KINGDOM OF CAMBODIA

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Technology Needs Assessment for the Kingdom of Cambodia

2023

National Council of Science, Technology & Innovation

Ministry of Industry, Science, Technology & Innovation

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Foreword

Science, Technology and Innovation (STI) is the fundamental tool in helping a nation to shift economic development from commodity dependence to sectors with higher productivity and skill intensity. This is particularly crucial considering the Royal Government of Cambodia's vision of becoming an upper middle-income country by 2030 and a high-income country by 2050.

Historically, nations with strong foundations in science and technology have shown effective growth and sustainable development. To realize the Royal Government of Cambodia's ambitious objective of becoming an upper-middle-income country by 2030 and a high-income country by 2050, strengthening national technology capabilities and increasing innovation performance would be a necessity. As indicated in Cambodia's STI roadmap 2030, STI will be critical in changing economic development from traditional growth toward inclusive and sustainable growth. STI will help to facilitate and accelerate the structural reforms that are required to increase the national economy, peace, security, and safety, as well as the well-being of citizens.

Like many other low-income developing countries, Cambodia faces challenges in realising inclusive and sustainable development. Thoughtful, strategic, and sustainable investments in the transfer and development of technologies, especially in well-identified sectors such as human capital development, renewable energy, and circular economy, will offer a sustainable path towards productive capacity building and the attainment of the Sustainable Development Goals.

The Royal Government of Cambodia through Ministry of Industry, Science, Technology & Innovation (MISTI) has conducted this Technology Needs Assessment (TNA) in collaboration with the UN Technology Bank for Least Developed Countries to serve as a guide to the country to identify key technologies needed to achieve the National Development Plan as well as prepare the country for sustainable graduation from LDCs category. The findings and recommendations of the TNA are closely aligned with the STI policies and strategies of the Royal Government of Cambodia and identifies prioritized development challenges, including energy deficiency, lower agricultural productivities compared to neighbouring countries and the role of technologies in other sectors such as education, human health, and conservation and environment.

This TNA also reflects the huge potential of the young people and women of Cambodia in the fields of science, technology, and innovation. Demographically, 31% of Cambodians are under 14 years old, and so investing in their future should be the foundation of planning.

To ensure a bright and productive future for the next generation, strong collaboration, and networking among key players such as the private sector, academia and government will be essential.

We would like to take this opportunity to congratulate the General Department of Science, Technology & Innovation for their management of the TNA process in collaboration with the UN Technology Bank for the Least Developed Countries. The findings presented in this report are an invaluable tool for enhancing Cambodia's technological and innovative capabilities and improving the quality of life of the people. This valuable report should serve as a compass guiding the relevant ministries and institutions in Cambodia in their efforts to implement the country's STI related policies and its ambition to become an upper-middle-income nation by 2030 and a high-income country by 2050.

Phnom Penh, 12 May 2023

Senior Minister
Ministry of Industry, Science, Technology & Innovation
and Chair of National Council of Science, Technology & Innovation

***Kitti Settha Pandita* CHAM Prasidh**

Tesfachew

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Contents

Acronyms and Abbreviations

AI	Artificial Intelligence
AR	Augmented Reality
ARDB	Agricultural and Rural Development Bank
ASEAN	Association of Southeast Asian Nations
CARDI	Cambodian Agricultural Research and Development Institute
CDC	Council for the Development of Cambodia
CGCC	Credit Guarantee Corporation of Cambodia
CHFCA	Canadian Hydrogen and Fuel Cell Association
CKFTA	Cambodia-Korea Free Trade Agreement
COVID-19	Coronavirus disease of 2019
CSO	Civil Society Organisation
DA	Department of Accreditation
ESCAP	Economic and Social Commission for Asia and the Pacific
FLP	Factor Literacy Programme
FAO	Food and Agriculture Organisation
FDI	Foreign Direct Investment
FTE	Full-Time Equivalent
FWUC	Farmers & Farmer Water User Community
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GNI	Gross National Income
GS-NSTC	General Secretariat of the National Science and Technology Council
GSM	Global System for Mobile Communications
HC	Head Count
HDI	Human Development Index
ICT	Information and Communication Technologies
IFI	International Financial Institutions
IP	Intellectual Property
IPR	Intellectual Property Rights
ISCED	International Standard Classification of Education
IT	Information Technologies
LDCs	Least Developed Countries
LNG	Liquefied Natural Gas

MAFF	Ministry of Agriculture, Forestry and Fisheries
MCFA	Ministry Culture and Find Art
MEF	Ministry of Economy and Finance
MISTI	Ministry of Industry, Science, Technology & Innovation
MoLVT	Ministry of Labour and Vocational Training
MoEYS	Ministry of Education, Youth and Sports
MOF	Metal-Organic Frameworks
MOP	Ministry of Planning
MOWRAM	Ministry of Water Resources and Meteorology
MPWT	Ministry of Public Works and Transport
NCSD	National Council for Sustainable Development
NGO	Non-Governmental Organisation
NIS	National Innovation System
NO	Nitric Oxide
NSDP	National Strategic Development Plan
ODA	Official Development Assistance
PCT	Patent Cooperation Treaty
PPP	Public Private Partnership
PV	Photovoltaics
R&D	Research and Development
RPL	Recognition of Prior Learning
RS	Rectangular Strategy
SCI	Science Citation Index
SDGs	Sustainable Development Goals
SME	Small and Medium Enterprises
SME&H	Small and Medium Enterprises and Handicraft
SNHU	Southern New Hampshire University
SST	Slurry-Separation Technology
STEM	Science, Technology, Engineering and Mathematics
STI	Science, Technology & Innovation
SWOT	Strengths, Weaknesses, Opportunities and Threats
TNA	Technology Needs Assessment
TRIPS	Trade-Related Aspects of Intellectual Property Rights
TVET	Technical and Vocational Education and Training

UIS	UNESCO Institute for Statistics
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNTAC	United Nations Transitional Authority in Cambodia
UNTBLDC	United Nations Technology Bank for the Least Developed Countries
VNRs	Voluntary National Reviews
VR	Virtual Reality
WFP	World Food Programme
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

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Executive Summary

This report presents the Technology Needs Assessment (TNA) for the Kingdom of Cambodia conducted through the collaboration with the UN Technology Bank for the Least Developed Countries (UNTBLDC) between May 2021 and November 2021. The overarching objective of the UNTBLDC is to help the Least Developed Countries (LDCs) build the Science, Technology & Innovation (STI) capacity that they need to promote the structural transformation of their economies, leverage social well-being, and foster sustainable development. The objectives of this study are therefore the identification of appropriate technologies to contribute to the realisation of the vision of the Royal Government of Cambodia (RGC), the Sustainable Development Goals (SDGs), and the strengthening of the STI capacity of the country to identify, absorb, develop, integrate and scale-up the deployed technologies and innovations.

In this study, technology refers to both physical components, such as a product, equipment, device, blueprint and process, and informational components such as know-how and technical knowledge. The methodology used is a mixed method approach, including the collection and analysis of primary and secondary data.

Based on the needs, a preliminary TNA implementation plan was prepared for the technologies that needs to be prioritised for Cambodia for further discussion and input during the technology implementation plan (TIP) phase.
The rest of this report is organised as follows: The second section gives an overview of the contextual background that shapes the framework in which STI policies and interventions are formulated and implemented. The third section describes the current status of the STI system and policy framework in the country. An analysis of the STI-related strengths, weaknesses, opportunities and threats (SWOT) for Cambodia is given in the fourth section. The fifth section gives the assessment of the technology needs of the country as expressed by the stakeholders through surveys and focus group meetings. The sixth section provides a list of available transferable technologies prioritised for Cambodia. The implementation plan for the prioritised shortlisted technologies is given in the seventh section.

Conclusions and recommendations

Cambodia is making notable progress in developing and implementing STI policies and enhancing its national STI system. The high commitment of the government on STI and the strengths and potential of the country create a strong trajectory for its sustainable and inclusive development and graduation from the LDC category.

Within this framework, Cambodia will hugely benefit from the adoption and deployment of technologies addressing the needs of the priority sectors as well as building necessary skills and competencies for the use and development of them.

Therefore, it is recommended that the government

- Continues to invest in developing STI governance system and policy framework also by designing and implementing sectoral STI strategies
- Establishes the systems and builds capacities to regularly collect internationally comparable STI statistics as well as monitoring and evaluation mechanisms for policies and policy instruments
- Enables MISTI to create a national STI R&D funding agency to design and implement support programmes similar to international peers
- Creates a balanced STI policy mix targeting not only start-ups and technology-based enterprises but also grass-roots innovators

- Develops human capital for STEM fields and attracts young people to pursue research career paths and innovation-based entrepreneurship, with a particular focus on attracting girls to STEM subjects to increase the participation of women in research and innovation
- Enhances communication and collaboration between research performers and the private sector, also by integrating the FDI in the innovation ecosystem
- Establishes and strengthens research institutes to conduct and commercialise R&D in the priority areas
- Invests in increasing the number and qualification of human resources for priority sectors of development
- Works closely with private sector and academia to cater their needs and improves investment and business ecosystem
- Establishes a policy framework to attract FDI with appropriate technology transfer mechanisms
- Invests in establishing a solid foundation of STI in the education system, including up-to-date and quality curricula, adequate infrastructure, qualified teachers, and mentoring programmes that promote higher enrolment in STEM subjects in higher education
- Raises awareness of patent system, industrial standards, trading law, innovation management and PPP.
- Developing TVET programmes and infrastructure to create a supply of intermediate-level employees to be engaged in STI in the priority sectors.

To support sustainable and inclusive development of Cambodia, it is recommended that the UN Technology Bank and other development actors assists Cambodia in:

- The transfer and deployment of technologies identified and listed in this report giving the priority to those listed in the implementation plan
- Developing necessary skills and capabilities in technology transfer and development
- Raising awareness for the adoption and use of new technologies
- Creating a national technology transfer office to coordinate the technology adoption process as well as commercialisation of R&D outputs from universities, research institutes and start-ups

Science, Technology & Innovation Review and Technology Needs Assessment for the Kingdom of Cambodia

1. Introduction

This report presents the Technology Needs Assessment (TNA) for the Kingdom of Cambodia conducted through the collaboration with the UN Technology Bank for the Least Developed Countries (UNTBLDC). The overarching objective of the UNTBLDC is to assist the Least Developed Countries (LDCs) build the Science, Technology & Innovation (STI) capacity that they need to promote the structural transformation of their economies, leverage social well-being and foster sustainable development. Its specific objectives, as outlined in its Charter, are to;l[1]

- Strengthen the STI capacity of LDCs, including the capacity to identify, absorb, develop, integrate and scale-up the deployment of technologies and innovations, including indigenous ones, as well as the capacity to address and manage Intellectual Property Rights issues;
- Promote the development and implementation of national and regional STI strategies;
- Strengthen partnerships among STI-related public entities and with the private sector;
- Promote cooperation among all stakeholders involved in STI, including, researchers, research institutions, public entities within and between LDCs, as well as with their counterparts in other countries;
- Promote and facilitate the identification, utilisation and access of appropriate technologies by LDCs, as well as their transfer to the LDCs, while respecting intellectual property rights and fostering the national and regional capacity of LDCs for the effective utilisation of technology in order to bring about transformative change.

To realise these objectives, the UNTBLDC implements several activities through partnerships and direct support to build STI capacities, ecosystem and regulatory frameworks that can harness the benefits of newly available technologies by;[2]

1. Attracting outside technology and facilitating technology transfer on voluntary and mutually agreed terms and conditions;
2. Supporting homegrown innovation and research; and
3. Bringing imported and indigenous technologies to market

The rest of this report is organised as follows: The second section gives an overview of the contextual background that shapes the framework in which STI policies and interventions are formulated and implemented. The third section describes the current status of the STI system and policy framework in the country. An analysis of the STI-related strengths, weaknesses, opportunities and threats (SWOT) for Cambodia is given in the fourth section. The fifth section gives the assessment of the technology needs of the country as expressed by the stakeholders through surveys and focus group meetings. The sixth section provides a list of

[1] UN, 'Charter of the Technology Bank for the Least Developed Countries', 2016, https://undocs.org/A/71/363.

[2] UNTBLDC, 'Supporting the Operationalization of the Technology Bank for the Least Developed Countries: A 3-Year Strategic Plan', 2016, http://unohrlls.org/custom-content/uploads/2016/08/Strategic-Plan-of-the-Technology-Bank-for-the-LDCs-8-August-2016.pdf.

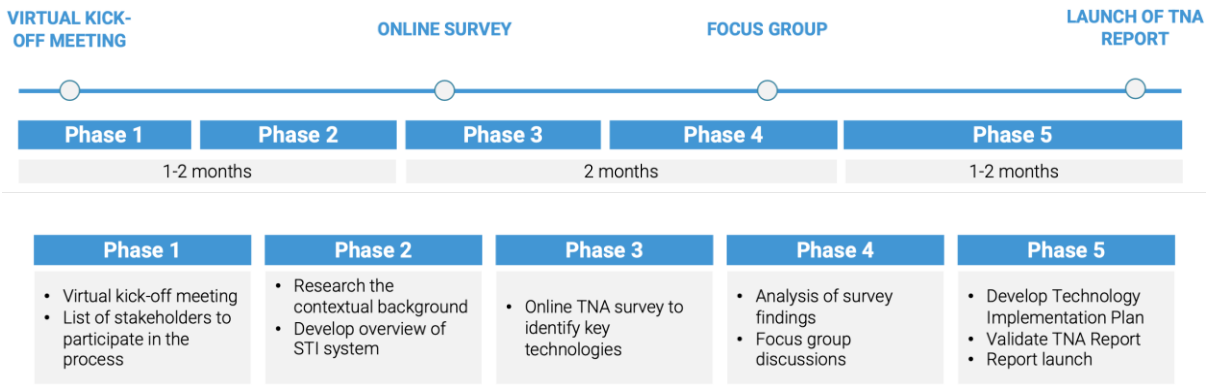
available transferable technologies prioritised for Cambodia. The implementation plan for the prioritised shortlisted technologies is given in the seventh section. The last section provides a summary of conclusions as well as the recommendations formulated for the Government of Cambodia and UNTBLDC.

The main objectives of the TNA study are to i) Provide critical insights into the functioning of national frameworks on science, technology and innovation in LDCs; ii) Identify the core areas of focus for each country and specific initiatives to maximise the impact of technology as an instrument to foster structural transformation, reduce poverty and promote sustainable development; iii) Identify priority sectors in the country and identify and prioritize technologies that can adequately and effectively address the country needs in the focus sector(s); iv) Improve the coordination between the different authorities in the country working on STI and technology issues; and v) Develop a technology implementation plan to support the transfer, adaptation, and implementation of validated priority technologies.

In this study, a technology is defined as both a physical component, such as a product, equipment, device, blueprint and process, and an informational component such as know-how and technical knowledge.

The methodology used is a mixed method approach, including the collection and analysis of primary and secondary data. For primary data collection, an online survey and focus group meetings with representatives of different stakeholders were implemented. Figure 1 describes the timeline and process undertaken during the study.

Figure 1. Technology Needs Assessment process



The online survey, implemented in August and September 2021 in collaboration with the Ministry of Industry, Science, Technology and Innovation (MISTI) aimed at collecting information on technology needs in key sectors, and was answered by 46 participants. The study team conducted focus group meetings/interviews with the participation of ~~1cv1~~ key national stakeholder organisations. The secondary data and information sources reviewed included the documentation published by national and international organisations.

2. Overview of the contextual background

The Kingdom of Cambodia has a land area of 181,035 square kilometres.[3] The country is bordered to the west and northwest by Thailand, to the northeast by Laos, to the east and southeast by Vietnam, and to the southwest by the Gulf of Thailand.

