[Development of a Framework and Roadmap
for a National Innovation System to foster low-carbon
and climate-resilient economic development in Zambia]

National Innovation System (NIS) Framework & Roadmap

Science and Technology Policy Institute (STEPI)

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UN environment programme | CTCN UN Climate Technology Centre & Network | STEPI SCIENCE AND TECHNOLOGY POLICY INSTITUTE | Ministry of Technology and Science

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Chapter 1.
Introduction

The impacts of climate change are intensifying globally, with climate-related disasters becoming more frequent and severe. Recognizing that no nation is immune to these effects, the international community committed in 2021 to reducing greenhouse gas emissions by 25–47% by 2030. Innovation has emerged as a cornerstone solution for addressing climate risks while simultaneously driving economic growth.

In this context, the Climate Technology Centre & Network (UN CTCN) initiated a collaboration with the Science and Technology Policy Institute (STEPI) in 2023. The joint project focuses on developing Zambia's National Innovation System (NIS) Framework and Roadmap to support a transition to a low-carbon economy and enhance climate resilience. The Zambian government's Vision 2030 emphasizes innovation as a mechanism for addressing climate challenges and progressing toward a middle-income economy. Realizing this vision requires fostering a robust innovation ecosystem and establishing an effective NIS.

Zambia faces several systemic challenges, such as information asymmetry, coordination failures, insufficient incentives, and underdeveloped institutions. To address these, the STEPI research team conducted a thorough assessment that involved stakeholder engagement, qualitative analysis of key policies and institutional frameworks, and international benchmarking. Lessons from other countries with successful innovation systems informed the design of Zambia's governance framework and roadmap for innovation.

The proposed framework emphasizes the importance of governance, with centralized leadership to ensure alignment with national priorities and cross-sectoral collaboration to harness the strengths of government, academia, industry, and civil society. A key focus is on fostering public-private partnerships and creating platforms to address challenges like climate change and economic diversification.

The roadmap identifies four critical domains—governance, science and technology, human capital,

and research—with specific policy targets and instruments to enhance Zambia's innovation capacity. These include strengthening STI linkages across sectors, increasing STEM graduates, expanding R&D investment, and promoting the development and commercialization of technologies. Phased implementation plans provide a clear timeline for achieving these goals, ensuring accountability and measurable progress.

By building on global best practices and tailoring solutions to Zambia's unique context, the project offers actionable strategies to foster sustainable, climate-resilient growth. The expected outcomes include an enhanced innovation ecosystem, effective stakeholder engagement, and strengthened institutional capacity to address national and global challenges. Through these efforts, Zambia can leverage innovation as a key driver of economic transformation and climate resilience.

Chapter 2.

NIS Governance Framework

1. Concept of NIS Governance Framework

The National Innovation System (NIS) refers to the set of institutions, policies, and practices within a country that work collectively to promote and sustain technological innovation. The NIS framework brings together government bodies, academic institutions, private enterprises, and non-governmental organizations to enhance the country's ability to innovate, foster economic growth, and improve the overall quality of life.

In essence, the NIS framework reflects the interconnections between various players in the innovation ecosystem, which work together to stimulate knowledge creation, diffusion, and utilization across sectors. Each entity plays a crucial role in promoting research, development, and technological advancements. The primary aim of NIS is to bolster a country's ability to develop cutting-edge technologies, generate economic value, and maintain global competitiveness.

The governance of a National Innovation System is essential because it ensures the effective coordination and management of science, technology, and innovation (STI) activities. Proper governance may:

- Aligns innovation with national development priorities
- Encourages cooperation between public, private, and academic sectors
- Supports the efficient allocation of resources, particularly for research and development (R&D)
- Enhances accountability and transparency in decision-making processes related to STI
- Facilitates international collaboration and adherence to global standards.

Without strong NIS governance, innovation efforts can become fragmented and inefficient, potentially hindering a nation's economic growth and global competitiveness.

Zambia is currently in the process of developing its NIS governance framework. The Zambian government recognizes that sustainable economic development can only be achieved through the effective integration of science, technology, and innovation into its policy agenda. This awareness has led to a national focus on economic development driven by innovation, research, and technology.

One of the critical challenges Zambia faces is building a cohesive governance framework that can effectively respond to the global shifts in technology while addressing local challenges, including climate change. The Zambian government is committed to using science and technology as tools for economic development, particularly in key sectors such as agriculture, mining, and energy. It plans to use the NIS framework to achieve sustainable development goals, respond to climate change, and bolster its technological capacity.

Zambia's ongoing efforts to strengthen its NIS governance also include the introduction of collaborative efforts between public and private sectors. This includes building Public-Private Partnerships (PPPs) and forming STI working groups to ensure a more comprehensive approach to national development.

Zambia requires an NIS governance framework that is inclusive, transparent, and adaptable to changing global conditions. The country needs to focus on:

- Centralized coordination: A national body should oversee the NIS and ensure alignment with national development goals.
- Public-private collaboration: The framework must facilitate active cooperation between the government, private sector, academia, and civil society, leveraging each sector's strengths in driving innovation.
- Sustainability and resilience: The governance framework must be designed to address global and national challenges, particularly climate change, and prioritize sustainable practices in technological advancements.
- Clear roles and accountability: Each entity involved in the NIS should have clearly defined roles and responsibilities to prevent overlap and ensure accountability in the innovation process.

- International benchmarking: The framework should consider models from other countries, like South Korea, that have successfully implemented national innovation systems, while customizing solutions for Zambia's local context.

Zambia's NIS governance framework should also promote policies that foster creativity, technological adoption, and continuous learning, ensuring that the country can compete on the global stage in terms of innovation and economic growth.

2. Case Study: Korea

2.1. STI Governance Structure

The governance structure for Science, Technology, and Innovation (STI) in Korea is a comprehensive and highly coordinated system that integrates various governmental bodies, research institutions, and private entities to drive national innovation. The STI governance model reflects a top-down approach with a strong role for central government authorities, while also encouraging collaboration between public and private sectors.

2.1.1. Strategic Orientation

At the core of Korea's STI governance structure is the **Presidential Advisory Council on Science and Technology (PACST)**, which provides strategic advice and guidance to the President and National Assembly on STI policies. PACST is divided into two key bodies:

- **Advisory Council**: This body offers expert advice to the President, ensuring that STI policies are aligned with Korea's long-term national development strategies.
- **Deliberative Council**: It plays a role in the consultation process, helping to shape and refine STI strategies and offering recommendations on resource allocation, innovation policy, and national priorities.

The President holds significant authority over STI governance, with direct influence over the strategic direction and priorities of the country's STI agenda. The National Assembly also plays a legislative role, ensuring that STI policies are integrated into the broader national framework.

1.2. Coordination and Planning

Below the President, the Prime Minister's Office serves as a coordinating body, connecting various ministries involved in STI activities. This coordination is essential to ensure that all aspects of Korea's innovation ecosystem—such as education, health, industry, and finance—are aligned toward common goals.

The Ministry of Science and ICT (MSIT) serves as the primary executive body for STI governance. The ministry houses the STI Office**,** which oversees the development and implementation of STI policies. MSIT collaborates with other key ministries such as:

- **Ministry of Education (MOE)**, which plays a role in developing human capital for STI through higher education and research institutions.
- **Ministry of Trade, Industry, and Energy (MOTIE)**, which focuses on the commercialization and industrial application of STI outputs.
- **Ministry of Health and Welfare (MOHW)**, ensuring the application of STI in the healthcare sector.
- **Ministry of SMEs and Startups (MSS)** and the **Ministry of Economy and Finance (MOEF)**, which focus on funding, supporting, and scaling innovation in small and medium enterprises (SMEs).

Each of these ministries coordinates with agencies and research councils to ensure that STI efforts are aligned with the needs of their respective sectors. Coordination between ministries is a crucial aspect of Korea's STI governance, ensuring that there is no overlap in policy implementation and that resources are efficiently utilized.

2.3.3. Policy Implementation

Policy implementation in Korea's STI governance is managed by a network of Research Councils, Institutes, and Funding Agencies**.** Some of the key organizations include:

- **National Research Council (NRC)** and **National Science and Technology Council (NST)**: These councils oversee various government research institutes (GRIs) such as the **Korea Institute of Science and Technology (KIST)** and **Korea Development**

Institute (KDI). These institutes are responsible for conducting government-funded research that aligns with national STI priorities.

- **Korea Institute of Science and Technology Evaluation and Planning (KISTEP)** and **National IT Promotion Agency (NIPA)**: These agencies play a critical role in evaluating the effectiveness of STI policies and planning future initiatives. Their work ensures that STI programs are data-driven and outcome-oriented.
- **National Research Foundation (NRF)**: It manages competitive grants for research institutions, universities, and companies. The NRF is central to the allocation of research funding, ensuring that resources are distributed based on merit and alignment with national priorities.
- **Korea Evaluation Institute of Industrial Technology (KEIT)** and **Korea Health Industry Development Institute (KHIDI)**: These agencies focus on specific sectors like industrial technology and healthcare, providing funding and support for research and development in these critical areas.

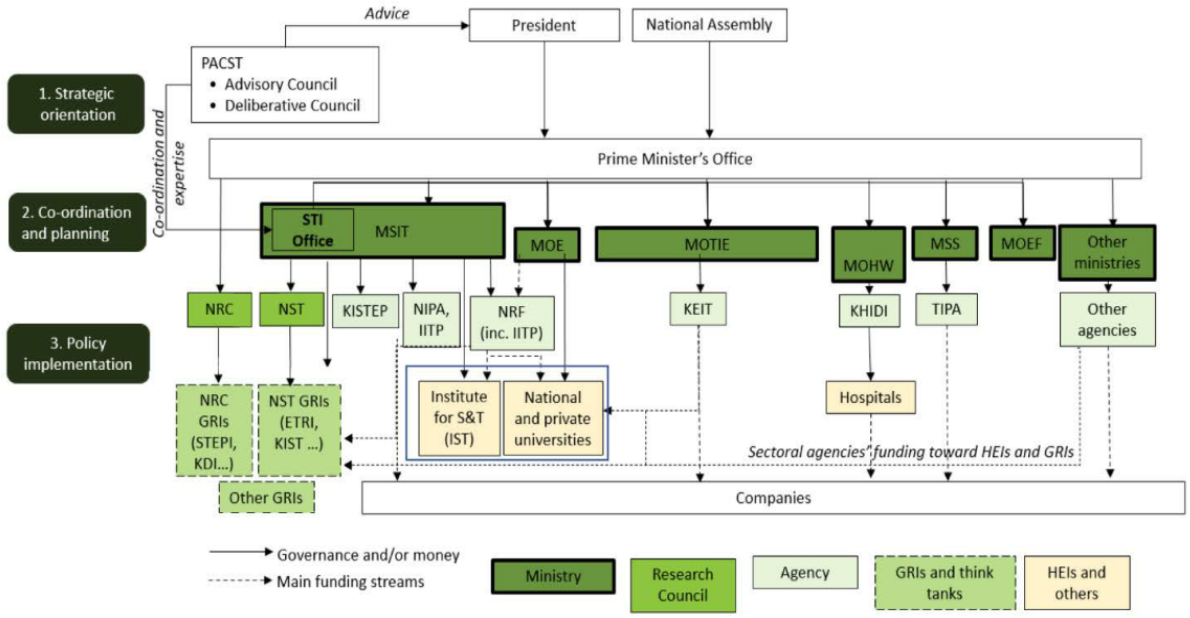
Additionally, Korea's STI governance system includes key research and educational institutions such as **national and private universities**, which are integral to generating knowledge and developing the human capital necessary for sustained innovation.

