STI Evaluation Criteria

Fundamental Framework of Science, Technology, and Innovation Evaluation for Public and Private Enterprises

National Council of Science, Technology & Innovation
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FOREWORD

Cambodia is undergoing a crucial phase of national transformation following the Pentagonal Strategy-Phase I of the Royal Government of Cambodia of the Seventh Legislature of the National Assembly. As the country positions itself to become a knowledge-based and high-income country by 2050, it must leverage the power of science, technology, and innovation (STI) to fuel its growth, resilience, and global competitiveness. STI is no longer a luxury or a peripheral policy domain; it is central to addressing critical development challenges—from industrial modernization and digitalization to climate resilience, public health, and inclusive economic participation.

To meet these demands, the Royal Government of Cambodia has recognized the urgent need to establish a robust and systematic approach to evaluating its STI landscape. This document, the Fundamental Framework for Science, Technology, and Innovation Evaluation, is a milestone in the nation's innovation journey. It provides a comprehensive, practical, and context-sensitive methodology for assessing STI performance at national, institutional, and enterprise levels.

This framework represents a strategic tool to empower evidence-based policymaking, enhance institutional accountability, and foster a culture of continuous improvement in the STI ecosystem. By establishing clear indicators and evaluation mechanisms, this document can be used as a reference for decision-makers to identify gaps, track progress, and prioritize investments that yield the highest impact. It also serves as a common reference point for stakeholders across government, academia, and industry, promoting greater coherence and alignment in Cambodia's STI development efforts.

Led by the Ministry of Industry, Science, Technology & Innovation, and supported by the Asian Development Bank, the framework is a product of strategic planning, analytical rigor, and inclusive dialogue. It brings together global best practices—such as those embedded in the Oslo Manual, Global Innovation Index, and European Innovation Scoreboard—with Cambodia's unique development priorities, institutional capacities, and sectoral realities.

The development of this document included an extensive consultative process, with inputs from a broad spectrum of stakeholders: inter-ministerial partners, private sector representatives, academic institutions, and the Advisory Board to the National Council of Science, Technology & Innovation. Their collective wisdom ensured that the framework would be operational, inclusive, and nationally owned.

As we move toward the implementation phase, I invite all STI actors—from policymakers and researchers to entrepreneurs and educators—to actively use, contribute to, and help to continue to develop this framework. In doing so, we build not just a tool for measurement, but a foundation for innovation-driven development.

Phnom Penh, 12 January, 2026

Minister

Hem Vanndy

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The preparation of the Fundamental Framework for Science, Technology, and Innovation Evaluation would not have been possible without the leadership, collaboration, and dedication of many individuals and institutions.

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Special acknowledgment is given to the technical experts who provided critical inputs and international best practices:

- Dr. Bradley J. Murg, International Expert
- Dr. Deth Sok Udom, National Expert

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EXECUTIVE SUMMARY

"Fundamental Framework of Science, Technology, and Innovation Evaluation for Public and Private Enterprises in Cambodia"

National Strategic Context and STI Imperative

The Royal Government of Cambodia (RGC) has identified science, technology, and innovation (STI) as pivotal drivers of national transformation, aligning with its broader development ambitions to attain upper-middle-income status by 2030 and high-income status by 2050. In this transformative pursuit, the Ministry of Industry, Science, Technology & Innovation, working collaboratively with stakeholders across government, academia, and industry—both domestic and international—developed the Fundamental Framework for STI Evaluation. This initiative marks a significant institutional commitment to building an innovation-driven economy by providing an adaptive, data-driven, and context-sensitive approach to assessing national and sectoral STI performance.

Alignment with Policy and Sustainable Development Goals

The framework is firmly anchored in Cambodia's policy architecture, including the National Policy on STI (2020–2030), the Industrial Development Policy (2015–2025), and Cambodia's STI Roadmap 2030. Collectively, these policies underscore the role of STI in enhancing industrial competitiveness, modernizing economic structures, and ensuring sustainable development. Moreover, the STI evaluation framework is aligned with the United Nations Sustainable Development Goals (SDGs), emphasizing its integrative role in promoting inclusive economic growth, fostering quality education, supporting climate action, and driving technological resilience. The framework's design ensures that it contributes directly to multiple SDGs, notably those related to industry and infrastructure, education, energy, climate, and innovation-driven economic growth.

Structural Composition of the Evaluation Framework

The framework adopts a multidimensional structure composed of two primary domains—STI Inputs and STI Outputs—each further subdivided into foundational pillars. The STI Inputs

domain is organized into four interlinked pillars: Governance, Resource, Performance, and Environment. Governance encompasses the institutional arrangements and policy mechanisms guiding STI activities. Resources refer to human capital, financial inputs, and infrastructure necessary for STI activities. Performance addresses the volume and quality of innovation activities and collaborative networks, emphasizing the scope and effectiveness of national and enterprise-level efforts. The environment pillar reflects the internal and external conditions influencing innovation, including the work environment, labor markets, regulatory landscapes, and the broader business climate.

The STI Outputs domain captures the tangible and intangible results of innovation efforts. It consists of three pillars: Scientific Knowledge, which includes peer-reviewed publications and research outputs; Technology Advancement/Integration, which comprises invention, technology transfer, and intellectual property rights; and Innovation Production, which encompasses both product innovation and business process improvements that facilitate commercialization and competitiveness. Each of these pillars is supported by detailed sub-indicators that enable granular evaluation and performance tracking.

Each pillar integrates a suite of indicators tailored to Cambodia's institutional realities and sectoral needs. These indicators facilitate comprehensive assessments at both the national and enterprise levels and support real-time feedback mechanisms essential for agile policymaking and strategic course correction. The structure promotes holistic evaluation and ensures a balanced assessment of inputs, processes, and outputs within STI systems.

Methodological Foundations and Customizability

The framework builds upon internationally recognized methodologies, including the OECD's Oslo Manual, the Global Innovation Index (GII), European Innovation Scoreboard (EIS), and the Community Innovation Survey (CIS). These instruments provide a robust methodological foundation for assessing formal and informal innovation*. Their integration within the Cambodian context allows for the evaluation of a broader spectrum of innovation activities, especially within the SME and informal sectors, where traditional R&D metrics are often inadequate.

* Informal innovation means creative and practical solutions made by individuals, small businesses, or communities outside the formal system. These ideas often come from the informal economy and are developed without formal research, using local knowledge, experience, and available resources.

A notable strength of the framework lies in its adaptability. It permits sector-specific customization, allowing institutions to calibrate the evaluation approach to align with their operational realities and strategic objectives. The Cambodia Enterprise Innovation Index (CEII) exemplifies this flexibility, offering a version of the national framework specifically tailored to the innovation landscape of Cambodian Small and Medium-sized Enterprises (SMEs). The CEII focuses on grassroots innovation*, incremental improvements, and the adoption of digital tools, all of which are prevalent in Cambodia's enterprise environment.

* Grassroots innovation means practical solutions created by local people or small groups to solve everyday problems. These ideas use local resources and traditional knowledge, often without formal education or support, to address social, environmental, or economic needs in the community.

Implementation Architecture and Evaluation Process

Effective implementation of the STI evaluation framework requires a robust governance model, coordinated institutional arrangements, and investment in STI infrastructure. Central to this process is the establishment of comprehensive and interoperable STI databases, the deployment of standardized data collection instruments, and the fostering of collaborative linkages among public, private, and academic sectors. These foundations ensure the reliability, consistency, and scalability of STI evaluation practices.

The scoring and ranking system utilizes a structured methodology based on weighted, normalized indicators aggregated into composite indices. This scoring methodology supports the classification of evaluated entities into performance tiers such as Innovation Leaders, Strong Innovators, Moderate Innovators, and Emerging Innovators. These designations facilitate comparative analysis, benchmarking, and the identification of performance gaps and best practices. The flexibility of the ranking mechanism also allows for the integration of sector-specific priorities and emerging innovation domains.

Challenges and Strategic Opportunities

The development and application of STI evaluation in Cambodia face a range of systemic and operational challenges. These include fragmented and inconsistent STI data sources, methodological limitations in evaluating informal innovation activities, and constraints in institutional capacity and technical expertise. Addressing these issues is critical to ensuring the effectiveness and long-term sustainability of the framework.

Nevertheless, several strategic opportunities exist to transform these challenges into strengths. These include the application of emerging digital technologies to enhance data analytics and monitoring; the integration of STI indicators into the broader national statistical ecosystem; and engagement with international networks for knowledge exchange, capacity building, and policy alignment. The adaptability of the framework also presents an opportunity to localize global best practices and develop evaluation instruments that are responsive to Cambodia's evolving economic and technological landscape.

Policy Recommendations and Next Steps

To realize the full potential of the STI Evaluation Framework, a set of strategic recommendations is proposed. It is imperative to enhance STI data collection and integration through the development of real-time, digital platforms that support transparency, reliability, and interoperability across sectors. The framework should incorporate broader evaluation metrics that reflect qualitative dimensions of innovation, including social impact, inclusivity, and environmental sustainability. Institutional coordination must be strengthened by establishing inter-ministerial platforms and multi-stakeholder forums that align STI policy across government, academia, and industry.

In parallel, investments in human capital are essential. This involves expanding training in STI evaluation methodologies, fostering analytical competencies, and cultivating an innovation-centric culture across educational and professional domains. Public-private partnerships should also be deepened to co-develop and pilot new evaluation tools, while encouraging experimentation and agile governance in innovation ecosystems. Furthermore, the alignment of STI strategies with national sustainability agendas, particularly those addressing climate resilience, clean energy, and food security, must be institutionalized through dedicated indicators and integrated reporting systems. These strategic actions will ensure that STI becomes a cross-cutting enabler of long-term development outcomes.

Conclusion

The STI Evaluation Framework represents a pivotal step in Cambodia’s journey toward a knowledge-based economy. Its comprehensive design, grounded in both global standards and local needs, offers a dynamic and responsive mechanism for

assessing and enhancing innovation capacity. By institutionalizing this framework and ensuring its iterative refinement, Cambodia positions itself to leverage science, technology, and innovation as foundational pillars of economic resilience, industrial competitiveness, and inclusive, sustainable development.

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SYMBOLS

α	Significant level
E	Absolute error
n_0	Enterprise size or sample size
n	Sample size in surveying practice
n_1	Sample size adjusted
n_h	Sample size of the stratum h
N_h	Population size of the stratum h
N	Population size
p	Proportion of the main variable
p_h	Sample proportion of stratum h
P_h	Population proportion of stratum h
r	Response rate
S_h	Sample standard deviation of stratum h
V	Ratio of E^2 to $Z^2_{\alpha/2}$
W_h	Ratio of N_h to N
$Z_{\alpha/2}$	Z-value above which we find an area of $\alpha/2$ under the normal curve
Z	Random variable of normal distribution

ABBREVIATIONS

ADB	Asian Development Bank
AI	Artificial intelligence
ASEAN	Association of Southeast Asian Nations
CEII	Cambodia Enterprise Innovation Index
CSIC	Cambodia Standard Industrial Classification
CIS	Community Innovation Survey
DMIE	Department of Policy Monitoring, Inspection, and Evaluation
EIS	European Innovation Scoreboard
GDSTI	General Department of Science, Technology & Innovation
GCI	Global Competitiveness Index
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GII	Global Innovation Index
HERD	Higher Education Expenditure on R&D
FTE	Full-Time Equivalent
ICT	Information and Communications Technology
IP	Intellectual property
IT	Information Technology
ITU	International Telecommunication Union
MISTI	Ministry of Industry, Science, Technology & Innovation
M&E	Monitoring and Evaluation
NCSTI	National Council of Science, Technology & Innovation
PPPs	Public-Private Partnerships
OECD	Organization for Economic Co-operation and Development
R&D	Research and development
ROII	Return On Innovation Investment
STI	Science, Technology, and Innovation

STEM	Science, Technology, Engineering, and Mathematics
SMEs	Small and Medium-sized Enterprises
SDGs	Sustainable Development Goals
TRL	Technology Readiness Level
UIL	University-Industry Linkages
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
WB	World Bank
WIPO	World Intellectual Property Organization

1 INTRODUCTION

1.1. Background

Science, technology, and innovation (STI) are widely recognized as essential drivers of economic growth, industrial transformation, and national competitiveness in the modern global economy. Countries that have successfully transitioned from low-income to middle- and high-income economies have done so by making substantial investments in their STI capabilities (OECD 2018). These investments include strengthening research institutions, fostering technological entrepreneurship, creating incentives for knowledge-intensive industries, ensuring strong collaboration between academia and industry, and prioritizing workforce development in Science, Technology, Engineering, and Mathematics (STEM) (Lundvall 1992).

Historically, economies that have undergone successful industrial transformation have leveraged STI to achieve sustainable economic progress. For instance, South Korea, Singapore, and Taiwan have demonstrated how strategic STI investments can lead to rapid technological advancement, increased industrial diversification, and the development of high-tech sectors (Freeman 1987). These nations have actively pursued policies that prioritize technological self-reliance, strong intellectual property protections, and state-driven R&D initiatives, enabling them to develop into innovation hubs and global leaders in science and technology (Cimoli, Dosi, and Stiglitz 2009).

The Royal Government of Cambodia recognizes the central role of STI in shaping the country's long-term economic trajectory. Cambodia's economic development strategy is explicitly linked to an STI-driven approach, as reflected in its major national policies, including the Pentagonal Strategy–Phase I, the Industrial Development Policy (2015–2025), the National Policy on STI (2020–2030), and Cambodia's STI Roadmap 2030 (Royal Government of Cambodia 2020). These policy frameworks emphasize the importance of building a robust innovation ecosystem, improving research capabilities, fostering entrepreneurship, and ensuring sustainable industrial transformation as part of Cambodia's broader strategy to achieve a high-income status by 2050 (World Bank 2022).

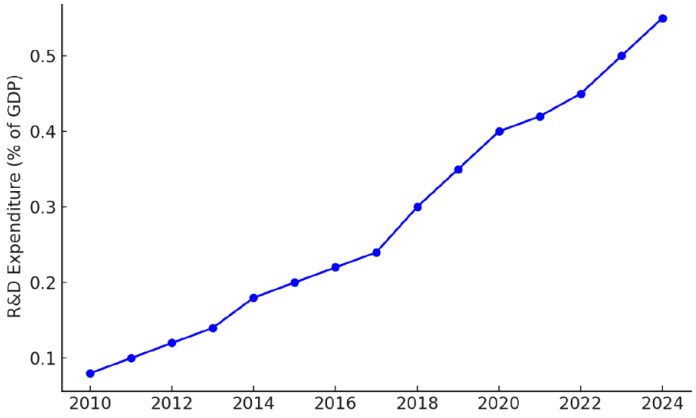


Figure 1. STI investment trends in Cambodia (World Bank, 2022)

Despite the remarkable economic progress Cambodia has achieved over the past two decades, the country faces significant structural challenges that could hinder its transition into a knowledge-based economy, with the relatively low investment depicted in **Figure** 1 above. A primary issue is its continued reliance on labor-intensive manufacturing, low-value agricultural exports, and informal enterprises, which limit its capacity to compete in the global knowledge economy (World Economic Forum 2021). The country's industrial base is characterized by low technological complexity, and much of its workforce remains concentrated in low-skilled jobs. This industrial structure makes Cambodia highly vulnerable to external economic shocks, as seen during the COVID-19 pandemic (United Nations Development Programme 2021).

The COVID-19 pandemic further exposed Cambodia's economic vulnerabilities, particularly in relation to its small and medium-sized enterprises (SMEs). Many Cambodian SMEs, which form the backbone of the national economy, faced severe disruptions due to supply chain breakdowns, declining consumer demand, and inadequate digital infrastructure (Asian Development Bank 2022). The pandemic also revealed critical weaknesses in Cambodia's ability to adopt digital transformation, as many businesses lacked access to the technological tools and online platforms necessary for remote operations and e-commerce (World Bank 2020). These challenges reinforced the urgent need for systematic, data-driven policy interventions to build technological resilience, strengthen STI capacity, and promote sustainable industrial transformation (United Nations Development Programme 2022).

International research and experience suggest that the conventional research and development (R&D) indicators used to measure STI progress, such as R&D expenditure as a percentage of GDP, patent filings, and the number of scientific publications, do not adequately capture the full scope of innovation activity in developing economies (Kraemer-Mbula and Wunsch-Vincent 2016). These challenges for Cambodia are depicted in **Figure** 2 below. Innovation often occurs outside of formal R&D institutions, particularly in emerging markets where enterprises and informal sectors drive technological adaptation and local problem-solving (Heeks, Foster, and Nugroho 2013).