Like in the rest of Southeast Asia, Cambodia's climate is governed by the monsoon winds, which defines two major seasons: From mid-May to early October, the strong prevailing winds of the southwest monsoon bring heavy rains and high humidity; from early November to mid-March, the lighter and drier winds of the northeast monsoon bring variable cloudiness, infrequent precipitation, and lower humidity. The weather between these seasons is transitional. The maximum temperatures are high throughout the year ranging from about 82 to 83 °F (28 °C) in January, the coolest month, to about 95 °F (35 °C) in April. Annual precipitation varies considerably throughout the country, from more than 200 inches (5,000 mm) on the seaward slopes of the southwestern highlands to about 50–55 inches (1,270–1,400 mm) in the central lowland region. Three-fourths of the annual rainfall occurs during the months of the southwest monsoon.[4]

Cambodia's environment provides natural resources including not only forests, waterways, plants, and wildlife but also minerals, energy and extractives. Some of the most important minerals include iron ore, copper, and gold. Regarding energy resources, the country has significant deposits of natural gas located both onshore and offshore. Additionally, its hydroelectric generating potential is considerable, especially if the swift current of the middle Mekong River is used in an environmentally sustainable manner.[5] Cambodia has a rich biodiversity, including an array of diverse flora and fauna and forest resources on which many poor people in the countryside depend for livelihood. However, in recent years, the forest resources have increasingly come under pressure from land utilisation for economic purposes. Meanwhile, the country is known to be vulnerable to the impacts of climate change due to its low mitigation and adaptation capacity. Rural populations are facing risks from destructive climatic events such as flood and drought.[6]

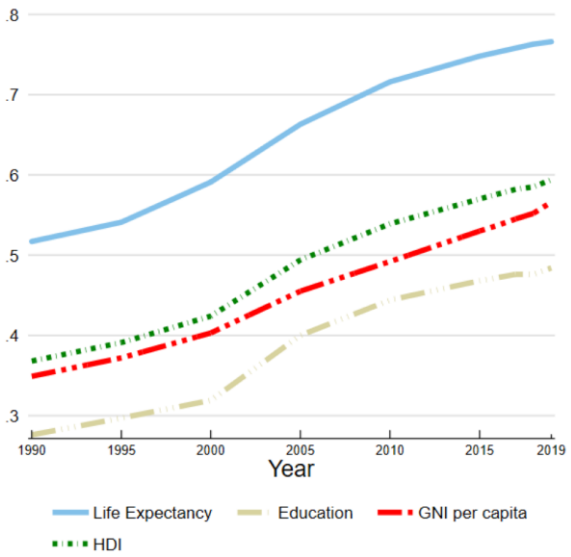
Cambodia's population is about 16.71 million inhabitants as of 2020.[7] Urban population represents 24.2 % (4,050,459 people in 2020)[8] Cambodia is predominantly a country of migration, driven by the search for work, education or marriage. Internal migration is more prevalent than international migration with rural to urban migration being the most common. The urban population is increasing, and urban expansion presents both opportunities and challenges. While it creates economic opportunities and new jobs, unstructured urbanisation can lead to significant socio-economic and environmental challenges including urban sprawl, insufficient provision of basic services and infrastructure such as housing, transport, energy, water supply and sanitation, increased congestion, pollution, unemployment, and inequality. For example, over the last 15 years about half Phnom Penh wetlands have disappeared

[3] World Bank 2018 https://data.worldbank.org/indicator/AG.SRF.TOTL.K2?locations=KH
[4] https://www.britannica.com/place/Cambodia/Climate
[5] Open Development Cambodia, 2021 https://opendevelopmentcambodia.net/topics/environment-and-natural-resources/
[6] UNDP, 2021 https://www.kh.undp.org/content/cambodia/en/home/countryinfo.html
[7] World Bank, 2020 https://data.worldbank.org/indicator/SP.POP.TOTL?locations=KH
[8] World Bank, 2020 https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=KH

because of urban expansion efforts, ignoring the essential role wetlands play in waste management, biodiversity and flood prevention in the region.[9]

According to the Human Development Report 2020[10] published by UNDP, Cambodia has moved up on the Human Development Index (HDI) to rank 144th globally in 2019, compared to the 146th ranking in 2018. The country has made major human development gains since the foundation of the modern nation in the early 1990s after a long period of conflict. Over the past nearly two decades, Cambodia's economy has been among the fastest growing economies, unmatched by any other post-conflict society. As a result, the country has registered massive gains and improvements on human development as measured by the HDI. Between 1990 and 2019, Cambodia's HDI value increased from 0.368 to 0.594, an increase of 61.4%, with fast growth in the three HDI dimensions. Figure 2 shows the contribution of each component index to Cambodia's HDI since 1990.

Figure 2. Trends in Cambodia's HDI component indices



Source: UNDP 2020. Briefing note for countries on the 2020 Human Development Report: Cambodia

2.1. Development agenda

Cambodia's long-term development vision is guided by the Rectangular Strategy (RS) Phase IV for Growth, Employment, Equity and Efficiency, and the National Strategic Development Plan (NSDP) 2019–2023.

- Rectangular Strategy

The main driving force for Cambodia's national development is the "Rectangular Strategy" which was launched in 1998 and has continued up to the present in four phases each of which parallels with the term of office of the Legislature of the National Assembly. The Phase IV of the strategy was adopted in 2018, immediately after the new government was formed, and will

[9] https://news.trust.org/item/20200726231402-r54ju/
[10] http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/KHM.pdf

end in 2022. The new phase establishes the following strategic "rectangles" (or pillars):

- Rectangle 1 - Human resource development: 1) Improving the quality of education, science and technology; 2) Vocational training; 3) Improving public healthcare and nutrition; and 4) Strengthening gender equality and social protection.
- Rectangle 2 – Economic diversification: 1) Improving logistics system and enhancing transport, energy, and digital connectivity; 2) Developing key and new sources of economic growth; 3) Readiness for digital economy and industrial revolution 4.0; and 4) Promoting financial and banking sector development.
- Rectangle 3 – Promotion of private sector development and employment: 1) Job market development; 2) Promotion of SMEs and entrepreneurship; 3) Public-Private Partnership; and 4) Enhanced competitiveness.
- Rectangle 4 – Inclusive and sustainable development: 1) Promotion of agricultural and rural development; 2) Strengthening sustainable management of natural and cultural resources; 3) Strengthening management of urbanisation; and 4) Ensuring environmental sustainability and readiness for climate change.[11]

- National Strategic Development Plan (NSDP) 2019-2023

NSDP 2019-2023 summarises the key achievements and challenges during the implementation of the NSDP 2014-2018, together with the macro-economic framework for NSDP 2019-2023. In addition, the NSDP outlines policies and priority actions for 2019-2023 that will be carried out by relevant ministries, and presents estimated values, including expenses, resources and an expenditure programme. The NSDP also includes the framework for monitoring and evaluation of the implementation for 2019-2023 phase and shows extensive conclusions.[12]

In 2019, Cambodia published the National Voluntary Review on the Implementation of the 2030 Agenda for Sustainable Development (VNR)[13] which highlights three major issues: (a) Resourcing and economic underpinning of SDGs delivery in the near and longer term; (b) The overarching threat posed by climate change, which challenges the progress in many of the SDGs; and (c) a set of questions regarding the governance aspects of the goals, including the mobilisation of all actors to support SDGs achievement.

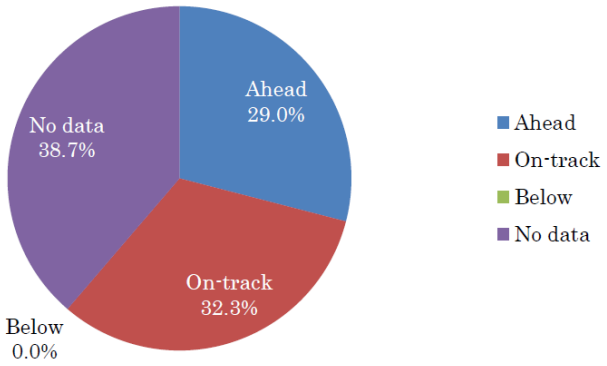
The VNR also reviews the progress, which has been promising, with a majority of SDG targets rated as "ahead" or "on track". This is especially true of the six prioritised goals (Education, Decent Work and Growth, Reduced Inequalities, Climate Action, Peace and Institutions, and SDG Partnerships), as shown in Figure 3.

[11] Government of Cambodia https://data.opendevelopmentcambodia.net/laws_record/rectangular-strategy-phrase-4-of-the-royal-government-of-cambodia

[12] Government of Cambodia https://data.opendevelopmentmekong.net/dataset/087e8a03-f09d-4eb2-94f2-00d8d237b342/resource/bb62a621-8616-4728-842f-33ce7e199ef3/download/nsdp-2019-2023_en.pdf

[13] Cambodia's national voluntary review 2019 on the implementation of the 2030 Agenda for Sustainable Development, 2019 https://sustainabledevelopment.un.org/content/documents/23603Cambodia_VNR_SDPM_Approved.pdf

Figure 3. SDG performance of six priority goals



Source: Cambodia's national voluntary review 2019 on the implementation of the 2030 Agenda for Sustainable Development

The SDGs fully align with the Royal Government's long-term development vision as articulated in Vision 2050, and in its medium-term instruments – the RS IV and the NSDP 2019-2023. The SDGs have been fully integrated within planning and policy-making cycles. The NSDP's monitoring and evaluation framework includes around 40% of the indicators; and the budgets and strategic plans of ministries and agencies include SDG-related outcomes.

2.2. Political and economic environment

Cambodia has achieved impressive economic growth and poverty reduction in the past two decades. It aims to become an upper middle-income country by 2030 and a high-income country by 2050 in accordance with the Rectangular Strategy Phase IV adopted in September 2018.

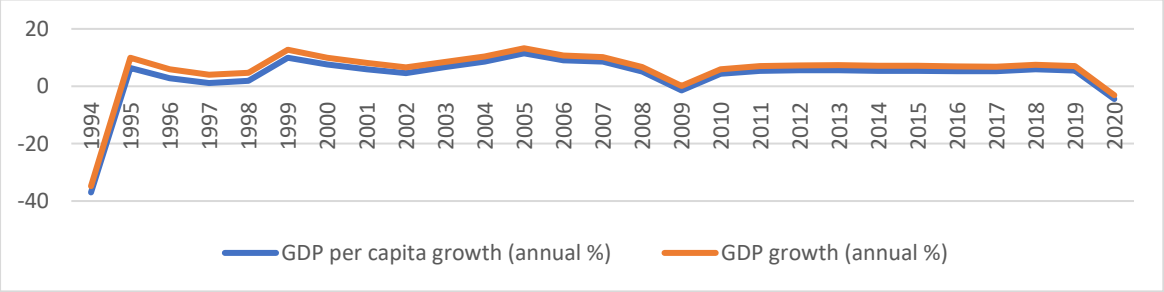
Traditionally, Cambodia is an agriculture-based country and agricultural development has always been the priority for addressing poverty reduction and rural development. The Fourth Cambodian Economic Forum on "Cambodian Economy in Post-Crisis Environment: Industrial Policy—Options Towards a Sustainable Development" held in February 2011 emphasised the strategic vision of the government in shifting the economic development from agriculture, garment, tourism, and construction dependence to a broad-based industrial and technology-oriented economy. During the COVID-19 crisis, the government has recognised agriculture as the most resilient and a strategic sector for not only economic growth but also contributing to the improvement of livelihoods and poverty reduction of rural people.[14] The sector has also been boosted by increased investment, thanks to good prospects of the newly signed Cambodia-China Free Trade Agreement (CCFTA), Cambodia-Korea Free Trade Agreement (CKFTA), and Regional Comprehensive Economic Partnership (RCEP).[15]

[14] FAO, 2021, https://www.fao.org/cambodia/news/rss/detail-events/en/c/1392052/
[15] World Bank, 2021 Cambodia Economic Update: Road to Recovery https://documents.worldbank.org/en/publication/documents-reports/documentdetail/788321624038286598/cambodia-economic-update-road-to-recovery

In 2019, the services sector accounted for 38.9% of Cambodia's GDP, industry for 34.2% and agriculture for 20.7%. The contribution of the services sector to the GDP has remained around 40% since 2000, while the contribution of the agriculture sector has been declining in favour of the industry sector. In 2017, the services sector accounted for 36.3% of the employed population. Within services, the transportation and storage sector accounted for 7.8% of Cambodia's GDP in 2019.[16]

In 1995, the government transformed the country's economic system from a planned economy to its present market-driven system. Following those changes, growth was estimated at a value of 7% while inflation dropped from 26% in 1994 to only 6% in 1995. Imports increased due to the influx of foreign aid, and exports, particularly from the country's garment industry, also rose. After four years of improving economic performance, Cambodia's economy slowed in 1997–1998 (4) due to the regional economic crisis, civil unrest, and political infighting. Also, in 1998 the main harvest was hit by drought. But in 1999, the first full year of relative peace in 30 years, progress was made on economic reforms and growth resumed at 4%.

Figure 4. Evolution of GDP growth in Cambodia, 1994-2020



Source: World Bank, 2021

Cambodia's impressive economic growth has also been built upon openness to trade and capital flows and driven by preferential trade treatment and large official development assistance (ODA) and foreign direct investment (FDI) inflows.[17]

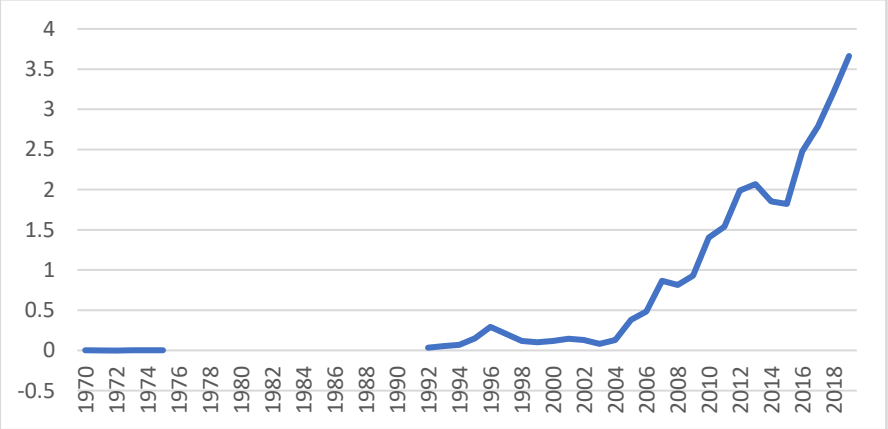
The net ODA flows of the country over the 2017-2019 period averaged USD874.6 million per year.[18] Moreover, it ranks 42nd amongst 47 LDCs according to the net ODA received as percentage of its GNI with 3.9% during 2019, while the region's aggregate (without high-income countries) amounts to 5.0%.[19] Japan is the top donor for Cambodia which provided USD172.7 million during the 2018-19 period. The second largest donor is France with USD135.9 million in the same period. Some 31% of ODA funds Cambodia received in 2018-

[16] OECD 2021, https://www.oecd.org/daf/competition/oecd-competition-assessment-reviews-cambodia-2021.pdf
[17] World Bank. 2017 Cambodia - Sustaining strong growth for the benefit of all.
[18] OECD, 2021, https://www.oecd.org/dac/financing-sustainable-development/development-finance-data/aid-at-a-glance.htm.
[19] World Bank, 2021 https://data.worldbank.org/indicator/DT.ODA.ODAT.GN.ZS?locations=KH-XL&most_recent_value_desc=true

19 were used for “other social infrastructure” projects, while economic infrastructure is the second sector with 21% of funds received.[20]

FDI[21] is a major source of GDP’s growth. Cambodia’s fast economic growth and open borders to international trade and investment have helped attract FDI to support manufacturing, construction, and tourism. The Cambodian economy is attracting the second highest level of FDI in the region of Southeast Asia and Oceania after Singapore.[22] Figure 5 shows the evolution of FDI in the country. Cambodia recorded its highest ever FDI in 2019, at USD 3.7 billion because of robust investments in manufacturing and services, making it the largest FDI host among LDCs in 2019. Most investments came from China, intra-ASEAN sources and Japan.[23]

Figure 5. Evolution of FDI net flows in Cambodia, 1970-2019 (billion USD)



Source: World Bank 2020

An Overview of the 2019 Global Competitiveness Index gives a snapshot of the challenges facing Cambodia in creating a competitive economy (Figure 6). According to the overview, the country needs improvements to foster the development of the private sector and promote more efficient use of its limited resources. Skills is the area that requires most attention. Employers in the industry and services sectors are increasingly demanding higher-labour skills relating to communication, customer service, digital literacy, and the ability to adapt to new equipment and procedures. One of the consequences of the limited skills availability is the underdeveloped National Innovation System (NIS) in the country represented by low absorptive capacity in most SMEs as well as incipient innovation and IPR culture. Another challenge for business investment is access to finance.

[20] OECD, 2021, https://www.oecd.org/dac/financing-sustainable-development/development-finance-data/aid-at-a-glance.htm.

[21] UNCTAD definition: Foreign direct investment refers to direct investment equity flows in the reporting economy. It is the sum of equity capital, reinvestment of earnings, and other capital. Direct investment is a category of cross-border investment associated with a resident in one economy having control or a significant degree of influence on the management of an enterprise that is resident in another economy. Ownership of 10 percent or more of the ordinary shares of voting stock is the criterion for determining the existence of a direct investment relationship. Data are in current U.S. dollars.

[22] UNESCO Science report 2021

[23] UNCTAD, 2020 World Investment Report

Figure 6. Overview of the 2019 Global Competitiveness Index

Source: WEF. 'The Global Competitiveness Report', 2019

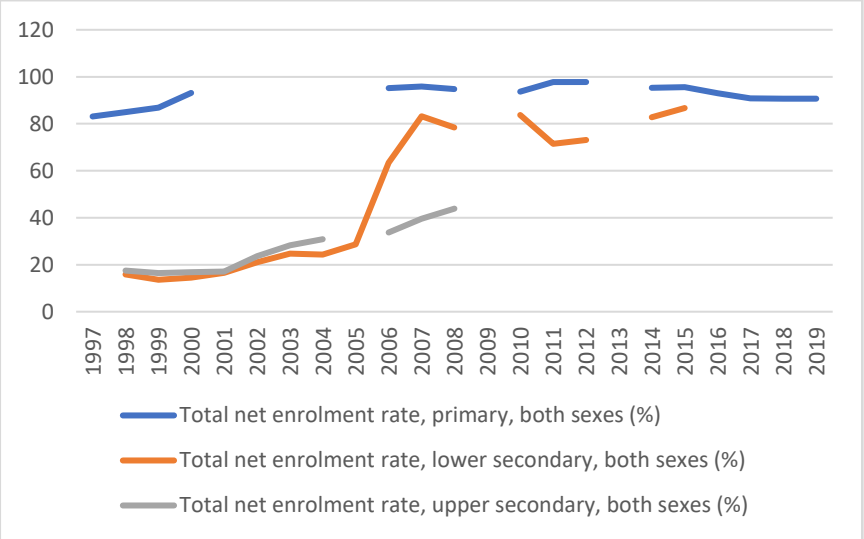
2.3. Education and Skills

Cambodia has made notable progress in educating its children. Since 2007, the number of children enrolled in preschool programmes has more than doubled.[24] Since 1997, the net enrolment rate[25] for primary education, lower secondary education and upper secondary education have improved (Figure 7). According to UIS, the completion rate of primary school is 91.03% as of 2019. However, the completion rate for lower secondary school remains at 57.74% in the same year, significantly lower than the average for lower middle-income countries (73.79%). The attendance rate for upper secondary school is only 38.75% (2014). High dropout rates, particularly at the lower secondary education level, remain a persistent issue.

