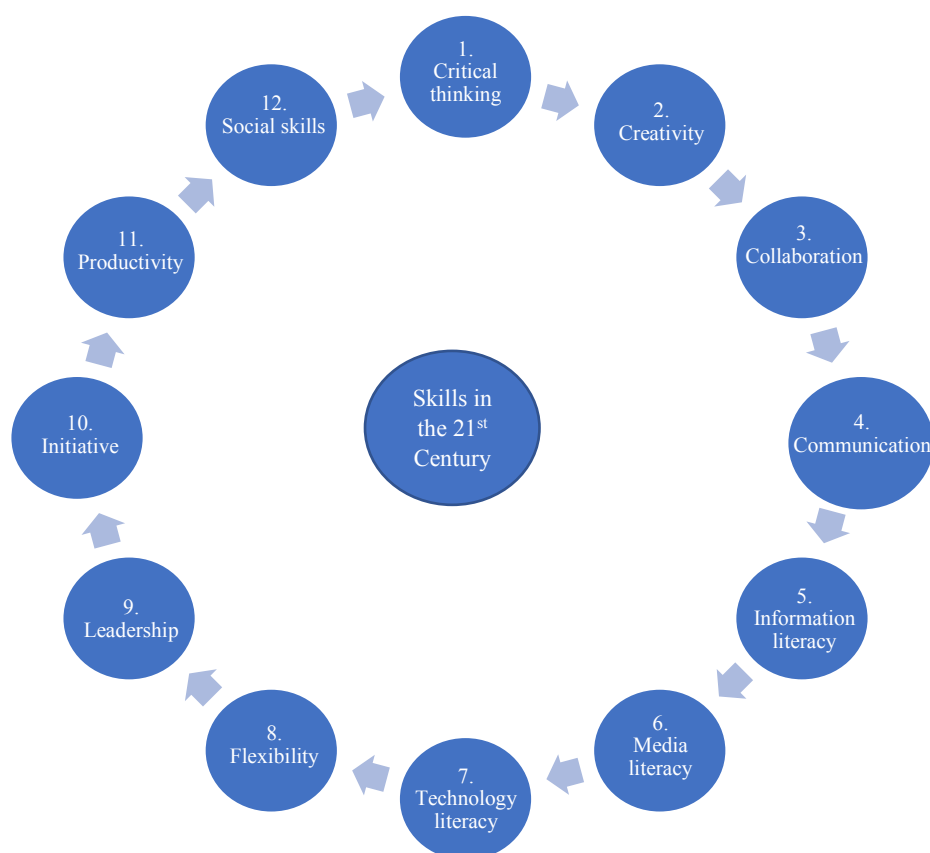


Figure 4: Skills in the 21st Century (Chu, S. et al., 2016)

In addition, the 21st Century skills are divided into the three categories, including (1) learning skills, (2) literacy skills, and (3) life skills. The learning skills explain the students about the mental processes, which is required to improve upon a modern work environment. The literacy skills emphasize on how students can determine the facts and the technology. The life skills observe the intangible elements of a student's daily life, including their professional and personal characteristics.

Critical thinking is one of the most important quality for the students, while creativity enables students to understand the concepts in different perspectives, which results in innovation. For collaboration, the students can work together and get the best possible results from resolving an issue, while communication is important for students to learn how to convey ideas among different personality types. Figure 5 shows the skills in the 21st century in terms of the learning skills.

The literacy skills are one of the skills categories in the 21st century, which concerns with a different element in digital comprehension. The information literacy is the foundational skill, which helps the students understand the facts. It teaches them how to separate the fact from fiction, while media literacy is useful for identifying the truth in the digital world. For technology literacy, it explains the students about the machines, which involves in the digital age. Figure 6 shows the skills in the 21st century in terms of literacy skills.