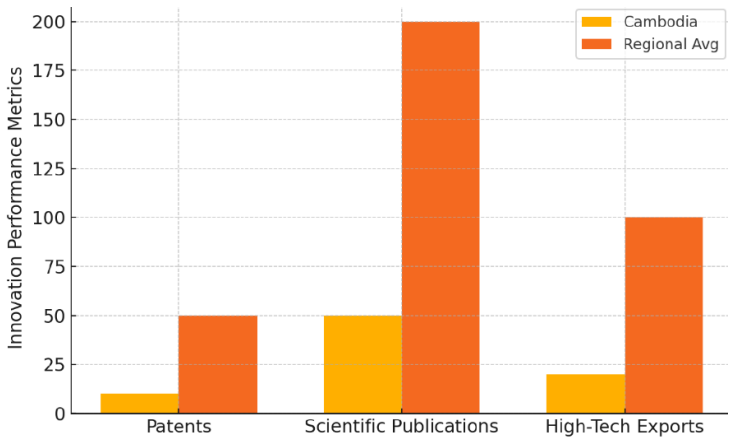


Figure 2. Comparison of Cambodia's innovation performance (World Bank, 2022)

1.2. Purpose and Scope of the Guidelines

The purpose of these guidelines is to establish a comprehensive, structured, and adaptable framework for evaluating STI activities across Cambodia's public and private sectors. STI evaluation is a critical component of national development planning, providing evidence-based insights that enable policymakers, businesses, research institutions, and development organizations to make informed decisions regarding innovation investment, policy formulation, and industrial transformation (Montalvo, Diaz Lopez, and Brandes 2020).

A key challenge in STI assessment is that traditional evaluation models often rely exclusively on quantitative indicators, such as the number of scientific publications, patent filings, and R&D expenditure as a percentage of GDP (OECD 2018). While these indicators are useful for measuring formal innovation activities, they do not capture the full scope of innovation occurring in an economy, particularly in developing and emerging markets (Karo and Kattel 2021). Many Cambodian businesses and industries, particularly SMEs and informal enterprises, innovate without engaging in formal R&D, relying instead on process improvements, indigenous knowledge systems, digital transformation, and grassroots problem-solving (Kraemer-Mbula and Wunsch-Vincent 2016).

Recognizing this, these guidelines advocate for a multidimensional approach to STI evaluation, integrating both quantitative and qualitative methodologies to capture a broader range of innovation activities. This approach ensures that Cambodia's STI evaluation framework reflects real-world innovation dynamics and supports inclusive and sustainable economic growth (World Bank 2021). By incorporating both global best practices and localized assessment criteria, this framework enables a more accurate, detailed, and context-sensitive evaluation of STI performance in Cambodia (Heeks, Foster, and Nugroho 2013).

The STI evaluation approach outlined in these guidelines draws upon internationally recognized methodologies, including the Global Innovation Index (GII), which provides a comparative analysis of national innovation capabilities by assessing factors such as human capital, infrastructure, knowledge creation, and market sophistication. It also incorporates insights from the

European Innovation Scoreboard (EIS), which focuses on enterprise-driven innovation, digital transformation, and industry-academia collaboration. The framework also aligns with the OECD's Oslo Manual (2018), which offers guidelines on how to measure innovation in businesses, particularly in developing economies where non-R&D-based innovation* plays a crucial role.

* Non-R&D-based innovation means improving products, services, or ways of working without doing formal R&D. It often comes from real-life experience, copying and improving ideas, learning by doing, or using the skills of workers and local people.

By aligning with these globally recognized methodologies while customizing evaluation criteria for Cambodia's unique industrial and economic context, these guidelines seek to establish a robust and scalable STI evaluation framework that is both internationally comparable and locally relevant.

The Oslo Manual's Community Innovation Survey (CIS) is an internationally recognized tool to systematically measure innovation activities within enterprises. The CIS primarily collects data on enterprise-level innovation, encompassing product innovation and business process innovation. This comprehensive survey approach provides valuable insights into both formal and informal innovation processes, making it particularly relevant for developing economies such as Cambodia.

The relevance of the CIS for Cambodia is significant given the country's economic landscape, characterized by a substantial informal sector and numerous SMEs engaging in incremental and non-R&D-based innovations. The CIS methodology addresses this gap by incorporating a wider range of innovation indicators that account for process improvements, grassroots technological adaptations, and digital transformation activities within enterprises.

Implementing the CIS methodology aligns closely with the objectives of the STI framework developed in these guidelines. Cambodia's approach to STI evaluation emphasizes the need for comprehensive, multidimensional, and context-sensitive assessment methods. Adopting the CIS would allow Cambodia to systematically capture informal innovation practices, which are prevalent but often underrepresented in traditional STI evaluations. By utilizing the CIS, clearer insights can be gained into innovation dynamics at the enterprise level, particularly in SMEs and informal sectors, thereby informing targeted and effective innovation policy interventions.

Finally, in many developing economies, STI evaluation efforts are hindered by data inconsistencies, a lack of sector-specific benchmarks, and weak integration between scientific research and industrial application. These guidelines aim to address these challenges by establishing standardized evaluation metrics that ensure comparability of STI performance over time. The framework integrates qualitative methodologies to complement traditional quantitative indicators. It also introduces feedback mechanisms that allow policymakers to adjust STI policies in response to emerging trends and technological advancements.

1.3. Goals and Objectives of the Guidelines

The primary goal of these guidelines is to establish a structured and evidence-based framework for evaluating STI activities in Cambodia. By developing a robust STI evaluation system, Cambodia aims to strengthen its innovation capacity, enhance research and technological development, and promote an ecosystem conducive to economic transformation. A well-structured STI evaluation framework enables policymakers, researchers, industry leaders, and other stakeholders to assess the effectiveness of innovation policies, identify gaps in national STI capabilities, and align Cambodia's innovation policies with international best practices (Mazzucato 2018).

The evaluation framework serves as a critical tool for informing government policy decisions, optimizing resource allocation, and fostering a culture of continuous improvement in STI-related activities. Furthermore, a comprehensive and adaptable STI evaluation framework helps ensure that scientific research, technological advancements, and industrial innovation contribute meaningfully to Cambodia's long-term economic vision (World Economic Forum 2021).

To achieve this goal, the guidelines are organized around four key objectives that collectively contribute to a more inclusive, resilient, and innovation-driven economy.

1. Recognizing Informal and Formal Innovation

While formal innovation activities are often captured through conventional STI metrics, many innovation processes occur outside formal research institutions and corporate R&D departments. Informal innovation—such as knowledge spillovers, grassroots technological adaptation, and industry-academia collaborations—plays a crucial role in driving economic transformation, particularly in developing economies like Cambodia (Crespi, Zuniga, and Dutrenit 2014).

2. Developing Best Practices for Data Collection and Analysis

Previous STI evaluations in Cambodia have faced significant methodological challenges, including inconsistent data collection practices, a lack of reliable enterprise innovation data, and difficulties in measuring non-traditional innovation activities. These guidelines seek to address these challenges by developing standardized STI evaluation methodologies that align with international best practices while being adaptable to Cambodia's specific economic and institutional context (OECD 2018).

3. Establishing a Continuous Learning Mechanism

Given the rapid pace of global technological advancements, STI policies and evaluation mechanisms must remain dynamic and responsive to emerging trends. These guidelines emphasize the importance of building an STI governance model that incorporates iterative feedback loops, real-time data analytics, and stakeholder engagement processes to ensure that STI evaluations remain relevant and impactful (Nelson 1993).

4. Enhancing Cross-Sectoral Coordination

Effective STI evaluation requires strong institutional coordination, as multiple entities are involved in funding, conducting, and applying research and innovation activities. These guidelines advocate for the establishment of multi-stakeholder platforms where government ministries, universities, business associations, and development partners can collaborate on STI evaluation initiatives, share best practices, and align their innovation policies (Tang and Wu 2021).

1.4. Fostering Continuous Improvement and Change

STI evaluation frameworks create feedback loops that facilitate continuous improvement in research practices, business model experimentation, and public-private innovation partnerships. Over the long term, these iterative processes strengthen Cambodia's innovation ecosystem, enabling firms and research institutions to remain competitive in rapidly evolving markets (Freeman 1987).

Continuous improvement in STI governance involves the regular review of innovation policies to ensure their alignment with changing global technological trends. As emerging technologies such as blockchain, quantum computing, and biotechnologies reshape global industries, STI evaluation frameworks must remain flexible and adaptable to new developments (Nelson 1993). Policymakers should integrate real-time innovation tracking tools, such as artificial intelligence-powered data analytics, to monitor changes in research productivity, technology commercialization rates, and industry R&D investment patterns (World Bank 2021).

For businesses and entrepreneurs, continuous improvement in STI evaluation ensures that innovation strategies remain competitive in the global marketplace. By participating in regular STI assessments, enterprises can refine their R&D focus areas, optimize technology adoption processes, and enhance collaboration with research institutions (Heeks, Foster, and Nugroho 2013).

1.5. Alignment of National Strategy and SDGs

Cambodia's national STI policies are closely aligned with the country's long-term development vision. This strategic alignment underscores the government's recognition of STI as a fundamental driver of economic modernization, industrial diversification, and global competitiveness (Royal Government of Cambodia 2020).

At the core of Cambodia's STI development efforts is a commitment to fostering sustainable, inclusive, and innovation-driven growth. The integration of STI into national planning ensures that scientific research, technological advancements,

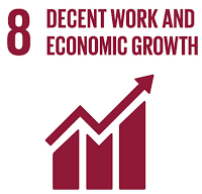
and industrial innovations contribute directly to both economic prosperity and social well-being. By aligning its STI strategies with global development frameworks, particularly the United Nations Sustainable Development Goals (SDGs), Cambodia is positioning itself to participate in international innovation networks while addressing domestic socio-economic challenges (United Nations Development Programme 2022).

The SDGs provide a roadmap for countries to integrate environmental, social, and economic dimensions into their development strategies. Cambodia has explicitly linked its national STI policies with several SDGs to ensure that technological advancements contribute to poverty reduction, industrialization, climate resilience, and human capital development (World Economic Forum 2021).

1.6. Contribution of STI to Key Sustainable Development Goals

STI contributes directly to multiple SDGs by fostering industrialization, improving economic opportunities, and enabling technological solutions for social and environmental challenges. Several SDGs are particularly relevant to Cambodia's national STI strategy:

This SDG emphasizes the need to build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation. Cambodia's STI framework aligns with this goal by prioritizing investments in R&D, strengthening industrial innovation capacity, and enhancing technology transfer mechanisms between universities and enterprises (World Intellectual Property Organization 2024).



Cambodia's STI policies contribute to this goal by creating a business environment that encourages startups, supports high-tech entrepreneurship, and facilitates the digitalization of traditional industries. The adoption of innovation-driven economic policies helps stimulate job creation in high-growth sectors such as ICT, renewable energy, biotechnology, and advanced manufacturing (World Bank 2021).

Cambodia's national STI strategy emphasizes the importance of STEM education, technical and vocational training, and digital literacy programs. Strengthening the education-innovation nexus ensures that Cambodia's workforce is equipped with the necessary skills for a knowledge-based economy (OECD 2021).

The government has prioritized research and innovation in solar power, hydropower, and energy-efficient technologies to enhance the country's energy security and reduce reliance on fossil fuels. STI evaluations in the energy sector measure the impact of R&D investments in green technologies and the adoption of renewable energy innovations (World Economic Forum 2021).

Cambodia's STI roadmap integrates climate adaptation technologies, green infrastructure development, sustainable water resource management, and agricultural innovation to support climate resilience. The inclusion of climate-focused indicators in STI evaluation frameworks ensures that technological progress aligns with sustainability objectives and contributes to national climate mitigation strategies (United Nations Development Programme 2022).

Innovation in precision farming, biotechnology, and sustainable irrigation systems has the potential to improve food security and increase agricultural productivity. Cambodia's STI policies support agritech research, digital tools for farmers, and climate-smart agriculture practices (World Bank 2021).

1.6.1. Integration of STI Evaluation into National Development Planning

To ensure that STI policies effectively contribute to these SDG objectives, Cambodia has integrated STI evaluation mechanisms into its broader national development planning processes. Key national policies that incorporate STI assessments include:

- The Pentagonal Strategy–Phase I, which outlines Cambodia's economic vision and emphasizes the role of innovation in achieving long-term industrial competitiveness (Royal Government of Cambodia 2023).

- The National Policy on STI (2020–2030), which sets out specific targets for research funding, intellectual property development, technology adoption, and human capital development in science and technology fields (Royal Government of Cambodia 2020).
- The Industrial Development Policy (2015–2025), which provides a roadmap for Cambodia's transition from a labor-intensive economy to a technology-driven industrial base (Royal Government of Cambodia 2015).
- The Cambodia's STI Roadmap 2030, which aligns with international best practices in innovation governance and provides a framework for measuring Cambodia's innovation performance relative to regional and global benchmarks (Ministry of Industry, Science, Technology & Innovation 2021).

1.6.2. Global and Regional STI Partnerships for Sustainable Development

To enhance its STI evaluation capacity and ensure alignment with global sustainability objectives, Cambodia actively engages in global and regional innovation collaborations.

Key international partnerships include:

- The Global Innovation Index (GII) – Aligning Cambodia's STI assessments with global best practices (World Intellectual Property Organization 2024).
- ASEAN STI Cooperation Programs – Strengthening Cambodia's regional innovation networks through partnerships with ASEAN nations.
- Other development partners such as United Nations Development Programme (UNDP), World Bank, Asian Development Bank (ADB), United Nations Industrial Development Organization (UNIDO), German Agency for International Cooperation (GIZ), etc. – Providing Cambodia with technical assistance, funding opportunities, and knowledge exchange in STI evaluation and development.

1.7. Key National STI Policies

As noted above, Cambodia has introduced several key policies aimed at fostering innovation, strengthening research capacity, and integrating technology into economic development. These policies outline the government's commitment to building a knowledge-based economy by promoting research excellence, industrial innovation, and digital transformation (Ministry of Industry, Science, Technology & Innovation 2021).

- The National Policy on Science, Technology, and Innovation (2020–2030) – A comprehensive framework for enhancing national research capabilities, promoting technology transfer, and fostering entrepreneurship (Royal Government of Cambodia 2020).
- The Industrial Development Policy (2015–2025) – Focuses on transforming Cambodia's industrial sector through technological upgrading, skill development, and investment in high-tech manufacturing (Royal Government of Cambodia 2015).
- The Cambodia Digital Economy and Society Policy Framework (2021–2035) – Outlines Cambodia's strategy for leveraging digital technologies to drive economic growth and enhance public service delivery (World Bank 2021).
- The Cambodia's STI Roadmap 2030 – Aligns Cambodia's national innovation policies with global best practices and regional benchmarks (Ministry of Industry, Science, Technology & Innovation 2021).

1.8. Challenges in STI Evaluation

The systematic evaluation of STI is essential for assessing national research and innovation performance, guiding policy adjustments, and ensuring that STI investments generate meaningful economic and social benefits. However, despite the increasing recognition of STI evaluation as a critical policy tool, many countries, particularly emerging economies such as Cambodia, face considerable challenges in implementing effective and comprehensive STI evaluation frameworks.

STI evaluation involves assessing multiple dimensions of innovation, including research outputs, technological adoption, industrial innovation, and knowledge transfer. Given the complexity of innovation systems, evaluating STI requires robust data collection mechanisms, internationally recognized performance indicators, and strong institutional coordination. Cambodia faces several challenges in this regard, including limited availability of quality STI data, methodological gaps in innovation measurement, weak institutional capacity, and difficulty in assessing informal and non-R&D-based innovation activities.

Addressing these challenges is crucial for ensuring that STI evaluations provide reliable and actionable insights. By understanding these barriers and learning from international best practices, Cambodia can strengthen its STI evaluation system and align its innovation strategies with long-term economic development goals.

1.8.1. Limited Availability and Quality of STI Data

One of the most significant challenges in STI evaluation in Cambodia is the limited availability of reliable and comprehensive STI data. The collection of STI-related data remains fragmented, with various government agencies, universities, and private sector actors collecting data independently, often without standardized methodologies or coordination. This lack of integration results in data inconsistencies, gaps in coverage, and difficulties in comparing STI performance over time.

Many of Cambodia's existing STI data remain underreported due to the absence of a centralized STI database and a weak data collection mechanism. To address these challenges, Cambodia must invest in strengthening its STI data infrastructure, including the establishment of a national STI data repository, the adoption of standardized data collection protocols, and the enhancement of data-sharing mechanisms between government agencies, research institutions, and private enterprises. The development of digital STI reporting platforms could further improve data accuracy and accessibility, allowing policymakers to make informed decisions based on real-time innovation trends.

1.8.2. Methodological Gaps in Measuring Innovation

A second major challenge in STI evaluation relates to methodological gaps in measuring innovation performance, particularly in sectors where innovation does not occur through formal R&D investments. Traditional STI measurement frameworks rely heavily on indicators such as R&D intensity, patent applications, and publication citations, which do not fully capture non-traditional innovation activities.