[24] UNICEF https://www.unicef.org/cambodia/education

[25] Net enrollment rate is the ratio of children of official school age who are enrolled in school to the population of the corresponding official school age.

Figure 7. Enrolment by level of education



Source: UIS, 2020

The recent progress in education took place thanks to concerted efforts by the Ministry of Education, Youth and Sports (MoEYS) and concerned stakeholders, through the implementation of the Education Strategic Plan 2014-2018.[26] The new National Education 2030 Roadmap for SDG4 was built on these achievements.[27]

As of 2019, Cambodia has a gross tertiary education enrolment rate[28] of 14.74%, lower than the average of lower- and middle-income countries (24.21%). Figure 8 shows the tertiary enrolment by International Standard Classification of Education (ISCED) levels[29] in 5,6,7 and 8. It reveals the low participation of students in master's (level 7) and PhD's (level 8) studies. In particular, female students account for only 24.38% and 5.78% in enrolment in master's and PhD studies, respectively. This points to a serious constraint for the development of research and innovation in Cambodia.

MOEYS has streamlined science, technology, engineering, and mathematics (STEM) throughout its Roadmap and has defined a number of specific indicators to monitor and evaluate STEM education[30].

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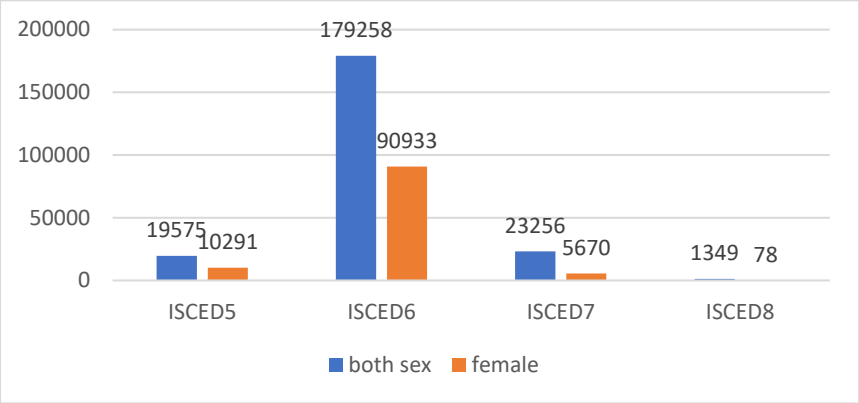
[26] Cambodia's Voluntary National Review 2019 of the Implementation of 2030 Agenda
[27] https://www.moeys.gov.kh/index.php/en/planning/2901.html#.YVLhryoRqL0
[28] Gross enrolment ratio is the ratio of total enrolment, regardless of age, to the population of the age group that officially corresponds to the level of education shown
[29] International Standard Classification of Education (ISCED): ISCED level 0 – Early childhood education; ISCED level 1 – Primary education; ISCED level 2 – Lower secondary education; ISCED level 3 – Upper secondary education; ISCED level 4 – Post-secondary non-tertiary education;
Tertiary education: ISCED level 5 – Short-cycle tertiary education; ISCED level 6 – Bachelor's or equivalent level; ISCED level 7 – Master's or equivalent level; ISCED level 8 – Doctoral or equivalent level.
http://uis.unesco.org/sites/default/files/documents/international-standard-classification-of-education-isced-2011-en.pdf
[30] https://www.misti.gov.kh/public/file/20210925163257368.pdf

Figure 8. Enrolment in tertiary education by ISCED level, both sexes and only women in 2019 (number)



Source: UIS 2020

Based on a study conducted by the National Employment Agency in Cambodia in 2017, nearly one-third of establishments interviewed faced a skill gap. Nonskilled workers with low levels of education attainment struggle to find meaningful work or transition to better-paid jobs. As Cambodia attempts to move to higher value-added activities and new technologies that require more complex skills, the country will need a better trained workforce.

To support the ability of the workers to pursue better long-term opportunities, particularly female migrant workers in the garment industry, UNESCO in partnership with the Ministry of Education Youth and Sport (MoEYS) launched the Factory Literacy Programme (FLP) in 2016. Through partner factories, FLP provides a customised literacy and mathematic learning package for garment workers that were unable to complete their primary education.

2.4. COVID-19 Impact

The pandemic has led to a large negative demand shock. Projections for GDP growth in 2020 range from -1.9% to -4.5%. The recession has been driven by contractions in the traditional sectors of tourism, garments, textiles and footwear, and a slowdown in construction activity. Impacts on the garments, textiles and footwear sector peaked in the second quarter of 2020 as buyers in Europe and the United States cancelled orders. By June 2020, 450 out of 1,100 factories in this sector in Cambodia suspended their operations. The sector began to recover in the third quarter of 2020, but, as of late November, more than 110 factories remained closed.[31]

According to the 2020 MISTI annual conference report, the total value of products during 202o decreased by 35.32% compared to the precedent year amounting to approximately US$ 9,622 million. This figure represents a reduction of 11.97% of the domestic market amounting to US$

[31] ADB, 'Kingdom of Cambodia: COVID-19 Active Response and Expenditure Support Program First Quarterly Monitoring Report', 2021, https://www.adb.org/sites/default/files/project-documents/54195/54195-001-dpta-en.pdf.

3,249 million and a decrease of 43.02% in the export value amounting to approximately US$ 6,373 million.

International tourism was suspended since the second quarter of 2020, and over 3,000 tourism-related establishments were suspended or closed operations. Domestic tourism increased but it could not fully offset the loss of demand from international visitors. The downturn in neighbouring economies also triggered the return of migrant workers, and by November 2020, 119,725 workers had returned from neighbouring Thailand.[32]

The recent data from a survey conducted by the World Bank in Cambodia provides important insights on the social impact of COVID-19:

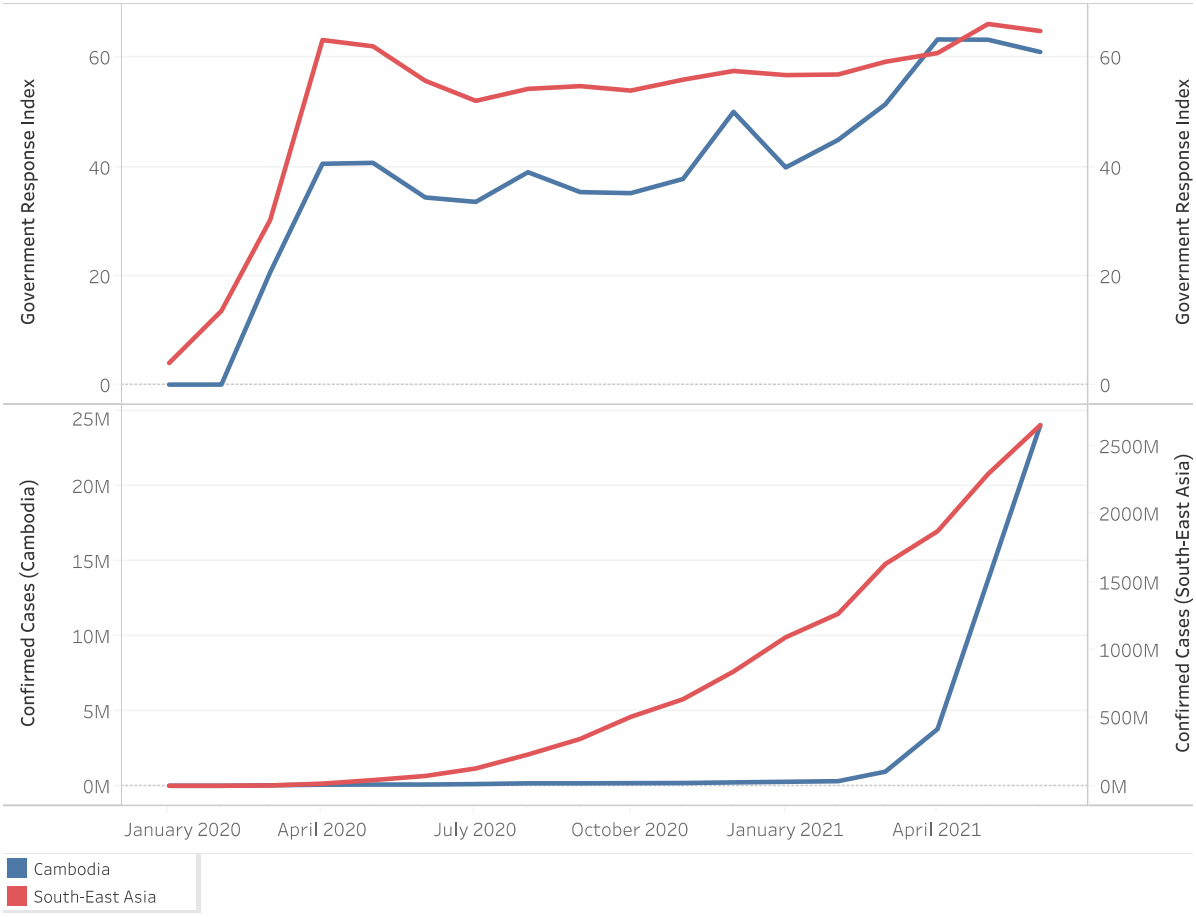
- Children's engagement in learning activities declined due to the school term holiday and the second nationwide closure of schools on November 30, 2020 following a local COVID-19 outbreak. The proportion of households with school-age children ages 6–17 engaged in learning activities declined from 92% in October—where it had reached pre-pandemic levels—to 57% in December 2020. Unlike the first nationwide school closure where instruction shifted to remote settings while the academic term progressed, the second school closure cancelled the remainder of the 2019–2020 academic year for public schools and suspended in-person instruction for private schools for 2 weeks while e-learning was applied during this period. Children returned to using remote alternatives, such as mobile learning applications, and fewer had face-to-face interactions with teachers. There was greater disengagement in learning activities for children in poor households who are more likely to rely on public education and have less access to e-learning resources at home.
- The prevalence of moderate-or-severe food insecurity was 17% in December 2020, which includes 0.5% of the population affected by severe food insecurity.
- While the share of households reporting declines in household income have slowed since May 2020, about 1 in 2 households continued to report that their household income had declined. Slowing declines in labour income and the provision of the government's cash relief transfers to assist poor and vulnerable households during COVID-19 appear to have helped mitigate some of the losses.[33]

Figure 9 shows quantitively the response of Cambodia to the pandemic according to the Oxford COVID-19 Government Response Tracker. Cambodia is the fourth country with fewer cases in the region, very distant from the aggregate of the region which is driven by Indonesia. Due to this trend, Cambodia's policy response was not as strict as its neighbours. The country started providing fiscal measures to support its population during the pandemic since July 2020, however only reached parity to its neighbours by April 2021, when stay-at-home requirements, restrictions on gatherings and facial covering measures reached its most severe state.

[32] ADB.

[33] Wendy Karamba, Isabelle Salcher, and Kimsun Tong, 'The Socioeconomic Impacts of COVID-19 on Households in Cambodia, Report No. 4 : Results from the High-Frequency Phone Survey of Households Round 4 (17 December 2020-12 January 2021)', 2021, http://hdl.handle.net/10986/35383.

Figure 9. Government Response Index and Confirmed Cases



Source: Hale, Thomas, Noam Angrist, Rafael Goldszmidt, Beatriz Kira, Anna Petherick, Toby Phillips, Samuel Webster, et al. 'A Global Panel Database of Pandemic Policies (Oxford COVID-19 Government Response Tracker)'. Nature Human Behaviour 5, no. 4 (April 2021): 529–38. https://doi.org/10.1038/s41562-021-01079-8.

3. STI System and Policy Framework

3.1. STI Indicators

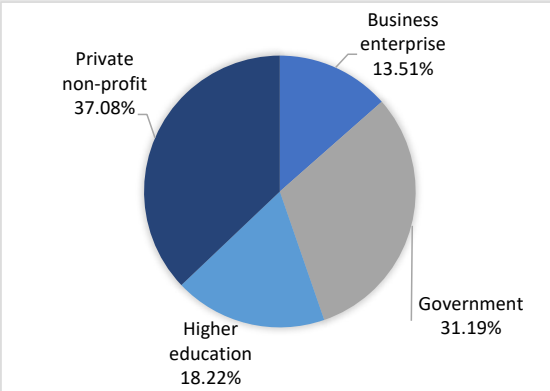
The statistical system in Cambodia requires strengthening to produce data necessary to monitor and evaluate the performance of the STI system in the country. The last comprehensive R&D survey recorded by the UIS, was conducted in 2015. There are no data available on innovation activities.

3.1.1. R&D Expenditure

Expenditure and human capital for R&D are the main indicators for STI inputs for a country, and R&D assessments must be conducted continuously. According to UIS, [34] R&D expenditure in Cambodia, expressed as the gross domestic expenditure on R&D (GERD) as a percentage of GDP[35] was 0.12% in 2015. This is significantly below the 1% spending on R&D of GDP recommended by UNESCO[36] .

In 2015, the majority of the R&D expenditure came from private non-profit sectors followed by the government (Figure 10). In terms of the source of funding, the majority of sources of R&D funding was from abroad (34.93%) (Figure 11). This reflects the fact that foreign donors, such as the World Bank and Asian Development Bank, are key financiers of R&D in the country. The share of funding from the government, private non-profit sectors and business enterprises were 23.5%, 22.06% and 19.44%, respectively. The share of funds from the higher education sector and other sectors remained negligible (Figure 11).

Figure 10. GERD by sector of performance, 2015



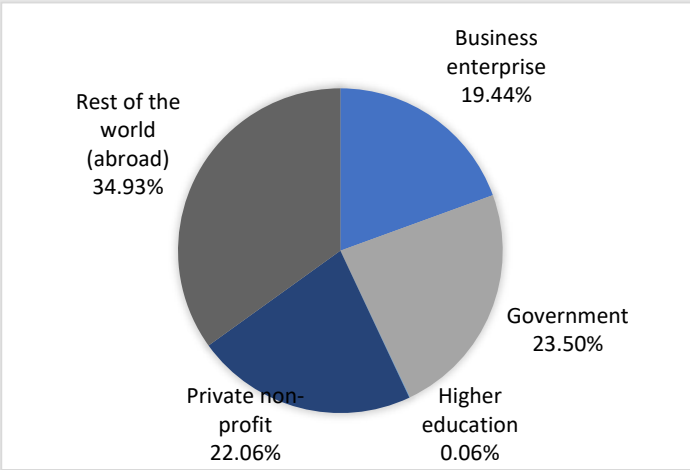
Source: UIS

[34] http://uis.unesco.org/en/country/kh

[35] Gross domestic expenditures on research and development (R&D), expressed as a percent of GDP. They include both capital and current expenditures in the four main sectors: Business enterprise, Government, Higher education and Private non-profit. R&D covers basic research, applied research, and experimental development.

[36] UNESCO Science Report 2021. https://www.unesco.org/reports/science/2021/en/dataviz/research-spending-share-gdp

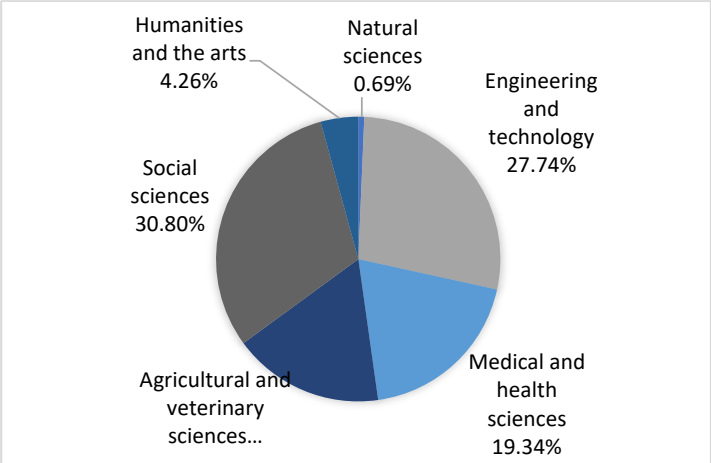
Figure 11. GERD by source of funds



Source: UIS

In 2015, the majority of R&D funding went to social sciences (30.8%), and engineering and technology (27.74%). Some 19.34% of the funding was allocated to medical sciences and 17.17% was allocated to agriculture sciences. The funding for humanities accounted for 4.26% while only 0.69% was allocated to natural sciences (Figure 12).