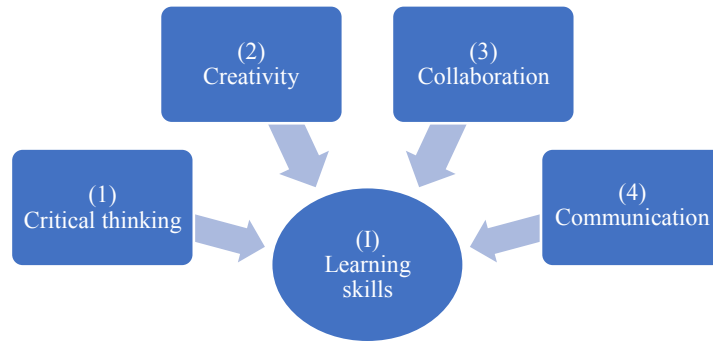


Figure 5: Skills in the 21st Century: Learning Skills

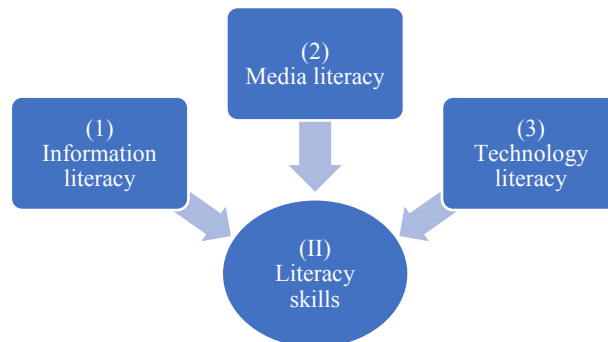


Figure 6: Skills in the 21st Century: Literacy Skills

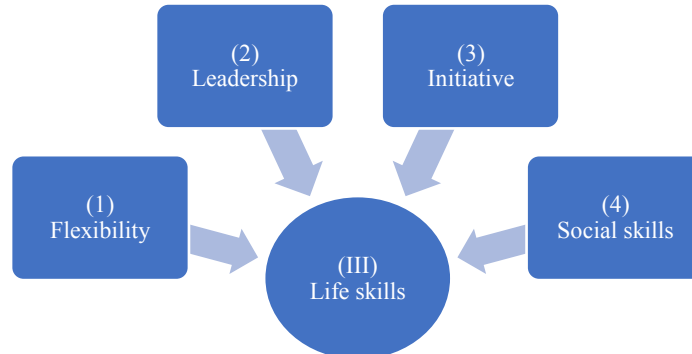


Figure 7: Skills in the 21st Century: Life Skills

Life skills, especially STEM education, is one of the categories in the skills of 21st century, which transforms into professional settings. For flexibility, it helps the students to deviate from plans as needed, while leadership motivates the students to take lead or accomplish a goal. The initiatives assist the students to come up with new ideas to plan their projects, while productivity assists the students to maintain efficiency. Lastly, social skills development and professional attitude improvement at schools and multifaceted training at the working place are in need to go hand in hand with the hard skill to match the supply and demand for future workforce to attain sustainable economic growth for the country. Human capital development in the top sectors to be prioritized should be prepared to cope with the fast change of technologies in the context of IR 4.0. Figure 7 shows the skills in the 21st century in terms of life skills.

2.5 Technology

Technology is where we apply science to create devices or services that can solve our daily life and demand. It is simply explained as the application of science. Science concepts have been made for making up of technologies. However, technology has vice versa served as a fundamental tool to explain science. Scientists may find it easier in this digital era to explain facts or natural phenomena through support of ICT as a tool. RGC has established key digital policy initiatives since the early 2000s, including Cambodia's ICT Master Plan 2020, Rectangular Strategy Phase IV, Telecom/ICT Development Policy 2020, E-commerce and Consumer Protection Law 2019, and Industrial Development Policy 2015-2025. Cambodia is currently preparing a long-term strategy for the digital economy 2020-2035, including digital and technical human resources, digital infrastructure, cognitive and soft skills, business ecosystems, and e-government. In addition, the Cambodian ICT Master Plan 2020 was launched in 2014. The plan aligns with the ASEAN ICT Master Plan 2015 to focus on digital literacy training, human resources, computer access of government employees, expanded ICT infrastructure, and cyber security. The specific goal is that 70% of Cambodian people are able to access the internet by 2020. Indeed, Cambodia's digital transformation is gathering pace and has exciting development prospects. Cambodia has rapidly transformed from a low-skilled, labour-intensive growth model to a skills-driven one. The government has also prioritized Industry 4.0 and concentrating on diversifying its workforces. Therefore, dealing differential impacts of digitalization will be critical to retain inclusiveness along the digital transformation path. Promoting inclusive development should be a central component of the new digital economy framework that the government is expected to roll out in 2020. Cambodia should consider the measures to foster an inclusive digital transformation in the future, including (1) transform innovation in the manufacturing sector; (2) provide good quality digital skills for the future; (3) nurture the digital start-up economy; (4) enable the most vulnerable groups to take part in the digital economy; (5) ensure a public sector leading by example; (6) provide coding or programing curriculum at the early stage of education from the primary school; (7) develop soft skills in digital technology; (8) building personal characteristic towards digital technology; and (9) build professional ethics towards digital technology (CDRI, 2019). Figure 8 indicated the inclusive digital transformation measures.

Besides the digital technologies in ICT sectors, the technology in other sectors like energy, food science, manufacturing, biotechnology, and others are important for industries and SMEs. Knowing trends and scouting of technologies help employers to maintain and catch-up new growth in their business. Thus, the support system allowing a good environment for technology to be served as a tool for socio-economic development is the best option for Cambodia.

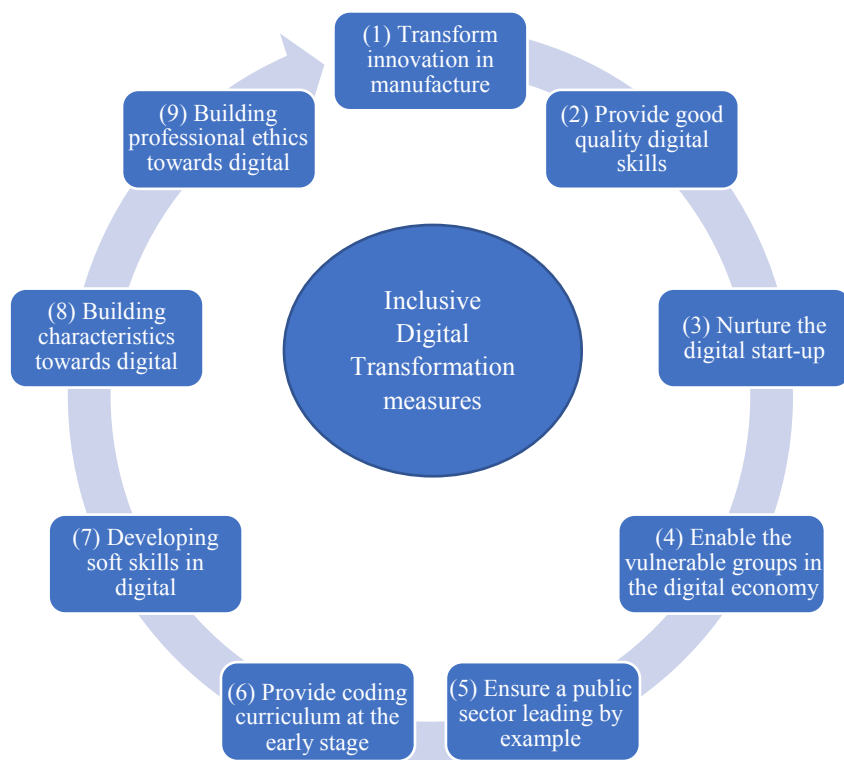


Figure 8: Extended Compilations on Inclusive Digital Transformation (CDRI, 2019)

3. STI opportunities and challenges

3.1 Opportunities

Cambodia is located in the Southeast Asia region; it is a developing country based on four important sectors including agriculture, garment, tourism, and construction; the vision of the Cambodia government is to strive to become a country with a high average income in 2030. In order to contribute to the vision of the government, it is important to diversify to other sectors. Cambodia remains to have a favorable environment to attract FDI since the country has a majority of young age and a cheap labour force within the short-term and medium-term. Geopolitics preference of being in the ASEAN region with more than 647.74 million population could make Cambodia one of the heart of the economic hub.