In Cambodia, a significant portion of innovation occurs outside of formal R&D environments. Many firms, particularly SMEs and informal enterprises, innovate through incremental improvements, process optimization, digital transformation, and knowledge-sharing mechanisms, rather than through structured R&D programs. However, existing STI evaluation methodologies often fail to recognize these alternative innovation pathways, leading to an underestimation of Cambodia's true innovation potential.

To address this issue, Cambodia needs to adopt a more inclusive approach to STI measurement that accounts for both formal and informal innovation activities. This could include survey-based assessments of business process innovation, the measurement of technology diffusion and digital transformation, and the incorporation of qualitative indicators, such as case studies on industry-academia collaborations. The adoption of the OECD's Oslo Manual recommendations on innovation measurement could help improve the methodological rigor of Cambodia's STI evaluation efforts.

1.8.3. Difficulty in Evaluating Informal and Non-R&D-Based Innovation

A further challenge in STI evaluation is the difficulty of assessing informal and non-R&D-based innovation activities, which play a crucial role in Cambodia's economic landscape. In many developing economies, particularly those with large informal sectors, innovation often takes place through practical problem-solving, indigenous knowledge applications, and low-cost technological adaptations, rather than through formal R&D investments.

For example, Cambodian farmers may adopt new irrigation techniques, organic fertilizers, or digital farm management

tools without engaging in structured R&D activities. Similarly, small businesses may leverage e-commerce platforms, mobile payment solutions, or digital marketing strategies to enhance their operations, yet such activities may not be captured in traditional STI evaluations. The informal sector's contributions to innovation remain largely unquantified due to the absence of tailored assessment methodologies.

To better capture informal innovation, Cambodia needs to integrate qualitative and participatory evaluation techniques into its STI assessment framework. This includes conducting innovation surveys targeting SMEs and informal enterprises, analyzing case studies on grassroots technological adaptation, and employing ethnographic research methods to document community-driven innovation practices. The inclusion of new metrics, such as digital adoption rates, industry-specific technology uptake, and social impact assessments, can also provide a more comprehensive picture of Cambodia's innovation ecosystem.

1.9. Opportunities for Strengthening STI Evaluation in Cambodia

Despite the challenges in evaluating STI activities in Cambodia, there are significant opportunities for improving the country's STI assessment frameworks. Strengthening STI evaluation is essential for ensuring that national innovation policies effectively contribute to economic growth, industrial transformation, and sustainable development.

By leveraging emerging technologies, adopting international best practices, improving institutional coordination, and enhancing human capital in STI assessment, Cambodia can establish a more robust, data-driven, and internationally comparable STI evaluation system. A well-developed evaluation framework will support evidence-based policymaking, attract investment in innovation, and strengthen Cambodia's position in regional and global innovation networks.

1.9.1. Enhancing STI Data Collection and Integration

A critical opportunity for improving STI evaluation in Cambodia lies in the enhancement of data collection mechanisms and the

integration of STI performance indicators into national statistical systems. The current fragmentation in STI data collection can be addressed through the development of a centralized national STI database, which consolidates data from government agencies, universities, research institutions, and private enterprises.

Digital technologies offer a major opportunity to improve data collection and STI performance monitoring. The use of artificial intelligence (AI) and big data analytics in STI evaluation can help identify trends, forecast future innovation dynamics, and measure the impact of national STI policies. Additionally, the expansion of e-government platforms can facilitate real-time reporting of R&D activities, patent filings, technology adoption rates, and business process innovations.

Moreover, an additional important step is the introduction of standardized STI survey instruments, such as enterprise innovation surveys (CEII, as noted above), academic research output assessments, and technology adoption studies, which will allow for more accurate and systematic data collection.

1.9.2. Adoption of International Best Practices in STI Evaluation

Cambodia has the opportunity to align its STI evaluation frameworks with international best practices, ensuring that national innovation performance is measured using globally recognized methodologies. By participating in benchmarking exercises such as the GII and the OECD's Oslo Manual, Cambodia can improve its STI performance tracking and compare its innovation capacity with peer countries in the region.

One key lesson from leading innovation economies such as Singapore, Finland, and Israel is the adoption of multi-dimensional STI assessment frameworks that measure not only R&D intensity and scientific output but also business innovation, digital transformation, and social impact. By broadening the scope of STI evaluations, Cambodia can gain a more holistic understanding of its innovation ecosystem and identify policy gaps that need to be addressed.

1.10. Future Directions for STI Evaluation in Cambodia

The future of STI evaluation in Cambodia will be shaped by efforts to refine assessment methodologies, strengthen institutional capacity, and ensure that innovation policies remain responsive to the country's evolving economic and technological landscape. A well-functioning STI evaluation system will be instrumental in driving evidence-based policymaking, fostering technological competitiveness, and positioning Cambodia as an emerging leader in innovation-driven development.

As Cambodia continues to integrate STI into its national development strategy, the country must adopt forward-looking evaluation mechanisms that account for global trends, digital transformation, sustainability considerations, and the changing dynamics of research and industry collaboration. By improving STI assessment frameworks, Cambodia can better track progress, address policy gaps, and ensure that innovation-led growth remains inclusive and sustainable.

1.10.1. Expanding the Scope of STI Evaluation

As noted above, the current STI evaluation framework in Cambodia focuses primarily on traditional indicators. While these metrics remain relevant, the future of STI evaluation must move beyond these conventional indicators to capture a broader and more accurate picture of innovation activities. The evaluation framework must expand to include emerging areas such as digital transformation, business process innovation, technology adoption rates, and social impact assessments.

One of the key areas for expansion is the measurement of digital innovation, particularly in sectors such as e-commerce, financial technology (fintech), artificial intelligence, and smart manufacturing. As Cambodia moves towards a digital economy, STI assessments must integrate indicators that reflect digital readiness, the adoption of automation technologies, and the effectiveness of government initiatives in supporting digital innovation. The incorporation of data-driven and real-time STI evaluation methodologies will also allow for more adaptive policy interventions.

Another important area of focus is sustainability-driven innovation. As global priorities shift toward green technologies,

Cambodia must ensure that its STI evaluation framework includes performance indicators related to climate adaptation technologies, renewable energy adoption, circular economy solutions, and sustainable agriculture. By aligning STI evaluations with Cambodia's climate action commitments, policymakers can assess the impact of innovation policies on national sustainability goals and develop targeted support mechanisms for green industries.

The expansion of STI evaluation should also extend to measuring knowledge transfer and industry-academia collaboration. In many advanced economies, universities and research institutions play a central role in commercializing innovations and driving industry growth. Cambodia must refine its STI assessment methodologies to evaluate the effectiveness of university-industry linkages, track the commercialization of research outputs, and assess the impact of public R&D investments on private sector innovation.

2

FUNDAMENTAL FRAMEWORK FOR STI EVALUATION IN CAMBODIA

2.1. STI Evaluation in the Cambodian Context

Cambodia has experienced substantial economic growth over recent decades, yet structural challenges remain that may impede the country's progression into a knowledge-based economy. The necessity for an STI evaluation framework arises from Cambodia's distinct innovation landscape, characterized by formal research institutions alongside extensive informal innovation practices within SMEs and informal sectors. Traditional indicators such as R&D spending, scientific publications, and patent filings alone do not fully capture the breadth and depth of innovation occurring across various sectors in Cambodia, particularly informal and incremental innovation activities that dominate much of the business landscape (Kraemer-Mbula & Wunsch-Vincent, 2016).

A robust STI evaluation framework for Cambodia draws upon international best practices while remaining adaptable to the country's unique economic and institutional context. Methodologies such as the OECD's Oslo Manual, the GII, and the EIS provide valuable international benchmarks but require customization to reflect Cambodia's specific circumstances (OECD, 2018).

2.2. Building on Best Practice

The conceptual framework utilized herein fundamentally consists of four main components: inputs, processes, outputs, and impacts. Each component is essential for evaluating STI performance, but should not be viewed in isolation, as they dynamically interact with and influence one another. These components provide a structured approach for understanding how STI resources translate into tangible economic and societal outcomes.

Inputs refer to the foundational resources essential for innovation activities, including investments in R&D, skilled human capital, infrastructure development, and financing mechanisms such as grants, subsidies, and private-sector investments. Human capital, particularly STEM education and workforce skill development, is a crucial input for innovation as it directly determines the country's capacity to develop, absorb, and utilize new technologies (Romer, 1990; OECD, 2018). In Cambodia, substantial improvements in STEM education, vocational training, and digital literacy initiatives are critical inputs needed to build a sustainable innovation ecosystem.

Processes encompass the mechanisms through which inputs are utilized to generate innovation outputs. Key processes in the Cambodian context include public-private collaborations, technology transfer and commercialization practices, government support schemes, and effective regulatory environments. Enhancing collaboration between universities and industry is particularly vital, as it facilitates technology commercialization and knowledge transfer essential for industrial innovation (Freeman, 1987). Establishing effective technology parks, business incubators, and research clusters across different Cambodian provinces would significantly improve the efficiency and effectiveness of innovation processes, enabling better outcomes from input investments.

Outputs are measurable results arising from STI processes, typically indicated by patents, research publications, technology commercialization, and innovation adoption rates in enterprises. Cambodia, however, must expand the scope of its output indicators to include metrics capturing informal innovations, such as process innovations in agriculture, digital platform usage among SMEs, and business model adaptations,

that are widespread but frequently undocumented (OECD, 2018; Cambodia Enterprise Innovation Index Guidelines, 2024). Acknowledging these informal innovation outputs allows for a more comprehensive assessment, ensuring STI evaluations reflect the full extent of innovation activities occurring in Cambodia's unique economic landscape.

Impacts refer to the broader economic, social, and environmental effects resulting from STI outputs. These include productivity growth, employment creation in high-tech and knowledge-intensive sectors, economic diversification, and contributions to sustainable development goals, particularly regarding environmental sustainability, healthcare, education, and climate resilience (United Nations Development Programme, 2022). For Cambodia, aligning STI evaluations with national development strategies—such as the Industrial Development Policy (2015–2025), National Policy on STI (2020–2030), and Cambodia's STI Roadmap 2030—is crucial to ensure innovation activities meaningfully contribute to achieving Cambodia's long-term vision (Royal Government of Cambodia, 2015, 2020).

Integrating STI evaluation frameworks with national development strategies and global sustainability objectives, particularly the SDGs, further enhances their relevance and effectiveness. For instance, STI evaluation should directly assess how innovation contributes to SDGs such as Goal 9 (Industry, Innovation, and Infrastructure), Goal 8 (Decent Work and Economic Growth), Goal 4 (Quality Education), and Goal 13 (Climate Action). Evaluating progress against these global standards reinforces accountability and ensures Cambodia's STI strategy addresses both domestic development priorities and international commitments (United Nations Development Programme, 2022).

2.3. Adaptive Fundamental Framework for STI Evaluation in Cambodia

This Fundamental Framework for STI Evaluation provides a comprehensive approach for assessing STI activities at both the national and firm/enterprise levels. The distinction between these levels highlights how systemic and organizational factors influence STI outcomes. It helps evaluate the inputs, processes,

and outputs that drive innovation and technological advancement, offering valuable insights into policy-making, resource allocation, and performance measurement for both public institutions and private sector entities.

The framework is essential for assessing the effectiveness of STI systems and policies, with a focus on measuring inputs, outputs, and performance in fostering STI development in Cambodia. It is designed to be adaptable to the Cambodian context and is divided into two main sections: STI Inputs and STI Outputs. The STI Inputs section includes four input pillars, which consist of ten sub-pillars that illustrate the structures, resources, and conditions that facilitate STI activities. The STI Outputs section includes three output pillars, with seven sub-pillars that reflect the results and outcomes of STI input activities (Figure 3).

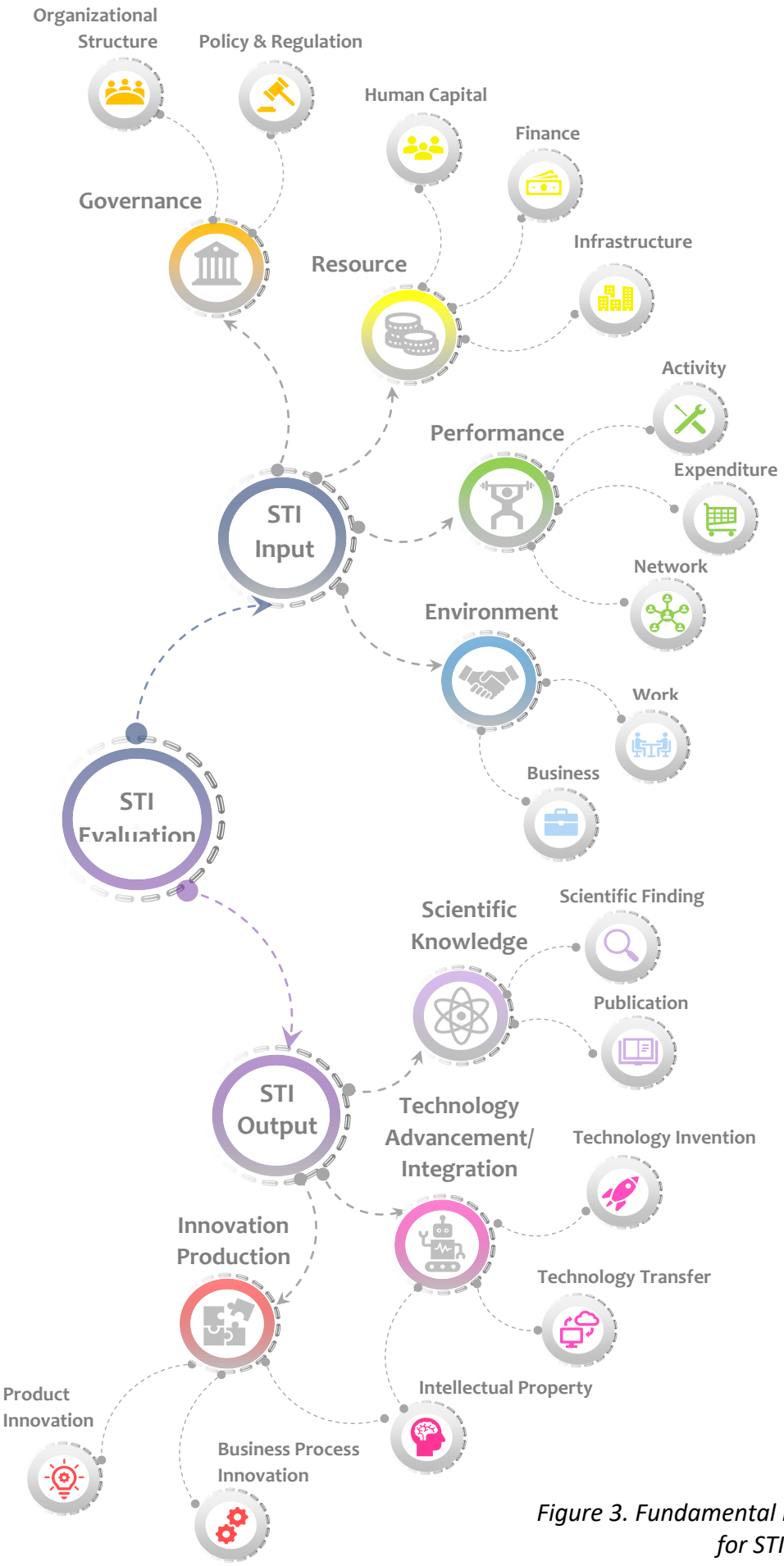


Figure 3. Fundamental Framework for STI Evaluation

2.3.1. STI Inputs

This refers to the resources and conditions that support the development of STI systems. It includes governance structures, human capital, infrastructure, financial resources, and environmental factors that affect performance at both the national and firm/enterprise levels.

The foundation of STI evaluation at both levels consists of the inputs that support STI activities. These inputs vary in scope at the national level and firm level, but are interconnected and necessary for driving STI efforts. At the national level: the inputs involve governance structures, resource allocation, performance assessment, and environmental conditions that shape the national STI ecosystem. At the firm/enterprise level: the inputs involve organizational structure, resource, expenditure, and environment enabling STI enhancement within firm/enterprise. The STI inputs have four input pillars: Governance, Resource, Performance, and Environment.

2.3.1.1. Governance

This pillar involves the roles and structure of the institutions and organizations that guide and manage STI activities. These include government institutions (such as ministries responsible for science and technology), universities, research institutions, and private sector entities. Effective STI governance ensures the proper alignment of national STI strategies and policies with practical outcomes. This pillar is defined by the sub-pillar Organizational Structure, and Policy & Regulation. At both the national and enterprise levels, governance structures play a vital role in shaping STI development.