Figure 12. GERD by field of science, 2015



Source: UIS

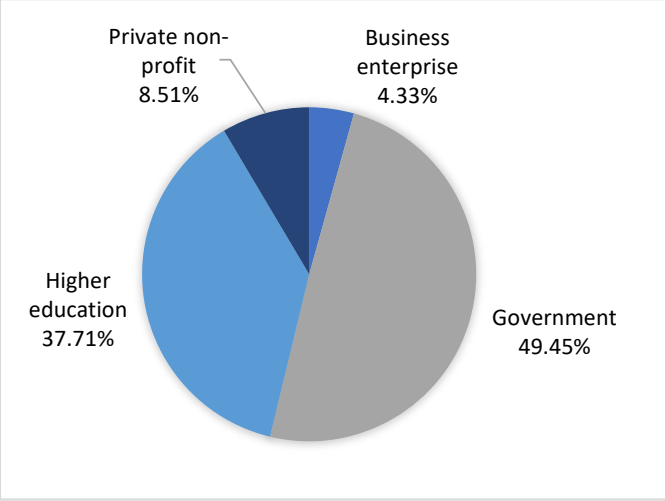
3.1.2. R&D Personnel

According to UIS,[37] the number of researchers (headcount) in Cambodia was only 51.16 per million inhabitants with 23.7 % female researchers in 2015. The number of researchers

[37] http://uis.unesco.org/en/country/kh

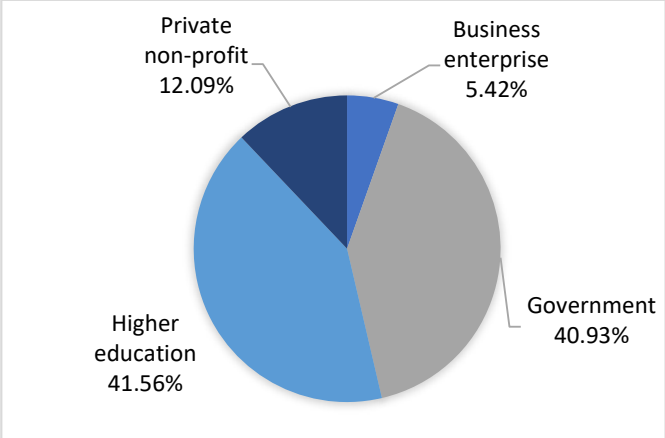
(FTE)[38] was only 30.37 per million inhabitants in the same year. This is substantially lower than the recommended 1000 per 1 million labour force referred to by UNESCO in the UNESCO Science Report 202139. The share of FTE researchers in the government is the highest among all sectors (49.45%) (Figure 13).

Figure 13. Researchers by sector of employment in full-time equivalents (FTE)



Source: UIS

Figure 14. Researchers by sector of employment in headcounts (HC)



Source: UIS

[38] The full-time equivalent (FTE) of R&D personnel is defined as the ratio of working hours actually spent on R&D during a specific reference period (usually a calendar year) divided by the total number of hours conventionally worked in the same period by an individual or by a group

39 UNESCO Science Report 2021, https://www.unesco.org/reports/science/2021/en/dataviz/researchers-million-habitants

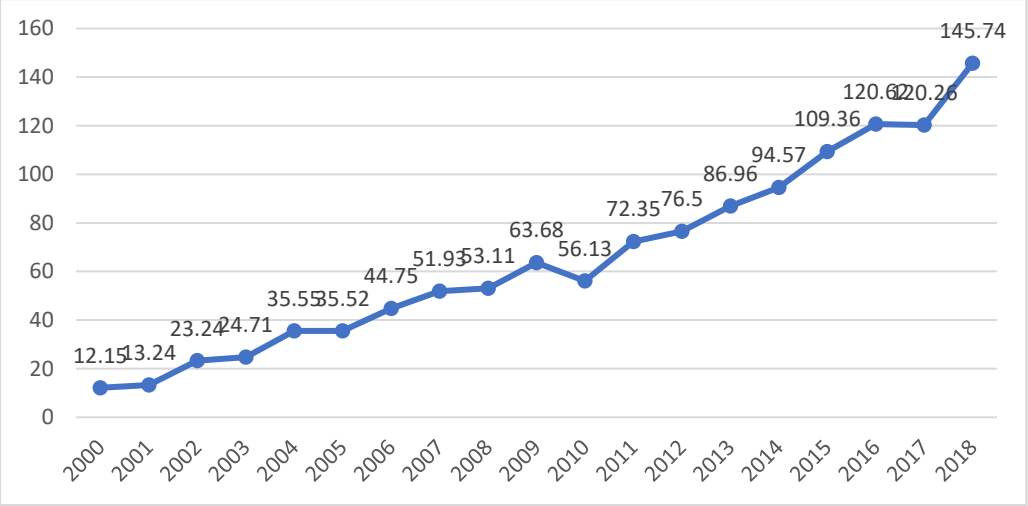
According to Figure 20, the majority of the researchers work for higher education and the government, while only 5.42% work for business enterprises.

3.1.3. Scholarly Work Outputs

Cambodian science was growing rapidly but had a low level of development that made it highly dependent on foreign researchers.[40]

The number of scientific and technical journal articles[41] increased from 12.15 in 2000 to 145.74 in 2018, with slight fluctuation.[42] According to the World Economic Forum's 2019 Global Competitiveness Report,[43] Cambodia's scientific publications were ranked 102nd out of the 141 countries that were featured in the report.

Figure 15. Evolution of the number of scientific and technical journal articles



Source: World Bank 2018 (from journals classified by the Institute for Scientific Information's Science Citation Index (SCI) and Social Sciences Citation Index (SSCI))

A study using data retrieved from the Science Citation Index Expanded (January 04, 2021) using the word "Cambodia" for the period from 1972 to 2019 found 3,689 publications, and 325 articles and 6,555 authors in 2019. Most documents are articles in English about health, particularly infectious and tropical diseases. The scientific output and citations of Cambodian science in the official language, Khmer, is locally important but missing in the Science Citation Index Expanded database. Figure 16 shows the institutions located in Cambodia according to the number of publications produced in the period 2011-2019.

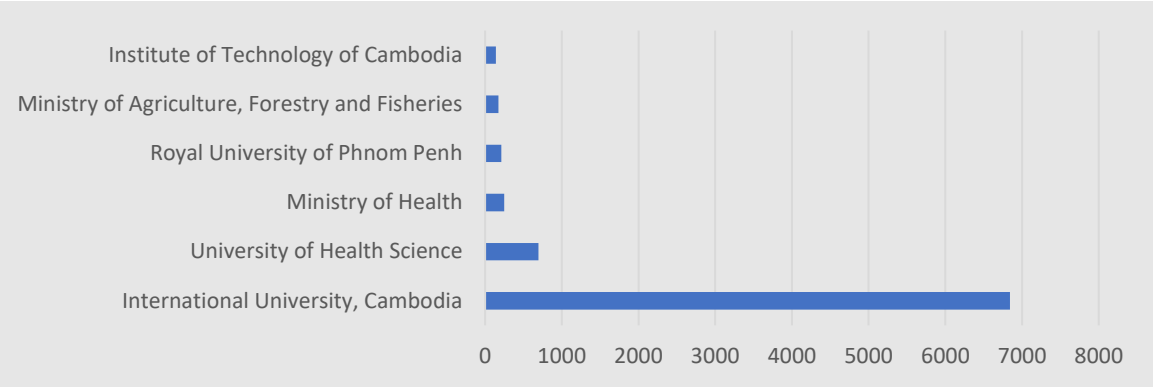
[40] Turpin, T., Zhang, J.A., Burgos, B.M., & Amaradsa, W. (2015). Southeast Asia and Oceania. In UNESCO Science Report: towards 2030 (pp. 698-713). Paris, France: UNESCO

[41] Scientific and technical journal articles refer to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.

[42] This number may exclude some publications of local importance and may reflect some bias toward English-language journals.

[43] http://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf

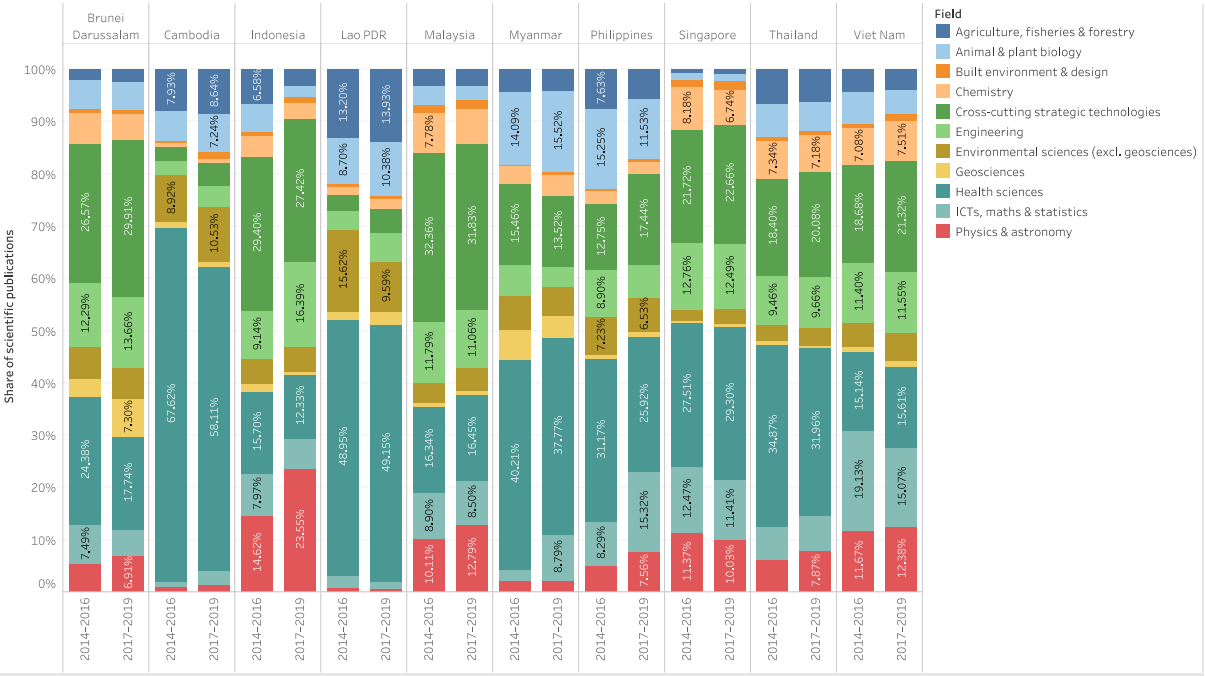
Figure 16. Top Institutions domiciliated in Cambodia producing scholarly works from 2011-2019



Source: Source: The Lens. 'Results The Lens - Free & Open Patent and Scholarly Search'. The Lens - Free & Open Patent and Scholarly Search, 2021. https://www.lens.org/.

The publications patterns of Cambodia remain stable over the years. The country publishes mainly in the health sciences field (Figure 17). The second largest field of publication is environmental sciences with 10.53% during 2017-2019.

Figure 17. Share of scientific publications by field in ASEAN Countries

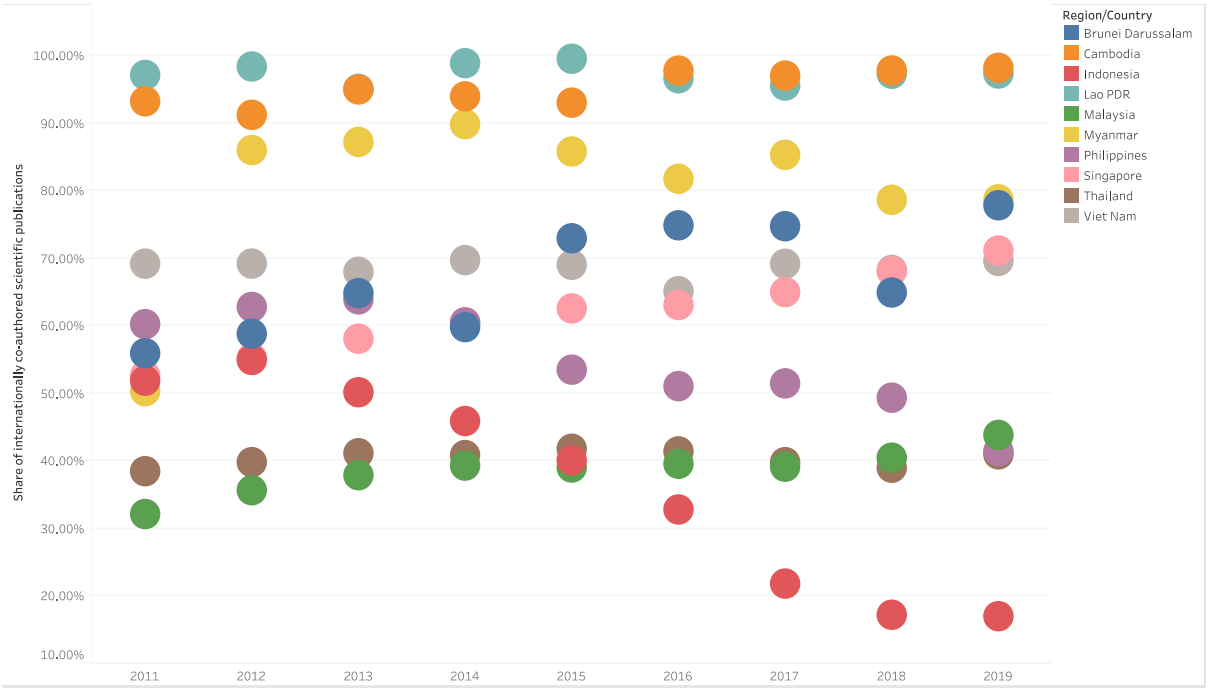


Source: UNESCO 2021

According to Figure 18, Cambodia has the highest share of scientific publications among ASEAN countries with an international co-author with 98.2%. Most international collaboration

is done with the USA, France, and Thailand. [44] The most productive institutions are the Cambodian Ministry of Health and the Cambodian National Centre for Parasitology, Entomology and Malaria control. The main outlets are PLoS One, Malaria and PLoS Neglected Tropical Diseases.

Figure 18. International collaboration in the production of scientific publications



Source: UNESCO 2021

3.1.4. Patents

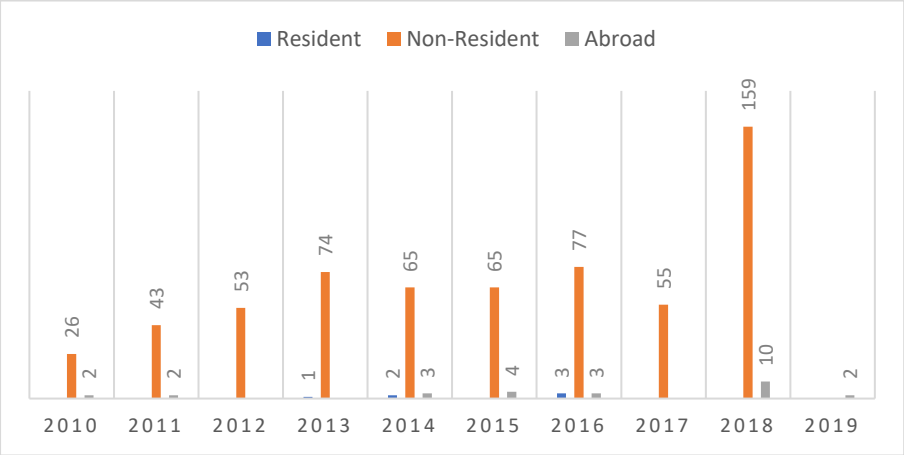
Statistics on Intellectual Property (IP) and scientific publications provide an indication of the STI outputs of a country. Cambodia's accession to the World Trade Organisation (WTO) in September 2004 brought obligations to implement a number of IP related laws and regulations. However, the application, registration and enforcement mechanisms are still in early stages of development. According to the World Intellectual Property Organisation's (WIPO) data, from 2015 to 2018, the number of non-residents' patent grants increase from 1 to 56, whereas there is no record of resident patent grants from 2010 to 2019. The number of trademarks filed rose from 936 in 2010 to 3,199 in 2019, and that of industrial designed filed increased from 7 in 2010 to 51 in 2014, and then decreased to 23 in 2015.[45]

There are procedures in place with respect to registration and some enforcement measures of IPR, which can be used by anyone who wishes to protect their IP. In addition, Cambodia is a member of the Paris Convention for the Protection of Industrial Property, and a member of the WIPO Convention, the Agreement of Trade-Related Aspects of Intellectual Property Rights (TRIPS). On 5 June 2015, it also became a party to the Madrid Protocol accessing the 'Madrid

[44] UNESCO Science Report: The Race Against Time for Smarter Development. Edited by S. Schneegans, T Straza, and J. Lewis. Paris, 2021. https://unesdoc.unesco.org/ark:/48223/pf0000377433_eng.
[45] WIPO, 2020 https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=KH

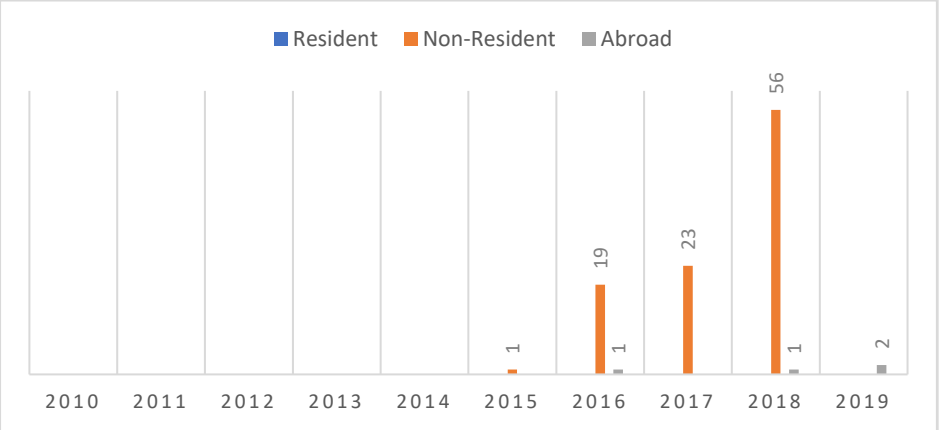
system' that makes it possible to protect a trademark in a large number of countries by obtaining an international registration that has effect in each of the countries that is amongst the signatories of the Madrid Protocol. From 8 December 2016 onwards, it became possible to seek patent protection in Cambodia through the filing of an international patent application under the framework of the Patent Cooperation Treaty (PCT).