The tourism sector remains a potential hub for historical and cultural leisure. Attracting high-quality tourism with diversified destination targets with better service is an immediate task to be addressed.

The civilization of nations in history had used science & technology as a means of development. The RGC understands the need of improvement in the sectors. For instance, the political platform of rectangular strategy phase IV was established with clear direction on science and technology as a means for development. Other national agendas are laid out as a priority in various ministries including STEM policy with MoEYS, STI policy with MoP, TVET Policy with MoLVT, and other related initiatives as mentioned in the above section. On the other hand, ASEAN has a clear structure for the promotion of STI. APASTI was made with concise thrusts directing the ASEAN member states for action. Contextually, there are drivers for the STI ecosystem in Cambodia. Those could be highlighted as a triangle concept as seen below:

- Government

- Favorable political platform outlined the rectangular strategy phase IV on the importance of science and technology. Additionally, national plans are designed to support according, which include official and legal frameworks such as STI policy, STEM policy, TVET policy, Digital government initiatives, newly-established NCSTI and MISTI, and National Committee of STI for ASEAN, and others.
- Funding institution should be made in place since MISTI is the coordinating body for STI. Development partners and private sectors had faced a challenging environment in the past once trying to work on STI since many local stakeholders working on the sectors. Now, we have MISTI and NCSTI as a working platform to promote STI as a means of collaboration for mutual benefits.

- Academia and research institutions

- Recently, MoEYS has committed in promoting STEM education. Higher education institutions received support for STEM development. For instance, HEIP project is one of the recent project in higher education. Public-private partnership model is found to be generally promoted. University-Industry Linkage is on the agenda for most top universities in the country. Research is given the priority to the collaboration with the private sectors. For instance, HEIP project secures 70% of research component budget for collaborative research with the private sector, while the other 20% and 10% are for policy-driven research and fundamental research, respectively. Human Resource Development Master Plan is being developed to increase the number of faculty staff with higher degrees in STEM. Study Club Policy is being formulated to improve student learning outcomes with particular emphasis on STEM. The policy also focuses on the mandate to create study clubs in secondary schools to implement project-based education in some key subjects. This initiative is to promote deep learning and STEM-based activities beyond the classroom. The policy is in line with the STEM Education Partnership Program and will help connect secondary schools to universities and vice versa.
- Researchers have paid more attention to their freedom in their job, and design career path is established. For instance, the royal decree on professorship title was made on 23 January 2013. Subsequently, MoEYS executed this royal decree for higher education institutions to have structuring of professorship title with the Prakas released on 28 August 2020. As results, the STI ecosystem will be yielded from knowledge creation by academic sectors.

- Private sectors and Employers

- High demand for human resources with quality by private sectors is a driving force and motivation behind policy support systems and academia as supply sides.
- Employers choose or upgrade skills for their workers to be readily cope with a dramatic change of technology and to catch up with new growth cycle

3.2 Challenges

Considering the rapid evolution of Cambodia patterns of economic development, the challenges caused by the COVID pandemic, the priorities for STI focus must be re-visited. The top challenge in realizing the main goal of RGC spelled out in the Six Rectangular Strategy Phase IV 2019-2023 is the low quality of human capital. The low quality of human capital is well recognized in policies and planning in all sectors. UNDP (2019) stressed that the low quality of human capital of today will have a big implication on the future economic growth of Cambodia. A review on measuring the human capital of 195 countries showed similarly that the human capital index of Cambodia is improving slowly from 1995 to 2016 (Lim et al., 2018). UNDP (2019) recognized in its country program document for Cambodia (2019-2023) that institutional capacity building of public institutions is so significant. Asian Development Bank (2018) and World Bank (2019) prioritized their programs on investment in addressing a shortage of skill.

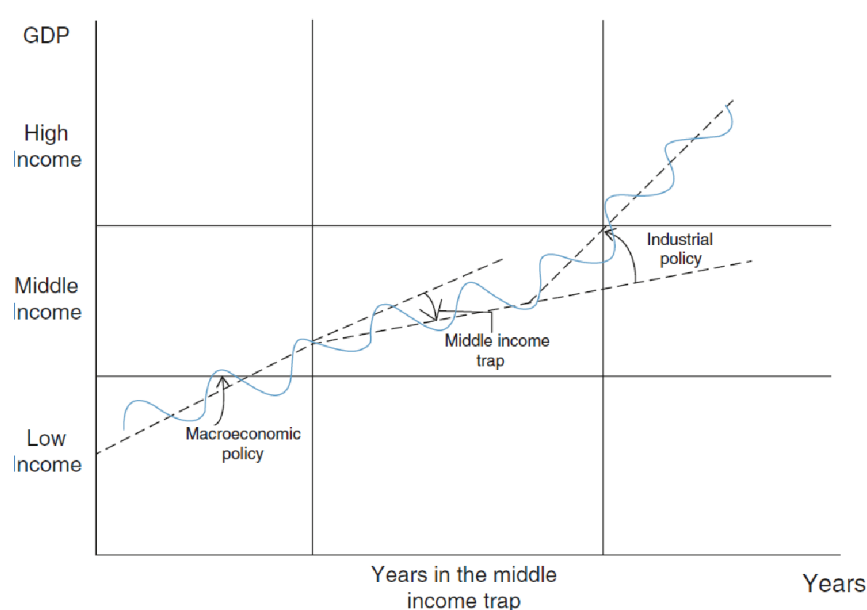


Figure 9: Industrial Policy and the Middle-income trap (Yülek, 2018)