Organizational Structure

- National Level: The institutional structure for managing STI policies typically includes ministries, agencies, and governmental bodies such as the Ministry of Industry, Science, Technology & Innovation. These bodies should have clear mandates, well-defined responsibilities, and effective coordination mechanisms.
- Firm/Enterprise Level: Companies must have internal governance structures that support innovation, such as R&D departments, innovation managers, and cross-

functional teams that integrate scientific and technological knowledge into their business operations.

Policy & Regulation

- National Level: Government policies, including the National Science and Technology Policy, determine how STI is integrated into national development plans. An effective STI policy involves setting clear goals for research, technology development, and commercialization. Policies must also address regulatory frameworks, intellectual property rights, and the fostering of innovation ecosystems.
- Firm/Enterprise Level: Firms need to align with national regulations related to innovation and intellectual property protection. For example, they must adhere to national standards for product development and implement internal policies that foster an innovative culture.

2.3.1.2. Resource

This dimension refers to the resources available for the development of STI, including Human Capital, Finance, and Infrastructure.

Human Capital

- National Level: The availability of skilled professionals, scientists, engineers, and technicians is crucial. Cambodia's educational institutions and research centers must produce a workforce capable of driving STI.
- Firm/Enterprise Level: Firms need access to specialized human resources, such as R&D scientists, product designers, engineers, and technical support staff. They must also provide training programs and foster an environment for continuous learning to stay competitive.

Finance

- National Level: Government funding through grants, subsidies, and STI-oriented funds is essential to support research institutions and innovation initiatives. Public-

private partnerships can also enhance financial resources.

- Firm/Enterprise Level: Private-sector investment in innovation is critical. Firms need access to venture capital, loans, and/or government incentives to fund R&D, product development, and technological advancements.

Infrastructure

- National Level: The physical and digital infrastructure that supports STI activities, including national laboratories, testing facilities, data centers, high-speed internet access, and innovation clusters like science parks or hubs.
- Firm/Enterprise Level: This includes in-house labs, digital tools, and IT systems that support experimentation, product development, and data analysis.

2.3.1.3. Performance

Performance measures how effectively the STI system operates in terms of Activity, Expenditure, and Network sub-pillars.

Activity

- National Level: Activities include the establishment of research projects, technology programs, partnerships with international institutions, and participation in global STI initiatives. The government must ensure that activities are aligned with national priorities.
- Firm/Enterprise Level: Firm activities must focus on product development, R&D, technology implementation, and market exploration. The effectiveness of these activities can be evaluated by examining the scale of their R&D efforts and market outcomes.

Expenditure

- National Level: STI funding should be tracked, including government expenditure on research grants, innovation initiatives, and technology infrastructure.

- Firm/Enterprise Level: Firms must invest in R&D and innovation projects, with clear budgets allocated for technological development and related activities.

Network

- National Level: The establishment of a national innovation network that includes universities, research institutions, industry, and government is essential for STI. This fosters collaboration, knowledge sharing, and synergies.
- Firm/Enterprise Level: Firms should actively engage in local and international networks for knowledge exchange, collaborations, and joint ventures with universities, research labs, and other companies to drive technological innovation.

2.3.1.4. Environment

The environment refers to the external conditions that support or hinder STI development, including the Work and Business (environment) sub-pillars.

Work

- National Level: The work environment includes a labor market conducive to innovation, with access to high-quality training programs and the promotion of research-driven industries. Government policies should ensure that the workforce is skilled, motivated, and adequately equipped to contribute to STI efforts.
- Firm/Enterprise Level: Companies must provide a work culture that encourages creativity, teamwork, and innovation. This includes fostering an open environment for idea generation, as well as offering incentives for employees to engage in research and development activities.

Business

- National Level: A conducive business environment includes an effective legal system, favorable tax policies, and incentives for firms that invest in innovation. The government should create a stable macroeconomic environment and promote entrepreneurial activities.

- Firm/Enterprise Level: The firm must create an environment that allows for entrepreneurship, risk-taking, and the commercialization of new ideas. This involves having a supportive management culture, access to markets, and appropriate infrastructure.

2.3.2. STI Output

STI outputs are the tangible and intangible results of STI activities. STI output has three pillars, including Scientific Knowledge, Technology Advancement/Integration, and Innovation Production. These outputs drive economic growth, improve public welfare, and contribute to achieving national development goals.

2.3.2.1. Scientific Knowledge

This pillar has Scientific Finding and Publication sub-pillars, which refer to the generation of new scientific discoveries, research, and publications.

Scientific Finding

- National Level: Scientific research and innovations should be evaluated based on the level of impact they have on addressing national challenges and advancing knowledge. The output of universities and research institutions should be closely monitored.
- Firm/Enterprise Level: Firms must be evaluated on their capacity to generate new knowledge through R&D activities, such as novel product designs or new technologies.

Publication

- National Level: The number and quality of scientific publications produced by researchers and institutions are essential indicators. Publications in peer-reviewed journals, international collaborations, and patents are measures of success.
- Firm/Enterprise Level: Companies that invest in R&D should contribute to scientific publications, patents, and other intellectual property outputs that demonstrate innovation.

2.3.2.2. Technology Advancement/Integration

This category includes the creation, adoption, and transfer of new technologies, as well as the protection of intellectual property. It has three sub-pillars, including Technology Invention, Technology Transfer, and Intellectual Property.

Technology Invention

- National Level: The ability of the country to develop new technologies, particularly in sectors such as agriculture, healthcare, energy, and ICT, is a key output indicator. National STI initiatives should encourage the invention of new technologies that benefit local industries.
- Firm/Enterprise Level: Firms must track the number of patents filed, inventions produced, and technological advancements introduced into the market.

Technology Transfer

- National Level: The government should facilitate the transfer of technology from research institutions to industries. National policies should promote collaboration between research organizations and firms to ensure that new technologies are commercialized.
- Firm/Enterprise Level: Firms should focus on how effectively they adopt new technologies and integrate them into their operations. Technology transfer can occur via international partnerships, local collaborations, or licensing.

Intellectual Property

- National Level: The creation of a strong IP framework to protect innovations is crucial. The country's legal infrastructure must support the protection of patents, copyrights, and trademarks to encourage innovation.
- Firm/Enterprise Level: Firms should be evaluated based on the number of patents filed, trademarks registered, and the commercialization of their intellectual property.

2.3.2.3. Innovation Production

Innovation products are the final outcome of the STI process, indicating the successful commercialization of new products or

services. Concomitantly, processes examine the development of and support for methods of production, management, etc. Three sub-pillars that define innovation production are Product Innovation, Business Process Innovation, and Intellectual Property.

Product Innovation

- National Level: The ability to transform STI outputs into products that respond to national or global needs is essential. This involves commercializing innovations that tackle Cambodia's key socio-economic challenges and determining the extent to which new or improved products reach national and international markets.
- Firm/Enterprise Level: Firms must innovate to produce new products or services that offer competitive advantages in the market. These could be entirely new products or improvements to existing ones.

Business Process Innovation

- National Level: At the national level, Business Process Innovation is often driven by government policies, digital transformation agendas, public-private partnerships, and innovation ecosystems. The aim is to modernize public services, improve economic competitiveness, and foster a conducive environment for enterprise innovation.
- Firm/Enterprise Level: The Oslo Manual defines firm-level business process innovation as the implementation of significantly improved methods in production, logistics, marketing, information systems, management, and process development to enhance efficiency, quality, and overall performance.

Intellectual Property

This is the sub-pillar between the Technology Advancement/Integration and Innovation Production Pillars, as these two pillars will produce IP to ensure that STI inventions are protected, licensed, or commercialized effectively.

- National Level: As discussed earlier, the generation and protection of intellectual property are essential in the

commercialization of innovations. Cambodia should focus on strengthening IP laws to incentivize innovation.

- Firm/Enterprise Level: Firms should actively manage their intellectual property portfolios, ensuring that their inventions are protected, licensed, or commercialized effectively.

2.4. Adaptation of the Framework to National or Enterprise Context

The Fundamental Framework for STI Evaluation is a versatile and adaptable tool designed for use by a wide range of entities, including public and private enterprises, government institutions, organizations, industries, and SMEs. The framework serves as a foundational structure that provides a comprehensive approach for evaluating STI efforts. It is designed to allow organizations to create their own evaluation framework based on their unique needs, goals, and operational contexts. The flexibility embedded in this framework ensures that it can be tailored to suit different industries, sectors, and organizational sizes.

2.4.1. Customizing the Framework for Specific Needs

One of the key strengths of the Fundamental Framework for STI Evaluation is its flexibility. Enterprises can adapt the framework by expanding or simplifying certain elements according to their specific evaluation requirements. For example, certain pillars of the framework may not be relevant to a particular enterprise due to its size, resources, or industry focus. In such cases, enterprises have the option to omit these pillars or replace them with others that better reflect their STI strategy and innovation priorities.

2.4.2. Example: Cambodia Enterprise Innovation Index (CEII)

A practical example of this adaptability can be seen in the Cambodia Enterprise Innovation Index (CEII) Guidelines. The CEII provides a tailored approach to evaluating the innovation performance of enterprises within Cambodia, with a particular focus on the unique landscape of SMEs in the country. While it is grounded in the same core principles of the Framework for STI Evaluation, the CEII has been specifically customized to

address the challenges and opportunities faced by Cambodian SMEs, which often have limited resources and face different barriers to innovation compared to larger organizations.

In the case of the CEII, the evaluation criteria are designed to measure the innovation capabilities of firms in the Cambodian context. This includes a focus on input factors such as access to financing, human capital, and technological infrastructure, and output factors such as product development, process improvement, and market adoption. The CEII guidelines allow firms to assess their innovation performance within the specific economic and regulatory environment of Cambodia, thus making the evaluation process more relevant and actionable.

While the CEII framework is specifically adapted to the needs of Cambodia's SME landscape, the overall system follows the same principles as the broader Framework for STI Evaluation. The CEII, for example, retains the focus on measuring both the inputs and outputs of innovation efforts within firms. The input factors assess the resources and capabilities that the enterprise has at its disposal, such as governance structures, human capital, financing, and technology infrastructure. On the other hand, the output factors evaluate the tangible outcomes of STI efforts, such as the development of innovative products, technologies, intellectual property, and market performance.

Thus, although the CEII framework presents a slightly different structure in terms of specific indicators and evaluation criteria, it adheres to the same fundamental principles of the broader STI framework. This ensures that the overall evaluation process remains consistent in terms of its focus on both the input and output dimensions of innovation and STI performance.

2.4.3. Benefits of the Adaptable Framework

The ability to adapt the Fundamental Framework for STI Evaluation to suit the specific needs of individual enterprises or sectors is a significant advantage. It allows organizations of all sizes and types to assess their innovation performance in a way that is aligned with their capabilities, goals, and external environment. Whether at the national or enterprise level, this flexibility ensures that the framework can accommodate a wide range of contexts and challenges.

By enabling enterprises to tailor the evaluation framework to their unique needs, it fosters a more dynamic and context-sensitive approach to STI evaluation. Organizations can use this framework to gain insights into their strengths and areas for improvement, helping them refine their innovation strategies and policies. This results in more effective decision-making and better alignment between innovation efforts and long-term business or national development goals.

In summary, the Fundamental Framework for STI Evaluation offers a solid, flexible foundation for evaluating the STI and innovation activities of public and private organizations. It empowers enterprises to design their own evaluation models, ensuring the relevance and effectiveness of the framework across different sectors and contexts. The CEII is a prime example of how this framework can be adapted to meet the specific needs of SMEs in Cambodia, while still maintaining the core principles of STI evaluation.

2.5. Identification of Key Indicators for Evaluation

After defining the evaluation framework, STI entities or enterprises need to define indicators reflecting their own framework. A robust STI evaluation framework must include a well-defined set of indicators that capture different dimensions of innovation activity, from research and development to technology adoption and economic impact. These indicators should be categorized into quantitative and qualitative measures to ensure a comprehensive assessment of STI capability.

2.5.1. Quantitative Indicators

Quantitative indicators provide numerical insights into the innovation landscape and enable comparisons over time and against international benchmarks.

2.5.2. Qualitative Indicators

Qualitative indicators complement numerical data by providing insights into the cultural, institutional, and behavioral aspects of STI development.

2.5.3. Impact Indicators

Impact indicators measure the long-term effects of STI investments on Cambodia's economy and society. These indicators assess the contribution of innovation to job creation, industrial competitiveness, social well-being, and environmental sustainability.

2.6. Set of Indicators Adapted to the Fundamental Framework for STI Evaluation

To create a more detailed and measurable framework, a set of specific indicators must be defined for each pillar of the STI Evaluation Framework at both the national and firm/enterprise levels. These indicators act as quantifiable metrics to assess STI capabilities, track progress over time, and identify areas that require improvement. They provide the necessary data to evaluate how effectively STI systems and policies are functioning, offering insight into the performance and impact of innovation efforts.

Similar to the Fundamental Framework for STI Evaluation, institutions or enterprises can define their own set of indicators that align with their specific evaluation model and objectives. This flexibility allows for the customization of the framework to better suit the unique context and needs of the organization or nation. For example, organizations can add or remove indicators, adjust their measurement methods, or adapt the metrics to reflect local conditions, industry-specific challenges, or particular strategic goals.

In this way, the STI evaluation process becomes dynamic and tailored to the evolving needs of the institution, sector, or country. This customization ensures that the indicators are relevant, actionable, and reflect the true impact of STI activities. Moreover, by regularly reviewing and updating these indicators, institutions and enterprises can ensure they stay aligned with emerging trends in technology, innovation, and global best practices while also fostering continuous improvement in their STI capabilities.

Table 1 presents descriptions of the key indicators associated with each sub-pillar of the fundamental framework. For a

complete and comprehensive list of all indicators, please refer to **Appendix A.**

Table 1. Set of indicators adapted to the Fundamental Framework

STI INPUT INDICATORS		
Governance	Organizational Structure	
	<u>National level</u> - Existence of a dedicated government body or agency responsible for STI policy and regulation - Clarity of roles and responsibilities among national STI agencies. - Effectiveness of inter-agency coordination for STI development.	<u>Firm/Enterprise level</u> - Presence of a dedicated innovation or R&D department. - Clear organizational roles and responsibilities related to STI initiatives. - Internal processes for decision-making regarding STI investments and activities.
	Policy & Regulation	
	<u>National level</u> - Existence and quality of national STI policies and strategies. - Integration of STI policies into broader national development plans. - Availability and implementation of regulatory frameworks supporting innovation (e.g., intellectual property laws, tax incentives for R&D).	<u>Firm/Enterprise level</u> - Alignment of the firm's R&D and innovation policies with national STI regulations. - Effectiveness of internal innovation policies (e.g., R&D funding, product development). - Compliance with national and international standards and regulations related to STI.

Resource	Human Capital	
	National level - Availability and quality of STEM (Science, Technology, Engineering, and Mathematics) graduates. - Number of research professionals and their research output (publications, patents). - Investment in education and training programs for enhancing STI skills.	Firm/Enterprise level - Number of R&D staff (scientists, engineers, innovators) within the firm. - Training and skill development programs for employees. - Retention and attraction of highly skilled workers (e.g., competitive salaries, career development opportunities).
	Finance	
	National level - Government expenditure on STI-related activities (R&D, innovation programs, technology infrastructure). - Availability of public and private funding for innovation (venture capital, grants, loans). - Public-private partnerships for financing STI initiatives.	Firm/Enterprise level - Level of internal R&D investment. - Access to external funding sources (e.g., venture capital, government grants). - Financial resources allocated for technology acquisition, innovation projects, and scaling.
	Infrastructure	
	National level - Number of Research and Innovation Facilities - Access to Advanced Infrastructure and Digital Connectivity - Support Services for STI Ecosystem.	Firm/Enterprise level - Access to Research, Testing, and Prototyping Facilities - Availability of research and lab facilities.

Performance	Activity	
	National level - Number of research and development projects initiated by government agencies. - Collaboration with international research institutions or networks. - Public sector involvement in promoting innovation in key sectors (e.g., health, agriculture, energy).	Firm/Enterprise level - Number and scale of innovation and R&D activities within the firm. - Collaboration with external partners (e.g., universities, research labs, other businesses). - Number of new products or services developed through innovation.
	Expenditure	
	National level - Percentage of GDP allocated to STI development (research funding, innovation grants, etc.). - National R&D expenditure as a percentage of the government budget. - Financial support for technology parks, innovation hubs, and startups.	Firm/Enterprise level - Percentage of revenue allocated to R&D and innovation activities. - Budgetary allocation for acquiring new technologies and improving existing products. - Investment in research infrastructure and prototyping.
	Network	
	National level - Existence of national STI networks or innovation clusters (e.g., tech parks, innovation hubs). - Number and quality of collaborations between government, academia, and industry. - Participation in international STI networks and initiatives.	Firm/Enterprise level - Engagement in local and international innovation networks (e.g., consortia, conferences). - Collaboration with universities, research institutions, or other firms on R&D projects. - Participation in industry clusters or business incubators.