Figure 19. Patent Application in Cambodia 2016-2019



Source: WIPO, 2020

Figure 20. Patent Grant in Cambodia 2016-2019



Source: WIPO, 2020

3.2. National Innovation System (NIS)

The NIS of Cambodia is on development. The system needs to be strengthened with reinforced links between different STI stakeholders in the country. The STI related roles are distributed across different ministries and other government agencies.

3.2.1. STI Policymaking

The organisations that are mainly involved in policymaking in Cambodia are the following:

- Ministry of Industry, Science, Technology & Innovation (MISTI): The Ministry is a coordinating body for National STI policy's implementation and monitoring of Cambodia's STI Roadmap 2030. MISTI is also responsible for managing and disseminating science and innovation activities and results in the country. Its name was changed from the Ministry of Industry and Handicrafts in March 2020 in response to the Fourth Industrial Revolution. The government also created two new units within the ministry: the General Department of Science, Technology & Innovation (GDSTI), and the National Institute of Science, Technology & Innovation (NISTI).

GDSTI has roles and responsibilities to be in charge with assessing Cambodia's STI performance as follows:

- ✓ Preparing strategic policy, roadmap, and law and regulation to serve STI sector
- ✓ Managing scientific discovery in order to serve the development of technologies in industrial sector as well as other sectors that are on demand for implementation having characteristic as strategic promotion and support to technology, innovation, invention, all new initiatives on science and digital technology in order to serve industrial sector and others
- ✓ Promoting network of AI, robotic and automation
- ✓ Organizing/preparing activities relating to electronic industry for both hardware and software
- ✓ Preparing technological park and innovation park
- ✓ Collaborating with relevant institutions responsible for STI and promoting participation of industry, support, and capacity improvement of SMEs as well as supporting big scale corporation to have higher innovation capacity
- ✓ Strengthening and facilitating public service on important science and technologies such as industrial intellectual property right, national standard certification, and global concession recognition
- ✓ Participating in international STI institutions and working together to assist to create and strengthen network for fund and human resource
- ✓ Preparing mechanism for following up, monitoring, and evaluation of STI implementation policy
- ✓ Promoting the development of smart technology and AI, space technology, cyberspace technology, and innovation ecosystem
- ✓ Preparing/Organizing/participating all events relating to promotion, development and dissemination of industry, science, technology, and innovation matter
- ✓ To implement other tasks assigned by the Government

In addition, it manages the activities of specific organisations, including the National Council of Science, Technology & Innovation of Cambodia since 2020.

- Ministry of Planning (MOP): The MOP is in charge of drafting and implementing national policies such as the NSDP 2019-2023. With the support of the Korea International Cooperation Agency, it drafted the National Science and Technology Master Plan 2014- 2020.
- General Secretariat of the National Council of Science, Technology & Innovation (GS-NCSTI): The GS-NCSTI is responsible for developing and promoting STI in the country. One of its main missions is to coordinate the stakeholders of the S&T ecosystem and to foster cooperation among them.
- National Council for Sustainable Development (NCSD): NCSD was an inter-ministerial policy-making body established in 2015, which brought together 36 ministries and

agencies as well as 25 capital and provincial governors. NCSD played a role in coordinating inter-ministerial political dialogues and decisions to lead sustainability policy and achieve sustainable development through formulating, directing and evaluating related policies, strategic plans, action plans, legal instruments, programmes and projects on behalf of the government. It was chaired by the Minister of Environment with the Prime Minister as the Honorary Chair. The operation of the NCSD was supported by a General Secretariat under direct oversight of the Council's Executive Committee which consisted of 12 members derived from the representatives of key ministries.

The different line ministries collaborate within the NIS include the Ministry of Education, Youth and Sport; the Ministry of Labour and Vocational Training; the Ministry of Post and Telecommunications; the Ministry of Mines and Energy; the Ministry of Commerce; the Ministry of Agriculture, Forestry and Fisheries; and the Ministry of Planning. [46]

3.2.2. STI Policy Implementation

At the operational level, a number of organisations are responsible for the actual performance of scientific research, technological development and innovation, as explained below.

- The National Productivity Centre of Cambodia was set up to improve productivity in industry, especially in the SME sector. It is responsible for formulating and implementing government policy and development strategy for productivity. The organisation is also tasked with the development and implementation of applied techniques and technology for enhancing efficiency, improving safety, encouraging environmental responsibility and increasing the value added of industrial products.
- STI National laboratory is responsible for the testing and analysis of product quality. Its main areas of responsibility include the promotion of R&D in product quality and safety improvement.
- The Technology Incubation Centre was established in early 2008 with the mandate to drive innovative technology development by carrying out applied research for the private sector, and developing and disseminating new technologies and know-how to private enterprises.
- The Royal Academy of Cambodia is responsible to i) establish cooperative relations in research with ministries, institutions and national and international organisations that have similar goals; ii) organise scientific and educational forums; iii) train researchers for master's degrees and doctorates; iv) distribute documents and research findings in national and foreign languages; v) collect and preserve research findings relevant to Cambodia, the other countries in the region and the rest of the world; vi) co-operate on the examination and evaluation of higher education graduate and postgraduate candidates; vii) participate in and co-operate on the protection of intellectual property; viii) examine and evaluate scientific research findings; ix) co-operate on the establishment of research institutes within ministries.
- Cambodian Agricultural Research and Development Institute established in 1999 as a semi-autonomous institute with the objective of promoting rural development focusing on applying technology that impacts on poverty alleviation and living standards, delivering high quality, highly valued research and development services, working in partnership with extension, NGO and private sector agencies to increase the impact of improved technologies, improving its capacity to deliver quality research and

[46] OECD, 2013 https://www.oecd.org/sti/inno/innovation-in-southeast-asia-2012-9789264128712-en.htm

development services that meet client needs, and promoting the impact and value of research for the development of Cambodia.

- Cambodia Rubber Research Institute conducts research to address the major constraints of the rubber industry in Cambodia. Research includes the introduction of higher yielding planting material to address the low yields, investigating improved tapping methods, inter-row planting to assist smallholder production and improving the grade of rubber emerging from processing plants.
- Cambodia Development Resource Institute (CDRI): It works to produce independent, objective, high quality policy-relevant development research to maximise its accessibility to policy makers, influencers and stakeholders and to have it affect policy in interrelated areas that are key for Cambodia's sustainable development.

In the higher education sector, the following universities as well as research units within them play an important role in performing STI activities: The Royal University of Phnom Penh, the Institute of Technology of Cambodia, the Royal University of Agriculture, the Royal University of Fine Arts, the National University of Management, the Royal University of Law and Economics, and the Royal University of Health Science.[47]

3.2.3. STI Services and Infrastructure

The actors responsible for STI services and infrastructure represent a mixed group of organisations that support the undertaking of STI activities. The type of support can be in the form of a collection of STI data and information, testing, standardisation, metrology, and quality control; activities related to patents and licenses, as well as the production of scientific publications. The main public actors include the following:

- MISTI is responsible for collecting the STI data and information, including R&D and innovation surveys and statistics on patents and licenses.
- National Training Board (NTB) established in 1996, has a direct responsibility to advance the status of TVET as a demand driven system responsive to the needs of the economy. It is charged with the task of ensuring that all training leads towards credit in a national framework and that Cambodians have access to skills development to build better lives for their families.
- Board of Engineers, Cambodia (BEC) is the sole national engineering institution in Cambodia to gather national engineers by means of registration and to upgrade professional qualification to an internationally accepted standards, contributing to the national development and leverage social well-being. [48]
- Accreditation Committee of Cambodia (ACC) established in 2003, is the national higher education quality and assessment body. [49]
- Institute of Standards of Cambodia (ISC) (under the MISTI) is the national standards body responsible for the preparation and publication of Cambodian standards and guidelines for products, commodities, materials, services and operations.
- The Cambodian Special Economic Zone Board (CSEZB) is in charge of the development, management and supervision of operations in the Special Economic Zones and is also charged with promoting industrial linkages and technology transfer via cluster development and inter-firm spillovers.

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[47] OECD https://www.oecd.org/sti/inno/innovation-in-southeast-asia-2012-9789264128712-en.htm
[48] ADB https://www.adb.org/sites/default/files/linked-documents/42334-01-cam-oth-02.pdf
[49] OECD https://www.oecd.org/sti/inno/innovation-in-southeast-asia-2012-9789264128712-en.htm

- Techo Start-up Center offers training programmes, mentoring, technical assistance and acceleration services to start-ups.
- Cambodian-Japan Cooperation Center (CJCC) provides business solutions and networking for start-ups and small- and medium-sized enterprises in addition to education and rich culture exchange between Cambodia and Japan.
- Cambodia-Korea Cooperation Center (CKCC) is a leading energetic and resourceful institution in Cambodia that contributes excellence standard in human resources training, Cambodia-Korea mutual exchange, and venue for meeting and events profession[50.]

3.3. STI Policies

In December 2019, the Royal Government of Cambodia approved the National Science, Technology and Innovation Policy 2020-2030.[51] The policy aims at strengthening STI foundation, improving STI environment, developing STI ecosystem for sustainable development and enhancing quality of people's life at all levels and sectors. The main goals of the policy are:

- Developing and strengthening adequate STI human resources with quantity, quality and composition; and professional ethics by considering gender equality.
- Enabling prominent STI human resources to perform leading tasks and establishing filtering and promoting mechanisms to create enabling environment for national STI human resources to perform their full potentials.
- Enabling 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.
- Developing and strengthening dynamic innovation ecosystem with capacity to synthesise technologies and engineering to acquire national achievements with incremental innovation in order to foster prioritised national industries and businesses for local consumption and export with the aim of more productive development.
- Instilling in society an STI culture in an inclusive manner, with the aim to ensure public confidence and trust in products and services that use national technologies and to ensure that those who made efforts and investments in STI development have satisfaction of their achievements as well as satisfaction of the outcomes of STI governance reform.

Built on the National STI Policy 2020-2030, the STI Roadmap 2030 was developed by MISTI under General Department of STI in cooperation with the Economic and Social Commission for Asia and the Pacific (ESCAP) of the United Nations.[52] The STI Roadmap, launched in 2021, focuses on 5 key pillars (governance, education, research, collaboration, and ecosystem) with the following strategies:

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[50] CKCC, http://www.ckcc.edu.kh/contact.php#undefined2

[51] https://misti.gov.kh/documents/index?dctype=NQ==

[52] https://data.opendevelopmentcambodia.net/library_record/cambodia-s-science-technology-and-innovation-roadmap-2030

- Enhance the governance of the STI system: Consolidate the mandate of MISTI clarifying the roles of MISTI and other stakeholders with regards to the promotion of STI; strengthen awareness and capacities of the Government to implement the STI Policy; and monitor and evaluate advances made in the promotion of STI.
- Build human capital in STI: Teaching STI from a very early age will help create a new generation of scientists and innovators. STEM skills will also need to be promoted in higher education. In addition, there is room for strengthening teaching and collaboration with the private sector in technical and vocational education and training institutions.
- Strengthen research capacity and quality: To support high quality research and development activities of national interest, it will be critical to develop a national research agenda with the academic community and in close collaboration with the private sector; provide funding to support excellence in science; support the internationalisation of research; and encourage collaboration with the private sector.
- Increase collaboration and linkages between different actors: To support innovation in SMEs and enhance their absorptive capacities, it will be critical to promote and sustain incubation and acceleration facilities, technological platforms open to the private sector and innovative clusters fostering collaboration.
- Foster an enabling environment for innovation: Supporting innovation capabilities and increasing the absorptive capacities of firms requires the financing and promoting intermediary structures that nurture new firms (start-ups), supporting technology transfer, and fostering domestic technologies. An enabling environment is needed for fostering institutions that provide technology and quality (i.e., norms and certification) services to firms. It is also required to increase access to finance for innovation activities, including through leveraging investments from the private sector, attracting funding from donors and incentivising FDI that supports the building of domestic technological capabilities.

3.3.1. Policies related to supply-side of STI

Supply-side policies aim at supporting the development of capabilities of organizations directly performing STI activities. The main strategies outlined by the policy are as follows:

- Use, strengthen, and enhance existing human resources through training and refresher training for immediate needs.
- Provide opportunity to human resources whose capacity has been built to engage in STI activities, and in national and international joint research in order to bridge theories and practices.
- Support knowledge and skills transfer from within and outside the country.
- Attract talents from abroad with appropriate support and encouragement.
- Qualify human resources in education and higher education in countries experiencing considerable investment in R&D and STI development, across both the medium and long term. Establish networks and clusters of intellectuals, as well as industry networks within and outside the country based on the trained human resources and with diplomacy support.
- Enable the built human resources to perform their duties with full capabilities.
- Monitor, assess and address problems and challenges of scientist performance.
- Build and effectively, fairly and sustainably operate talent assessment mechanism and qualification system with the aim of providing incentives in the form of pecuniary benefits and honorary awards to human resources delivering outstanding achievements in order to promote national talents.
- Create a national STI programme for youth that are in capacity development stage.

- Ensure R&D facilities, equipment and infrastructures needed or efficiency of investment, establish prioritised national science research centres for common and specialised uses, which is operated by trained technicians. These centres are to complement science facilities and infrastructures existing at the various science research institutions. Meanwhile, build R&D facility and equipment information system with up-to-date data and information on number, status, and uses of those facilities and equipment.
- Apply ratio of 1:2:7 for the investment on basic research, applied research, and experimental development, respectively, in consideration of innovation priority.
- Prioritise necessary technology transfer and import to localise, aiming at incremental innovation based on "make-some-and-buy-some" strategy.
- Set five potential technology domains as national priority: (1) Agricultural yield increase, produce diversification and agro-processing; (2) Modern production and engineering; (3) Health and biomedical; (4) Materials science and engineering; and (5) Services and digital economy. Besides, pay attention and take use of emerging technologies such as artificial intelligence technology, space technology and spatial technology having capability to provide real-time macro management.
- Create National Research and Development Programme to attract and use human resources, financial resources, and national and international cooperation aiming at achieving nationally prioritised STI development.[53]

3.3.2. Policies Related to Demand-side of STI

Demand-side policies aim at increasing demand for STI creating bigger incentives for it, improving conditions for the uptake of innovations and to speed up the diffusion of new technologies. The main strategies outlined by the policy are the following:

- Participate in establishing and supporting public and private entrepreneurship programmes providing concessional loan and financial grant; stimulate and promote national and international private-private, and national-international partnerships; promote and increase industrial participation; support and increase capability of SMEs, while stimulate large corporations to achieve higher innovation capability.
- Build and encourage to build Technology and Innovation Parks as technology and innovation beds to attract technologies, adapt technologies and synthesise engineering for innovation; to develop prototype; and to incubate national entrepreneurship.
- Promote and support commercialisation of products, processes, and services of national technologies and accomplishments in order to gain trust and preference nationally and internationally, with national pride.
- Synergise public and private investments in research and innovation to achieve average ASEAN's Global Innovation Index.[54]

3.3.3. Policies to Connect the Supply-side and Demand-side of STI

The main strategies outlined by the policy are the following:

[53] https://misti.gov.kh/documents/index?dctype=NQ==
[54] https://misti.gov.kh/documents/index?dctype=NQ==

- Create a National Innovation Programme to support, promote, facilitate, and bridge higher education institutions, research institutes, and business enterprises in transforming research into innovation to rapidly benefit socio-economy.
- Create technology transfer or University Industrial Linkage (UIL) office/unit in R&D organisations and institutes, having duties in accepting and connecting needs in innovation ecosystem, bridging technology demand and technology development, having technology dissemination and demonstration programme, and gaining extensive support on innovation under national coordination mechanism.
- Strengthen education, training, and advocating system qualifying "Science for All" with professional ethics; and encourage creativity, innovation, and entrepreneurship.
- Cultivate trust and preference on national technologies, products and achievements by explaining and demonstrating its unique and natural characteristics. Public procurements to lead this endeavour by ensuring that procurement items have national value-added or are national achievements. Meanwhile, quality and price of the procured items continuously to be improved through national research and innovation system.
- Construct public STI infrastructures for community such as STI library and museum; arrange STI forums, STI day and STI events; encourage participations and supports; and cultivate creativity and innovation. Increase geographical indication products and entrepreneurship in the community.
- Offer opportunities for inclusive businesses and social enterprises that demonstrate social and environmental responsibility nationwide.[55]

Cambodia implemented other sectoral policies that have concrete implications for the STI system. These are as follows:

- Cambodia's Technical and Vocational Education and Training (TVET) Policy 2017–2025 aiming to improve the livelihood and dignity of people and to enhance Cambodia workforces or human resources with knowledge, competences, skills, working attitudes, professional ethics, high productivity and competitiveness for lifelong employability.
- 2021-2035 Digital Policy Framework: The framework focuses on five major priorities: developing digital infrastructure, fostering digital trust and confidence, creating digital citizens, building the digital government and promoting digital businesses.
- Five-Year SME Development Plan: To support SMEs, MISTI promulgated the Five-Year SME Development Plan in the early 2020 to create synergies with the current work attached to the Industrial Development Policy and the ASEAN Strategic Action Plan on SME Development 2016–2025.
- ICT Master Plan 2020: The master plan has four strategic thrusts: (i) "Empowering People" comprises ICT human resource development and e-awareness; (ii) "Ensuring Connectivity" consists of three sectors; namely, national ICT infrastructure, legal framework and cyber security; (iii) "Enhancing Capabilities" is formulated with three sectors: ICT industry, ICT standards, and research and development (R&D); and (iv) "Enriching e-Services" includes e-government services, e-public services, e-economy services and e-education services.
- National Higher Education 2030 Roadmap: Developed by the Ministry of Education, Youth and Sports (MOEYS), the roadmap provides the overarching framework for a long-term holistic sector-wide approach for the development and delivery of education services and sets priorities and strategies on how Cambodia will achieve these targets.