Quality human capital is a key to unlock the door of sustainable development and inclusive growth. It is the only driver to transform Cambodia into a high middle-income by 2030 and a high-income nation by 2050 (RGC, 2019). Sustainable development and inclusive growth heavily, largely and solely depend on a green-based and skills-based economy. In addition, rigorous policy for industrial innovation is yet to be addressed in Cambodia. The empirical study suggested that the industrial policy is a significant driver to avoid the economic trap of the middle-income level as seen in Figure 9 (Yülek, 2018). Thus, the path to the visions of 2030 and 2050 is to be going through an innovative approach in economic upgrading, diversification, productivity, commercialization and competitiveness. This pathway needs to integrate STI in industrial sectors from an evidence and sound national innovation system as a means for more efficient production/consumption in the supply chain ecosystem.

- Lack of STI integration for a required evidence-based planning and investment in economic upgrading, diversification, productivity, commercialization and competitiveness
- Insufficient quality transformation of physical infrastructures such sectors as transports, water resources, electrical powers, agricultures, science and technology

- Lack of well-designed planning and investment in quality research for top and strategic sectors
- Quality R&D and its ecosystem remain behind needs for required growth addressed in existing plans.
- Unfavorable environment attributed to no well-designed plan and investment in STI to attract high-quality researchers

However, national innovation system must be in place in order to synergize human capital components. The human capital divides into five components: 1) quality human capital to support the management of funding and financing in STI, 2) human capital in infrastructural development, 3) human capital in regulatory and policy development, 4) human capital in skill and 5) human capital in tools for STI development and innovation. The national innovation system model is presented in detail in Figure 10.

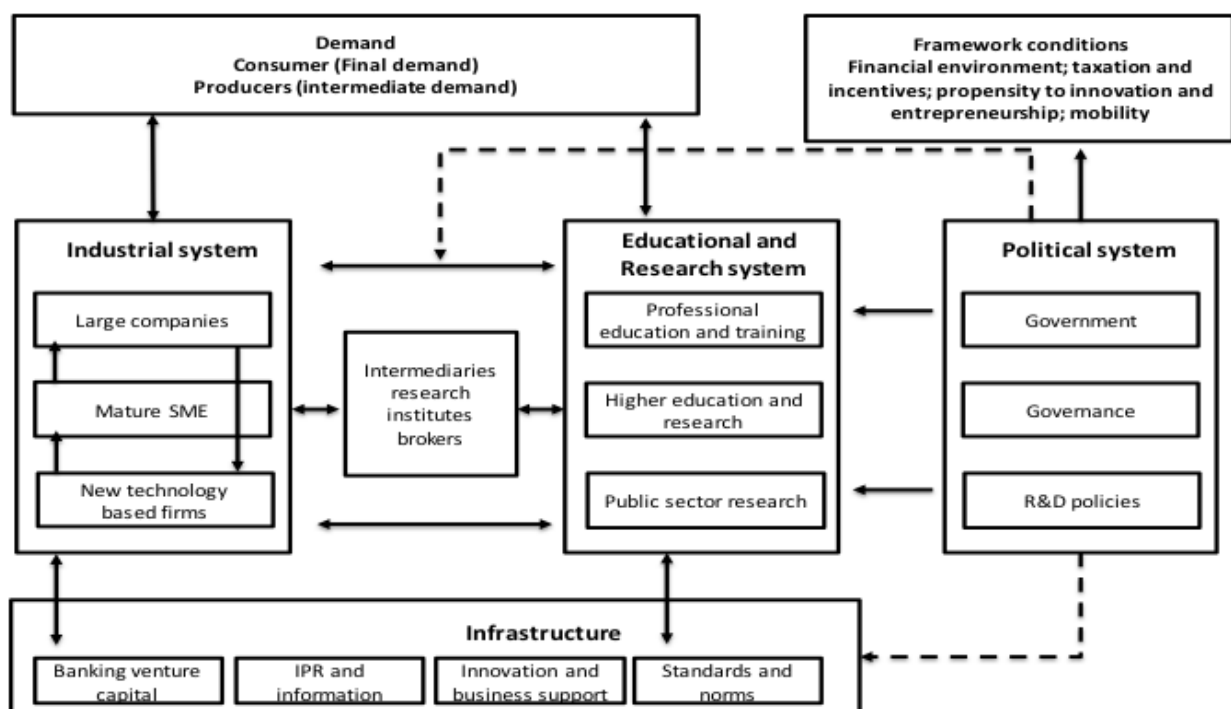


Figure 10: National Innovation System Model (Kuhlmann and Arnold, 2001)

4. Strategic Directions and Recommendations

4.1 STI Investment

Investment in science & technology through the improvement of industrial capacity and support in the education sector has been itemized in the agenda of most emerging and advanced development nations such as Japan in 1968, the Republic of Korea in 1945, China in 1949, and Singapore in 1965 (UNDP, 2019). Although Cambodia has possessed considerable progress economically and socially in the last few decades, however the development of a knowledge-based workforce of STI background is suggested for attaining inclusive and long-term growth. Therefore, serious commitment with the action of sound readiness to modify the development plans from continuous monitoring and evaluation is necessary to reach the vision. MISTI must stay in a strong position to coordinate and work closely with relevant stakeholders including MoEYS, MoLVT, MoH, and MAFF to foster the STI quality education at all levels and other STI related players to have a favorable ecosystem in the country. The strategy is to invest in the education and on the job training for private sectors and shape the human capital from

primary level to university with a sound-relevant program of teaching/learning and research agenda. This will give the students engaging in science and its useful application rather than learning about the science. Developing a favorable ecosystem of having scientific attitudes in society is the ultimate goal of RGC to meet set vision. Connection to this goal, science museums are a major part to develop positive attitudes towards science in relation to history, with particular reference to young people and to educate the public about science and technology. The ecosystem in the museum will create a prosperous learning environment, especially, for the children.