2.3.4. Sectoral Integration

Korea's STI governance structure reflects a sectoral integration approach, where sectoral ministries and agencies coordinate funding streams to higher education institutions (HEIs), government research institutes (GRIs), and think tanks. For instance, sectoral agencies such as KEIT and KHIDI fund research that is critical for both public health and industrial competitiveness, ensuring that innovation reaches the market and generates tangible economic and societal benefits.

In addition, there is a well-established public-private collaboration mechanism in place, allowing for the seamless integration of government-driven research efforts and industry needs. By engaging companies in the innovation process, Korea's STI system ensures that scientific advancements translate into marketable technologies and services.

Figure 2-1. Korea's STI Governance Structure



Source: OCED (2023), OECD *Reviews of Innovation Policy: KOREA 2023,* p. 55.

Korea's STI governance structure demonstrates a high degree of centralized coordination combined with multi-sectoral integration. The President plays a critical role in setting the STI agenda, while various ministries and agencies ensure that national STI policies are implemented effectively across sectors. This system enables Korea to remain competitive in global innovation rankings, promoting sustained economic growth and technological leadership. The model's success can be attributed to the coordinated efforts between government, research institutions, and industry**,** which work together to create an innovation ecosystem capable of responding to both domestic challenges and global trends.

2.2. STI Governance System

The **Science, Technology, and Innovation (STI) governance system** in South Korea is a highly structured and strategically oriented framework designed to align the nation's long-term science and technology goals with annual planning and budgeting processes. The system involves multiple levels of planning, from a **ten-year strategic vision** to **annual R&D investment and monitoring**, ensuring that innovation policies are consistently updated and aligned with the country's development objectives.

2.2.1. Long-Term Strategic Orientation

At the core of Korea's STI governance system is the **Ten-Year Science and Technology Vision**. This long-term vision is formulated every ten years and serves as a guiding framework for the country's national STI policies. It outlines the strategic direction Korea will take in advancing science and technology, with the aim of boosting national competitiveness and economic growth. The vision is designed to address emerging global challenges and opportunities, ensuring that Korea stays at the forefront of technological innovation.

2.2.2. Five-Year STI Basic Plan

To operationalize the ten-year vision, the **Five-Year Science and Technology (S&T) Basic Plan** is developed. This plan, revised every five years, provides more detailed goals and priorities that align with the overarching ten-year vision. It sets out specific objectives for enhancing Korea's innovation capacity, improving research infrastructure, and promoting the commercialization of scientific discoveries. The **Five-Year S&T Investment Strategy** works in tandem with the basic plan. This strategy details how financial resources will be allocated to meet the objectives of the five-year plan, ensuring that investments in research and development (R&D) are aligned with both national priorities and global trends.

2.2.3. Annual R&D Investment and Guidelines

The next step in the STI governance process involves the development of **annual R&D investment directions and guidelines**. These guidelines ensure that resources are allocated effectively and transparently, in line with the five-year strategic priorities. Ministries are given specific instructions on how to implement the STI goals within their respective sectors, ensuring that R&D activities are not isolated but integrated into the broader economic and societal needs.

2.2.4. Integrated Annual Monitoring and Action Plan

To ensure that Korea's STI policies are not only implemented but also regularly evaluated, an **Integrated Annual Monitoring and Action Plan** is put in place. This annual process allows for:

- The monitoring of previous year's activities, assessing whether they met the defined targets.
- The development of an action plan for the coming year, taking into consideration the lessons learned from the monitoring process. This iterative approach ensures that policies remain adaptive and responsive to both domestic needs and international trends.

2.2.5. Ministerial STI Plans and Action Plans

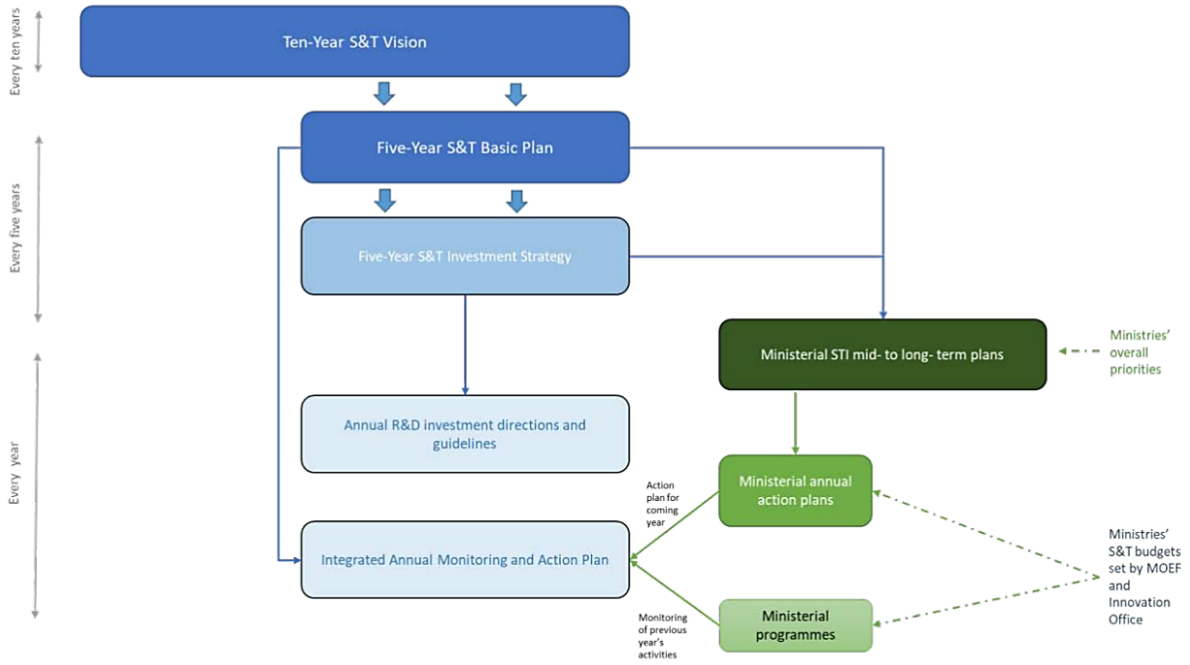
Korea's STI governance system emphasizes the role of individual ministries in implementing national science and technology policies. Each ministry is required to develop mid-to-long-term STI plans, which are aligned with both their specific mandates and the broader national vision. These plans define the overall priorities of each ministry and ensure sectoral integration of science and technology in areas such as health, education, industry, and the environment.

Ministries then develop annual action plans**,** which translate their mid-to-long-term goals into specific programs and projects for the upcoming year. This ensures that STI policies are continuously updated and that ministries remain accountable for their contributions to the national innovation agenda. These ministerial action plans are further linked to ministerial budgets**,** which are allocated based on priorities set by the Ministry of Economy and Finance (MOEF) and the Innovation Office**.**

2.2.6. Continuous Adaptation and Alignment

The governance system depicted in **Figure 2-2.** reflects a highly **dynamic and cyclical process**. While the **ten-year vision** provides long-term stability and direction, the **five-year plans** and **annual action plans** allow for continuous adaptation based on real-time feedback from monitoring activities and changing global circumstances. This ensures that Korea's STI system remains flexible, responsive, and forward-looking, with all policies linked to budget allocations that support national development objectives.

Figure 2-2. Korea's STI Governance System: From long-term strategic orientations to annual programming and budgeting



Source: OCED (2023), OECD *Reviews of Innovation Policy: KOREA 2023,* p. 251.

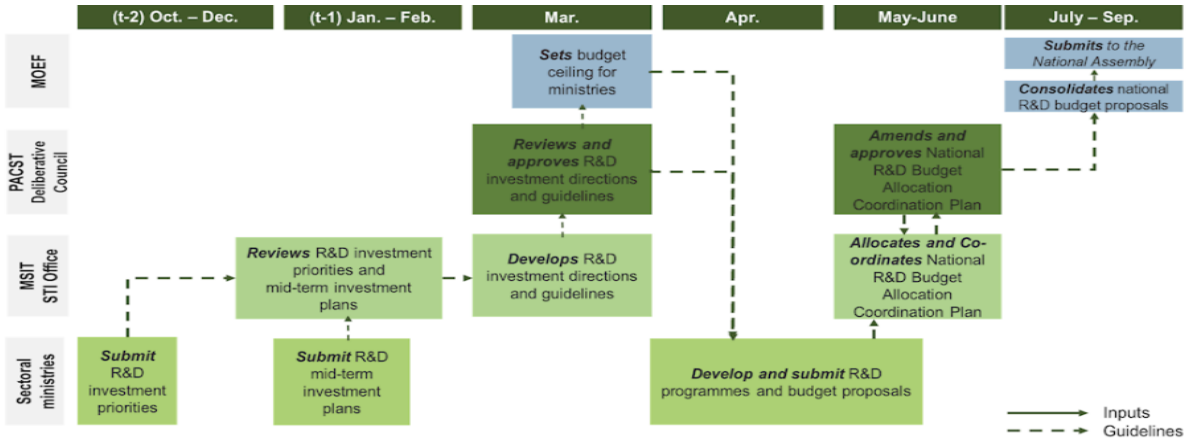
In summary, South Korea's STI governance system is characterized by its long-term vision, strategic planning, and continuous monitoring. The system integrates inputs from various ministries and sectors, ensuring that R&D investments are aligned with national priorities and global trends. By combining ten-year strategic orientations with annual programming and budgeting, the governance system allows Korea to maintain a strong and adaptive innovation ecosystem that drives economic growth and national competitiveness.

2.3. R&D Budgeting Process

The Research and Development (R&D) budgeting and programming process in South Korea is a meticulously structured system designed to align national science, technology, and innovation (STI) policies with the country's long-term developmental objectives. The process involves the coordination of multiple stakeholders, including the Ministry of Economy and Finance (MOEF), the Presidential Advisory Council on Science and Technology (PACST), the Ministry of Science and ICT (MSIT), and various sectoral ministries, ensuring that R&D funding is optimally allocated to meet both national and sectoral priorities. The process spans

an entire fiscal year and involves several stages of planning, review, approval, and coordination, as illustrated in Figure 2-3.

Figure 2-3. Overview of Korea's Annual Budgeting and Programming Process



Source: OCED (2023), OECD *Reviews of Innovation Policy: KOREA 2023,* p. 268.