<table>
<tr><td rowspan="4"> 
Environment</td><td colspan="2">  Work</td></tr>
<tr><td><u>National level</u>

- Availability of programs that support workforce development for innovation (e.g., STEM education, entrepreneurship training).
- Presence of national policies that promote flexible labor markets to support innovation-driven sectors.
- Quality of the work environment for researchers and innovators (e.g., access to state-of-the-art research facilities, funding for projects).</td><td><u>Firm/Enterprise level</u>

- Employee satisfaction with working conditions, particularly in R&D roles.
- Organizational culture promoting creativity, collaboration, and idea generation.
- Investment in employee well-being, professional development.</td></tr>
<tr><td colspan="2">  Business</td></tr>
<tr><td><u>National level</u>

- Business environment conducive to innovation (e.g., ease of doing business, access to markets, financial services).
- Policies that encourage private sector innovation and entrepreneurship.
- Availability of infrastructure supporting business and innovation (e.g., internet connectivity, transport).</td><td><u>Firm/Enterprise level</u>

- Availability of resources (financial, human, and technological) for firms to engage in innovation.
- Business strategies focused on product development and market competitiveness.
- Entrepreneurial mindset within the firm, fostering risk-taking and the development of new business models.</td></tr>
</table>

STI OUTPUT INDICATORS

<table>
<tr><td rowspan="4"> 
Scientific Knowledge</td><td colspan="2">  Scientific Finding</td></tr>
<tr><td><u>National level</u>

- Number of scientific discoveries or innovations reported by national research institutions.
- Impact of national scientific findings on addressing societal challenges (e.g., health, environment, energy).
- Participation of national researchers in global research projects.</td><td><u>Firm/Enterprise level</u>

- Number of internal R&D findings or innovations that contribute to the industry.
- Patents, prototypes, or papers published as a result of R&D activities.
- Integration of scientific findings into new products or processes.</td></tr>
<tr><td colspan="2">  Publication</td></tr>
<tr><td><u>National level</u>

- Number of peer-reviewed publications produced by national research institutions or universities.
- Citations and influence of national publications in international research.
- National participation in international academic and research conferences.</td><td><u>Firm/Enterprise level</u>

- Publications in academic or industry journals resulting from internal R&D activities.
- Patents or technical papers filed/published by the firm.
- Internal dissemination of research findings through conferences, seminars, or publications.</td></tr>
</table>

<table>
<tr><td rowspan="6"> 
Technology Advancement/ Integration</td><td colspan="2">  Technology Invention</td></tr>
<tr><td><u>National level</u>

- Number of New Technologies Developed by all sectors
- Innovation in key national sectors
- Government-supported programs for fostering technological invention and commercialization.</td><td><u>Firm/Enterprise level</u>

- Number of new products or technologies invented by the firm.
- Degree of innovation in new technologies compared to industry standards.
- Investment in product or process innovation.</td></tr>
<tr><td colspan="2">  Technology Transfer</td></tr>
<tr><td><u>National level</u>

- Number of successful technology transfer programs linking research institutions with the private sector.
- Support for technology commercialization through government programs.
- Policies promoting technology transfer across industries and borders.</td><td><u>Firm/Enterprise level</u>

- Number of adoptions of new technologies developed externally (from universities, partners, or global markets).
- Number of collaborations leading to the transfer of technology to the market.
- Licensing or patenting of technologies developed internally.</td></tr>
<tr><td colspan="2">  Intellectual Property</td></tr>
<tr><td><u>National level</u>

- Number of patents filed by national institutions or businesses.
- Government support for intellectual property protection and management.
- Awareness of intellectual property laws and protection mechanisms at the national level.</td><td><u>Firm/Enterprise level</u>

- Number of patents or trademarks registered by the firm.
- Commercialization of intellectual property through licensing or joint ventures.
- Use of intellectual property to gain a competitive advantage in the market.</td></tr>
</table>

<table>
<tr><td rowspan="6"> 
Innovation Production</td><td colspan="2">  Product Innovation</td></tr>
<tr><td><u>National level</u>

- Number of new products developed through public-private R&D partnerships.
- Contribution of innovative products to national exports and economic growth.
- Government support for product development and commercialization.</td><td><u>Firm/Enterprise level</u>

- Number of innovative products developed and brought to market.
- Revenue generated from innovative products and services.
- Market share and consumer adoption of new products.</td></tr>
<tr><td colspan="2">  Business Process Innovation</td></tr>
<tr><td><u>National level</u>

- Percentage of firms improving processes
- Sectoral process innovation benchmarks
- National digital transformation index.</td><td><u>Firm/Enterprise level</u>

- Operational cost savings from new processes
- Time-to-market improvement
- Internal productivity improvements.</td></tr>
<tr><td colspan="2">  Intellectual Property</td></tr>
<tr><td><u>National level</u>

- Impact of intellectual property laws on fostering national innovation.
- Use of IP as a tool for national economic development and competitiveness.</td><td><u>Firm/Enterprise level</u>

- Revenue generated from licensing intellectual property.
- Degree of integration of IP strategy into business models.
- Strength of IP portfolio and its contribution to firm competitiveness.</td></tr>
</table>

3

SCORING AND RANKING METHODOLOGY

After defining indicators tailored to the evaluation framework, the scoring and ranking process becomes a critical component of assessing STI performance. This section aims to provide a comprehensive example of how ranking methodologies work within two different frameworks: the CEII and the GII. Although these frameworks are used for different levels of evaluation - GII at the national level and CEII at the enterprise (firm) level - the methodologies behind their rankings are quite similar, with both emphasizing a blend of innovation inputs and outputs.

The ranking methodology follows a structured process, ensuring that each entity, whether a firm (for CEII) or a country (for GII), is evaluated using a balanced and comparable set of indicators. These indicators are categorized into several key areas that influence innovation capabilities, such as human capital, infrastructure, business sophistication, and innovation outputs (e.g., patents, R&D, etc.). Despite the different scales of these frameworks, both CEII and GII rely on a similar scoring process based on these indicators to rank firms or countries.

Below is a synthesis of the ranking process based on the GII and CEII frameworks.

3.1. Data Collection and Scoring

3.1.1. Data collection

At the national level, data for these indicators is collected from multiple sources, such as international organizations (e.g., World Bank, UNESCO, WIPO, ITU) and/or national statistical agencies. In the case of the CEII, data collection may focus on firm-level data, this data is collated from the firm survey.

3.1.2. Weighting and Aggregating Scores

Each indicator is scored based on pre-established benchmarks. For instance, a firm might be evaluated on its R&D spending as a percentage of revenue, and a country may be assessed based on the number of patents filed per million people.

Once the indicators are scored, they are aggregated based on specific weights assigned to each category. These weights reflect the relative importance of each indicator in contributing to the overall innovation ecosystem.

Innovation Inputs are often given a higher weight than outputs because a strong innovation input environment (e.g., skilled workforce, robust infrastructure) is seen as the foundation for future innovative outputs.

Innovation Outputs reflect the actual innovation results but are dependent on the level of inputs. Therefore, these are weighted to ensure that outputs are appropriately considered in relation to the resources and policies invested.

The exact weighting may vary across frameworks. For example, in the GII, the total score is derived from a balanced weighting of 0.5 for inputs and 0.5 for outputs. However, some countries may adjust weights based on their own policy focus or sector priorities.

3.2. Ranking Methodology

After scoring and aggregating the results, the final step is ranking the entities - whether they are firms (in the case of CEII) or countries (in the case of GII). The ranking process involves the following:

3.2.1. Normalization

Scores are adjusted to ensure that entities are compared on a level playing field. For instance, firms with vastly different sizes may be normalized to ensure a fair comparison.

3.2.2. Calculation of Final Index

The final index is computed by combining the normalized scores for both input and output pillars. In GII and CEII, this index ranges from 0 to 100, with higher values indicating better innovation performance.

3.3. Comparative STI Ranking

Once scores are finalized, firms or countries are ranked relative to each other. This ranking reflects their position within a global or local context, helping to identify areas of strength and areas that need improvement.

After calculating the total index score, it is crucial to understand what the score represents. This section will help to classify the enterprise into one of several STI levels, providing valuable insights into the current STI status and offering guidance for the next steps toward improvement. Below are two key examples of STI-level classification and ranking.

3.3.1. Example 1: European Innovation Scoreboard

The first example is the firm or enterprise-level classification based on the European Innovation Scoreboard (EIS) framework. These frameworks assess the innovation performance of businesses by considering factors such as research and development activities, the adoption of new technologies, and overall innovation capabilities. This framework classifies enterprises based on their innovation performance into four categories: Innovation Leader, Strong Innovator, Moderate Innovator, and Emerging Innovator (**Figure** 4).

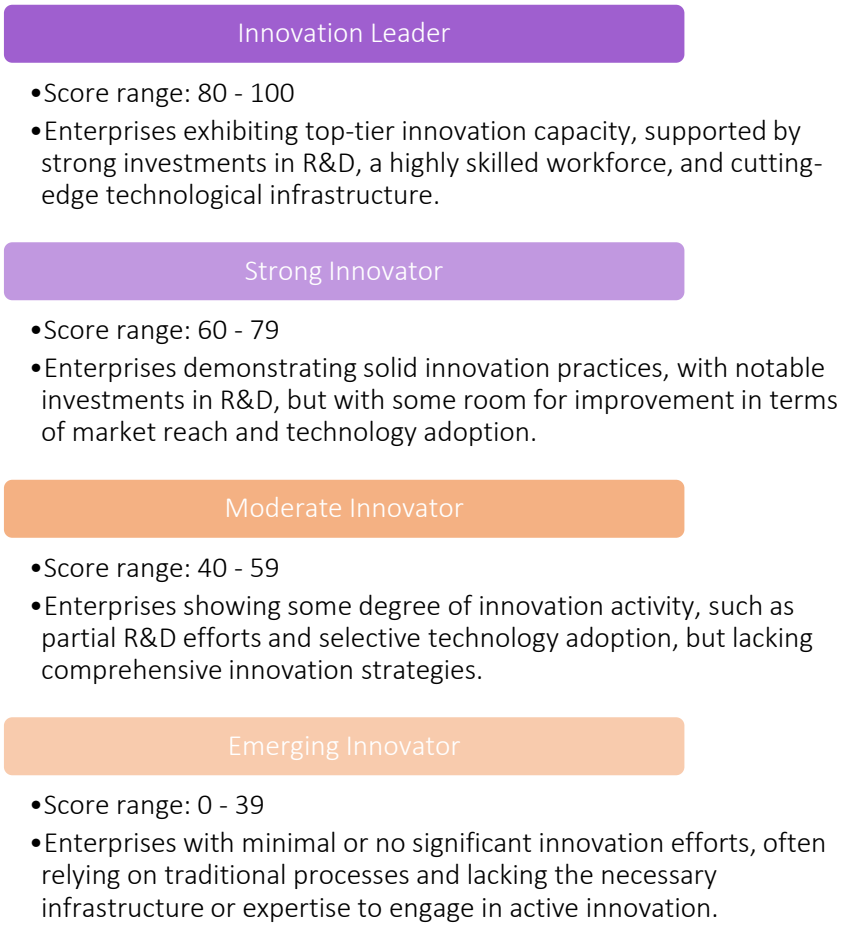


Figure 4. EIS innovation classification

3.3.2. Example 2: Global Innovation Index

The second example is the national-level ranking provided by the GII that evaluates countries based on their capacity to foster and sustain innovation, offering a comprehensive perspective on how innovation drives economic growth, competitiveness, and development.

Countries are ranked using a composite of Innovation Input and Innovation Output indicators. The Input sub-index captures factors that enable innovation, such as institutions, human capital, infrastructure, and business environment, while the Output sub-index measures the tangible results of innovation, including knowledge creation, technological outputs, and creative products. Although the GII does not explicitly categorize countries into formal “innovation levels,” its rankings effectively reflect relative performance.

In addition to global rankings, the GII allows for meaningful year-over-year comparisons, enabling countries to track progress or setbacks in innovation performance over time. It also supports regional benchmarking, helping countries evaluate their standing relative to neighbors or peers within the same economic or geographic region. For instance, countries like India, Vietnam, and the Philippines have demonstrated consistent upward movement in recent years, surpassing several regional peers and outperforming expectations based on income level. Conversely, others may experience stagnation or decline, highlighting areas needing policy attention or investment.

3.4. Alternative Classification

In practice, classification will rely on data from surveys and scores of enterprises across all levels and sizes. To identify top performers and support those with lower performance scores, the scoring range will be adjusted after each survey. However, enterprises can always use standard classification methods to assess and enhance their performance, regardless of the survey results.

4

IMPLEMENTATION OF STI EVALUATION

4.1. Institutional Coordination and Governance

The successful implementation of an STI evaluation framework in Cambodia requires strong institutional coordination and governance mechanisms. STI evaluation is a multi-stakeholder process that involves government agencies, academic institutions, research organizations, industry associations, and private-sector enterprises. Establishing clear governance structures ensures that evaluations are conducted systematically, data collection processes are harmonized, and evaluation results are used to inform policy and decision-making.

The Ministry of Industry, Science, Technology & Innovation plays a central role in overseeing the national STI evaluation framework. However, effective STI evaluation also requires collaboration with other key institutions, including the Ministry of Economy and Finance; the Ministry of Education, Youth and Sport; and the Ministry of Commerce. These ministries are responsible for various aspects of STI, such as funding research initiatives, promoting higher education and skills development, and supporting innovation-driven enterprises.

To strengthen institutional coordination, Cambodia should establish a National STI Evaluation Committee, which would serve as the governing body for STI assessments. This committee would bring together representatives from government agencies, academia, industry, and development partners to oversee the design, implementation, and refinement of STI evaluation methodologies. The committee would also ensure alignment between STI evaluation efforts and broader national development strategies.

A critical component of STI governance is defining clear roles and responsibilities for different stakeholders involved in the evaluation process. Government agencies should focus on policy evaluation and regulatory oversight, universities and research institutions should contribute expertise in research impact assessments, and industry representatives should provide insights into innovation adoption and commercialization trends. Development partners and international organizations can offer technical assistance, capacity-building support, and benchmarking expertise to help Cambodia align its STI evaluation framework with global best practices.

4.2. Capacity Building for STI Evaluations

The effective implementation of STI evaluations requires a workforce equipped with the necessary technical skills to conduct assessments, analyze data, and generate policy-relevant insights. Capacity building for STI evaluations should focus on strengthening the technical expertise of policymakers, researchers, and industry stakeholders involved in STI assessment.

Capacity development programs should cover topics such as innovation measurement methodologies, impact assessment techniques, data analytics for STI policy, and benchmarking against international indicators. Training workshops, certification programs, and specialized courses in STI evaluation should be offered to government officials, academic researchers, and private-sector professionals to enhance their skills in conducting comprehensive STI assessments.

To further build local capacity, Cambodia should develop partnerships with international organizations such as the OECD, WIPO, and other development partners to facilitate knowledge exchange and best-practice sharing in STI evaluation. Collaborative programs with universities and research institutes can also help develop a new generation of professionals specialized in STI measurement and impact assessment.

Another key area for capacity building is enhancing the statistical and data-gathering capabilities of national agencies responsible for STI evaluation. Strengthening Cambodia's STI

data infrastructure, improving survey methodologies, and integrating digital tools for STI analytics can significantly enhance the quality and reliability of innovation assessments.

4.3. Policy Integration and Feedback Mechanisms

STI evaluations should not be conducted in isolation but should be integrated into broader national policy review and decision-making processes. A well-designed STI evaluation framework provides valuable insights into the effectiveness of innovation policies, research funding allocations, and private-sector support programs. Integrating STI evaluations into policy formulation allows decision-makers to refine strategies, allocate resources more efficiently, and address gaps in innovation performance.

To institutionalize policy integration, Cambodia should develop a National STI Monitoring and Evaluation Framework, which would outline clear guidelines for incorporating STI assessment results into policy planning. This framework should require that all major STI-related policies and initiatives undergo regular evaluation to measure their impact and effectiveness.

A key component of policy integration is establishing feedback mechanisms that allow policymakers to adjust STI strategies based on evaluation findings. Regular policy reviews, stakeholder consultations, and impact assessment reports should be used to guide improvements in STI governance. By ensuring that evaluation results are actively used to inform decision-making, Cambodia can create a more responsive and adaptive STI policy environment.

To enhance transparency and accountability, the government should also make STI evaluation results publicly available through regular reports and policy briefs. Disseminating evaluation findings to the broader research community, private sector, and civil society promotes informed debate on STI issues and encourages collaborative efforts to address innovation challenges.