It is necessary to promote the applied research at universities or research institutions through incubation or startup centers and to serve for the industry. With the creation of a dissemination channel of STI to the public, it would be further flourishing the STI culture in our society. Lessons learnt from advanced economic nations impress that R&D plays an essential factor in their GDP. It is suggested in general that economic growth can be realized automatically once a country allows scientists to conduct their research on national interest sectors and security (Bush, 1995). Since Cambodia is still in the development phase, the strategic capacity building in STI is necessary through the collaboration among national and international stakeholders. Building a strategic plan to attract scientific talent, giving them suitable social status, and securing another support system for the right man-power is inevitable for speedy STI development. On the other hand, the right public-private partnership model in the STI sector is significant to spur funds for useful R&D.

According to the Global Innovation Index Database in 2020 as shown in the Table 2, it shows that Cambodia requires to promote STI investment urgently. Cambodian innovation is low performance compared to Cambodia's neighboring countries which are shown to be above the expectations for level of development within the same group of lower-middle-income (Dutta et al., 2020).

To improve Cambodia's innovation performance index, more support, promotion, and funds are an immediate task for RGC. MISTI is serving as an important entity in structuring this urgent directive with its new mandates. MISTI is currently putting its efforts into drafting new policies regarding STI as well as promoting the benefits of STI to the public and other stakeholders focusing on the development of support systems for finance/funding, infrastructure, regulatory frameworks, skill/talent, and technology.

Enabling market-driven programs for R&D, entrepreneurship development, an advanced technology start-up, and scale-up on top sectors are suggested for MISTI, while evidence-based technology transfer means must be in place to ensure favorable FDI with locally built knowledge handover. For these reasons, investment in STI must be strategically made based on the commitment of the country's vision. Contextually, it is observed that the ecosystem has been twinkled by government stakeholders, private sectors, and development partners. It is, however, viewed as project-based and there is no information centered with monitoring and evaluation systems in place to oversee if all activities are in line with the government priority agenda. Thus, the foregoing factors embedded STI as the heart and hub in the development cycle is viewed as the new engine for inclusive growth. A call for inter-and trans collaboration across ministries and stakeholders will ease the STI ecosystem contributing to the above-mentioned priorities as the new engine for inclusive growth.

Table 2: Innovation performance at different income levels, 2020 (MoP, 2010, 2016)

	High-income group	Upper middle-income group	Lower middle-income group	Low-income group
Above expectations for level of development	Switzerland Sweden United States of America United Kingdom Netherlands Denmark Finland Singapore Germany Republic of Korea Hong Kong, China France Ireland Japan Canada	China Armenia South Africa Georgia North Macedonia Thailand Serbia Jamaica Costa Rica Bulgaria	Vietnam Ukraine India Philippines Republic of Moldova Mongolia Tunisia Kenya Morocco	Malawi Rwanda United Republic of Tanzania Niger Madagascar Mozambique
In line with level of development	Luxembourg Austria Norway Iceland Belgium Australia Czech Republic Estonia New Zealand Portugal Italy Cyprus Spain Malta Latvia Hungary Slovenia Croatia Poland Greece	Montenegro Brazil Colombia Malaysia Jordan Mexico Bosnia and Herzegovina Iran (Islamic Republic of) Peru Albania Belarus Mauritius Lebanon	Kyrgyzstan Senegal Indonesia El Salvador Zimbabwe Uzbekistan Honduras Cabo Verde	Nepal Burkina Faso Tajikistan Uganda Togo Mali
All other economies	Chile Slovakia Lithuania Uruguay United Arab Emirates Panama Saudi Arabia Qatar Brunei Darussalam Bahrain Kuwait Oman	Ecuador Azerbaijan Turkey Argentina Paraguay Russian Federation Sri Lanka Guatemala Namibia Botswana Dominican Republic (the) Algeria Kazakhstan	Cambodia Cote D'Ivoire Pakistan Ghana Egypt Cameroon Bolivia (Plurinational State of) Bangladesh Zambia Nigeria Lao People's Democratic Republic Myanmar	Ethiopia Guinea Benin Yemen

Source: MoP (2016)

4.2 Institutional Governance

This section aims to provide the recommendation, direction, a set of policy as well as the institutional arrangement which facilitates the STI investment and development. New data and information obtained through broad consultations with ministries, the private sector and development partners should be considered in setting new priorities to meet the new normal conditions of Cambodia, the region and beyond.

1. Government:

- Rethink the directionality and set out an evidence-based direction for national growth with ambitious but realizable vision, strategic plans, and activities in short-, medium-, and long-terms.
- Review and amend the mandates, regulations, and laws of relevant institutions with a well prior-defined scope of jurisdiction and its responsibility especially between the ministries to avoid the redundant efforts and wastage of the national budget.
- Strengthen the capacity of the government officials in the relevant institutions, with a strict regulatory system.
- Reduce any bureaucratic procedures that could hinder innovation such as some registration and business application procedures, and facilitate investment and business environment.
- Develop standards, templates, and a broad framework for ensuring uniformity, interoperability, and security for any applications in Cambodia, regardless of the ministry or agency developing it.
- Develop a unified government portal and guiding framework for security and uniform look and feel that will link to public sector websites.
- Provide rewards to businesses that invest in on-the-job training and internship-based training (potentially in the form of tax cuts or cost-sharing) that could significantly create a community of internships.
- Promote the investment on R&D, necessarily initiated with the government first, that could lead to national commitment toward investment on R&D among public and private sectors.
- Identify and prioritize the champion industrial sector in order to effectively promote local and foreign direct investment.
- Reinforce education system in STEM majors and STI role models, improve physical infrastructure and macroeconomic framework to maintain the momentum and growth rate of 7% of GDP, or even higher, and to avoid the so-called *middle-income country trap*. Moreover, consider mobilizing from labour-based to knowledge-based manufacturing sectors, and improve R&D infrastructure.
- Promote the investment of the Multi-National Companies (MNCs) on heavy industry sectors such as electronic and electrical appliances, semiconductor, bio and genetic technology related industries and chemical industries.
- Mobilize human resources, know-how, sophisticated and higher skill sets from abroad to upgrade manufacturing enterprises to diversify the higher value-added exports.
- Import the modern tech-embedded machinery and production line through FDI, development partners as well as technology vendors.
- Promote cooperation or/and experience sharing program with the unicorn companies to replicate the excellences from those successful businesses.
- Provide the technical support from advanced technological development countries to upgrade manufacturing sectors to increase efficiency and productivity.
- Create, nationally and internationally, comparable databases on the links between industry, technology, competitiveness and globalization to inform research, debate and policymaking.
- Develop and reinforce the monitoring and evaluation framework to continuously assess the progress and revise, if necessary, of the policy implementation.
- Set up the institutional bodies in charge of policy implementation monitoring and evaluating of STI, possibly National Council of STI, and the newly established institution.