2.3.1 Early Stages: Setting Priorities and Plans

The R&D budgeting process typically begins in October to December of the previous year (t-2) when sectoral ministries submit their R&D investment priorities and mid-term investment plans to the MSIT. These inputs provide the foundation for aligning sectoral objectives with national goals, ensuring that the specific needs of each ministry are considered within the broader context of Korea's STI strategy. In the following months, from January to February (t-1), the MSIT's STI Office reviews the R&D priorities and investment plans submitted by the ministries. This review process helps to refine and ensure that the proposed investments are in line with Korea's long-term innovation strategy. The result of this review is then passed on to the PACST Deliberative Council, where further evaluation and coordination take place.

2.3.2 Mid Stages: Budget Ceiling and Investment Guidelines

During March, the Ministry of Economy and Finance (MOEF) sets the budget ceiling for each ministry, based on the broader fiscal policy and national financial considerations. The MOEF's role is crucial in ensuring that the available financial resources are aligned with the economic goals of the country and that the budget for R&D is realistically set to match these objectives. Once the budget ceiling is established, PACST reviews and approves the R&D investment directions and guidelines. These guidelines provide a framework for the detailed allocation of R&D resources, ensuring that the budget addresses Korea's national innovation priorities.

Simultaneously, the MSIT STI Office develops the R&D investment directions and guidelines, which form the basis for ministerial programming and ensure that ministries' STI plans align with the national R&D strategy.

2.3.3 Late Stages: Developing and Allocating the R&D Budget

During April, ministries develop their R&D programmes and submit their budget proposals. These proposals are then reviewed by the PACST and the MOEF to ensure that they are consistent with the established guidelines and priorities. The proposed budgets are reviewed to check that they reflect both the financial constraints set by the MOEF and the strategic directions established by PACST.

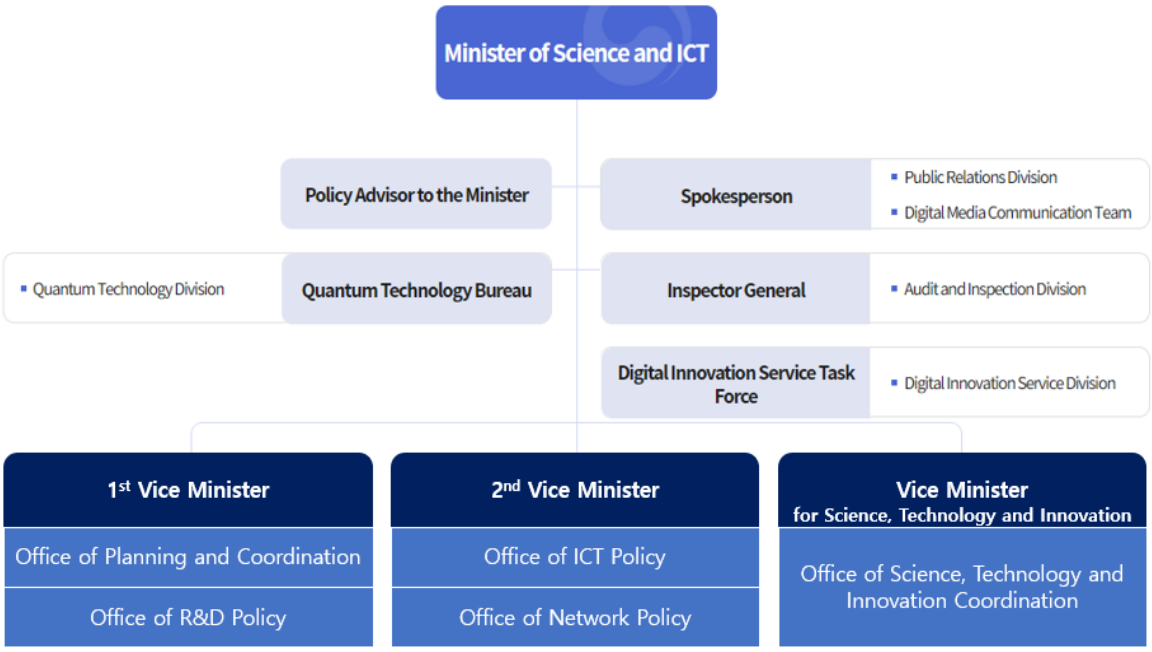
From May to June, PACST and the relevant ministries amend and approve the National R&D Budget Allocation Coordination Plan. This coordination plan ensures that resources are allocated equitably and efficiently across ministries and sectors. The emphasis during this stage is on ensuring that the budget addresses cross-sectoral needs and avoids duplication of efforts in R&D investment.

In July to September, the consolidated National R&D Budget is finalized and submitted to the National Assembly for approval. The submission of the budget to the legislative body ensures that the budget undergoes a final layer of scrutiny and democratic oversight before it is officially adopted.

2.4. Ministry of Science and ICT (MSIT)

The Ministry of Science and ICT (MSIT) in South Korea plays a pivotal role in the country's governance and coordination of science, technology, and innovation (STI). It is tasked with formulating national policies related to science and technology, overseeing information and communication technology (ICT) development, and fostering innovation to enhance Korea's global competitiveness. The ministry's structure reflects a comprehensive and multi-faceted approach to STI governance, with various divisions and bureaus dedicated to planning, coordination, and policy implementation.

Figure 2-4. Ministry of Science and ICT



Source: Korea Ministry of Science and ICT, https://www.msit.go.kr/eng/contents/cont.do?sCode=eng&mPid=19&mId=25

2.4.1. Leadership and Key Roles

At the top of the MSIT hierarchy is the Minister of Science and ICT, who is supported by several advisory and task-specific roles, including:

- Policy Advisor to the Minister: This individual provides strategic counsel to the Minister, ensuring that decisions align with the broader STI vision of the country.
- Quantum Technology Bureau: A specialized division focusing on quantum technologies, an emerging field that Korea views as critical for its future technological leadership.
- Digital Platform Government Support Task Force: A unit dedicated to supporting Korea's transition to a digital government platform, reflecting the growing importance of ICT in public administration.

The Ministry also includes a Spokesperson and Inspector General roles, ensuring transparent communication with the public and accountability within the ministry. The Spokesperson oversees public relations, while the Inspector General manages internal audits and inspections, ensuring that operations adhere to legal and ethical standards.

2.4.2. Vice Ministers and Key Divisions

The Ministry is divided into several bureaus and divisions, overseen by three Vice Ministers, each responsible for different areas of the Ministry's mandate.

① 1st Vice Minister: Office of Planning and Coordination

The first vice minister's office is responsible for high-level strategic planning and coordination. This includes the Policy Planning Bureau, which comprises:

- Planning and Finance Division: Responsible for budgetary oversight and ensuring that financial resources are allocated effectively across STI initiatives.
- Organization and Management Innovation Division: Focused on internal organizational development and the continuous improvement of management systems within the ministry.

② 2nd Vice Minister: Office of ICT Policy

The second vice minister focuses on ICT policy, critical for maintaining Korea's leadership in global technology sectors. The ICT Policy Bureau is composed of several key divisions:

- ICT Policy Coordination Division: This division ensures that ICT policies are aligned with broader national priorities, promoting integration across different governmental sectors.
- Digital Society Planning Division: It oversees the digital transformation of Korean society, focusing on infrastructure and policy development to foster a fully digitalized economy.
- Digital Industry Policy Division: This division is responsible for policies supporting Korea's digital industries, including the tech sector and ICT-driven enterprises.

③ Vice Minister for Science, Technology, and Innovation

The third vice minister is responsible for coordinating policies related to science and technology. The Office of Science, Technology, and Innovation Coordination manages the following bureaus:

- Science and Technology Policy Bureau: This bureau handles national policies aimed at fostering innovation, supporting research and development (R&D), and promoting scientific advancements. It plays a critical role in ensuring that Korea remains competitive in global scientific research.

2.4.3. Specialized Divisions

The Quantum Technology Division under the Quantum Technology Bureau is a notable example of Korea's focus on cutting-edge technologies. As quantum technologies have the potential to revolutionize areas such as computing, cybersecurity, and communications, this division represents Korea's commitment to staying ahead in frontier technologies. The Digital Platform Government Support Task Force is also key to Korea's transition toward a more efficient, transparent, and digitalized governance model. By providing support to the digital transformation of governmental services, this task force ensures that technology is used to enhance public service delivery and administration.

2.4.4. Coordinated Approach to National Priorities

The structure of the MSIT reflects South Korea's comprehensive and coordinated approach to managing its STI priorities. By dividing responsibilities across three vice ministers, the ministry can simultaneously address broad areas like strategic planning, ICT policy, and science and technology innovation. This allows the ministry to effectively integrate technological advancements into all sectors of the economy, ensuring that Korea remains at the forefront of global innovation. The Ministry of Science and ICT is not only a central institution for Korea's scientific and technological progress but also a model of how structured governance can promote innovation across multiple sectors.

2.5. Presidential Advisory Council on Science & Technology (PACST)

The **Presidential Advisory Council on Science and Technology (PACST)** is a key consultative body that plays a critical role in shaping South Korea's science and technology policy framework. The council ensures that national policies in science, technology, and innovation (STI) are aligned with the country's broader economic and social development objectives. PACST operates through three primary components: the **General Meeting**, **Advisory Council**, and **Deliberative Council**, each of which serves distinct but complementary functions in the decision-making process.

Figure 2-5. PACST: Organisational Structure

Source: Presidential Advisory Council on Science & Technology (PACST) https://www.pacst.go.kr/

2.5.1. Structure and Functions

① General Meeting

The **General Meeting** serves as the main platform for deliberation among all PACST members. It is composed of the full assembly of council members who meet to discuss significant matters related to the functioning and strategic direction of the PACST. The General Meeting provides an inclusive forum where all council members have the opportunity to present their perspectives and opinions, ensuring that policy decisions reflect a broad range of insights.

The responsibilities of the General Meeting include deliberating on the operational aspects of PACST and making decisions on major science and technology issues that require collective input. This body is particularly important for addressing high-level policy concerns and ensuring the coordination of national STI efforts.

② Advisory Council

The **Advisory Council** of PACST is tasked with providing expert advice on critical issues pertaining to science and technology. This council consists of 13 civilian committee members, which include prominent figures from academia, industry, and public administration. The council is chaired by the President of South Korea, with the Vice Chairperson and several secretaries acting as key aides in delivering advice on complex STI matters. A notable feature of the Advisory Council is the presence of a subcommittee, which is responsible for conducting

preliminary reviews of issues before they are brought to the full Advisory Council. This subcommittee plays a crucial role in filtering and analyzing policy proposals, allowing the Advisory Council to focus on the most pertinent and strategically important matters. By performing an advisory function, this council ensures that science and technology policies are based on expert knowledge and reflect current trends in innovation.

③ Deliberative Council

The **Deliberative Council** focuses on the detailed evaluation and refinement of national STI policies. It is composed of 11 civilian council members, alongside 5 government officials, who provide direct insights into how STI policies can be effectively implemented within the national framework. The President chairs this council as well, supported by the Vice Chairperson and other key government officials from relevant ministries and agencies involved in STI governance. The main function of the Deliberative Council is to engage in in-depth discussions about science and technology policies that require further clarification or adjustments. This council's deliberations ensure that policies are not only technically sound but also aligned with the strategic priorities of the nation. The council works closely with other governmental bodies to translate high-level policy decisions into actionable programs that can be implemented across various sectors.