[55] https://misti.gov.kh/documents/index?dctype=NQ==

- New Generation School Policy: The policy provides guidance to educators and students on new methods of learning aiming to enhance educational innovation throughout the school system and empower the education system to be competitive in the ASEAN region, where there is an urgent need for a work force with 21st century skills.
- Agriculture Development Strategic Plan 2020–2025: The Ministry of Agriculture, Forestry and Fisheries developed the Agriculture Development Strategic Plan 2020–2025 to accelerate agriculture development, including enhanced agricultural productivity, diversification and commercialisation, promotion of livestock farming and aquaculture, land reform and sustainable management of natural resources. It identifies specific efforts within technology, education and research.[56]

3.4. STI policy instruments

Cambodia has a limited number of policy instruments for the promotion of STI which are concentrated into research grants and awards.

- Entrepreneurship Development Fund: The fund aims for economic diversification, innovation and decent job creation. Created in 2019, it is a government trust fund, supporting entrepreneurs, innovative start-ups, SMEs and partnering institutions which implement any innovative activity and create economic value-added in the Cambodia's economy.
- Small and Medium Enterprises (SMEs) Cluster Park: To attract investors, reduce cost and ensure sustainable market, the Ministry of Industry and Handicrafts (the current The Ministry of Industry, Science, Technology & Innovation) has cooperated with private sector to pilot an SMEs Park in Kandal province. The Ministry has also proposed feasibility study to create two other SMEs parks in different provinces (Kompong Chhnang and Kompong Cham). In 2017, the ministry continued to conduct studies and encourage the development of SMEs Park under the theme of "One Province, One Small and Medium Enterprise and Handicraft (SMEH) Park".
- Nuclear science and technology centre (construction in progress): An agreement was drafted with Russia to establish a Nuclear Science and Technology Centre in Cambodia in 2016 and a year later with China. The MoUs aimed at boosting cooperation on nuclear energy and the use of nuclear technology in priority areas such as industry, agriculture, food safety, energy, construction, the environment, and medicine. Discussions included the establishment of a nuclear information centre aimed at raising public awareness of the potential of nuclear power.

4. STI SWOT Analysis

Based on the findings of desk and field research, including the focus group meetings with the stakeholders, an analysis of the STI-related strengths, weaknesses, opportunities, and threats (SWOT) for Cambodia is given below. The summary of the SWOT is given in Table 1 below.

[56] https://misti.gov.kh/documents/index?dctype=NQ==

4.1. Strengths

- **Political stability:** Over the past two decades, the country has undergone a significant transition, achieving political stability and economic growth fostered by public policies that ensure macroeconomic stability and an open economy.

- **Consistent and continuous long-term development vision:** Cambodia's rectangular strategy embodies an adaptative approach where the national vision evolves over time based on emerging national and international development priorities, while maintaining conceptual and directional consistency.

- **Favourable STI governance structure:** In 2020, a new legislation adopted the new governance structure for STI, including the new Ministry of Industry, Science, Technology & Innovation and the inter-ministerial National Council of Science, Technology and Innovation, providing a strong basis for the development of the national STI system.

- **Strong momentum in start-up ecosystem building:** Universities and training institutes introduce entrepreneurship and technical programmes, and the government launches support measures and infrastructure for entrepreneurs. As of 2020, these developments promoted more than 300 active technology-based start-ups at various stages of development.

- **Notable levels of foreign direct investment (FDI):** The Cambodian economy is attracting the second highest level of FDI in Southeast Asia and Oceania after Singapore and was the highest across all LDCs in 2019. Moreover, the legal framework of the country is being improved through a new investment law that was promulgated on 15 October 2021 to attract international investment on technology-based sectors, R&D or technology transfer.[57]

4.2. Weaknesses

- **Need to strengthen the articulation and coordination amongst the actors of the national STI system:** The new governance structure for STI is an attempt to overcome the challenge presented by diffused responsibility for science and technology across 11 key ministries and the challenge of effective communication among ministries. This new structure is yet to produce results in changing the limited coordination culture existing in the public sector.

- **Need to create a balanced policy mix by designing operational STI policy instruments:** Cambodia is making tangible efforts to incorporate the concept of policy mix into the new STI policy. However, further efforts are needed to transform the principles and actions defined in the policy into operational policy instruments with adequate resources.

- **Need to create a national STI funding agency and provide sufficient resources to finance STI projects:** The absence of a dedicated national agency to design and implement support programmes and the limited availability of adequate funds to

[57] https://www.dfdl.com/resources/legal-and-tax-updates/cambodia-promulgation-of-the-law-on-investment/

finance STI are major weaknesses prohibiting the accelerated sustainable development of the country.

- **Need to develop skilled human capital and researchers:** There is a need to invest in human resources development in line with the needs of the country. The education and training system is underdeveloped for producing adequate supply of graduates, postgraduates and people with vocational qualifications. It is also necessary to increase the participation of women and young people in science, technology, engineering, and invest in developing higher number of researchers.

- **Need to strengthen the support for enterprise development:** While the programmes supporting businesses in early stage of development are becoming more available, there are limited number of incubators and accelerators for mid-stage start-ups. Another dimension that requires support is access to investment capital and funding for companies in various sectors and life cycles.

- **Need to improve evidence-based policy-making and implementation:** Cambodia should create necessary systems and build capabilities to collect and publish internationally comparable STI statistics. In addition, systematic monitoring and evaluation practices should become an integral part of the policy cycle. Steps are required to be taken to evaluate the relevance, efficiency, effectiveness, impact and sustainability of the existing policy instruments, including the innovation infrastructures, and to take necessary measures to improve them.

- **Need to support knowledge generation activities:** While the government has focused investments on supporting innovation at the enterprise level so far, investment in research activities requires strengthening. In addition, there is a need to strengthen the coordination between relevant actors to better design and implement the research agenda, as well as the links between research institutions and the private sector.

4.3. Opportunities

- **Steady development of the economy:** The transformation of Cambodia's economy results in progressive industrialisation and modernisation across sectors. This trend will facilitate the increase of R&D efforts in the country. Additionally, rising consumption and construction demands witnessed through rising imports of durable goods and construction materials presents an opportunity for the local industry to diversify and intensify the knowledge content of their activities and for entrepreneurs to fill emerging market gaps.

- **Government's commitment in STI as a part of political priorities:** Recent developments on the STI governance system as well as the role of STI articulated in the national development agenda are important opportunities to channel resources to the areas where needs are most urgent. The country would benefit from sufficiently funded policy instruments run by experts that guarantee the sustainability of the policy direction.

- **Government instruments for promoting access to finance:** Newly created financing organisations such as the SME Bank and policy instruments such as the Entrepreneurship Development Fund, addresses the need to improve access to finance and presents an important opportunity to prioritise technology-based entrepreneurship that answers to the needs.

- **Technology start-ups building digital enabling infrastructure:** The progress of the start-up ecosystem at developing digital platforms and infrastructure, marketplaces and businesses concentrated on consumer technology presents an important opportunity to build on these efforts and further develop essential activities for the modernisation of the economy, particularly in the areas such as e-commerce, logistics, fintech, digital media and advertising.

- **Mobilising the diaspora:** Cambodian entrepreneurs, professionals and researchers are present in the countries where STI systems are well developed. Therefore, a dynamic network of diaspora engaged in STI-focused activities have the potential of bridging the skills gap, building entrepreneurial and innovative culture in the country and integrating Cambodia into global STI ecosystems.

4.4. Threats

- **Adverse effects of climate change:** The economic activities in Cambodia are very vulnerable to extreme climatic events, and the growing population and socio-economic development may exacerbate the country's vulnerability. Effective use of STI policy interventions and the use of appropriate technologies are essential to increase the capacity of the country to adapt to climate change and mitigate its impact.

- **Shocks to the global trade and economy:** Notwithstanding the growing trend of FDI despite the COVID-19 crisis, external threats to global investments and economies could slow down the growth and the expansion of the economy.

- **Disarticulation between start-ups and the rural sector and more vulnerable populations:** The majority of start-ups are working on urban solutions. This is also true for solutions that target higher socioeconomic market segments. Therefore, it is essential to promote innovative entrepreneurship as a mechanism for inclusive development providing opportunities to rural communities as well as vulnerable populations.

- **Exodus of talented individuals:** Cambodia is in a region of rapid economic and technological development that demands skilled. human capital. Therefore, the country needs to manage the risk of brain-drain through a set of measures to create attractive opportunities for educated human resources. This could include active collaboration with technology based FDI to create linkages with the local industry and to promote entrepreneurship focused on the value chains.

Table 1. STI SWOT analysis of Cambodia

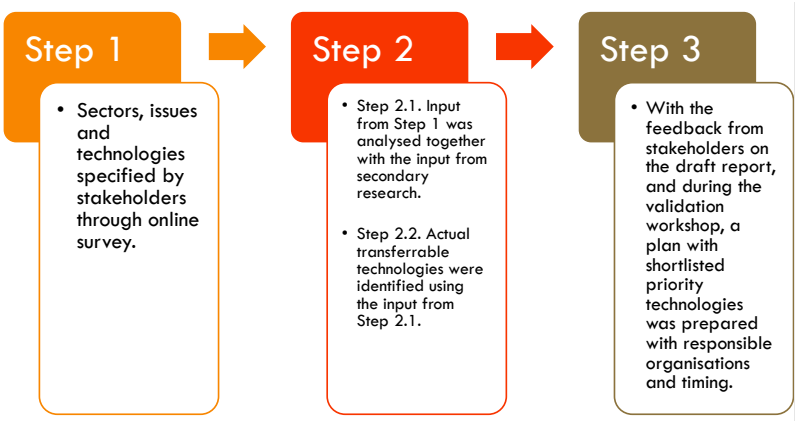
Strengths	Weaknesses
- Political stability - Consistent and continuous long-term development vision - Favourable STI governance structure - Start-up ecosystem building strong momentum - Notable levels of FDI in the country	- Need to strengthen the articulation and coordination amongst the actors of the national STI system - Need to create a balanced policy mix by designing operational STI policy instruments

	- Need to create a national STI funding agency and provide sufficient resources to finance STI projects - Need to develop skilled human capital and researchers - Need to strengthen the support for enterprise development - Need to improve evidence-based policy-making and implementation - Need to support knowledge generation activities
Opportunities	**Threats**
- Steady development of the economy - Government's commitment in STI as a part of political priorities - Government instruments for promoting access to finance - Technology start-ups building digital enabling infrastructure - Mobilising the diaspora	- Adverse effects of climate change - Shocks to the global trade and economy - Disarticulation between start-ups and the rural sector and more vulnerable populations - Exodus of talented individuals

5. Technology needs assessment

The technology needs for Cambodia were assessed through a three-step process (Figure 21). First, issues and technologies were identified for the following priority sectors by the national stakeholders: energy, agriculture and food, education, human health, and conservation and environment. These are listed in tables 2 to 7. Based on the needs and issues expressed by the stakeholders and identified in the secondary sources, available transferable technologies having the potential of highest positive impact were investigated (Section 6). The final input for the TNA was received from the stakeholders both on the draft lists and during the validation workshop organised under the study. As a result, a preliminary TNA implementation plan was prepared for the technologies that needs to be prioritised for Cambodia which also includes the responsible organisations as well as the estimated timing for the implementation of technology transfer and adoption (Section 7). This section (7) will be elaborated further during the technology Implementation Plan (TIP) phase.

Figure 21. Technology needs assessment process



The issues and technologies needed for the priority sectors of Cambodia are given below based on the findings of the online TNA survey completed by the national stakeholders.

Energy

As already stated in this document, energy remains an important sector for Cambodia, but the country is being challenged to keep up with the rapid demand growth while continuing to expand access the previously unserved areas and addressing issues of energy security, affordability, and environmental sustainability.

With climate change remaining an important issue, transitioning to green energy is the main focus of the country in the energy sector. From the survey sent to stakeholders, it confirmed that that the energy sector focus is around the use of solar, wind and other sources of renewable energy; energy efficiency, etc.as given in the following table.

Table 2. Technology needs for the energy sector

No.	Issues	Responsible organisation	Technology needs	Expected Users	Capacity building needed
1	High cost of electric power and energy quality	MME, EAC, EDC, MISTI and REEs	Smart grid technologies, Renewable energy, Nuclear power plant	Developers, technicians and end users	Capacity building on identified technologies
2	Reliability and stability of		Smart grid system		

	distribution need improvement		Automatic management system Home automation Data technology		

Agriculture and Food Sector

Agriculture as discussed is one of the main sectors for Cambodia, however the country still lags behind regional counterparts in terms low agriculture factor productivity, very limited value addition, and market trading of agricultural commodities. The issues and technology needs expressed in the survey for the agriculture and food sector (farming, agro-processing, agro-forestry, poultry, fisheries and aquaculture, floriculture, health food, animal feed, apiculture, horticulture, dairy, food manufacturing, processing and storage, etc.) are given in Table 3.

The respondents also explained the high input costs (such as electricity and fuel) for farms and plants, supply chain issues and skill development need as important sectoral issues that should be addressed.

Table 3. Technology needs for the agriculture and food sector

No.	Issues	Responsible organisation	Technology needs	Expected Users	Capacity building needed
1	Need for advance breeding technology and varieties for both crops, livestock and aquaculture (both access to the high quality of varieties and breeds and new varieties and breeds)	Agriculture universities and related research institutes (CARDI, Fisheries Institute etc.)	Molecular and conventional breeding for crops, livestock and aquaculture	Academic scholars, university students, and researchers	Laboratory and facility establishment, local human capacity building and technology transfer
2	High input cost and inadequate advanced technologies for crop production and sustainable intensification	Relevant ministries and authorities, universities and research institutes	Urban agriculture (indoor farming, vertical farming), and soilless cultivation technologies, bio-pesticide, bio-fertiliser	Academic scholars, university students, and farmers	Laboratory and facility establishment, laboratory management, human capacity building (targeting mainly farmers, and academia as needed)
3	Need for an improved logistic management (Irrigation system, packaging and storage technology and facility, road conditions, long distance from farm to table)	Universities and research institutes; related ministries (MPWT, MISTI, MAFF, etc.)	Packaging and cool storage facility, improved and standardised storage facility, logistic system	Farmers and academic scholars and vendors	Capacity building for the establishment and operation of laboratory and storage infrastructure and capacity building on whole logistic management
4	Low productivity (land quality degradation,	MAFF, MOWRAM, MISTI, MoC, MEF,	Seeds (new, resilient, profitable); use of mechanisation (e.g.,	Farmers	Farming techniques and

	seeds, traditional farming techniques, ineffective extension service, limited use of mechanisation, climate change, water/irrigation)	private sector, farmer community	drone, harvesting machines), drying facilities; complete and smart irrigation systems; net house/ greenhouse; dripping system; land preparation techniques; crop rotation; public-private extension services		capacity building on mechanisation
5	Low competitiveness (high cost of production, competition with informal and formal Import of agricultural products, lack of skills and limited use of modern technologies; logistic costs)		Low-cost energy technology (price/kw or capacity charge fee reduction); low-cost logistics; betterment of import control; development of agri-food industrial park (AIP), smart agriculture technology	Farmers, intermediaries	Production and operation knowledge, STI Park and Agri-food Industrial park creation
6	Limited access to finance	MAFF, MEF (ARDB, SME Bank, CGCC)	Strengthening ARDB, SME Bank, and CGCC	Farmers	Advertisement and direct marketing,
7	Water resources management and development	MOWRAM	Smart irrigation technologies	General Farmers & Farmer Water User Community (FWUC)	Training to FWUC on smart irrigation
8	Lack of climate resilience growing technique	MAFF, MoEYS, MoWRAM and MoE	Hydroponic, Smart Farm Assistant	Farmers, Researchers	
9	Food processing (large amount of food is wasted without proper processing or recycling), product development	Young innovators, and start-ups, universities and ministries	Composting technology, food processing machinery and technology, ICT, remote sensing, Biotechnology, AI, 3D printing, Preservation techniques, waste to energy technology	CSOs, General public, businesses	
10	Issues related to standards and quality of products, such as: - Limited services for analytical standardisation procedures - Quality and safety of agricultural products for local consumption and	Related ministries (MISTI, MAFF), accredited private labs, institutions (ISC, DA, Metrology Centre), WFP	- Relevant policy improvement (laws and regulations ensuring the identification & application of quality and production standards in agriculture, including the implementation of tracking and monitoring infrastructure) - Strengthen the roles and capacity of	MAFF, Local entrepreneurs (food business operators including farmers, private firms, such as exporters), policy makers, and local authorities	Policy development, regional and international knowledge transfer

	export (need for standardisation, quality check, etc.)		Quality Infrastructure Institutions (e.g. ISC, Metrology Centre, DA) and encourage private investment in quality infrastructure services; GAP; PGS, GMP, HACCP - Make use of digital technologies: Quick test tool, smart sensor, QR code, remote sensing, blockchains		
11	Market and trading related issues such as: -Unable access to the regional and global supply chain -Market linkages (poor implementation of contract farming, lack of wholesale markets, dominance of monopolized market system, unstable supply of agricultural products) -Need to ensure customer trust (mechanism or platform to ensure customer get the highest quality products so that they willing to pay more)	Related line ministries (MoC, MAFF, MEF, MISTI...), Cambodia Chamber of Commerce, CDC and other relevant authorities, farmer community	-Entrepreneurship, contract farming and commercialisation policy improvement - Digital technologies (smart phones, blockchain etc.); enhancing the implementation of contract farming; development of wholesale market (e.g. vegetable wholesale markets, community fish landing site); strengthening and establishing farmer community/group.	Local entrepreneurs (food business operators), related authorities, farmers and consumers	- Establishment of business and incubation centres for entrepreneurship, tech transfer, STI Park (intellectual property, patenting process support) - Community/group management skills, Market Intelligence skills - Farmer, government official capacity building

<u>Education</u>

The issues and technologies needed for education sector (STEM, TVET, higher education, virtual/distance education, etc.) is given in the following table.