2. **Education:**

- Adopt a mechanism to monitor the changing skill needs. This could take the form of industrial surveys or frequent (e.g. quarterly) dialogues between industry representatives, government and academia
- Reconstruct the higher education system to prepare for Industry 4.0.
- Reform the curriculum of primary and secondary school to prepare the future generation for IR4.0 by implementing IT, ICT, Coding, and Programing in the curriculum.
- Improve and strengthen the capacity of teachers to ensure that they have adequate qualifications especially on Industry 4.0.
- Promote and intrigue students to choose STEM subjects among students in primary and secondary schools with a whole range of equipment for experimentation in the field of science.
- Provide or find scholarships on science related subjects: physics, mathematics, engineering, reverse-engineering, manufacturing, mechanical engineering, electronic and electrical engineering, biotechnology and genetic engineering, nano precision and material engineering and so on.
- Promote STI Talent Circulation through attracting overseas Cambodians and foreign talents.
- Revolutionize the teaching and learning method by deploying modern technological equipment and tools such as AR, VR, 3D-printing and so on.
- Provide on-the-job training to upgrade the capacity especially in the manufacturing sectors.
- Enhance the University and Industry Linkages (UILs) to transition from a traditional university to an entrepreneurial university through patenting the researched products and promoting the deployment of researched products by private sectors to upgrade manufacturing capacity to increase the high value-added productivity.

3. *Supporting Infrastructure:*

- Improve and expand the physical infrastructure such as Internet coverage, logistics , reliable electricity, and clean water.
- Improve the standard and intellectual property law to improve innovation and maintain the competitiveness in local, regional and international markets.
- Provide the liquidity fund to the prioritized private sectors that are about to transition from start-up to scale-up to grown-up and become conglomerates and Multinational Companies (MNCs).
- Develop financing mechanisms to support SMEs especially in the pre-prioritized sectors by providing a little to no-interest loan.
- Consider improving the role of business advisory services. This may include: support for standards compliance; market intelligence; information on affordable technologies; and technology vouchers to help SMEs acquire technologies.
- Help to create the momentum for any promising startups and accelerate the transformation from start-up to scale-up to grown-up company.
- Enhance private-public partnership since private could have innovative solutions for some issues such as improving infrastructure.
- Promote the development of STI parks as well as SMEs clusters, start-ups and accelerator centers.

4.3 STI Monitoring & Evaluation (M&E)

Monitoring and evaluation is the key for successful, sound and efficient STI policy implementation. It is a mirror for policy implementers and particularly policy makers (Figure 11). Thus, M&E serves the government with assessing the progress and performance of policy

implementation with evidence-based resolution to the challenges faced. Therefore, it is suggested as follows:

- Acknowledge the important role of M&E in the STI policy implementation.
- Develop the rigorous results-based monitoring and evaluation frameworks and systems to provide feedback on policy implementation and performance.
- Establish the basic monitoring and evaluation capabilities and data infrastructures.
- Embed well-designed programs in M&E systems: usually, well designed programs are easier and cheaper to monitor and evaluate.
- Establish effective reporting systems or mechanisms which must be in place for M&E of the progress and achievements on the implementation of set objectives and indicators.

Example: Real-time reporting platform should be created and applied.

- Evaluate programs and institutions periodically for research infrastructures as well as teaching quality for higher education; and to assure full transparency of evaluation for organizational arrangement with exchanging methodologies in an organized forum.
- Permit M&E body to access reliable information and data from relevant multi-stakeholders for accepting the data-based indicators.
- Foster a culture of monitoring, evaluation and learning among public officials by increasing their capacity to regularly conduct exercises for these purposes in collaboration with relevant stakeholders.
- Enhance accountability and provide legitimacy for the use of public funds and resources
- Collect relevant STI indicators and building monitoring databases is key to improving the implementation of STI policies.

Example: Indicators form an important basis for accountability and learning

- Promote the use of evidence resulting from M&E efforts
 - Should carry out the impact study to assess the changes after implementing a program/or project. Example: better and quality jobs and better pay with protected employment right are the consequences of the successful strategies
 - Should apply the incentive or awarding mechanisms for best STI practices.
- Example: Number of companies or individuals that receive a national or an international award.

- Fund M&E particularly a provisional 1-3% of the project budget.
- Support M&E by donors for technical assistance capacity-building and funding to conduct major evaluations for rigorous impact evaluations.
- Adopt as a whole-of-government strategy as to bring all on board out of their comfort zone

Yet, there are still mandatory factors that influence the success and the sustainability for M&E. It is recommended that frequent surveys, as it is being done somewhere else such as “Enterprise R&D and Innovation Survey” (UNESCO, 2014) must be in place at least every 3 or 4 years to assess progress and impact in Cambodia. Figure 11 illustrates a results-based monitoring and evaluation system adopted from Kusek and Rist (2004) and Yülek (2018). Measuring the success of the designed policy requires a rigorous M&E framework based on the obtained results. The resources employed in implementation decisions significantly determine the efficiency of the process and the institutional capacity of the country. In this proposed M&E system, ten steps to a results-based monitoring and evaluation system as described below serve additionally as both policy design and implementation decisions.