④ Integrated Structure and Function

The PACST structure is designed to facilitate a seamless interaction between strategic advice, deliberation, and operational decision-making. The General Meeting ensures wide participation from all members, while the Advisory Council provides specialized knowledge to shape policy directions. Meanwhile, the Deliberative Council is responsible for fine-tuning policies and ensuring their coherence with national priorities. These components create a dynamic decision-making environment where expert knowledge, high-level policy insights, and stakeholder inputs are combined to drive Korea's national STI strategy. PACST's integrated approach allows for the effective governance of science and technology initiatives, fostering an innovation-driven environment that supports Korea's leadership in global STI development. By maintaining this tripartite structure, PACST is able to provide the South Korean government with actionable and well-rounded recommendations, ensuring that STI policies are both forward-looking and responsive to the evolving technological landscape.

2.5.2. Councils and Missions

PACST is composed of three key councils: the Plenary Council, the Advisory Council, and the Deliberative Council. Each council plays a distinct role in the formulation, evaluation, and promotion of science, technology, and innovation (STI) strategies. These councils operate through various subcommittees, ensuring that each aspect of S&T policy is thoroughly reviewed and aligned with national goals.

① Plenary Council

At the top of the PACST structure is the Plenary Council, which serves as the overarching decision-making body that incorporates all members of PACST. The Plenary Council is tasked with reviewing and approving major policies and proposals related to STI. Its mission is to provide comprehensive oversight over the development of S&T strategies, ensuring that the national agenda remains cohesive and forward-looking. Through the Plenary Council, PACST is able to centralize discussions on the country's long-term science and technology goals, while addressing cross-sectoral challenges that require coordinated solutions.

② Advisory Council

The Advisory Council plays a pivotal role in providing expert advice on specialized areas of science and technology. It consists of civilian members, with up to 20 experts from academia, industry, and other relevant sectors. The Advisory Council is divided into three subcommittees that reflect critical domains of S&T policy development:

- **Science and Technology Infrastructure Subcommittee:** This subcommittee focuses on the development of foundational infrastructure necessary for advancing scientific research and technological innovation. It addresses issues related to the physical and institutional support systems required for a robust S&T ecosystem.
- **Science and Technology Innovation Subcommittee:** This group focuses on driving forward innovative solutions and policies that promote technological advancement across industries. The mission of this subcommittee is to ensure that Korea remains at the cutting edge of global innovation.
- **Science and Technology Society Subcommittee:** This subcommittee deals with the social implications of technological advancement. It explores how S&T policies can be

designed to address societal challenges, foster inclusivity, and ensure that the benefits of technological progress are distributed equitably.

Each subcommittee under the Advisory Council is responsible for conducting in-depth reviews and providing recommendations on specific areas of concern, allowing PACST to maintain a focused and specialized approach to S&T governance.

③ Deliberative Council

The Deliberative Council has a complementary role to the Advisory Council but involves both civilian and government members, with up to 20 participants. This council is tasked with conducting thorough deliberations on proposed S&T policies, ensuring that they align with the government's overarching priorities and can be effectively implemented across various sectors. The Deliberative Council is supported by four specialized bodies:

- **Steering Committee:** This committee manages the overall operations of the Deliberative Council, ensuring that the council's agenda remains focused and that all members are fully engaged in policy discussions.
- **Special Committee**: The Special Committee handles ad-hoc issues and topics of immediate concern to the council. It ensures flexibility within the council's operations, allowing PACST to adapt quickly to emerging challenges or opportunities in the S&T landscape.
- **Local Science and Technology Promotion Council:** This body focuses on promoting S&T development at the local level, ensuring that regional needs and capabilities are integrated into the national S&T strategy. It emphasizes the importance of fostering innovation across all parts of the country, not just in major urban centers.
- **Fundamental Research Promotion Council:** This council is tasked with promoting basic research, which is crucial for long-term scientific and technological breakthroughs. By prioritizing fundamental research, PACST ensures that Korea continues to build its knowledge base and supports the early stages of the innovation pipeline.

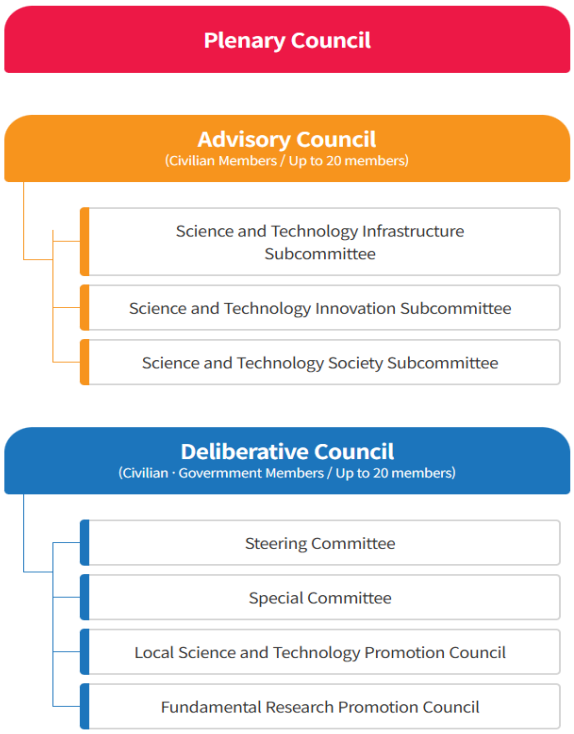
④ Mission of PACST's Councils

The integrated mission of PACST's councils is to strengthen Korea's position as a global leader in science and technology by providing comprehensive, multi-faceted advice on national S&T policies. The councils work in tandem to ensure that policies are not only scientifically sound but also feasible, sustainable, and aligned with both domestic needs and international trends.

The Advisory Council offers expert guidance on specialized areas of policy development, while the Deliberative Council ensures that these recommendations are practically implemented within the broader governmental framework. The Plenary Council brings these discussions together, providing a unified platform for decision-making that takes into account the various inputs from the advisory and deliberative bodies.

In sum, the PACST structure allows for a coordinated approach to STI governance, ensuring that both high-level strategic goals and sector-specific needs are addressed. This system of governance promotes innovation, advances technological capabilities, and supports Korea's long-term economic and social development.

Figure 2-6. PACST: Councils and Missions



Source: Presidential Advisory Council on Science & Technology (PACST) https://www.pacst.go.kr/

2.5.3. Composition of Members

PACST comprises a diverse group of individuals who play a crucial role in shaping South Korea's science, technology, and innovation (STI) policies. The membership of PACST is strategically designed to integrate both civilian and government expertise, ensuring that the council's decisions are well-rounded and reflective of a wide array of perspectives. The total number of members does not exceed 30, and these individuals are divided into two main categories: **civilian members** and **government members**.

① Civilian Members

The **civilian members** of PACST are professionals appointed by the Chairperson, who is the President of South Korea. These members are selected based on their extensive experience and knowledge in fields relevant to science and technology, as well as in other important sectors such as politics, economics, society, and culture. This broad expertise ensures that the council benefits from a variety of viewpoints, allowing for a more comprehensive and interdisciplinary approach to policymaking. Civilian members serve a **term of one year**, during which they contribute their expertise to the council's discussions and deliberations. Their input is particularly valuable in ensuring that science and technology policies are aligned with societal needs and economic realities, as well as in addressing broader political and cultural implications.

② Government Members

The government members of PACST include high-ranking officials from key government ministries and agencies, as outlined by a Presidential Decree. These individuals occupy crucial roles in the central government and are responsible for implementing the policies that PACST helps to shape. The government members include:

- Minister for Strategy and Finance
- Minister of Education
- Minister of Science and ICT
- Minister of Trade, Industry, and Energy
- Minister of SMEs and Startups
- Presidential Secretary in charge of science and technology affairs

The inclusion of government members ensures that the council's recommendations are grounded in the practical realities of governance and public administration. These officials bring to the council an in-depth understanding of the institutional mechanisms through which science and technology policies are executed, making them vital in translating PACST's strategic insights into actionable governmental policies.

The combination of civilian and government members allows PACST to benefit from both academic and practical expertise. Civilian members provide innovative ideas, critical analyses, and societal perspectives, while government members ensure that these ideas are feasible within the governmental framework.

<Rwanda: STI policy and governance of research and development>[1]

- By the approval of the 2005 policy, the Ministry of Education took over the then-Ministry responsibilities of science, technology and scientific research. The Ministry of Education introduced the Department of Science, Technology and Research (DSTR) in 2009 in order to coordinate national research, operate R&I funding, manage regulation and oversee the policy implementation.
- The Rwandan Leadership created the National Council for Science and Technology (NCST), and the responsibility of national research coordination moved to the NCST from the Ministry of Education. In that process, the DSTR was downsized and transformed into a specialized unit focusing on education for science, technology, research and innovation.
    - The Minister of Education was designated as co-chair of NCST.
    - The NCST was located under the Prime Minister's office as a think-tank as well as advisory body for all ministries.
- The Rwandan Leadership promoted the NCST to the President's office and assigned duties of R&D funding additionally in 2017.
    - The promotion of NCST as the highest office has solved a series of issues in government structure, policy governance as well as research coordination.
    - The mandate of R&I funding along with its budgetary autonomy has provided a strong incentive to NCST for negotiating R&I funds with private and public research entities as well as the government.

[1] Twiringiyimana et al. (2021), "STI policy and governance in Sub-Saharan Africa: Fostering actor's interaction in research and innovation".

- In 2019, the Rwandan Leadership created the Ministry of Information and Communication Technology (ICT) and Innovation, and assigned the main mandate of providing policies on ICT and innovation.

<Rwanda: STI policy and governance of research and development>[2]

- In 2019, the revised STI policy was approved in South Africa, and the STI governance has changed as a result. The Department of Science and Technology (DST) and the Ministry of Higher Education and Training were merged in this change.
    - The Ministry of Higher Education and S&T was formed to enhance R&I and S&T based innovation.
    - The role of STI policy is emphasized in transiting to the knowledge-based society on the basis of the structural change in governance.
    - However, this complex structure with dual mandates can face conflicts of prior setting and operational inefficiencies.
    - For example, the issues in education and research may be more popular than those in science and technology, so funding can be more oriented toward education and research.
    - Thus, there should be internal mechanism that can secure check-and-balance between dual mandats.

3. Zambia NIS Governance Framework

3.1. Conceptualizing NIS Governance 1: Zambia NIS Working group Survey

In preparation for developing a National Innovation System (NIS) governance framework, a survey was conducted among key stakeholders, including representatives from various government ministries in Zambia. The purpose of the survey was to gather insights and recommendations on the structure, roles, and expectations for the NIS governance framework. The following sections provide a detailed description of the survey findings, categorized by the key questions posed to the respondents.