4.4. Strengthening Data Collection and Management Systems

One of the biggest challenges in STI evaluation is ensuring the availability of accurate, reliable, and up-to-date data. In Cambodia, innovation-related data is often scattered across multiple agencies, with limited coordination in data collection efforts. Strengthening data collection and management systems is crucial for improving the effectiveness of STI evaluations.

The establishment of a National STI Data Repository would provide a centralized platform for collecting and storing information on research output, technology adoption, and enterprise-level innovation activities. This repository would serve as a comprehensive database for tracking Cambodia's STI performance and supporting evidence-based policymaking.

To improve data collection, Cambodia should adopt standardized survey instruments and reporting mechanisms for STI indicators. Conducting regular enterprise innovation surveys, R&D investment assessments, and technology diffusion studies will enhance the comprehensiveness of STI evaluations.

Leveraging digital technologies, such as big data analytics and artificial intelligence, can also enhance the efficiency and accuracy of STI data management. Implementing real-time STI dashboards and digital reporting tools can help policymakers monitor innovation trends and respond more quickly to emerging challenges.

International collaboration can also support Cambodia's efforts to strengthen STI data collection systems. Partnering with international organizations can provide technical assistance in developing advanced STI data platforms and benchmarking tools.

4.5. Promoting Public-Private Collaboration in STI Assessments

Public-private collaboration is essential for improving the relevance and applicability of STI evaluations. While government agencies and research institutions play a critical role in conducting STI assessments, private-sector engagement

is necessary to ensure that evaluations reflect the realities of industry-driven innovation.

One approach to fostering public-private collaboration is establishing Innovation Advisory Committees, composed of representatives from academia, industry, and government. These committees can provide expert input on STI evaluation methodologies, identify priority areas for assessment, and suggest policy interventions to enhance Cambodia's innovation ecosystem.

Encouraging private enterprises to participate in STI surveys, share innovation data, and engage in policy dialogues can further strengthen STI evaluations. Industry associations and business chambers can act as intermediaries, facilitating knowledge-sharing between companies and policymakers.

Another area for collaboration is co-developing STI performance indicators that reflect business-driven innovation activities. Metrics such as technology transfer rates, R&D investments by private firms, and the commercialization success of university research should be integrated into national STI evaluation frameworks.

4.6. Future Directions for STI Evaluation in Cambodia

As Cambodia seeks to enhance its STI evaluation capabilities, several emerging trends and opportunities should be considered to ensure long-term success.

A major priority is the adoption of digital tools for STI evaluation, including the use of artificial intelligence, big data analytics, and blockchain technology for tracking innovation trends. These technologies can enhance the accuracy, efficiency, and scalability of STI assessments.

Another key area is international benchmarking and cross-country comparisons. Cambodia should regularly compare its STI performance with regional and global standards, using metrics from the Global Innovation Index and European Innovation Scoreboard. These comparisons can help identify strengths, weaknesses, and areas where policy interventions are needed.

Strengthening regional and global STI collaborations will also be crucial for Cambodia's future innovation landscape. Participating in international research networks, joint R&D programs, and cross-border innovation initiatives can provide Cambodia with access to cutting-edge technology, funding opportunities, and capacity-building programs.

By implementing these future-oriented strategies, Cambodia can build a more comprehensive, adaptive, and internationally competitive STI evaluation system that supports long-term economic growth and technological advancement.

5

CONCLUSION AND RECOMMENDATIONS

The development and implementation of a robust STI evaluation framework in Cambodia are both essential for achieving sustainable economic growth, industrial diversification, and long-term competitiveness in an increasingly knowledge-driven global economy. Through this evaluation process, key areas of progress, challenges, and opportunities for improvement have been identified.

Cambodia has made significant progress in establishing national STI policies, and these policies demonstrate a clear commitment to fostering innovation and scientific advancement. However, structural weaknesses, such as limited R&D investment, weak industry-academia linkages, and the absence of a systematic STI evaluation framework, continue to hinder Cambodia's innovation potential.

Several challenges have been identified in STI evaluation implementation, including the lack of high-quality innovation data, insufficient technical capacity for conducting STI assessments, fragmented institutional coordination, and the absence of standardized STI performance indicators. Furthermore, the integration of informal innovation activities, particularly those within SMEs and rural enterprises, remains limited in current STI assessment methodologies.

To address these challenges, Cambodia needs to adopt a structured and evidence-based STI evaluation framework that aligns with international best practices while being tailored to local economic realities.

Strengthening data collection mechanisms, capacity-building programs, and policy integration processes will be essential in ensuring that STI evaluations generate actionable insights that inform decision-making.

5.1. Key Recommendations

The evaluation of STI in Cambodia is essential for ensuring that innovation policies effectively contribute to economic growth, industrial modernization, and sustainable development. A strong STI evaluation framework allows policymakers to assess national innovation performance, identify gaps, and implement targeted interventions to enhance technological progress. The previous sections have outlined various challenges and opportunities for improving STI evaluation in Cambodia. This section provides a summary of key recommendations for strengthening the country's STI assessment system.

5.1.1. Strengthening STI Data Collection and Integration

A major priority for Cambodia is improving STI data collection mechanisms and integrating innovation performance indicators into national statistical systems. The absence of centralized and standardized STI data has led to inconsistencies in performance tracking and difficulty in measuring the impact of national innovation policies. Establishing a national STI database will consolidate data from multiple government agencies, research institutions, universities, and private enterprises, ensuring that innovation metrics are systematically collected and analyzed.

The creation of a National STI Observatory could serve as a dedicated platform for managing, processing, and disseminating STI-related data. By adopting digital reporting systems and real-time STI monitoring tools, Cambodia can enhance the accuracy and accessibility of innovation performance data. The use of AI-powered analytics will further enable policymakers to identify trends, forecast innovation trajectories, and optimize resource allocation for high-impact R&D initiatives.

5.1.2. Expanding STI Evaluation Metrics

STI evaluation in Cambodia must move beyond traditional indicators such as R&D expenditure, patent filings, and

scientific publications. While these metrics remain relevant, the evaluation framework must be expanded to include new indicators that reflect digital transformation, industry-academia collaboration, and the social impact of innovation.

The assessment of digital innovation should include metrics on the adoption of automation technologies, the growth of the fintech sector, and advancements in smart manufacturing. Similarly, STI evaluations should incorporate sustainability-driven innovation indicators, such as the development of green technologies, the adoption of renewable energy solutions, and the effectiveness of circular economy initiatives.

Sectoral STI evaluations should be implemented to measure innovation in specific industries, including agriculture, healthcare, and manufacturing. By refining STI performance tracking at the sectoral level, Cambodia can develop tailored innovation policies that address the unique challenges and opportunities within each industry.

5.1.3. Improving Institutional Coordination in STI Evaluation

Institutional fragmentation remains a significant challenge in STI governance in Cambodia. Various ministries and agencies oversee different aspects of STI policy, but the lack of coordination between these institutions has resulted in inefficiencies and duplication of efforts. Strengthening inter-agency collaboration is essential for creating a more coherent STI evaluation system.

The establishment of a National STI Evaluation Committee could serve as a coordinating body to oversee the development and implementation of standardized innovation performance indicators, align STI evaluation priorities with national economic policies, and ensure that government agencies, research institutions, and private sector actors are working collaboratively on innovation assessments.

Greater coordination between central and provincial authorities is also necessary to ensure that STI evaluations capture innovation dynamics at the regional level. The creation of regional STI development hubs will enable policymakers to track technological advancements outside major urban centers and support localized innovation ecosystems.

5.1.4. Enhancing Policy Responsiveness Through Real-Time STI Monitoring

The ability to respond quickly to emerging technological trends requires an STI evaluation system that incorporates real-time monitoring mechanisms. Traditional STI assessments often rely on retrospective analysis, making it difficult for policymakers to anticipate innovation challenges and adjust policies accordingly.

By adopting AI-powered data analytics and big data processing tools, Cambodia can implement a real-time STI monitoring framework that allows for the continuous assessment of national innovation performance. The development of digital STI dashboards will improve data visualization, enhance transparency, and provide key stakeholders with easy access to up-to-date innovation metrics.

Open-data platforms will play a crucial role in fostering collaboration between government agencies, universities, and industry leaders. By ensuring that STI evaluation data is publicly available, policymakers can encourage greater private sector participation in innovation assessments and promote a culture of data-driven decision-making.

5.1.5. Strengthening Human Capital for STI Evaluation

The effectiveness of STI evaluation in Cambodia depends on the availability of skilled professionals trained in research methodologies, data analysis, and policy impact assessment. A key priority for improving STI evaluation capacity is investing in human capital development and ensuring that policymakers, researchers, and industry experts have access to specialized training in innovation measurement techniques.

Cambodia should establish STI evaluation training programs for government officials and researchers, integrate STI assessment methodologies into university curricula, and provide scholarships and research grants for students pursuing advanced degrees in science policy and innovation governance. International partnerships with academic institutions and STI think tanks can facilitate knowledge exchange and provide Cambodian researchers with access to global best practices in innovation assessment.

The long-term development of STI evaluation expertise requires a sustainable knowledge-sharing ecosystem where STI policymakers and analysts can continuously update their skills based on the latest advancements in innovation governance. This can be achieved through participation in international STI forums and collaboration with organizations specializing in STI performance measurement.

5.1.6. Expanding Public-Private Partnerships in STI Evaluation

Public-private partnerships (PPPs) can enhance STI evaluation by ensuring that national assessments reflect real-world business innovation activities. Private enterprises are key drivers of technological progress, and their participation in STI performance reviews will provide valuable insights into industry-specific innovation trends.

Cambodia should promote greater engagement between the public and private sectors by organizing innovation policy dialogues, establishing industry-led STI evaluation committees, and supporting joint research initiatives between academia and businesses. Strengthening collaboration between the government and private enterprises will ensure that STI assessments align with industry needs and encourage greater private-sector investment in R&D.

The inclusion of business innovation metrics in STI evaluation frameworks will provide a more accurate understanding of how firms are adopting new technologies, developing innovative products, and competing in global markets. By integrating business-led innovation assessments into national STI evaluations, Cambodia can create a more comprehensive and market-driven approach to tracking innovation performance.

5.1.7. Strengthening Cambodia's Integration into Global STI Networks

Cambodia must enhance its engagement with international STI organizations and benchmarking platforms to improve the quality of its innovation assessments. Participation in global STI performance ranking systems will allow Cambodia to track its progress relative to other countries, adopt best practices in innovation governance, and align its evaluation frameworks with internationally recognized methodologies.

Closer collaboration with regional and global STI institutions will facilitate capacity-building initiatives, joint research projects, and policy development exchanges. Strengthening international partnerships will also help Cambodia attract foreign investment in innovation-intensive industries by demonstrating a commitment to evidence-based STI policy making.

By participating in global STI benchmarking exercises, Cambodia can ensure that its innovation policies are guided by internationally validated assessment methodologies. This will support long-term innovation-driven economic growth and strengthen Cambodia's reputation as a competitive player in the ASEAN knowledge economy. Strengthening STI evaluation in Cambodia requires a multi-faceted approach that includes improving data collection, expanding performance metrics, enhancing institutional coordination, adopting real-time monitoring mechanisms, investing in human capital, strengthening public-private collaboration, and integrating Cambodia into global STI networks. By implementing these recommendations, Cambodia will develop a robust, internationally aligned, and forward-looking STI evaluation system that supports evidence-based policymaking, drives innovation-led economic growth, and enhances national competitiveness.

5.1.8. Final Thoughts

Building an effective STI evaluation framework is a long-term process that requires continuous improvement, stakeholder engagement, and alignment with national development goals. Cambodia's success in fostering an innovation-driven economy depends on the ability to measure, track, and refine STI policies based on evidence-based assessments.

By implementing the recommendations outlined in this report, Cambodia can establish a globally competitive STI evaluation system, positioning itself as a leader in science, technology, and innovation-driven economic transformation in the ASEAN region. A well-executed STI evaluation strategy will ensure that Cambodia's innovation policies contribute to sustainable development, industrial modernization, and inclusive economic growth, driving the country toward its long-term vision of becoming a high-income knowledge economy by 2050.

WAY FORWARD

The development of the Fundamental Framework for STI Evaluation is a foundational milestone in Cambodia's STI agenda. However, its long-term impact will depend on sustained political will, institutional commitment, and stakeholder collaboration.

Moving forward, it is imperative to institutionalize the framework by establishing a National STI Evaluation Committee to oversee its implementation and integrate STI evaluation responsibilities into MISTI's core functions. This committee should foster cross-sectoral coordination and establish formal linkages with NCSTI and other line ministries.

Equally critical is the need for continuous capacity building. Cambodia must invest in training national and subnational officials on STI data collection, analysis, and application. Technical guidelines and toolkits should be developed to help institutions and enterprises operationalize the framework. Building STI literacy in the public sector and education system will be key to long-term institutionalization.

Strengthening the STI data infrastructure is essential. Standardizing STI survey tools and ensuring their compatibility with the broader National Statistical System will provide reliable, up-to-date data to support evidence-based planning.

Policy feedback mechanisms must be embedded to ensure that insights from the STI evaluation inform strategic and budgetary planning. An adaptive policy environment should be promoted, supported by real-time data and iterative learning systems across ministries and subnational entities.

The implementation of this framework must be inclusive and decentralized. Regional innovation dynamics should be assessed and supported, with dedicated indicators for gender, youth, and SME contributions. Rural and underserved areas must be integrated into the national innovation narrative.

Finally, Cambodia should actively pursue international benchmarking and cooperation. By engaging with global indices, platforms, and partners, the country can measure its

progress, learn from global peers, and position itself as a credible innovation actor within ASEAN and beyond.

Through these efforts, Cambodia can build a robust, data-informed, and inclusive STI ecosystem that accelerates its transformation into a dynamic and sustainable knowledge economy.

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APPENDIX A

List of STI Indicators

Section	Pillar	Sub-Pillar	National-Level Indicator	Firm/Enterprise-Level Indicator
STI Input	Governance	Organizational Structure	- Existence and clarity of national STI strategies or roadmaps - Presence of a national STI coordinating body - Degree of decentralization in STI governance - Number of STI-related ministries or agencies - Number of dedicated STI institutions or agencies	- Existence of a dedicated R&D or innovation department - Presence of an internal innovation strategy - Defined STI governance structure or hierarchy - Number of employees assigned to innovation functions - Adoption of innovation management systems (e.g., ISO 56002 compliance) - Decision-making autonomy for innovation teams
		Policy & Regulation	- Regulatory quality and transparency in STI sectors - Innovation-friendly business policies and regulations - Entrepreneurship policies and culture - Number of STI-related policies/laws enacted or updated - IP protection strength (e.g., WIPO score) - Ease of doing business for technology start-ups - Policy coherence index (alignment between science, industry, and education policies)	- Company policies on R&D and IP - Compliance with IP, safety, and innovation-related regulations - Use of public STI policy incentives (e.g., tax credits, grants) - Firm's participation in regulatory sandboxes or testbeds - Impact of regulations on innovation decision-making

STI Input	Resource	Human Capital	- Labor force with tertiary education (% of total labor force) - Researchers per million inhabitants (FTE) - Number of R&D personnel (per million population) - Share of researchers in total employment - Percentage of STEM graduates (by gender) - Percentage of Master's or PhDs in STEM (by gender) - Tertiary enrolment rate (gross%, female) - Gender and diversity distribution in the STI workforce - % of workforce with STEM degrees - Professional and technical workers (female) - Number of specialized universities in science and technology - Existence of national researcher training programs - Researcher mobility (domestic and international)	- Labor force with tertiary education - Researchers and R&D personnel (including gender breakdown) - Percentage of employees with Master's or PhDs in STEM (by gender) - Professional and technical workers (female) - Gross tertiary enrolment rate (female) - R&D staff as a percentage of total employees - Percentage of employees with STEM qualifications - Internal training programs in innovation and R&D - Staff training hours in innovation, R&D, or digital skills - Turnover or retention rate of innovation-critical personnel
		Finance	- Gross Domestic Expenditure on R&D (GERD) as % of GDP - Public budget for STI as % of GDP - Higher Education Expenditure on R&D (HERD) - Business Expenditure on R&D (BERD) - Public vs. Private R&D funding ratio - R&D tax incentives utilization - Government innovation grants - Venture capital availability - Investment in innovation start-ups or SMEs	- R&D spending as a percentage of revenue or total sales - Share of revenue reinvested in innovation - Number of R&D projects funded - Access to external funding for R&D (e.g., venture capital, government grants, partnerships) - Return on innovation investment (ROII)