1. Conducting a Readiness Assessment: building a foundation of the M&E system

2. Agreeing on Outcomes to Monitor and Evaluate: selecting outcomes to monitor and evaluate as the outcomes reveal the road ahead
3. Selecting Key Indicators to Monitor Outcomes: monitor the progress of selected key indicators with respect to inputs, activities, outputs, outcomes and impacts
4. Baseline Data on Indicators — Where Are We Today? building a performance baselines (quantitative or qualitative) which is a starting point of the monitoring.
5. Planning for Improvement — Selecting Results Targets: Select the results targets based on the baseline indicator levels and desired levels of improvement.
6. Monitoring for Results: collecting quality performance data.
7. The Role of Evaluations: deal with the uses, types and timing of evaluation.
8. Reporting Findings: report on the analysis of data, which can help decision makers to make some improvements in the projects, policies and programs.
9. Using Finding: sharing knowledge from the finding within the governments and organizations.
10. Sustaining the M&E System within the Organization: focusing on challenges in keeping results-based M&E systems sustained which includes demand, clear roles and responsibilities, trustworthy and credible information, accountability, capacity and appropriate incentive.

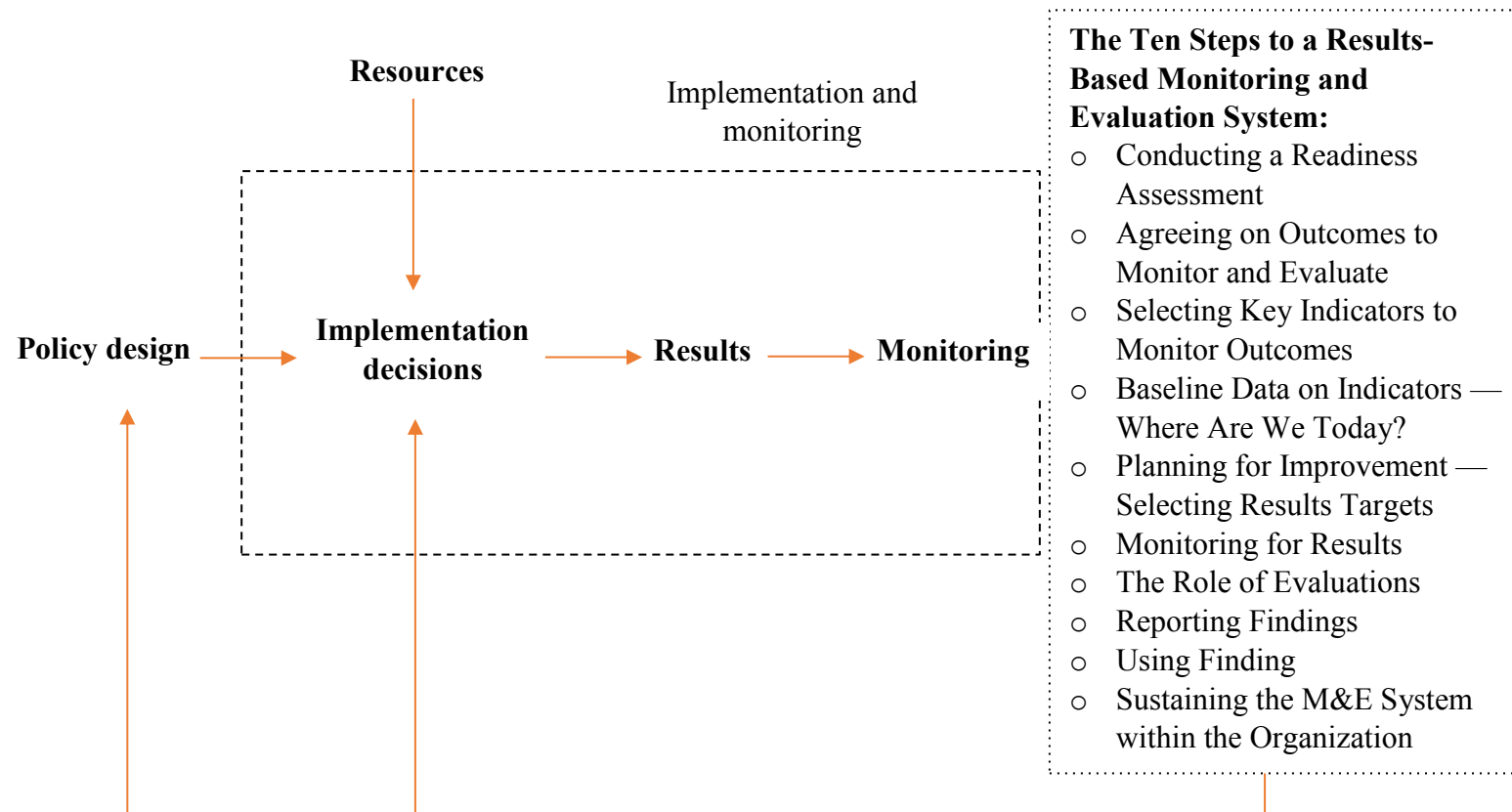


Figure 11: Suggested Illustration to Sustaining a Results-based Monitoring and Evaluation System
(Adopted from Zall & Rist (2004) and Yülek (2018))