[2] Twiringiyimana et al. (2021), "STI policy and governance in Sub-Saharan Africa: Fostering actor's interaction in research and innovation".

3.1.1. Recommendations and Ideas for the NIS Governance Framework in Zambia

The first question of the survey aimed to gather recommendations and general ideas about the potential structure and functionality of Zambia's NIS governance framework. Several important themes emerged from the responses:

- **Presidential leadership and private sector involvement:** A significant number of respondents recommended that the governance framework be chaired by the highest office (the President), ensuring that all ministries are obligated to align their activities with national innovation strategies. Additionally, respondents emphasized the critical role of private sector involvement, suggesting that private sector actors be incentivized to contribute to innovation through public-private partnerships (PPP). Think tanks and advisory boards were also recommended to promote accountability and provide expert insights to policymakers.
- **Cross-sectoral coordination**: Respondents suggested that the framework should ensure distinct separation of powers between policymakers, implementers, and regulators, with roles clearly defined to avoid overlaps. This would enhance efficiency and accountability within the system.
- **Inclusion of additional ministries:** Several respondents recommended the inclusion of the Ministry of Education in the NIS secretariat, given the essential role academia plays in fostering innovation. Additionally, the Ministry of Justice was suggested to provide legal guidance on the governance framework's implementation.

These recommendations underscore the need for an inclusive and flexible governance model that prioritizes both public and private sector engagement, with a clear mandate from the highest office to ensure cross-sectoral alignment.

3.1.2. Expected Role of Private Sectors in the NIS Framework

The second section of the survey focused on the expected role of private sector actors in Zambia's NIS governance framework. The responses highlighted the following key roles:

- **Bridging innovation with market needs:** Respondents stressed the importance of the private sector in translating scientific innovation into market-driven solutions. This includes contributing to the formulation of R&D investment strategies, assessing market feasibility, and providing input on risk tolerance to ensure sustainable innovation.
- **Providing feedback and evaluation:** The private sector is expected to offer quick feedback on the workability of policies, due to its ability to operate with less bureaucracy. This feedback would help identify gaps in policy implementation and support timely adjustments.
- **Sustainable development:** Private sector actors would also play a role in advancing sustainable development, particularly by adopting new technologies and knowledge in their business models and contributing to value-added processes, such as the use of locally developed technologies to enhance raw material processing.
- **Cross-sector expertise**: The private sector is expected to contribute to policy formulation, risk assessment, and technological advancements, leveraging their expertise to ensure the framework remains adaptable to evolving challenges such as cybersecurity.

This response reflects a strong expectation for the private sector to serve as a key driver of innovation within the NIS, bridging the gap between research and commercialization.

3.1.3. Suggested Forms of Participation of Private Sectors in the NIS Framework

Building on the expectations of the private sector's role, respondents provided suggestions on the form of participation that private sector actors should have within the NIS governance framework. The main forms of participation identified are:

- **Policy formulation and governance:** The private sector should be involved in policy formulation, particularly through entities like the Ministry of Small and Medium Enterprises (SME) and the Ministry of Commerce. Private sector representatives would provide input and feedback during the development and revision of policies, ensuring that the policies are aligned with industry needs.
- **Regular consultations and workshops:** Respondents recommended the establishment of industry-specific workshops where private sector actors can provide real-world

insights into policy development. Designated representatives from the private sector should also be included in key decision-making processes to ensure their perspectives are integral to the development of the NIS framework.

- **Transparent communication channels**: Another common suggestion was the creation of transparent communication channels between the public and private sectors. This would enable continuous collaboration, particularly on issues like cybersecurity resilience. Regular joint exercises, such as simulated cyber-attacks, could be used to test the resilience of the NIS framework and ensure both sectors are aligned in their approach to innovation.

These suggestions highlight the need for formalized and continuous interaction between the public and private sectors, ensuring that private sector perspectives are integrated into policy decisions and that there is ongoing collaboration.

3.1.4. Additional Opinions on the NIS Governance Framework

The final section of the survey asked respondents to provide any additional opinions on the NIS governance framework. Key points raised include:

- **Integration with national development goals:** Respondents emphasized the importance of ensuring that the NIS framework is closely aligned with Zambia's Vision 2030 and the 8th National Development Plan, as well as the Sustainable Development Goals (SDGs).
- **Clarification of roles and mandates:** Several respondents called for clear definitions of the roles and responsibilities of each ministry and institution involved in the NIS. This clarity would ensure that each entity is held accountable for its contribution to the innovation system.
- **Cybersecurity**: Given the growing concerns around cybersecurity threats, respondents recommended that the framework be regularly updated to address these challenges. This includes collaboration with international partners and continuous training for cybersecurity professionals, as well as public awareness campaigns.
- **Vice-presidential involvement:** One suggestion was to assign the Vice President as the chair of the NIS governance framework, particularly given the President's busy schedule. This would still provide high-level leadership while allowing for more direct involvement in the day-to-day management of the system.

The survey results highlight a strong consensus among Zambia's government ministries on the importance of creating a flexible, inclusive, and well-coordinated NIS governance framework. The involvement of the private sector is seen as essential for driving innovation, while the need for clear roles, transparent communication, and alignment with national development goals is emphasized. As Zambia moves forward with the development of its NIS governance framework, these insights will be critical in shaping a system that supports the country's innovation ecosystem and fosters sustainable development.

3.2. Conceptualizing NIS Governance 2: KOREA's PACST case

The development of an effective National Innovation System (NIS) governance framework in Zambia can benefit significantly from benchmarking against international best practices. One such model is South Korea's Presidential Advisory Council on Science and Technology (PACST), a central body in Korea's STI governance structure. The PACST functions through a system of Advisory and Deliberative Councils, as illustrated in Korea's STI governance structure, which ensures strategic coordination and expert input in national policy-making processes. Zambia can draw essential lessons from the structure and functions of PACST's councils when establishing its own NIS governance committee to ensure effective innovation governance.

3.2.1. The Role of Advisory and Deliberative Councils in Strategic Orientation

In Korea's PACST model, the Advisory and Deliberative Councils are key in shaping the country's science, technology, and innovation (STI) policy. The Advisory Council provides high-level guidance and expert advice, drawing from civilian experts in academia, industry, and research. The Deliberative Council, on the other hand, focuses on evaluating policies and ensuring alignment between governmental actions and broader national goals. Both councils work in tandem to ensure that STI policies are strategically oriented, integrating expertise across sectors and providing a feedback loop for continuous improvement of policy implementation.

For Zambia, benchmarking this dual-council model would be valuable in establishing a similarly structured NIS governance committee. By creating an Advisory Council composed

of leading experts from academia, industry, and government, Zambia could ensure that its innovation policies are informed by evidence-based insights and are aligned with global STI trends. Additionally, forming a Deliberative Council would enable Zambia to scrutinize policies, ensuring that the NIS governance framework remains responsive to both domestic priorities and global challenges, such as the need for digital transformation and sustainable development.

3.2.2. Coordinating Policy Development and Planning

In Korea, the PACST's Advisory and Deliberative Councils coordinate with the Ministry of Science and ICT (MSIT) and other key ministries (e.g., Ministry of Education, Ministry of Trade, Industry and Energy) to ensure that science and technology policies are well-integrated across sectors. This structure provides a clear link between the high-level advice of the PACST and the operational activities of government ministries. The councils also facilitate coordination between strategic planning and budget allocation, ensuring that resources are directed toward key areas of innovation, research, and development.

Zambia can learn from this coordination mechanism by ensuring that its NIS governance framework includes structured communication channels between the proposed committee and various governmental ministries. Establishing a similar framework for cross-ministerial collaboration would enable Zambia to align its innovation policies with national development plans, such as Vision 2030. By doing so, Zambia's NIS can ensure that resources are allocated efficiently and that the efforts of the Ministry of Technology and Science, the Ministry of Commerce, and the Ministry of Education are synchronized to support national innovation goals.

3.2.3. Emphasis on Flexibility and Responsiveness

The Deliberative Council within Korea's PACST ensures flexibility in governance by allowing for continuous feedback and adjustments to existing policies. This responsiveness is critical in addressing emerging global challenges, such as climate change, digital transformation, and cybersecurity. The Deliberative Council is empowered to review and propose modifications to policies based on real-time challenges and opportunities, ensuring that Korea's STI governance remains adaptive.

Zambia can adopt this adaptive governance model by ensuring that its NIS governance committee, through a Deliberative Council, is capable of evaluating policies on a regular basis. Such a council would serve as a platform for reviewing innovation strategies, identifying gaps, and making necessary adjustments to ensure the NIS governance framework is agile and responsive to new technologies, market trends, and socio-economic shifts.

3.2.4. Public-Private Collaboration and Inclusivity

A central feature of Korea's PACST is its emphasis on public-private collaboration. The Advisory Council is composed of experts from academia, the private sector, and public institutions, ensuring a comprehensive approach to STI policy development. This model recognizes that innovation is not solely the domain of the public sector but also relies on the input, expertise, and investments of private industry. By including a broad range of stakeholders in the governance process, PACST ensures that innovation ecosystems are nurtured and that policy outcomes are aligned with both public and private sector needs.

Zambia can benchmark this collaborative approach by establishing an NIS governance framework that actively engages the private sector and civil society in its decision-making processes. This could be achieved by forming an Advisory Council that includes representatives from leading industries, technology firms, and academic institutions. Such collaboration would ensure that Zambia's innovation policies are practical and market-oriented, facilitating the commercialization of scientific research and encouraging private-sector investments in R&D.

3.2.5. Accountability and Strategic Alignment

The inclusion of the President and the National Assembly in the governance structure of Korea's PACST ensures that STI policies are politically aligned with the country's national development agenda. This high-level oversight provides accountability and ensures that innovation is prioritized at the highest levels of government. Additionally, the involvement of top political figures ensures that PACST's recommendations are integrated into broader policy-making processes, such as budgetary planning and national economic strategies.

Zambia could learn from this model by ensuring that its NIS governance framework has direct political oversight from either the President or Vice President. This would ensure that the

proposed committee's decisions are aligned with national priorities and that innovation governance is integrated into broader national strategies, such as economic diversification, job creation, and technological advancement.