STI Input	Resource	Infrastructure	- Number of research centers, institutions, and laboratories - Number of innovation hubs, science parks, or incubators (including STI parks: smart city, green farm, tech park, etc.) - Availability of specialized research equipment and facilities - Access to national broadband and ICT infrastructure - Broadband penetration rate - High-performance computing capacity and advanced laboratory infrastructure - Platforms supporting and connecting researchers in STI fields - Availability of technical training, health services, and entrepreneurial ecosystem support - Public funding for research infrastructure and support services - Number of digital libraries - Public internet accessibility	- Access to labs, testing facilities, and prototyping environments - Use of advanced digital tools (e.g., AI, data analytics, IoT) in operations - Membership in innovation hubs - Availability of research and lab facilities - Investment in digital transformation infrastructure
	Performance	Activity	- Science and technology activity (including experimental studies and technology invention/transfer) - Innovation activity (including product/process innovation) - Number of national R&D projects initiated/completed - Number of innovation programs or initiatives launched - Participation in international collaborations - Number of scientific conferences, workshops, and cross-sector STI initiatives held - Number of patents filed by public institutions	- Science and technology activity (including experimental studies and technology invention/transfer) - Innovation activity (including product/process innovation and new product/process development efforts) - Number of R&D projects per year - Number of R&D projects or innovation initiatives per year - Collaborations with external researchers (e.g., universities, startups) - Share of employees involved in innovation activities - Number of experimental or pilot projects launched

STI Input	Performance	Expenditure	- Human capacity development for innovation - Public and private sector funding for innovation projects - Public/private R&D expenditure breakdown - R&D expenditure per researcher - Sectoral distribution of R&D funds (by government, business, higher education) - Share of STI expenditure in the national budget - International collaboration expenditure - Proportion of R&D budget allocated to basic vs. applied research	- R&D expenditure per annum - Human capacity development for innovation - R&D budget allocation - ROI from innovation investments - Innovation-related cost savings - Total innovation-related expenditure (including design, marketing, training) - Allocation of expenditure by innovation type - Efficiency of R&D spending (innovation output per dollar spent)
		Network	- R&D alliances and co-patents - University-industry linkages (UIL) - Interdisciplinary collaboration levels in research and innovation projects - Number of research-industry-government partnerships - International scientific collaborations (e.g., joint publications, patents) - Number of national innovation networks - Number of international research collaborations - Public-private partnership initiatives in STI - Researcher exchange programs and fellowships - STI network density or connectivity index	- Number of external R&D partnerships - Technology licensing agreements - Participation in innovation consortia - Number of innovation partnerships (e.g., research institutions, customers, suppliers) - Involvement in open innovation platforms - Participation in industry or cluster innovation networks - Engagement in joint ventures or co-creation projects

STI Input	Environment	Work	- Perceived innovation culture within organizations - Effectiveness of government support programs for innovation - Researcher satisfaction and retention rate - Freedom of scientific research - Inclusivity and diversity in science - Work-life support policies - Quality of work environment in STI institutions - Availability of funding and career progression opportunities - Labor mobility between academia and industry	- Leadership support for innovation - Teamwork and collaboration in innovation projects - Availability of infrastructure for innovation - Internal innovation culture (employee feedback and surveys) - Incentives for innovators and reward systems for innovative ideas - Flexible work arrangements for R&D teams - Time allocated for experimentation or intrapreneurship - Availability of flexible structures for project-based innovation
		Business	- Availability of infrastructure for innovation - Export structure/status - Sales share of new or highly improved services and export activities - Volume of medium and high technology imports and exports - Ownership and market share - Price competition and competitors - Availability of venture capital for technology-based enterprises - Ease of doing business score - Innovation market readiness - Access to financing and IP service - Tech commercialization ecosystem - Industry participation in public research programs - University-industry collaboration rate	- Availability of infrastructure for innovation - Customer satisfaction - Market share and industry competition level - Price competition and competitor analysis - Access to customers and markets for new innovations - Collaboration with customers for innovation - Innovation embedded in business strategy - Digital maturity level of the enterprise - Customer involvement in product/process development - Organizational agility in adopting new technologies

STI Output	Scientific Knowledge	Scientific Finding	- Scientific discovery and breakthroughs (national and international) - Bibliometric/scientometric indicators (e.g., citations, publications) - Absorptive capacity (ability to internalize and apply external knowledge) - Scientific capacity/assets (infrastructure, talent, and institutional resources) - Participation in major international research projects - Awards and prizes for scientific achievements - Influence of scientific results on policy or practice - Media coverage or public engagement with scientific results	- Scientific discoveries and firm-generated scientific findings - Bibliometric/scientometric indicators (e.g., publications, citations, h-index) - Absorptive capacity (e.g., ability to adopt and apply scientific knowledge) - Research capacity/assets (infrastructure, researchers, labs) - Participation in scientific, applied, and fundamental research projects - Research results supporting product development - Research results with commercial potential - Industry-relevant research papers produced
		Publication	- Number of scientific publications in indexed journals - Number of peer-reviewed publications/articles - Scientific and technical journal articles per labor force (%) - International co-authored publications - International citations per publication - Citation impact (e.g., H-index, Field-Weighted Citation Index) - Open-access publication rate - Database and indexing coverage (e.g., Scopus, Web of Science) - Journal impact factor of published research - High-Impact Journal Publication Rate (HIJPR)	- Number of employee-authored publications (peer-reviewed or industry-specific) - Scientific and technical journal articles per labor force (%) - Indexed scientific publications and journal impact factor - Scientific output in industry journals - Collaboration in scientific publishing with external entities - Internal knowledge repositories and knowledge-sharing publications - Use of recognized publication databases (e.g., Scopus, Web of Science)

STI Output	Technology Advancement/ Integration	Technology Invention	- Technological improvement and high-tech development - Technological impact (e.g., adoption rate, market influence) - Number of national technological inventions - Number of new technology prototypes developed - Technology Readiness Level (TRL) of emerging technologies - Number of registered patents - Patent citations as a measure of impact - Number of high-tech products developed - Time-to-market for new technologies	- Technological improvement and impact - High-tech development - Number of new technologies developed or customized by the firm - Number of prototypes tested or launched - Process automation technologies created - Percentage of revenue generated from in-house technologies - Use of advanced manufacturing or digital technology in production Number of platforms/applications
		Technology Transfer	- Technology adoption rate - Technology sales revenue - Share/value of technology transfer agreements - Percentage of firms adopting digital transformation solutions - Number of tech transfer agreements (e.g., university-industry) - Number of technology licenses issued - Licensing income from public research - Number of spin-offs from public R&D - Number of collaborative R&D projects with industry - Technology maturity levels (e.g., TRL – Technology Readiness Level)	- Technology adoption (including adoption of external technologies) - Technology sales - Share of technology transfer (inbound/outbound) - Inbound/outbound technology licensing agreements - Internal technology transfer to business units - Technologies adopted from universities or research centers - Licensing agreements with external technology providers - Number of employees trained in new technologies

STI Output	Technology Advancement/ Integration	Intellectual Property	- Number of IP applications (patents, trademarks, copyrights, trade secrets) - Number of patent applications and granted patents (national and international) - Patent applications by residents and non-residents - IP applications per 100,000 inhabitants - IP granted vs. applied ratio - Licensing revenue generated from IP - IP income from commercialization - Use of IP in commercialized products - Number of standards adopted or developed - Number of licenses issued or acquired	- Number of patents, trademarks, copyrights, and trade secrets filed - Patent applications by residents and non-residents - IP applications per 100,000 inhabitants - Patents filed by the firm - Trademarks and copyrights registered - Number of licenses issued or acquired - Number of standards adopted or developed - IP-generated revenue or royalty income - Licensing income from proprietary technologies - Commercialization rate of IP
	Innovation Production	Product Innovation	- Creative knowledge and product/process innovation - Market impact of new technologies and products - Number of startups and technology-based enterprises - Share of firms introducing new or significantly improved products - Revenue from new products as a percentage of total revenue - Number of new product launches per year - National innovation awards - Percentage of GDP from high-tech products	- Creative knowledge and product/process innovation - Market impact of new products - Number of new products launched in the last 3 years - Percentage of revenue from new products - Customer adoption rate of new products - Percentage of new or significantly improved products launched - Share of total revenue from new products - Time-to-market for new products - Market share growth due to product innovation

STI Output	Innovation Production	Business Process Innovation	- Share of high-tech exports in total exports - Foreign direct investment in innovation-driven sectors - Percentage of firms improving processes - Sectoral process innovation benchmarks - National digital transformation index - Share of firms implementing process innovations - Productivity improvements linked to innovation - Reduction in production costs or cycle time due to innovation	- Operational cost savings from new processes - Time-to-market improvement - Internal productivity improvements - Process efficiency improvements (e.g., cost/time savings) - Customer service enhancements - Internal quality or compliance improvements - Use of AI, RPA, or digital tools in operational workflows - Production of goods or services - Distribution and logistics efficiency improvements - Marketing and sales process improvements - Information and communication systems improvements - Administration and management process enhancements - Product and business process development
		Intellectual Property	- Number of patents, trademarks, copyrights, and trade secrets - Copyleft agreements - Patent applications by residents and non-residents - IP applications per 100,000 inhabitants - Number of IP filings attributed to innovation - Number of standards developed or adopted - Number of licenses issued or acquired - Product announcements related to new IP - Commercial success rate of IP - IP valuation statistics - Growth in IP portfolios - Commercialization rate of patented technologies - IP-related exports (e.g., royalties, technology services) - Licensing revenue from IP	- Number of patents, trademarks, copyrights, and trade secrets - Copyleft agreements - Patent applications by residents and non-residents - IP applications per 100,000 inhabitants - Number of standards developed or adopted - Number of licenses issued or acquired - Product announcements related to new IP - IP generated from innovation - Licensing deals or spin-offs - Legal protection of innovative outputs - Volume of IP created during innovation projects - IP portfolio growth rate - IP used in strategic partnerships or spin-offs - Industrial design - Utility models

APPENDIX B

Questionnaire Examples

Below are examples of questionnaires developed based on the fundamental framework and specific refinements. For real-world examples, please refer to the Community Innovation Survey and the Cambodia Enterprise Index Guidelines.

Example 1: National Level – Based on the Fundamental Framework

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STI Input

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1. Governance

Sub-Pillar 1: Organizational Structure

1. Does your country have a dedicated government body or agency responsible for STI policy and regulation?
   ☐ Yes ☐ No

2. Are the roles and responsibilities of national STI agencies clearly defined?
   ☐ Yes ☐ No

3. Does your country have a centralized or decentralized STI organizational structure?
   ☐ Centralized ☐ Decentralized ☐ Both

Sub-Pillar 2: Policy & Regulation

4. Does your country have a comprehensive national STI policy or strategy in place?
   ☐ Yes ☐ No

5. Does the national government provide regulatory frameworks supporting innovation (e.g., tax incentives, intellectual property laws)?
   ☐ Yes ☐ No

6. Are there any laws or regulations related to intellectual property, technology transfer, or R&D commercialization?
   ☐ Yes ☐ No

7. Is there a national program designed to foster private sector innovation?
   ☐ Yes ☐ No

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2. Resource

Sub-Pillar 1: Human Capital

8. What percentage of your country's population holds degrees in STEM fields (Science, Technology, Engineering, Mathematics)?
   Answer: _____ %

9. Are there national programs aimed at developing human capital in science, technology, and innovation?
   ☐ Yes ☐ No

10. How many national research universities or institutions are focused on STEM education and research?
    Answer: _____

Sub-Pillar 2: Finance

11. What percentage of your country's GDP is allocated to R&D?
    Answer: _____ %

12. Does the national government provide financial support (e.g., grants, subsidies) for innovation and R&D activities?
    ☐ Yes ☐ No

13. Does the national government offer funding for early-stage technology commercialization?
    ☐ Yes ☐ No

Sub-Pillar 3: Infrastructure

14. How accessible are specialized research centers, laboratories, or innovation hubs in your country?
    ☐ Highly Accessible ☐ Moderately Accessible ☐ Not Accessible

15. Does your country have robust digital infrastructure (e.g., broadband, data centers) supporting R&D and innovation activities?
☐ Yes ☐ No

16. Are there public-private partnerships supporting the development of innovation infrastructure?
☐ Yes ☐ No

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3. Performance

Sub-Pillar 1: Activity

17. How many new R&D projects were initiated by national research institutions or universities in the past year?
Answer: _____

18. Are there national innovation competitions or awards to incentivize R&D activity?
☐ Yes ☐ No

Sub-Pillar 2: Expenditure

19. How much did your country spend on R&D activities in the past year?
Answer: _____ (Currency/Value)

20. What proportion of the national budget is allocated to STI-related expenditures (e.g., innovation programs, R&D subsidies)?
Answer: _____ %

Sub-Pillar 3: Network

21. Does your country have formal innovation clusters or STI networks promoting collaboration between research institutions, universities, and industries?
☐ Yes ☐ No

22. Are there national or regional initiatives to strengthen international collaborations in STI?
☐ Yes ☐ No

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4. Environment

Sub-Pillar 1: Work

23. Does your country have policies that promote a skilled workforce in STI areas (e.g., STEM training programs)?
☐ Yes ☐ No

24. Are there government programs supporting the mobility of researchers across different sectors (academia, industry, government)?
☐ Yes ☐ No

Sub-Pillar 2: Business

25. How conducive is the national business environment for innovation and technology-based entrepreneurship?
☐ Very Conducive ☐ Moderately Conducive ☐ Not Conducive

26. Are there policies in place to support innovation-driven small and medium enterprises (SMEs)?
☐ Yes ☐ No

STI Output

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1. Scientific Knowledge

Sub-Pillar 1: Scientific Finding

27. How many scientific discoveries or innovations have been reported by national public research institutions in the last year?
Answer: _____

28. Does the country have a national system for tracking and promoting scientific discoveries and breakthroughs?
☐ Yes ☐ No

Sub-Pillar 2: Publication

29. How many publications in high-impact journals (indexed) have been produced by national research institutions or universities in the last year?
Answer: _____

30. Does the country support research dissemination through open-access platforms?
☐ Yes ☐ No

2. Technology Advancement/Integration

Sub-Pillar 1: Technology Invention

31. How many new technologies or inventions have been developed by national public institutions in the last year?
    Answer: _____

32. Does your country have a national patent office that supports the commercialization of technological innovations?
    ☐ Yes ☐ No

Sub-Pillar 2: Technology Transfer

33. How many successful technology transfer programs or licensing agreements have been established by national agencies or research institutions in the past year?
    Answer: _____

34. Is there a national technology transfer office or agency that facilitates industry-academic collaboration?
    ☐ Yes ☐ No

Sub-Pillar 3: Intellectual Property (IP)

35. How many patents have been filed by public research institutions or universities in the last year?
    Answer: _____

36. Does the government have policies to protect intellectual property and support patent commercialization?
    ☐ Yes ☐ No

3. Innovation Production

Sub-Pillar 1: Product Innovation

37. How many new products developed by public or private institutions in your country have been successfully commercialized in the past year?
    Answer: _____

38. Does the country have a formal process for supporting product development from concept to market?
    ☐ Yes ☐ No

Sub-Pillar 2: Business Process Innovation

39. What percentage of national firms have implemented new business processes or innovations in the past year?
    Answer: _____ %

40. Are there national programs supporting business process innovation in SMEs?
    ☐ Yes ☐ No

Sub-Pillar 3: Intellectual Property (IP)

41. How important is IP in fostering innovation in your country?
    ☐ Very Important ☐ Somewhat Important ☐ Not Important

42. Are there government initiatives that promote IP rights and technology commercialization?
    ☐ Yes ☐ No

Example 2: National Level – Based on Specific Refinement

1. Governance & Policy

1. Is there a dedicated national agency for STI policy and coordination?
   ☐ Yes ☐ No
   - If yes, please provide the name and mandate of the agency.
2. Are roles and responsibilities clearly defined among national STI institutions?
   ☐ Very clear ☐ Somewhat clear ☐ Not clear
3. How effective is inter-agency coordination in STI governance?
   ☐ Very effective ☐ Moderate ☐ Weak ☐ Non-existent
4. Does a national STI strategy or roadmap exist?
   ☐ Yes ☐ No
   - If yes, provide title and year: _____
5. To what extent are STI policies integrated into broader national development plans?
   ☐ Fully ☐ Partially ☐ Not integrated
6. Rate the effectiveness of STI-related regulations (IP laws, tax incentives, etc.):
   ☐ Highly effective ☐ Moderately effective ☐ Ineffective

2. Human Capital

7. How would you rate the availability of STEM graduates to meet national R&D needs?
   ☐ High ☐ Moderate ☐ Low
8. Provide the number of active R&D personnel per 1,000 labor force:
   _____
9. Are there national programs for researcher training and mobility?
   ☐ Yes ☐ No
   - If yes, list key programs: _____
10. Share of women in R&D workforce:
    _____% (approximate or actual data)

3. Finance & Infrastructure

11. Gross Domestic Expenditure on R&D (GERD) as % of GDP: _____
12. Is there a government budget line specifically for STI infrastructure?
    ☐ Yes ☐ No
13. Availability of public innovation grants and seed funding:
    ☐ Widely available ☐ Limited availability ☐ Not available
14. Number of operational science parks, incubators, or innovation hubs:
    _____
15. National broadband penetration rate (% of population): _____