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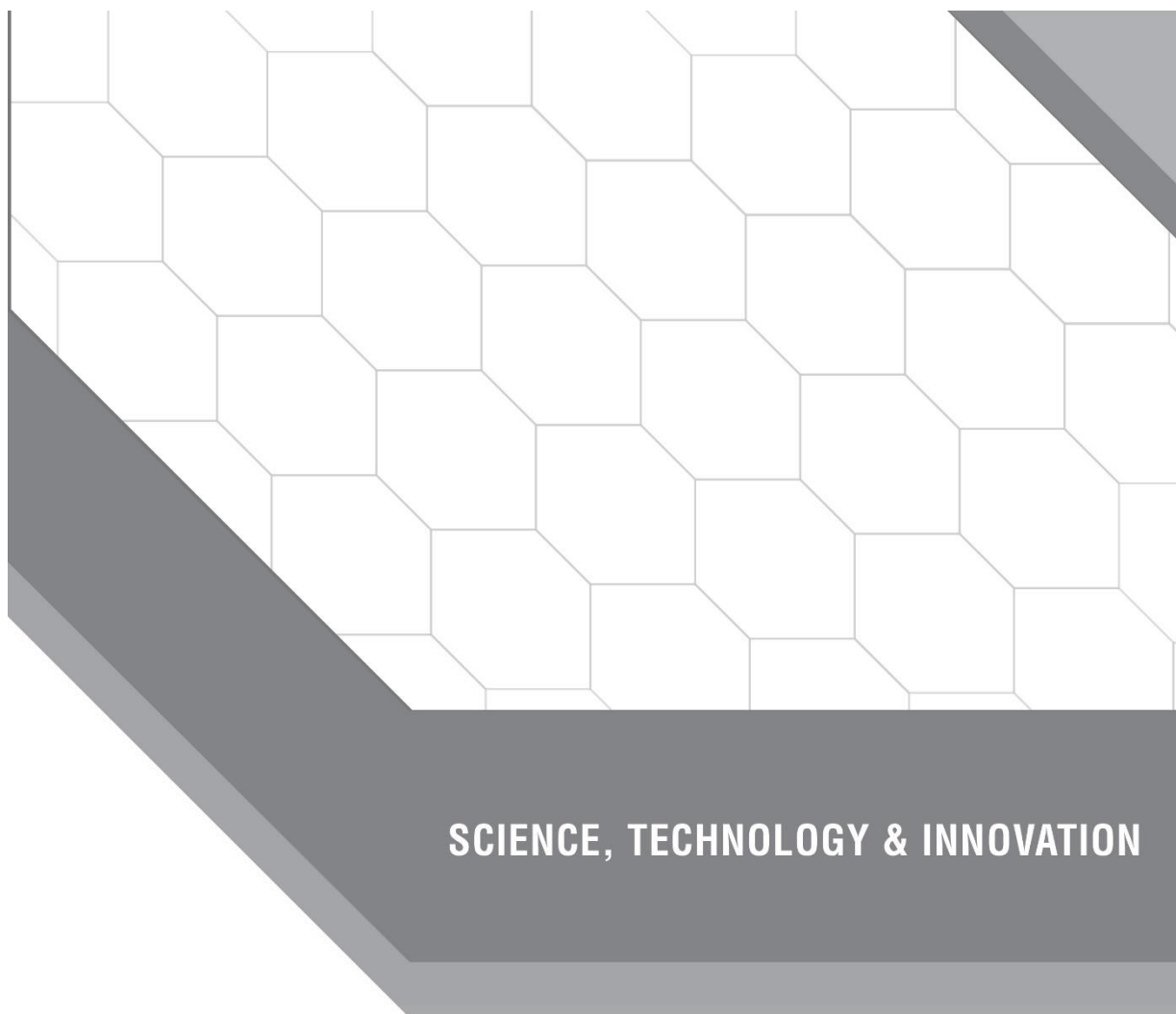
Appendix 1: Series of STI Report Team Meetings

Meeting	Date	Key points
1	October 20, 2020	- Getting feedback from Dr. Chhem Kieth Rethy on the draft outline. - Discussion among team members about the key points to be included in the report.
2	October 28, 2020	- Getting instructions from Dr. Chhem Kieth Rethy on the report structure and the key points that we should articulate in the introduction, body and recommendation part of the report. - Relevant documents sharing among the team members.
3	November 04, 2020	- Getting more directions from Dr. Chhem Kieth Rethy - Team discussions about feasibility of the points to be included in the report.
5	November 29, 2020	- First round of comments from Dr. KUOK Fidero
6	December 06, 2020	- Discussions among team members about the progress of addressing the comments. - Fix the deadline for the revised report which is further improved by Dr. HUL Seingheng.
7	December 23, 2020	- Discussions about comments by the advisory board members of STI council, led by Dr. HUL Seingheng.

Appendix 2: Gross Expenditure of Research and Development (GERD) as a percentage of GDP

Indicator		GERD as a percentage of GDP					
	Time	2013	2014	2015	2016	2017	2018
Country							
Brunei Darussalam		..	..	..	..	..	0.28
Cambodia		..	..	0.12	..	..	..
Indonesia		0.08	..	..	0.25	0.24	0.23
Lao People's Democratic Republic		..	..	..	..	..	..
Malaysia		..	1.26	1.30	1.44	..	..
Myanmar		..	..	..	..	0.03	..
Philippines		0.14	..	0.16	..	..	..
Singapore		1.92	2.08	2.18	2.08	1.94	..
Thailand		0.44	0.48	0.62	0.78	1.00	..
Viet Nam		0.37	..	0.44	..	0.53	..
ASEAN average		0.59	1.28	0.80	1.14	0.75	0.25
World Bank Income Groups		..	..	..	..	..	..
Low income countries		0.31	0.30	0.30	0.30	0.29	..
Lower middle income countries		0.45	0.44	0.43	0.44	0.43	..
Middle income countries		1.04	1.07	1.10	1.13	1.15	..
Upper middle income countries		1.31	1.36	1.41	1.45	1.48	..
High income countries		2.36	2.38	2.37	2.37	2.42	..

Source: http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_DS



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