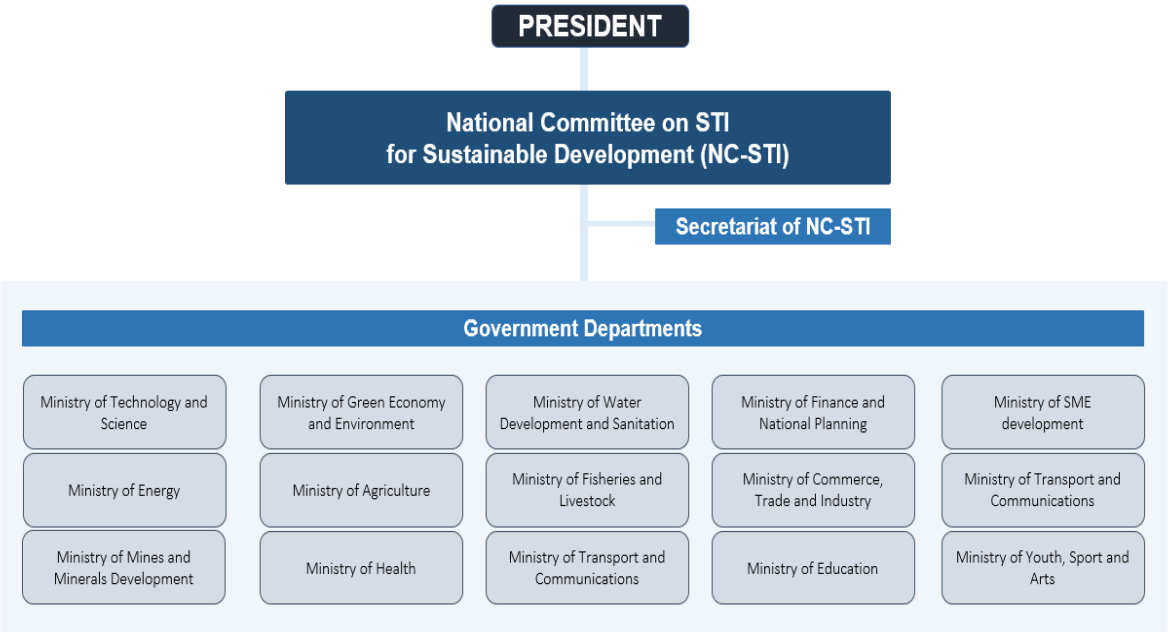
By benchmarking Zambia's NIS governance framework from Korea's PACST model, Zambia can build an effective committee that drives innovation across sectors. Additionally, Zambia can benefit from ensuring high-level political oversight, fostering public-private collaboration, and maintaining flexibility in its governance structures to address emerging challenges and opportunities. These elements will be crucial in developing a sustainable and impactful NIS governance framework that supports Zambia's long-term innovation and development goals.

3.3. Final Version of Zambia NIS Governance Framework

To design and implement Zambia's national innovation system, the establishment of the **National Committee on Science, Technology, and Innovation for Sustainable Development (NC-STI)** is proposed. (Figure 2-7)

The proposed National Innovation System (NIS) Governance Framework for Zambia presents a centralized and strategic structure designed to advance the country's innovation and sustainable development agenda. The National Committee on Science, Technology, and Innovation for Sustainable Development (NC-STI) may serve as the central coordinating body, overseeing the formulation, implementation, and monitoring of STI policies in Zambia. This governance framework emphasizes cross-sectoral coordination, bringing together various ministries and stakeholders to ensure that science and technology play a pivotal role in driving national growth and addressing global challenges.

Figure 2-7. Final version of Zambia NIS Governance Framework



At the top of the governance structure is chaired by the President of Zambia. The inclusion of the President as the chairperson ensures high-level political commitment, which is crucial for mobilizing resources, securing cross-ministerial coordination, and ensuring that STI policies are aligned with Zambia's broader national development goals, including its Vision 2030 and the Sustainable Development Goals (SDGs). This committee can have functions as the deliberation and decision-making body, tasked with reviewing and approving national STI policies, strategies, and the allocation of the R&D budget.

▣ Role of the Secretariat: Ministry of Technology and Science

The Ministry of Technology and Science (MTS) plays a central role in the governance framework, acting as the secretariat of the National Committee on STI. In this capacity, the MTS is responsible for:

- **Setting the National STI Committee agenda:** The Ministry will coordinate the policy discussions and ensure that all relevant issues concerning science and technology are addressed within the committee.
- **Drafting the National R&D Budget**: The MTS will develop a national budget for research and development (R&D), which will be reviewed and approved by the

National Committee. This budget will be critical for allocating resources to priority areas of innovation and research.

▣ Multi-Ministerial Collaboration

One of the key strengths of this proposed governance model is its emphasis on cross-sectoral collaboration. The governance framework includes representatives from several line ministries, each playing a critical role in the advancement of STI policies. The inclusion of these ministries ensures that the NIS governance framework addresses sector-specific needs while promoting a cohesive and integrated approach to national innovation. For instance, the Ministry of Agriculture and the Ministry of Health can focus on leveraging STI for advancements in agricultural technologies and health innovations, respectively, while the Ministry of SME Development can ensure that innovations are commercialized and scaled within the private sector.

▣ Public and Private Sector Participation

The governance framework emphasizes the need for public-private collaboration, with the private sector actively involved as members of the National Committee. This inclusion reflects the recognition that innovation is not solely the domain of the public sector. The private sector plays a pivotal role in commercializing scientific research, investing in new technologies, and driving market-oriented innovation. Their involvement will ensure that policies are practical, market-driven, and aligned with industry needs. By fostering a triple-helix model of collaboration—integrating government, academia, and industry—the NIS governance framework promotes a holistic innovation ecosystem. This ecosystem is essential for addressing Zambia's development challenges, fostering economic growth, and ensuring the country's competitiveness in the global knowledge economy.

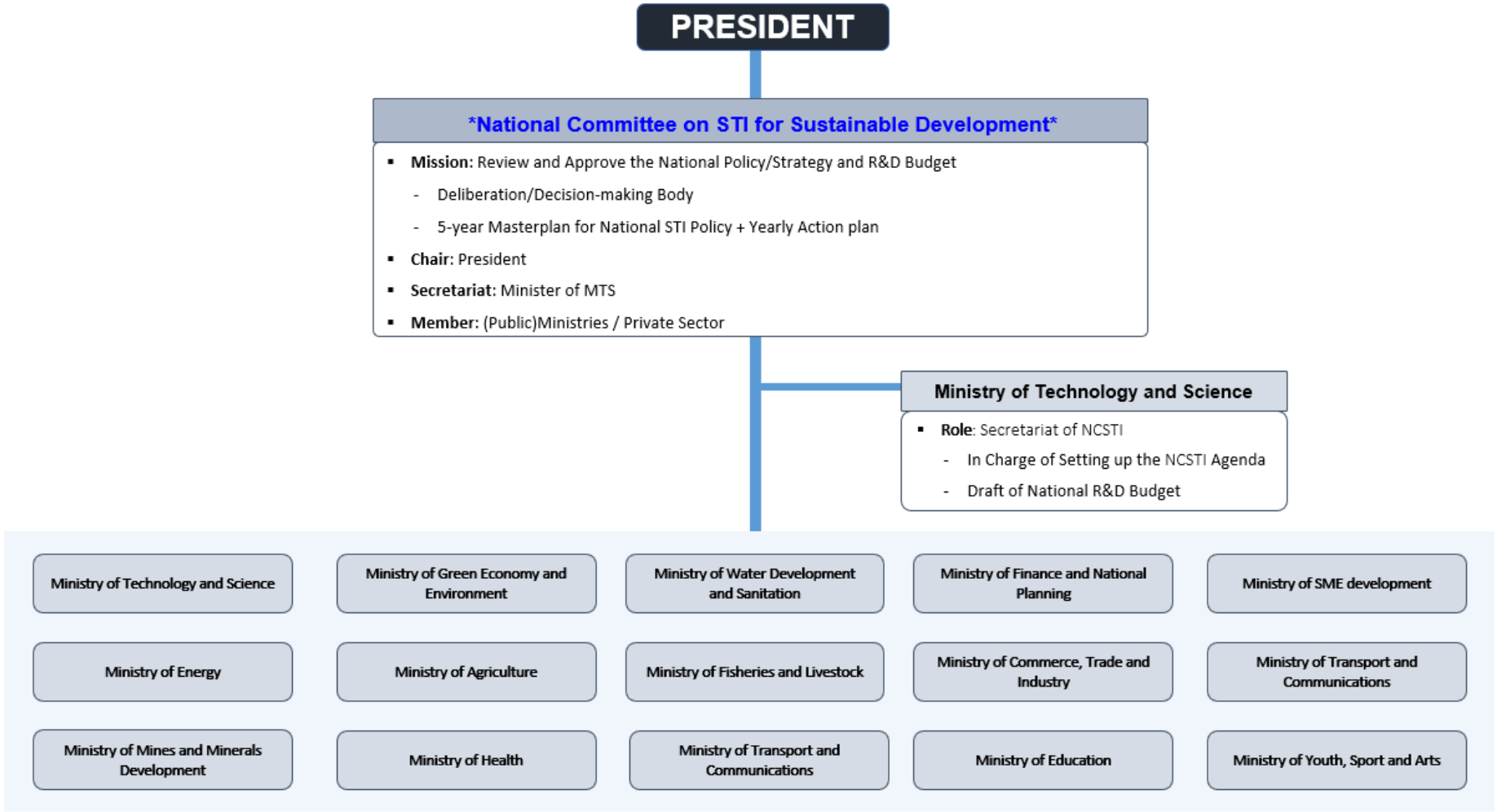
▣ Accountability and Strategic Alignment

The governance framework's structure is designed to ensure accountability and strategic alignment with national priorities. The President's chairmanship of the National Committee ensures that STI remains at the forefront of Zambia's development agenda, while the MTS's secretariat role ensures that the committee's decisions are efficiently implemented across

ministries. Moreover, the creation of a five-year master plan for STI provides a long-term strategic direction, with clear performance targets and regular monitoring to ensure that objectives are met. The inclusion of line ministries from a broad range of sectors ensures that STI policies are integrated across all facets of government, supporting Zambia's efforts to build a knowledge-based economy.

The suggested Zambia NIS governance framework provides a thorough and inclusive approach to promoting innovation, utilizing science and technology to advance sustainable development. With decision-making centralized under the NC-STI for Sustainable Development, led by the President, the framework ensures strong political alignment and effective cross-sector collaboration. The Ministry of Technology and Science plays a pivotal role, overseeing policy execution and budget planning, while the involvement of various line ministries ensures that STI policies address sector-specific challenges and opportunities. This governance structure lays the foundation for Zambia's shift toward a knowledge-based economy, encouraging innovation and growth aligned with the country's national development goals.

Figure 2-8. Detailed Structure of National Committee on STI for Sustainable Development (NC-STI)



Chapter 3.
NIS Roadmap

Executive Summary

The NIS roadmap for Zambia has 4 key domains, which are governance, science and technology, human capital and research. NIS roadmap for governance domain includes policy targets such as 'align all research funding', 'operationalize and coordinate the NRA', 'design a robust legal and policy framework for STI', and 'establish a STI think tank'. To implement the roadmap for governance, 'mapping of existing collaborators', 'review national research agenda', 'stakeholder engagement for the review and development of the S&T Act', 'formulation of policies', 'writing of white papers' and 'establish an interim think tank committee' are suggested by 2025 as a phase 1. In phase 2(2026~2027), 'establishment and review of S&T Act' is needed. In phase 3(2027~2028), 'operationalize the NIA budget', 'formulate action plans for operation', 'set up and review the research and innovation units in all ministries working group', 'operationalize the Act', 'finalized formulation of all policies to guide operation of the NIA', 'introduce fiscal policies for innovation', 'data collection for R&D data base' are expected.