Table 4. Technology needs for the education sector

No.	Issues	Responsible organisation	Technology needs	Expected Users	Capacity building needed
1	E-learning platform is limited	MoEYS, digital start-up and other stakeholders	E-learning application Using online/offline platform to support online and blended learning. Developing online learning resources/curriculum Building digital ecosystem to support online learning Game based learning	Teachers, digital Start-up	Teacher training Develop ICT blueprint and provide online training to all focal points at school level Technical capacity for developers to develop online learning resources
2	Limited access to digital infrastructure	MoEYS, MLVT, MPTC, MEF, MPWT, MISTI, MAFF,MoH, MoD,MoI	ICT Basic access to the internet, digital devices, learning centres in rural areas/school/disadvantaged community, digital technology (Data centre, data base), Internet access, Research & Innovation centre	Teachers and Students	Student training on Digital Technologies
3	The enrolment in TVET sector is challenging	MoLVT, DGTVET, local Authority, TVET Institutes, DPs, and Private Sectors	TVET E-Learning Platform, expanding to rural arears	TVET Institutes, Students, Private Sectors, Community, and etc.	TVET Teacher Skills Training, Digital Skills, Training Platform
4	Improvement of quality of education	MoEYS, MoLVT, MPTC, MEF, MPWT, MISTI, MAFF, MoH	Computer, software, internet and AI	For teaching and learning online	Equipment and infrastructure
5	Virtual learning and teaching		Professional and academic software, digital technology (Data centre, data base), Internet access, Research & Innovation centre	Digitalization of university management	Human resources development
6	Lack of clear guideline of expense for research for public sector	MEF, MISTI, MoEYS	National database of researchers in each field	All researcher, Research institutes	Human resource capacity building
7	University curriculum - outdated (e.g. Computer Science degree) & underdeveloped	MoEYS	Digital learning platforms, interactive multimedia, learning management system	Teachers and students	One-off intensive training, coaching

	curriculum (e.g. FinTech degree)				
8	University infrastructure - inadequate (e.g. lab, lab facility and R&D unit, etc.)		Facilities management system, space database	Facilities department and IT department	Management / organisational development consultancy
9	University's cooperation approach - work in silos, not ecosystem-like (e.g. university-educational institution, university-job provider, etc. & all together)	MoEYS and Universities	Digital data-sharing platforms	University, its target partners, public and private institutes	Technical assistance
10	Need to improve the absorption capacity of school/university and teachers-in terms of new technologies	MoEYS	Project-based learning	All schools and universities	Professional development training
11	New contents of STEM education at primary and high schools	MoEYS	Improvement of contents and quality on STEM education	Private and Public High Schools and Universities	Training of trainers
12	TVET Digital Transformation (Learning System and RPL)	MoLVT (DGTVET)	Digital System for RPL and Skill Certification	TVET, Training Centres, Youths out of school, low-skilled workers, migrant workers, employers	System orientation to users and certification institution
13	Gaps in digital skills vs. increasing demand	MoEYS, MEF, MPTC, MISTI, Private sector	Career outlook platform which provides powerful job information and in-depth analysis of labour market using data input from provincial administrations, industrial sectors	Youth, Job seekers, government, private sector	System orientations, database management, Job market analysis tools
14	Need to develop Industry 4.0 skills	MoLVT , MoC, MEF, MoEYS, MPTC, MPWT, MISTI, MAFF,MoH	Advanced technologies (AI, automation, sensors), digital technologies (Data centre, database)	Universities, Centre of Excellence, Students, Start-ups	Teacher training, industrial collaboration platforms

Human Health

The technologies needed for human health sector (pharmaceuticals, medical devices, health services, traditional medicine, telemedicine, etc.) is given in the following table.

Table 5. Technology needs for the human health sector

No.	Issues	Responsible organisation	Technology needs	Expected Users	Capacity building needed
1	Global health security (emerging disease, re-emerging disease)	Multi sectoral ministries or agencies	Robust surveillance system	Relevant ministries and agencies	Integrated information management (online and offline), cyber security, online application, Health care system human resource capacity building.
2	Increasing aging population/	MoH, MEF, MPTC, MoFAIC, Citizens, MCFA, MRC	Blueprint for aging society with emphasis on digitalization		
3	Increasing health care cost PPP in health care	MoH, MEF, MVLT (National Social Security Fund)	Online integrated information system, supply and demand data analysis	Healthcare providers and related workforce	
4	Limitation of capacity of modernization in public health system and need for health technologies	MoH, MEF, MME, MPTC, MISTI, MoEYS	Infrastructure support for digital roadmap: database, telemedicine, e-pharmacy		
5	Improve quality of training of health care service providers	MoH	Technical knowledge and infrastructure	Health universities	
6	Human health (pharmaceuticals, medical devices, health services, production of traditional medicine, tele medicine, etc.)	MoH, MEF, MoI, MISTI, MPTC, Private sector	High-end technology and equipment for the diagnosis and treatment of human diseases, clinical research Infrastructure and capabilities for developing, producing and marketing traditional medicine	Medical doctors, Health service provider, pharmacists,	

Conservation and environment

The issues and technology needs expressed in the survey for the conservation and environment (wildlife, land, water and forestry management, water and air quality, waste management, pollution control, etc.) are given in **Error! Reference source not found.**.

Table 6. Technology needs for conversation and environment sector

No.	Issues	Responsible organisation	Technology needs	Expected Users	Capacity building needed
1	Inadequate solid waste and	MoE, MoI, Sub-National levels	Solid waste recycling	Recycling companies	On-the-job training for government

	wastewater management				official and civil society
2	Challenges in monitoring and management of protected areas		Satellite image	MoE; MAFF	
3	Biodiversity loss	MoE; MAFF; Sub-National levels	Wildlife tracking, GSP build on wildlife		
4	Natural resource management	MoE; MAFF; MME; Sub-National levels	Resource efficiency and cleaner production	Private industries; MISTI	
5	Sustainable Energy resource development	MoE; National Council for Sustainable Development; and other stakeholders	Solar power, equipment and skills development of renewable energy	Private industries; MME; Electricity of Cambodia, Universities, NGOs	Training on conceptualizing the development of renewable energy technology and how to use new equipment
6	Water infrastructures	MOWRAM	Telemetry system (Hydro-met system	Government officials (water management)	Training to government officials on data acquired from telemetry system and data analysis for water management
7	Climate Change	Government, academia, private sector, and other relevant stakeholders	Technical expertise and know-how	Government, Academia, policy-makers at all levels, private sector, relevant stakeholders	Technical knowhow and expertise to be provided
8	Weak enforcement of natural resource governance mechanisms		Tools to undertake research and data analysis		Strengthening capacities for research, data collection, analysis and dissemination
9	Deforestation		Equipment / tools for conservation monitoring and law enforcement		Training for using equipment and tools effectively to implement relevant policies
10	Lack of adequate data on ????		Frameworks for integrating environment into mainstream economic processes		Knowledge frameworks and models to be introduced, piloted and demonstrated
11	Limitation of human resource capacities		Skills development / capacity building for managing environmental change and sustainably		Training, including sensitising stakeholders, advocacy and building capacity to manage environmental resources sustainably

Private Sector Development

The issues and technologies needed for the development of private sector is given in the following table.

Table 7. Technology needs for the private sector development

No.	Issues	Responsible organisation	Technology needs	Expected Users	Capacity building needed
1	Need for technology adoption and advancement to meet development of regional and international markets	MISTI; MPTC	E-commerce related technology	Businesses	Multimedia campaign, selective training, webinar, workshop
2	Need for supporting ecosystem in supporting trade development for the private sector	MoC, MEF, MISTI, MPTC	Smart logistics and supply chain		
3	Need for international market insights and skills	MEF, MoC, Cambodia Development Council (CDC),	Secure international payment gateways		
4	Need for export-readiness skills among business, particularly small and medium enterprises	MoC, MISTI	Trade data management system and sharing technology	Businesses and government	

6. Transferable technologies to address priority needs

The available transferable technologies identified by the study team through a comprehensive research based on the issues and technology needs expressed by the national stakeholders as well as those identified through background research and SWOT analysis are given in the following Table 8.

This table will provide the Cambodian authorities with a long list of technologies that can be sourced from different technology suppliers depending on the availability of funds and/or donor interest and/or technologies made available to the LDCs by their owners.

Table 8. Transferable technologies to address priority needs

Sector	SDG	Technology	Description	Potential suppliers	Links (if available)
Agriculture	2	Agricultural online marketing	A mobile B2B platform connecting farmers with retail market actors	Twiga (Kenya)	https://twiga.com/
Agriculture	2	Aquaponics	Aquaponics is a combination of aquaculture (raising fish, snails or prawns in tanks) and hydroponics (using water) whereby the nutrient rich aquaculture water is fed to the plant's cultivation environment.	Ichtys Aquaphonics (as an example. It is a large aquaponics hub in South Africa, providing trainings to starters as well)	https://aquaponics.africa/
Agriculture	2	Bee Vectoring	The technology uses a naturally occurring fungus called BVT-CR7, or Vectorite, that helps protect crops from a variety of diseases. The Vectorite solution is placed inside a hive of commercially raised bees and the bees collect the solution whenever they exit the hive. The solution is then distributed by the bees to the surrounding crops and fields. No pesticides and no water needed.	BVT (Canada)	https://www.beevt.com/solution/hive-bees-bee-vectoring-technology
Agriculture	2	Integrated Farming	Integrating crop production with livestock management and/or fisheries (in some cases forestry) which in a way complement each other with a symbiotic relationship which at the time is economically viable and profitable, environmentally suitable, and benefit giver of diversification of production.	Various individual technologies can be used together to increase efficiency. It is an approach, rather than being a turn-key solution.	https://www.sciencedirect.com/science/article/abs/pii/S0959652617323569 https://ars.els-cdn.com/content/image/1-s2.0-S0959652617323569-fx1_lrg.jpg http://www.fao.org/3/y5098e/y5098e.pdf http://www.songhai.org/index.php/en/home-en/16-songhai/189-bioproduction-en

Agriculture	2	Precision Agriculture, Agro-Monitoring	Monitor crops, farms, fields with drones, UAVs (Unmanned Aerial Vehicles), satellites and collect data to increase production by using lesser resource, decrease chemical, synthetic pesticide usage, etc.	AgEagle (USA) Precision Hawk (USA) Gamaya (Switzerland, Brazil) TaniBox (Estonia)	https://ageagle.com/agriculture/ https://www.precisionhawk.com/ https://www.gamaya.com/ https://www.tanibox.com/
Agriculture	2	Agricultural Productivity	A digital platform providing information, as well as interactive solutions needed to increase productivity such as: Weather forecast Pest alerts Seed exchange Remote / on-line trainings Agro-input market (e-commerce platform for non-tool inputs such as fertilizers, pesticides etc.) Tool, equipment and machinery platform (renting machinery, buying/selling/exchanging tools and equipment etc.)	Various	Examples: https://prise.org/ https://hellotractor.com/ https://aquaponics.africa/
Agriculture	2	Precision Livestock Production	Using ICT and AI to observe nutritional, behavioural, health and environmental activities that can impact production	Cainthus (Ireland, USA) Rex Animal Health (USA)	https://www.cainthus.com/ http://rexanimalhealth.com/
Agriculture / Fisheries	2	Carbon Transformation	All-natural microbes are used to transform CO2 and other gases into high-valued nutrients, oils, and bio-based products. The platform, which extends early NASA research, converts carbon dioxide from diverse industrial and agricultural sources into new materials using proprietary gas fermenting microbes.	Kiverdi (USA)	https://www.kiverdi.com/
Agriculture	2	Affordable Machinery	Using “scale-appropriate” machinery from planting to harvesting. (e.g. Walking tractors with replaceable attachments, such as plough, seeder/ planter etc.)	Various	Examples https://www.walkingtractors.co.ke/ https://www.honest-industrial.com/ http://www.bcsagri.it/
Agriculture / Forestry/ Conservation	2,15	Seed ball shooting	Delivering airborne seed ball shoots by drones in areas that need to be afforested	Ecording (Turkey) BioCarbon Engineering (UK)	https://ecording.org/en/ecodrone/ www.biocarbonengineering.com

Education	4	e-learning distribution platform	A mobile platform that helps institutions (including higher education) to prepare and publish e-training content. Both training providers and beneficiaries (not only students, but enterprise, Teachers, life-long learners etc.) register the appropriate program and launch the content. Evaluation and other tracking features help all parties (instructors, parents, students etc.) monitor the performance of their programs	Chalkboard Education (Ghana)	https://www.chalkboard.education/
Education	4	Affordable equipment for online / distance learning	To connect mobile network and to access wide range of learning resources, tablets are better than mobile phones. Affordable tablets with bundled apps and supporting equipment would provide an efficient platform.	School in a Box (a non-profit organisation founded in South Africa for K-12 students)	https://schoolinabox.co.za/
Education	4	AR & VR in Education	Using Augmented Reality (AR) and Virtual Reality as a supporting interactive tool. AR can be used in tablets and mobile phones.		
Education	4	e-learning content	New e-learning methods to improve student's basic math and science skills for further STEM education. Mobile apps with interactive videos/games provide such content	Many. As an example, eLumi (Kenya) aims to provide such an environment all over Africa, involving teachers, primary school students and parents. Green Shoots (South Africa) connects ICT with educations and uses a cloud-based Moodle platform to implement an online Maths Curriculum for South African grades 3-9 (ages 8 -15).	https://e-limu.org/ https://www.greenshootsedu.co.za/
Education	4	Inclusive Online Education	Adding parents as a part of online education together with students and teachers	As an example: Edmodo (USA)	https://go.edmodo.com/distancelearning/
Education	4	Supporting higher education	Joint programs run by universities in developed countries with university students in LDCs with a combined curriculum of in-person and online courses.	As an example: Kepler is an entity working in Rwanda, in partnership with Southern New Hampshire	https://kepler.org/about-us/

				University. SNHU provides students with access to accredited American degrees through competency-based online degree. It has two centres in Rwanda.	
Education	4	Supporting teachers for e-learning and distance education	Improving digital skills of teachers to better adopt online / remote education, as well as delivering professional materials and soft resources to them.	International Youth Foundation (USA) provides free online learning resources for educators and students during COVID-19. The Dr. C.L. Smith Foundation (South Africa) aims to improve the capacity of teachers on a digital platform (zibuza.net) Instill Education (South Africa) developed a mobile platform for training teachers on online-education with practical content	https://iyfglobal.org/ https://zibuza.net/ https://instill.education/
Energy		Pyrolysis	Pyrolysis is thermal degradation either in the complete absence of oxidizing agent, or with such a limited supply that gasification does not occur to an appreciable extent or may be described as partial gasification. With biomass pyrolysis, solid biomass and wastes are converted into liquid products. These liquids, as crude bio-oil or slurry of charcoal of water or oil, have advantages in transport, storage, combustion, retrofitting and flexibility in production and marketing.	Enoven (Turkey)	http://www.enoven.com.tr/

Energy	7	Microgrids	Microgrid technology is a decentralized version of the massive electrical grids that exist in most developed nations. More definitively, a microgrid is "a local energy grid with control capability" that can work autonomously to both produce and supply power to small communities. The autonomy of microgrids limits the negative aspects of larger power grids, such as rolling blackouts. Most popular approach is using solar power as the primary energy source. There are applications in African countries such as, Kenya, Tanzania, Sierra Leone, Nigeria.	PowerGen (Kenya, Tanzania, Sierra Leone, Nigeria) Energicity (Ghana, with subsidiaries in West African countries) TesVolt (Germany)	https://www.powergen-renewable-energy.com/ http://energicitycorp.com/ https://www.tesvolt.com/en/applications/micro-grid.html
Energy	7	Solar Energy	Portable, in-house solar power solutions. Consists of PV panel and a battery unit. Ready to feed electronic equipment for daily use. Several purchasing methods are available. As an example: An initial payment is made at purchase. Depending on the equipment and initial payment, annual or two-year plan is applied. Customer pays a certain amount of monthly fee (added to GSM bills). At the end of the plan, customer becomes the owner of the system.	There are several companies in operating in Africa, such as: Lumos Global (Netherlands) Barefoot Power (founded in Australia, bought by African subsidiaries. Operates in Kenya)	https://www.lumos-global.com https://www.barefootpower.com/index.html
Energy[58]	2,13,15	Combustion Rocket Stove for Cooking	Rocket Stove design is based on a dual combustion process where wood gas and smoke is drawn into a secondary combustion chamber which burns the smoke and releases an abundance of additional heat. With the product, it is aimed to use less wood and contribute to the protection of forests, as well as preventing air pollution with %90 less smoke emission.	Himalayan Rocket Stove (produced in India, already available in Nepal and Bhutan)	https://himalayanrocketstove.com/product/ecomini-rocket-stove/

[58] Energy efficiency and related technologies are identified as priorities for the mitigation of climate change effects at the TNA project implemented by the United Nations Environment Programme. "Energy efficient household appliances" is an explicitly specified item. (https://tech-action.unepdtu.org/country/cambodia/).