4. Performance & Output

16. Number of nationally funded R&D projects initiated last year: _____
17. Number of patents filed by public institutions last year: _____
18. Number of scientific publications by national research bodies (last calendar year): _____
19. Rate the level of international STI collaboration (projects, networks):
    ☐ High ☐ Medium ☐ Low ☐ None

5. STI Environment

20. Do national policies promote labor flexibility in innovation sectors?
    ☐ Yes ☐ No
21. Is there an inclusive and diverse environment for researchers (e.g., gender, age, background)?
    ☐ Strongly inclusive ☐ Moderately inclusive ☐ Not inclusive
22. Rate the overall innovation culture in public institutions:
    ☐ Strong ☐ Moderate ☐ Weak

Example 3: Firm/Enterprise Level – Based on the Fundamental Framework

STI Input

1. Governance

Sub-Pillar 1: Organizational Structure

1. Does your firm have a defined organizational structure for managing STI (e.g., R&D, innovation departments)?
   ☐ Yes ☐ No

2. Who is responsible for making decisions related to innovation and R&D within your firm?
   ☐ Senior Management ☐ Dedicated R&D Team ☐ Other: _____

Sub-Pillar 2: Policy & Regulation

3. Does your firm have an internal policy on innovation and intellectual property management?
   ☐ Yes ☐ No

4. Does your firm ensure compliance with national and international regulations regarding R&D and innovation activities?
   ☐ Yes ☐ No

2. Resource

Sub-Pillar 1: Human Capital

5. What percentage of your firm's employees have formal education in STEM disciplines?
   Answer: _____ %

6. Does your firm have internal programs for training or developing innovation capabilities among employees?
   ☐ Yes ☐ No

7. How many employees in your firm are directly involved in R&D activities?
   Answer: _____

Sub-Pillar 2: Finance

8. What percentage of your firm's annual revenue is allocated to R&D and innovation?
   Answer: _____ %

9. Does your firm receive external funding or grants for R&D?
   ☐ Yes ☐ No

10. Does your firm collaborate with external organizations (e.g., universities, research institutions) for co-funding R&D projects?
    ☐ Yes ☐ No

Sub-Pillar 3: Infrastructure

11. Does your firm have access to dedicated R&D facilities (e.g., labs, testing facilities)?
    ☐ Yes ☐ No

12. How well-equipped is your firm to support digital transformation (e.g., AI, IoT)?
    ☐ Very Well-Equipped ☐ Moderately Equipped ☐ Not Well-Equipped

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3. Performance

Sub-Pillar 1: Activity

13. How many R&D projects or innovation initiatives has your firm launched in the past year?
    Answer: _____

14. Does your firm participate in industry-specific innovation competitions or programs?
    ☐ Yes ☐ No

    Sub-Pillar 2: Expenditure

15. What was the total R&D expenditure for your firm in the past year?
    Answer: _____ (Currency/Value)

16. Does your firm allocate a percentage of its revenue specifically for innovation purposes?
    ☐ Yes ☐ No

Sub-Pillar 3: Network

17. Does your firm collaborate with external organizations for R&D (e.g., universities, research institutions, industry partners)?
☐ Yes ☐ No

18. Does your firm engage in industry or technology networks to foster innovation?
☐ Yes ☐ No

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4. Environment

Sub-Pillar 1: Work

19. Does your firm support flexible working arrangements for R&D and innovation teams?
☐ Yes ☐ No

20. Are employees encouraged to engage in continuous learning or skills development related to innovation?
☐ Yes ☐ No

Sub-Pillar 2: Business

21. How well is your firm positioned to adopt and commercialize new innovations?
☐ Strongly Positioned ☐ Moderately Positioned ☐ Weakly Positioned

22. Does your firm have a formal strategy for integrating innovation into its overall business model?
☐ Yes ☐ No

STI Output

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1. Scientific Knowledge

Sub-Pillar 1: Scientific Finding

23. Has your firm developed any significant scientific findings or discoveries in the past year?
☐ Yes ☐ No

24. Does your firm publish scientific papers or research findings in academic journals or conferences?
☐ Yes ☐ No

Sub-Pillar 2: Publication

25. How many research papers or articles have been published by your firm in the past year?
Answer: _____

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2. Technology Advancement/Integration

Sub-Pillar 1: Technology Invention

26. How many new technologies or inventions has your firm developed in the past year?
Answer: _____

27. Does your firm patent its inventions or technological innovations?
☐ Yes ☐ No

Sub-Pillar 2: Technology Transfer

28. Has your firm transferred or licensed any technology to external parties (e.g., other firms, universities)?
☐ Yes ☐ No

Sub-Pillar 3: Intellectual Property

29. How many patents or trademarks has your firm filed in the last year?
Answer: _____

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3. Innovation Production

Sub-Pillar 1: Product Innovation

30. How many new products has your firm introduced to the market in the past year?
Answer: _____

31. Are there any formal processes in your firm for developing and commercializing new products?
☐ Yes ☐ No

Sub-Pillar 2: Business Process Innovation

32. Has your firm introduced any new business processes in the past year?
    ☐ Yes ☐ No

33. Are these innovations directly linked to improved productivity or competitiveness?
    ☐ Yes ☐ No

Sub-Pillar 3: Intellectual Property

34. How important is IP management in your firm's overall innovation strategy?
    ☐ Very Important ☐ Moderately Important ☐ Not Important

35. Does your firm protect its innovations through patents, copyrights, or trademarks?
    ☐ Yes ☐ No

Example 4: Firm/Enterprise Level – Based on Specific Refinement

1. Innovation Governance & Strategy

1. Does your firm have a dedicated R&D or innovation department?
   ☐ Yes ☐ No
2. Does the firm follow a formal innovation strategy aligned with national STI policies?
   ☐ Yes ☐ No
   - If yes, provide a brief description: _____
3. Are there defined decision-making structures for innovation?
   ☐ Yes ☐ No
4. Number of employees dedicated to innovation/R&D: _____

2. Human Capital

5. Percentage of staff with STEM qualifications: _____%
6. Percentage of employees with Master's or PhDs in STEM: _____%
7. Does your firm offer internal training in innovation or R&D-related skills?
   ☐ Yes ☐ No
8. Staff retention rate in innovation/R&D roles (approx.): _____%

3. Innovation Finance & Infrastructure

9. R&D expenditure as % of annual revenue: _____%
10. Does your firm access external funding for R&D (e.g., grants, VC)?
    ☐ Yes ☐ No
    - If yes, please specify source(s): _____
11. Return on innovation investment (if measured):
    ☐ Positive ☐ Neutral ☐ Negative ☐ Not Measured
12. Do you use advanced tools (e.g., AI, data analytics) in innovation?
    ☐ Yes ☐ No

13. Are you a member of any innovation hub or cluster?
☐ Yes ☐ No

4. Innovation Activity & Collaboration

14. Number of innovation/R&D projects conducted in the past year: _____

15. Does your firm collaborate with universities or external researchers?
☐ Yes ☐ No

- If yes, please list key partners: _____

16. Share of employees involved in innovation activities: _____%

17. Number of pilot or experimental projects launched last year: _____

5. Innovation Output & IP

18. Number of new products/services introduced in the past year: _____

19. Revenue from products introduced in the last 3 years:
☐ <25% ☐ 25–50% ☐ >50%

20. Number of patents or trademarks registered last year: _____

21. Does the firm license any of its IP to external parties?
☐ Yes ☐ No

22. Does the firm measure customer satisfaction related to new innovations?
☐ Yes ☐ No

6. Work Environment & Culture

23. Rate the organizational support for innovation:
☐ Strong ☐ Moderate ☐ Weak

24. Are employees given time or resources to experiment with new ideas?
☐ Yes ☐ No

25. Does the firm provide incentives or rewards for innovative contributions?
☐ Yes ☐ No

APPENDIX C
Sampling Methodology

Overview

Sampling methods in research can be broadly categorized into two types: probability sampling and non-probability sampling. In probability sampling, every individual or unit in the population has a known chance of being selected. The most common types of probability sampling are:

- Simple random sampling, where every individual has an equal chance of selection.
- Systematic sampling, where every person is selected from a list after a random start.
- Stratified sampling, where the population is divided into subgroups* (e.g., by size, industry, or region), and a random sample is selected from each subgroup.
- Cluster sampling, where the population is divided into clusters* (e.g., by region), and entire clusters are selected randomly.
- Multistage sampling, which combines several of the above methods.

* Subgroup: A set of individuals within a population who share the same characteristics (e.g., size categories such as small, medium, or large, or belonging to the same sector).

* Cluster: A set of individuals randomly drawn from the population, consisting of different types (e.g., a mix of small, medium, and large categories, or multiple sectors).

In contrast, non-probability sampling means that not all individuals have a known or equal chance of being selected. This includes methods like:

- Convenience sampling, which selects individuals who are easiest to reach.
- Judgmental or purposive sampling, where the researcher chooses participants based on their judgment.
- Snowball sampling, where existing participants refer others to join the survey.
- Quota sampling, where a set number of participants are chosen from different groups without random selection.

For innovation surveys in firms, such as the Community Innovation Survey (CIS) in Europe or similar national surveys,

probability sampling is preferred. Stratified sampling is the most commonly used method, as it ensures representation of firms across different characteristics like size, industry, and location. In this method, firms are grouped into strata (such as small, medium, and large firms), and a random sample is taken from each group. This method provides more accurate results and allows for comparisons between different groups. Systematic sampling is used when there is a complete list of firms, where researchers select every firm from the list. While it is easy to implement, it can lead to bias if there are patterns in the list. Multistage sampling is employed in large-scale surveys, where regions or industries are selected first, and then firms within those units are sampled. While simple random sampling is straightforward, it does not always capture the diversity of different firm types. Non-probability methods are generally avoided in these surveys because they can introduce bias.

Common Sampling Methods in Official Statistics

Sampling surveys are the primary method used in official statistics to collect data, balancing costs and errors in estimation. While larger sample sizes reduce errors, they also increase costs, and the appropriate sample size must be calculated carefully. Different sampling techniques should be considered to estimate costs and achieve the best results.

Simple random sampling and stratified random sampling are the most commonly used methods in surveys. Simple random sampling is easy to use, but it can be more expensive when applied to national-level surveys. Stratified random sampling, on the other hand, is more frequently employed because it allows for more control over errors and sample size while providing accurate information. The choice of sampling method should be based on local experience and take into account the region’s specific needs and practices. These methods serve as general guidelines for estimating sample sizes in official statistics.

Simple Random Sampling

The sampling method known as simple random sampling gives every member of the population an equal chance of being selected for the study. We may use the following formula to estimate each sector cross point.

$$n_0 = \frac{p(1-p)Z^2_{\alpha/2}}{E^2} \quad [1]$$

p is the proportion of the main variable. The proportion can alternatively be set to 0.5, which p(1-p) will result in a maximum value of 0.25. Based on the assumption that p = 0.5 will fit all values, the sample size will be the greatest, and may result in greater expenses.

Z is a standardized random variable of normal distribution that will be used in the confidence interval determined by α and E represents the proportion's absolute error, which can be adjusted to 0.05 (5%) if p is sufficiently large or 0.02 (2%) if p is a small value.

After that, the population size N can be taken into account when adjusting the sample size using formula [2]. The actual sample size n should be greater by taking into account the response rate r using formula [3], which is the sample size in surveying.

$$n_1 = \frac{n_0}{1+\frac{n_0}{N}} \quad [2]$$

$$n = \frac{n_1}{r} \quad [3]$$

For instance, the following table shows the population size, N, from private and public higher education institutions (**Table** 2). This population size is an example to estimate the sample size.

Table 2. Example population sizes for the simple random sampling method

Type of Higher Education Institution	Population Size, N
Private	163
Public	85
Total	248

The following calculation is an example of finding the sample size for a private higher education institution.

From the formula [1], the value of n_0 as follows, and the value of $Z_{\alpha/2}$ is equal to 1.96 in the case of a 95% confidence interval. The value of p is chosen to be 0.5, and E is taken equal to 0.05.

$$n_0 = \frac{p(1\text{-}p)Z_{\alpha/2}^2}{E^2} = \frac{0.5(1\text{-}0.5)\times 1.96^2}{0.05^2}$$

$n_0 = 384.16$

Then, the value of n_1 can be found by using the formula [2] as shown in the following.

$$n_1 = \frac{n_0}{1+\frac{n_0}{N}} = \frac{384.16}{1+\frac{384.16}{163}}$$

$n_1 = 114.44$

Finally, the sample size in the survey can be determined by using formula [3] as shown below.

$$n = \frac{n_1}{r} = \frac{114.44}{0.9}$$

$n = 127$

Similarly, the sample size for public higher education institutions is equal to 77.

Table 3 summarizes the results of finding the sample size using simple random sampling

Table 3. Sample results from the simple random sampling method

Type of Higher Education Institution	Population Size, N	Sample size, n (r = 90%, E = 5%, p = 50%)
Private	163	127
Public	85	77
Total	248	204

Stratified Random Sampling

In stratified sampling, the whole population is divided into some homogeneous groups or classes with respect to the characteristic under study, which are known as strata. Stratified random sampling can be used to determine the overall sample size using formulas [4].

$$n_1 = \frac{\sum \frac{W_h^2 S_h^2}{w_h}}{V + \sum \frac{W_h S_h^2}{N}} \approx \frac{\sum \frac{W_h^2 P_h(1-P_h)}{w_h}}{V + \sum \frac{W_h P_h(1-P_h)}{N}} \quad [4]$$

Then, the sample size, n_1 will be adjusted by formula [3], where r is the response rate.

Last, this adjusted sample size, n, will be divided among each stratum using formula [5].

$$n_h = n \frac{W_h S_h}{\sum_{h=1}^{L} W_h S_h} = n \frac{N_h S_h}{\sum_{h=1}^{L} N_h S_h} \quad [5]$$

where:
h is the strata
N is the population size
N_h is the sub-population size of each stratum
S_h is sample standard deviation of stratum h

$$W_h = \frac{N_h}{N};\ S_h = \sqrt{p_h(1-p_h)};\ w_h = \frac{W_h S_h}{\sum_{h=1}^{L} W_h S_h};\ V = \frac{E^2}{Z_{\alpha/2}^2}$$

p_h is Sample proportion of stratum h

The following calculation is an example of finding the sample size using stratified random sampling. The data in **Table** 2 is used in this example, and the value of $Z_{\alpha/2}$is equal to 1.96 in the case of a 95% confidence interval. The value of p_h of each stratum is chosen to be 0.5, and E is taken equal to 0.05.

The value of V can be determined as follows.

$$V = \frac{E^2}{Z_{\alpha/2}^2} = \frac{0.05^2}{1.96^2}$$

$$V = 0.000625$$

The values of the variables are calculated as shown in **Table** 4.

Table 4. Example population sizes and variables for the stratified random sampling method

Higher Institution	N_h	p_h	S_h	W_h	$W_h^2S_h^2$	W_hS_h	w_h	$\frac{W_h^2S_h^2}{w_h}$	$\frac{W_hS_h^2}{N}$
Private HEI	163	0.5	0.5	0.657	0.108	0.329	0.657	0.164	0.000663
Public HEI	85	0.5	0.5	0.343	0.0294	0.171	0.343	0.0857	0.000346
N	248				Total	0.5	Total	0.25	0.001008

From **Table 4**,

$$\sum W_hS_h = 0.5;\ \sum \frac{W_h^2S_h^2}{w_h} = 0.25;\ \sum \frac{W_hS_h^2}{N} = 0.001008$$

Then, the value of the overall sample size can be determined as follows.

$$n_1 = \frac{\sum \frac{W_h^2S_h^2}{w_h}}{V+\sum \frac{W_hS_h^2}{N}} = \frac{0.25}{0.000625+0.001008}$$

$$n_1 = 153.09$$

Then, the sample size, n_1, will be adjusted by the following formula, and the response rate is set equal to 0.9.

$$n = \frac{n_1}{r} = \frac{153.09}{0.9}$$

$$n = 170$$

The sample size of each higher education institution can be calculated as below.

$$n_{h,private} = n\frac{W_h S_h}{\sum_{h=1}^{L} W_h S_h} = 170\times\frac{0.329}{0.5}$$

$$n_{h,private} = 112$$

$$n_{h,public} = n\frac{W_h S_h}{\sum_{h=1}^{L} W_h S_h} = 170\times\frac{0.171}{0.5}$$

$$n_{h,public} = 58$$

Table 5 summarizes the results of finding the sample size using stratified random sampling.

Table 5. Sample results derived from the stratified random sampling method

Type of Higher Education Institution	Population Size, N	Sample size, n (r = 90%, E = 5%, p = 50%)
Private	163	112
Public	85	58
Total	248	170

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