NIS roadmap for S&T domain includes policy targets such as 'strengthen linkages between and among STI stakeholders', 'enhance practical application of STI in all economic sectors', 'enforce intellectual property regimes', 'acquire and upgrade STI training infrastructure and R&D academic institutions'. To implement the roadmap for S&T, 'stakeholder engagement to familiar with S&T goals and research goals', 'review technology transfer and commercialization guidelines', 'develop national technological innovation plan', 'develop fiscal policies to increase growth in total factor productivity through technological innovations', 'writing of white papers to repeal patents act', 'review to strengthen the institutional and national IP policies' are supposed to be implemented by 2025. In phase 2(2026~2027), 'conduct feasibility study for establishing the public prototyping center', 'repeal the Patent Act' will be done. In phase 3(2027~2028), 'operationalize technology transfer guideline', 'stimulate private sector involvement in financing', 'operationalize new Patents Act' are expected to be implemented.

NIS domain for human capital includes policy target such as 'promote STEM graduates and skilled technicians in the core sector to 70%'. To implement the roadmap for human capital, 'review of current STEM curricula at all levels of education' is done by 2025. In phase

2(2025~2027), ‘creation of incentives to stakeholders for provision of scholarship and total involvement in STEM education’, ‘improve collaboration with international partners and experts’ need to be done. In phase 3(2027~2028), ‘implement internationally assisted programs for student exchange’ is expected.

NIS domain for research includes policy targets such as ‘increase R&D investment to 2% of GDP’, ‘increase number of researchers and scientists by 20%’, ‘create a data base for all scientific research in Zambia’. To implement the roadmap for research, ‘review national research agenda’, ‘formulate national research and funding policies’, ‘conduct FS for establishing public research funding infrastructure’, ‘stakeholder engagement with all research goals’ are needed by 2025. In phase 2(2026~2027), ‘stimulate private sector involvement in financing’, ‘design and implement dissemination system for research output’ are expected to be done. In phase 3(2027~2028), ‘secure increased government sector investment in university and RIS’, ‘improve funding from internal revenue by universities and RIS’, ‘develop mechanism for incentives and rewarding system’, ‘develop research ethics and guidelines’ will be implemented.

1. Introduction

For developing countries, innovation is not only a driver of economic growth but also a critical tool for addressing complex challenges such as poverty, inequality, and environmental vulnerability. A National Innovation System (NIS) provides a framework for strengthening the institutions, policies, and collaborations needed to foster innovation that supports sustainable and climate-resilient economic development.

In particular, Zambia faces the dual pressures of achieving economic progress and mitigating the impacts of climate change, an NIS roadmap becomes essential. It offers a strategic pathway to build innovation capacity, facilitate knowledge transfer, and promote the development of technologies and practices that align with both economic and environmental objectives.

By mobilizing resources and fostering cooperation among governments, industries, academic institutions, and civil society, an NIS roadmap can empower Zambia to enhance resilience, reduce dependence on external aid, and achieve sustainable progress.

The NIS roadmap is a critical element to support an effective operationalization of the NIS Policy Framework. Thus, it needs to be established complexly by considering the existing policies structure, support mechanism and capacity development programmes and others. This chapter explores the methodology that we used to derive the NIS roadmap and the suggested NIS roadmap for Zambia, with a particular emphasis on its role in driving inclusive innovation and supporting climate-resilient economic strategies.

2. Methodology

We investigate three case studies regarding the NIS roadmap including Korea, South Africa and Cambodia. The main contents and its implication to the national development are shared with the Zambia working group members. In addition, the Zambia working group and STEPI team discussed the current challenges and goals of Zambia to accomplish the sustainable and climate resilient development for the next decade.

STEPI and the Zambia working group for this project have discussed about establishing the NIS roadmap both at the offline meetings and through the online meetings. The Zambia working group brainstormed to set the direction and detailed plans with the support of expertise of STEPI team and other Korean experts. Based on the discussion and the implications based on the analysis of NIS of Korea, South Africa and Cambodia, the outline of NIS roadmap for Zambia is provided in this section. The NIS roadmap contains 4 main and key domains and its policy targets by either 2025 and 2030. The policy actions and instruments for the key domains are presented and the final NIS roadmap is prepared. The main contents of three case studies are illustrated in the appendix 1 and the discussion materials for the working group are provided in the appendix 2 for the better understanding of this process.

3. NIS Roadmap for Zambia

3.1 Key domains and policy targets

Key domains are recognized as core elements to develop NIS for Zambia. To establish sustainable and climate resilient development Zambia is requested to enhance its capacity in terms of science, technology and innovation. Four key domains for Zambia NIS are identified to be governance, S&T, human capital and research. In each domain, policy targets are set by the Zambia working group. Some of the policy targets are aimed to accomplish by 2025 and others by 2030.

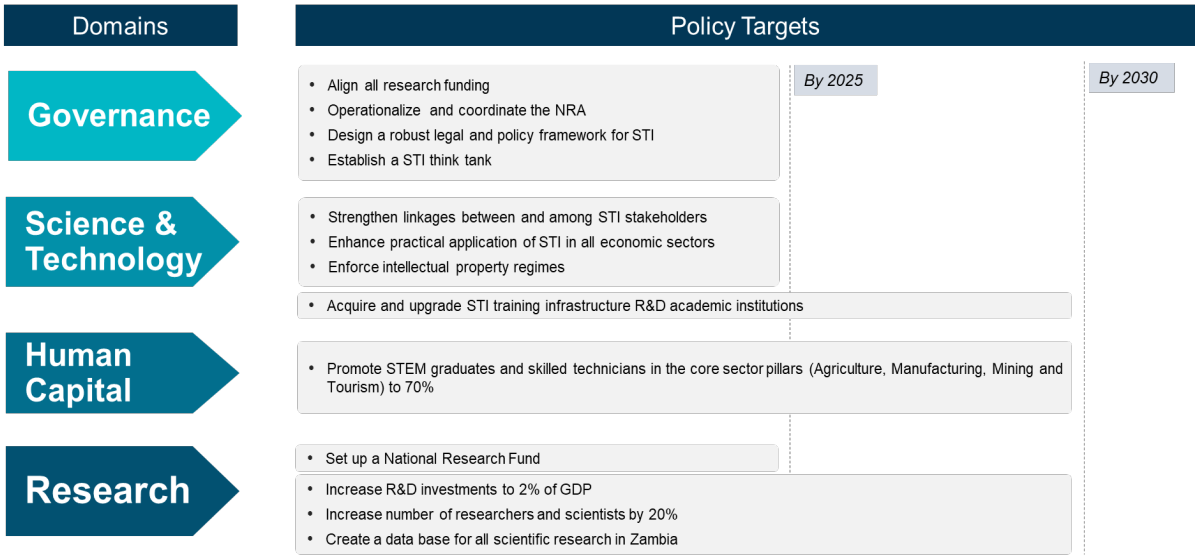
First, the policy targets for governance domain are 1) align all research funding, 2) operationalize and coordinate the NRA (National Research Agenda), 3) design a robust legal and policy framework for STI, and 4) establish a STI think tank. These targets are due by 2025.

Second, the policy targets for S&T domain are 1) Strengthen linkages between and among STI stakeholders, 2) Enhance practical application of STI in all economic sectors, and 3) Enforce intellectual property regimes. These targets are also set by 2025. One more target for S&T is 4) Acquire and upgrade STI training infrastructure R&D academic institutions by 2030.

Third, for human capital domain, the policy target is to promote STEM graduates and skilled technicians in the core sector pillars (Agriculture, Manufacturing, Mining and Tourism) to 70% by 2030.

Last, the policy targets for research are 1) set up a National Research Fund, which is set by 2025, and 2) increase R&D investments to 2% of GDP, 3) increased number of researchers and scientists by 20%, and 4) create a data base for all scientific research in Zambia.

Figure 3-1. Four domains and its policy targets



3.2 Policy actions and instruments

The policy targets can be explained in practical way by policy actions and instruments. The policy action is activity that need to be done to reach the policy target. The instruments are tools and methods that can be used to implement the actions. The instruments contain STI policy instrument and financing instrument. The working group designed policy actions and STI policy instruments and financing instruments in order to reach the policy targets presented in the above part.

For the governance, 4 policy actions are suggested, and the necessary policy and financing instruments are proposed in the table 3-5.

Table 3-1. Policy actions and instruments for Governance

Actions	STI Policy Instruments	Financing Instruments
ACTION 1 Alignment of all (from 0 to 100%) national research and its funding to STI by 2025	**Instruments 1-1** Amendment of the current S&T Law that will create a structure for national research and set up an Agency (e.g. NATIONAL INNOVATION AGENCY, NIA)	Government and cooperating partners
ACTION 2 Operationalize and coordinate the NRA (National Research Agenda) by 2025	**Instruments 2-1** This is currently in draft form but may be operationalized once the review of the STI Policy is finalized.	Government and cooperating partners
ACTION 3 Designating a robust legal and policy framework for STI by 2025	**Instruments 3-1** Review the process for the current S&T Act to include the mandate and operationalization for the NIA from the various sectors of the economy.	National Budget (innovation and research allocation, developmental funding)
ACTION 4 Establish a multi sectorial committee of experts in STI (Think Tank) by 2025	**Instruments 4-1** This (composition and establishment of the committee) should be included in the act. Governing regulations and policies	Government and cooperating partners

There are 4 policy targets set for the Science and technology. The relevant STI policy instruments and financing instruments are presented in the table 3-6.

Table 3-2. Policy actions and instruments for Science and technology

Actions	STI Policy Instruments	Financing Instruments
ACTION 1 Acquire and upgrade state-of-the-art infrastructure for STI training and R&D academic institutions by 2030	**Instruments 1-1** Infrastructure development policy (for both physical and digital in a sustainable manner)	• National Budget allocation for infrastructure as well as ministry allocations • Developmental funds (World Bank/EU) • Private sector Sponsorships & CSR • Community Developmental funds • ESG proposals to attract green Funds
ACTION 2 Strengthen linkages between and among STI stakeholders by 2025	**Instruments 2-1** Collaboration and cooperating policies (these can be for both local and international levels)	• Government through various allocations such as Constituency Development funds • Private sector support (CSR)
ACTION 3 Enhance practical application of STI in all areas 2025	**Instruments 3-1** STI Policy and the S&T Act and other regulation policies **Instruments 3-2** Technology transfer and commercialization support Strategy	Government and cooperating partners
ACTION 4 Enforce intellectual property regime by 2025	**Instruments 4-1** Intellectual property rights policy **Instruments 4-2** Technology transfer and commercialization support Strategy	Government and cooperating partners

The STI policy instruments and financing instruments for Human capital and Research are presented in the table 3-7 and 3-8 respectively.