Energy, Agriculture	2, 7	Underground Cooling	A barrel like container is dug in and covered with the excavated soil from its new location. Temperature within the container barely varies. Furthermore, it is fitted with a battery-driven ventilator for fresh air, which is used one hour a day.	GroundFridge (Netherlands)	https://www.groundfridge.com/groundfridge/installation/
Energy, Waste Management	2, 15	Biogas Digesters	Slurry-Separation Technology (SST) used in biodigesters tackles waste management at the source, generates alternative energy known as biofuel, and provide independence from water demands. It aims to reduce the reliance on non-sustainable biomass and mitigate deforestation. Biodigesters are installed in Uganda, Mozambique, Togo, Ethiopia and Haiti.	Green Heat (Uganda)	http://www.greenheatinternational.com/biogas/
Environment and Forestry	15	Boosting reforestation by biomimicry	Device that mimics leaf litter by keeping soil from intact and moist, and protecting newly planted trees against predators. It helps surviving the seedling phase of trees with minimum maintenance requirements, therefore boost reforestation of fields	Nucleário (Brasil)	https://www.nucleario.com/
Forestry	15	Prevent illegal trading of log to neighbouring border	A network of old mobile phones is installed in appropriate locations in a forest with small solar-panels as power generators. Sound in / of the forest is monitored in real-time with an intelligent software analysing the collected data. Any sound matching the operation of a chainsaw or other tool / machinery generates an alarm with location coordinates.	Rainforest Connection (USA)	https://rfcx.org/
Forestry	15	Real-time monitoring	Global Forest Watch is a project that monitors forest areas via satellite imagery all over the world in real time and shares the data as an open-source material for free. Similarly, FAO offers an open-source cloud-based platform allowing countries to access their data.		https://www.globalforestwatch.org/ https://sepal.io/
Forestry	15	Real-time monitoring	With the help if IoT and Cloud technologies, forest are monitored in real-time. Devices equipped with several sensors are attached to trees. They provide various data including humidity,		https://www.orfonline.org/research/modern-technology-for-sustainable-forest-management-in-india/

			temperature, disturbance in forest areas to the cloud. Authorities are warned in unusual cases and they can use the data for tracking the forests.		
Health	3	Oxygen Generation	A set of interconnected medical oxygen generators, will allow each hospital to produce its own oxygen. Each station is connected to electricity and produces 93% pure oxygen from the natural air. The station has a battery plus a solar panel and is 3G-enabled granting the users and operators the ability to monitor it effectively, even remotely by using mobile phones.	Oxynnet by Arthur Zang (Cameroon)	https://www.prosygma-cm.com/index.php/en/news/cameroon-coronavirus-arthur-zang-designs-the-oxynnet-system-to-help-hospitals-produce-medical-oxygen
Health	3	Pandemic Awareness	Raising awareness for COVID-19 among the society with mobile apps. Several solutions are available varying in a large spectrum from chatbots and specialist reviews to personal assistants for handicapped individuals (with special features including sign language, voice recordings, info about prevention, symptoms and personal care etc.)	Various apps developed by entrepreneurs, especially in Africa (e.g. Eritrea, Kenya, Zimbabwe)	https://play.google.com/store/apps/details?id=org.undp.er.health&hl=tr&gl=US ("Eritrea tackling COVID-19" mobile app for Android phones) https://play.google.com/store/apps/details?id=com.dencroft.covidapp&hl=en&gl=US ("ZimCovid Safe" mobile app for Android phones)
Health	3	Portable medication against aerial bacteria and viruses, including SARS-COV-2	RESP301 is a nitric oxide (NO) generating medication that the patient inhales from a simple hand-held nebuliser. The fine particle droplets release NO into the lungs and upper airways. NO is produced normally in healthy lungs and is the first line of defence against viral or bacterial infection. RESP301 replenishes the NO and helps boost the body's immune system. A huge advantage of the NO produced by RESP301 is that it remains effective even against the new variants of the virus.	30 Technology (UK)	https://30.technology/approval-post-exposure-clinical-trial-covid-19/
Health	3	Self-test	Works with a mobile app and a specially designed "strip-like" kit. The strip has a colour matrix on it. It is dipped in fresh urine sample, and left there for two minutes. After that, the strip is scanned by the app via the camera of the	AssayMe (USA)	https://assayme.cc/

			mobile phone. Discolorations on the colour matrix is analysed by the app, and urine test results are shown. It can be shared with a doctor and stored to keep track of the individual's health conditions		
Health	3	Telehealth / Telemedicine	Video-consulting or virtual-visits provide patients to reach physicians for remotely diagnosable conditions such as allergy, rash, cold/flu symptoms, local pains and aches, minor cuts and burns etc. In addition, prescriptions are sent to local pharmacies. In some cases, patients can consult to psychiatrists and neurologists (when they suspect that they are having a stroke). A mobile app is downloaded to their phones, and after a one-time registration process, they can choose their physician and start the session. Can be used as a pro-active tool for COVID-19	Many health care facilities in several countries provide this service. Similar service is provided by a Swedish start-up (GLOBAL PLENITUDE) where volunteering refugees, migrant nurses, or doctors are connected with patients from poor socio-economic backgrounds	
Health, Environment	3,15	Reusable facemasks	Reusable, affordable and biodegradable facemasks help preventing the spread of pandemic and protecting the environment (from the spread of disposable masks). A mask made from a proprietary cotton, embedded with accelerated copper oxide and silver particles, and a nanofiber textile that blocks pathogens would be a solution	Ecomask (Uganda)	https://ecoplastile.com/ecomask/
Health	3	Improvement of Healthcare Services	Comprehensive surveillance system built on thorough data warehouse solutions for keeping track of national health-care services, developing health statistics, including medication use, disease monitoring and detailed patient record keeping	Undertaken as national public projects by governments	

Water[59]	6	Fog harvesting	Large vertical mesh nets (called fog fence / fog collector / fog harp etc.) are installed in appropriate regions. Water drops condensed on the mesh flow down to a collector. Advanced instalments can collect up to 10% moisture in the air. Most advanced technology in this field is called the CloudFisher. Works better where humidity is high.	Water Foundation (uses CloudFisher)	Water Foundation (link for the project example in Bolivia)
Water	6	Water capture through the air	Moist air goes into a condenser box through filters. Air runs through springs cooled by refrigerant gases. Condensed water is ozonized for further filtration. Warm air blew out by fans that generate reverse ventilation for the inflow of moist air. Needs energy to operate, which can be supplied by solar panels.	AirDrink (France)	https://airdrink.fr/en/content/6-Drinkableair-awg-process
Water	6	Water capture via MOFs	MOF (Metal-Organic Framework) tech is used to capture water through dry air by the help of sunlight. With 1kg of powder-like MOF, 2.8 litres of water can be pulled in 12 hours under ambient sunlight (even when humidity is as low as 20-30%).	University of California, Berkeley (USA) Water Harvesting Inc. (USA, founded by the inventor of the tech. at UC Berkeley, Professor Omar Yaghi)	https://news.berkeley.edu/killed/04/13/device-pulls-water-from-dry-air-powered-only-by-the-sun/ https://pubs.acs.org/doi/10.1021/acscentsci.0c00678 http://www.wahainc.com/
Water[60]	6	Water treatment with sunlight	Two 5lt of containers are joined like a book. Each container is filled with water and put under sun facing the transparent side up. Indicators located on each container turns green when UV purification is complete. Provides clean and hot water within 2-6 hours depending on	Solvatten (Swedish Social Enterprise)	https://solvatten.org/

[59] Water related technologies are identified as priority technologies for Cambodia at the TNA project implemented by the United Nations Environment Programme. Water is a selected sector contributing to the Clean Water and Sanitation (6th Sustainable Development Goal).
(https://tech-action.unepdtu.org/country/cambodia/).

[60] According to the World Bank, 21% of Cambodia's population (3.4 million people) did not have access to improved water, and 34 % (5.4 million people) did not have access to improved sanitation in 2020. With the majority of Cambodians living in rural areas, poor access to safe water and sanitation disproportionately affects the rural communities. Access to affordable financing for water and sanitation remains a barrier for families to secure water connections and toilets for their homes.
(https://www.worldbank.org/en/country/cambodia/overview)

			the pathogens in water. Each unit has 7-10 years of life time. Used in Malawi.		
Water / Agriculture	2,6	Rainwater harvesting	Harvesting rainwater by collecting it in catchment areas installed on rooftops, ground or via big reservoirs. Filtration can be done at several levels. Filtered water can be used in-house (in WC reservoirs, for washing clothes), for irrigation and livestock feeding, even for drinking (advanced filtration is needed). Collector tanks can be above or under the ground. Commercial applications for large plants are also available.	Several (mostly NGOs).	https://www.stormsaver.com/commercial-rainwater-harvesting/how-it-works https://www.rainwaterharvesting.co.uk/ https://www.ctc-n.org/technologies/rainwater-harvesting https://www.savetherain.org/ VentureRadar
Water, Environment	6, 13	Flood Forecasting	With the help of ICT (computer vision, data analysis, image processing, AI etc.), and sensors/gauges/loggers implanted in rivers, groundwater hot-points early-warning systems can be established and forecasting of floods can be made.	Many companies are working in this field. Selected ones are: Adasa (Spain) Cloud to Street (USA) ISMOP (Project, co-funded by National Centre of Research and Development of Poland) Fathom (UK, founded by the University of Bristol Hydrology Research Group	(Selected) https://www.adasasystems.com/en/ https://www.cloudtostreet.ai/ https://ismop.ki.agh.edu.pl/en https://www.fathom.global/fathom-global
Water, Environment	6, 13	Flood Protection	Innovative flood barriers provide protection from extreme waves of water and help redirecting the flow.	Innovative Global (Canada)	https://innovativeglobal.net/products/what-is-rapid-h2o/
Water, Environment	6,13	Permeable/ pervious paving	Permeable/pervious paving can: eliminate, or greatly reduce, stormwater run-off, protect urban fields from flood, and help recharging dwindling ground water.	Pervious Products (USA)	https://perviousproducts.com/

7. TNA implementation plan and prioritisation

Based on the needs and technologies identified for Cambodia in line with the issues and challenges facing the country discussed in the previous sections as well as the inputs received from the stakeholders both on the draft lists and during the validation workshop organised under the study, the TNA implementation plan is given below for the technologies that needs to be prioritised for Cambodia (Table 9).

Table 9. TNA implementation plan and prioritisation

Sector	Issues	Technologies	Responsible Organisations	Timing[61]
Energy	Need for reliability and stability of energy distribution and energy efficiency	- Establishing smart grid systems and microgrid technologies; automated energy management systems and home automation technologies - Achieving the digitalisation of the energy systems	MME, EAC, EDC and REEs	Short-term
Education	Need for a modern e-learning platform	- Developing online learning resources and curricula - Building digital ecosystem to support online learning - Building capabilities of educators on online teaching	MoEYS	Short-term
Education	Need for improving technological infrastructure	- Setting up a thorough ICT infrastructure, including internet access, acquisition of digital devices, construction of learning centres in rural areas and schools, with a particular focus on disadvantaged community	MoEYS, MLVT, MPTC, MEF, MPWT, MISTI, MAFF, MoH, MoD, DPs	Short-term
Conservation & Environment	Deforestation and protected area management	- Obtaining and using equipment and tools for conservation monitoring - Receiving technical assistance on improvement and enforcement required legislation - Building capabilities for active use of the Global Forest Watch that monitors forest areas via satellite imagery in real time and shares the data as an open-source material - Using IoT and Cloud technologies for real-time monitoring of forests	MoE and other relevant ministries and public authorities, academia, private sector, INGOs, NGOs, civil society, development partners	Short-term
Health	Need to improve health services	- Establishing telemedicine systems and services with video-consulting/virtual-visit technologies to help patients reach physicians for remotely diagnosable conditions and for consultations	MoH	Short-term

[61] Short-term refers to a period of 1-3 years, mid-term 3-6 years and long term more than 6 years. However, depending on the circumstances, global issues, and country-specific conditions, they may vary. Therefore, it is preferred to use "terms", instead of specific durations in this report

Agriculture & Food	Need to increase productivity and addressing climate change	- Obtaining harvesting and post-harvesting (drying) technologies; smart irrigation systems; net house/ greenhouse systems; dripping systems; composting technologies - Establishing crop rotation systems as well as public-private extension services	MAFF, MOWRAM, MISTI, private sector, farmer community	Short-term
Agriculture & Food	High input cost and need for advance technologies for crop production	- Creating systems for urban agriculture (indoor farming, vertical farming) - Local production of fertiliser, pesticide, animal feed - Obtaining soilless (hydroponics, aquaponics and aeroponics) cultivation technologies	MAFF and other relevant ministries and public authorities (MEF, MISTI, MoLVT, MoEYS…), universities and research institutes	Short-term
Health	Need for global health security (emerging disease, re-emerging disease)	- Establishing robust surveillance system - Putting in place comprehensive data warehouse solutions for keeping track of national health-care services, developing health statistics, including medication use, disease monitoring and detailed patient record keeping	MoH, multi sectoral ministries or agencies	Short-term
Health	Increasing health care cost	- Establishing online integrated information system built on and interacting with the surveillance & tracking system	MoH, MEF, MVLT (National Social Security Fund)	Medium-term
Education	Need for improvement of quality of education	- Improving the quality of education with complementary and sophisticated software, as well as new technologies like AI, VR, AR	MoEYS, MLVT, MPTC, MEF, MPWT, MISTI, MAFF, MoH, MoD, DPs	Medium-term
Health	Need for improving human health	- Obtaining high-end technologies and equipment for the diagnosis and treatment of diseases and clinical research - Creating the infrastructure and capabilities for developing, producing and marketing traditional medicine	MoH, MEF, MoI, Private sector	Medium-term
Agriculture & Food	Need for efficient food processing	- Obtaining and disseminating efficient food processing equipment - Implementing capacity building on the application of quality standards	MAFF, private sector companies, young innovators, and start-ups, universities	Medium-term
Agriculture & Food	Need for achieving safety and quality of food & agricultural products	- Identifying and establishing quality and production standards in agriculture and food sectors - Establishing tracking and monitoring infrastructure from cultivation to market delivery with surveillance systems such as QR codes, mobile test kits, smart sensors etc.	Institute of Standardization, WFP, MAFF, MISTI (ISC, DA, Metrology Centre), MOC, private labs, private companies, farmers	Medium-term

Agriculture & Food	Need for expanding markets	- Putting in place the systems for and creating capacities on contract farming and commercialisation	Related line ministries (MAFF, MEF, MISTI...), Chamber of Commerce and other relevant authorities (CDC etc.)	Medium-term
Agriculture & Food	Need for productivity enhancement	- Obtaining, developing and disseminating new, resilient, profitable seeds - Using drone technology, UAVs (Unmanned Aerial Vehicles) and satellites to for data collection - Adopting land preparation techniques	MAFF, MOWRAM, private sector, farmer community	Medium-term
Health	Need for health technologies	- Establishing e-pharmacy solutions	MoH	Medium-term
Agriculture & Food	Access to the right markets – both at local and international levels	- Creating a mobile B2B platform connecting farmers with retail market actors	Related line ministries (MAFF, MEF, MISTI...), Chamber of Commerce and other relevant authorities (CDC etc.)	Medium to longer term

8. Conclusions and recommendations

As discussed in previous sections, Cambodia is making notable progress in developing and implementing STI policies (including the Cambodia's STI Roadmap 2030) and enhancing its national STI system. The high commitment of the government on STI and the strengths and potential of the country create a strong trajectory for its sustainable and inclusive development and graduation from the LDC category.

Within this framework, Cambodia will hugely benefit from the adoption and deployment of technologies addressing the needs of the priority sectors as well as building necessary skills and competencies for the use and development of them.

Therefore, it is recommended that the government

- Continues to invest in developing STI governance system and policy framework also by designing and implementing sectoral STI strategies
- Establishes the systems and builds capacities to regularly collect internationally comparable STI statistics as well as monitoring and evaluation mechanisms for policies and policy instruments
- Enables MISTI to create a national STI R&D funding agency to design and implement support programmes similar to international peers
- Creates a balanced STI policy mix targeting not only start-ups and technology-based enterprises but also grass-roots innovators
- Develops human capital for STEM fields and attracts young people to pursue research career paths and innovation-based entrepreneurship, with a particular focus on attracting girls to STEM subjects to increase the participation of women in research and innovation
- Enhances communication and collaboration between research performers and the private sector, also by integrating the FDI in the innovation ecosystem
- Invests in developing the quality, metrology and standardisation infrastructure, and offer internationally recognised certification in all sectors
- Establishes and strengthens research institutes to conduct and commercialise R&D in the priority areas
- Invests in increasing the number and qualification of human resources for priority sectors of development
- Works closely with private sector and academia to cater their needs and improves investment and business ecosystem
- Establishes a policy framework to attract FDI with appropriate technology transfer mechanisms
- Invests in establishing a solid foundation of STI in the education system, including up-to-date and quality curricula, adequate infrastructure, qualified teachers and mentoring programmes that promote higher enrolment in STEM subjects in higher education
- Raises awareness of patent system, industrial standards, trading law, innovation management and PPP.
- Developing TVET programmes and infrastructure to create a supply of intermediate-level employees (laboratory technicians, radiographers, renewable energy and energy efficiency experts, etc.) to be engaged in STI in the priority sectors.

To support sustainable and inclusive development of Cambodia, it is recommended that the UN Technology Bank and other development organizations assist Cambodia in

- The transfer and deployment of technologies identified and listed in this report giving the priority those listed in the implementation plan provided above
- Developing necessary skills and capabilities in technology transfer and development
- Raising awareness for the adoption and use of new technologies
- Creating a national technology transfer office to coordinate the technology adoption process as well as commercialisation of R&D outputs from universities, research institutes and start-ups

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