Table 3-3. Policy actions and instruments for Human capital

Actions	STI Policy Instruments	Financing Instruments
ACTION 1 Promotion of STEM graduates and skilled technicians in the core sector pillars (Agriculture, Manufacturing, Mining and Tourism) to 70% by 2030 policies	**Instruments 1-1** STEM education policy and Strategy **Instruments 1-2** Innovation and Entrepreneurship support Strategy	• National Budget allocation through ministries and CDF • Sponsorships • Fundraising activities to raise resources for STEM students

Table 3-4. Policy actions and instruments for Research

Actions	STI Policy Instruments	Financing Instruments
ACTION 1 Set up a National Research Fund by 2025	**Instruments 1-1** The Act to specify in the medium to long term **Instruments 1-2** The National R&D policy in the interim	Government and cooperating partners
ACTION 2 Increase R&D investments to 2% of GDP by 2030	**Instruments 2-1** Objective of a strategic plan established NIA **Instruments 2-2** National Research Funding and Investments polices and strategy	Government and cooperating partners
ACTION 3 Increase number of researchers and scientists by 20% by 2030	**Instruments 3-1** Action Plan of set Agency	Government and cooperating partners
ACTION 4 Create a data base for all research in Zambia	**Instruments 4-1** This may be included in the new Act in the medium to long term **Instruments 4-2** National Research Policy in the Interim **Instrument 4-3** ZamStats	Government and cooperating partners

3.3 Policy Implementation roadmap

The policy actions and relevant instruments will be implemented according to the predetermined timeline and responsible stakeholders, which are key elements of the NIS roadmap. We have 4 distinguished domains in the roadmap, and they show different timeline to be reached because the current surroundings and condition related to the domain are all not same. Thus, the time goal for each key domain is unique and the time frame is divided into 3 phases.

In the table 3-5, the policy implementation roadmap for governance is exhibited. The time frame for this is phase 1(2024~2025), phase 2(2026~2027), and phase 3(2027~2028).

Table 3-5. Policy implementation roadmap for Governance

Key Domain	Phase 1 (2024~2025)	Phase 2 (2026~2027)	Phase 3 (2027~2028)
Governance	• Stakeholder engagement for the review and development of the Science and Technology Act • Writing of white papers • Establish an interim Think Tank Committee • Formulation of policies • Mapping of existing collaborators	• Establishment/review of S and T act	• Operationalize the Act • Operationalise the NIA budget • Finalize formulation of all policies to guide operations of the NIA • Formulate action plans for operationalization • Set up/review the research and innovation units in all ministries and establish a cross-ministries working group • Introduce fiscal policies for innovations (e.g. R&D subsidies and tax incentives • Data collection for R and D data base

The policy implementation roadmap for science and technology is illustrated in the table 3-6. The time frame for this is same as the one for governance.

Table 3-6. Policy implementation roadmap for Science and technology

Key Domain	Phase 1 (2024~2025)	Phase 2 (2026~2027)	Phase 3 (2027~2028)
Science & Technology	• Stakeholder engagement to familiarise with S and T goals • Writing of white papers to repeal patents act number 40 of 2016 • Review Technology transfer and commercialisation guidelines • Develop national technological innovation plan • Develop fiscal policies to increase growth in total factor productivity through technological innovations • Review with a view to strengthen the institutional and national IP policies	• Repeal the Patents Act number 40 of 2016 • Conduct feasibility study for establishment of the public prototyping centre	• Operationalise Technology Transfer guidelines • Operationalise new Patents Act • Stimulate private sector involvement in financing of technological innovations activities

The table 3-7 contains the policy implementation roadmap for human capital. The three phases are also defined but the phase 3 is from 2027 to 2030.

Table 3-7. Policy implementation roadmap for Human capital

Key Domain	Phase 1 (2024~2025)	Phase 2 (2026~2027)	Phase 3 (2027~2030)
Human Capital	• Engagement of stakeholders to familiarise with the human capital goals in the NIS/NIA • Review of current STEM curricula at all levels of education	• Creation of incentives to stakeholder for provision of scholarships and total involvement in STEM education • Improve collaboration with international partners/experts of STEM education	• Implement internationally assisted programs for student exchange and expat engagements.

Lastly, the policy implementation roadmap for research is presented in the table 3-8. The time frame for this is same as the one for governance.

Table 3-8. Policy implementation roadmap for Research

Key Domain	Phase 1 (2024~2025)	Phase 2 (2026~2027)	Phase 3 (2027~2028)
Research	• Stakeholder engagement to familiarize with all research goals • Review National research agenda • Formulate national research and funding policies • Conduct feasibility study for establishment of the public research funding infrastructure	• Stimulate private sector involvement in financing of academic research activities (such tax exemptions mechanisms for industries involved in research) • Design and implement appropriate dissemination systems for research outputs into communities and industries	• Development of Research Ethics guidelines • Secure increased government sector investment in university and RIs research and innovation • Development of mechanism for providing Incentives and rewarding outstanding researchers and innovators • Improvement of funding of research from internal revenue by Universities and RIs

The following figure demonstrates how the policy targets, policy actions and instruments and the implementation roadmap are matched for each key domain. For governance domain, the policy targets are summarized as funding, NRA, legal and policy framework and think tank. The recommendation for the policy actions is understanding the current status, establishing new policy, act and institutions or updating/upgrading the existing ones, and communicating and negotiating with relevant stakeholders.

Figure 3-2. NIS roadmap for Governance

Policy Targets	Policy Actions	Policy Instrument	Financing Instrument	Implementation Roadmap		
				Phase 1 (2024-25)	Phase 2 (2026-27)	Phase 3 (2027-28)
Align all research funding	Alignment of all (from 0 to 100%) national research and its funding to STI by 2025	• Amendment of the current S&T Law that will create a structure for national research and set up an Agency	• Government and cooperating partners			• Operationalise the NIA budget
Operationalize and coordinate the National Research Agenda (NRA)	Operationalize and coordinate the NRA by 2025	• This is currently in draft form but may be operationalized once the review of the STI Policy is finalized.	• Government and cooperating partners	• Mapping of existing collaborators • Review National research agenda		• Formulate action plans for operationalization • Set up/review the research and innovation units in all ministries and establish a cross-ministries working group
Design a robust legal and policy framework for STI	Designating a robust legal and policy framework for STI by 2025	• Review the process for the current S&T Act to include the mandate and operationalization for the NIA from the various sectors of the economy	• National Budget (innovation and research allocation, developmental funding)	• Stakeholder engagement for the review and development of the Science and Technology Act • Formulation of policies • Writing of white papers	• Establishment/review of S&T Act	• Operationalize the Act • Finalize formulation of all policies to guide operations of the NIA • Introduce fiscal policies for innovations (e.g. R&D subsidies and tax incentives
Establish a STI think tank	Establish a multi sectorial committee of experts in STI (Think Tank) by 2025	• This (composition and establishment of the committee) should be included in the act. • Governing regulations and policies	• Government and cooperating partners	• Establish an interim Think Tank Committee		• Data collection for R&D data base

For the science and technology domain, the policy targets can be focused on linkage among STI stakeholders, STI & Economic sectors, Intellectual Property Regime, and STI infrastructure. The implications to relevant and necessary policy actions are identifying relevant stakeholders in STI, figuring out the synergies of strengthened linkage, designating the coordinating institution/agency.

Figure 3-3. NIS roadmap for Science and technology

Policy Targets	Policy Actions	Policy Instrument	Financing Instrument	Implementation Roadmap		
				Phase 1 (2024-25)	Phase 2 (2026-27)	Phase 3 (2027-28)
Strengthen linkages between and among STI stakeholders	Strengthen linkages between and among STI stakeholders by 2025	• Collaboration and cooperating policies (these can be for both local and international levels)	• Government through various allocations such as Constituency Development funds • Private sector support(CSR)	• Stakeholder engagement to familiarise with S&T goals • Stakeholder engagement to familiarize with all research goals		
Enhance practical application of STI in all economic sectors	Enhance practical application of STI in all areas 2025	• STI Policy and the S&T Act and other regulation policies • Technology transfer and commercialization support Strategy	• Government and cooperating partners	• Review Technology transfer and commercialisation guidelines • Develop national technological innovation plan • Develop fiscal policies to increase growth in total factor productivity through technological innovations	• Conduct feasibility study for establishment of the public prototyping centre	• Operationalise Technology Transfer guidelines • Stimulate private sector involvement in financing of technological innovations activities
Enforce intellectual property regimes	Enforce intellectual property regime by 2025	• Intellectual property rights policy • Technology transfer and commercialization support Strategy	• Government and cooperating partners	• Writing of white papers to repeal patents act number 40 of 2016 • Review with a view to strengthen the institutional and national IP policies	• Repeal the Patents Act number 40 of 2016	• Operationalise new Patents Act
Acquire and upgrade STI training infrastructure & R&D academic institutions	Acquire and upgrade state-of-the-art infrastructure for STI training and R&D academic institutions by 2030	• Infrastructure development policy (for both physical and digital in a sustainable manner)	• National Budget allocation for infrastructure as well as ministry allocations • Developmental funds(world bank/EU) • Private sector Sponsorships & CSR • Community Developmental funds • ESG proposals to attract green Funds			

The policy target for human capital domain is to promote STEM graduates and technicians in core sector to 70% and messages to the policy actions are identifying the current level (Universities, Research institutes, Private sectors), forecasting trend of population, demand and supply of higher education, and forecasting the post graduate stage/job market.

Figure 3-4. NIS roadmap for Human capital

Policy Targets	Policy Actions	Policy Instrument	Financing Instrument	Implementation Roadmap		
				Phase 1 (2024-25)	Phase 2 (2025-27)	Phase 3 (2027-30)
Promote STEM graduates and skilled technicians in the core sector pillars (Agriculture, Manufacturing, Mining and Tourism) to 70%	Promotion of STEM graduates and skilled technicians in the core sector pillars (Agriculture, Manufacturing, Mining and Tourism) to 70% by 2030 policies	• STEM education policy and Strategy • Innovation and Entrepreneurship support Strategy	• National Budget allocation through ministries and CDF • Sponsorships • Fundraising activities to raise resources for STEM students	• Engagement of stakeholders to familiarize with the human capital goals in the NIS/NIA • Review of current STEM curricula at all levels of education	• Creation of incentives to stakeholder for provision of scholarships and total involvement in STEM education • Improve collaboration with international partners/experts of STEM education	• Implement internationally assisted programs for student exchange and expat engagements.

There are three policy targets for Research, which are to increase R&D investment to 2%, to increase number of scientists and researchers by 20%, and to create data base for STI. The suggestions to the relevant policy actions are identifying the current level and defining the purpose and function of data base such as inputs, outputs, collaboration, etc.

Figure 3-5. NIS roadmap for Research

Policy Targets	Policy Actions	Policy Instrument	Financing Instrument	Implementation Roadmap		
				Phase 1 (2024-25)	Phase 2 (2026-27)	Phase 3 (2027-28)
Increase R&D investments to 2% of GDP	Set up a National Research Fund by 2025	• The Act to specify in the medium to long term • The National R&D policy in the interim	• Government and cooperating partners	• Review National research agenda • Formulate national research and funding policies • Conduct feasibility study for establishment of the public research funding infrastructure		
	Increase R&D investments to 2% of GDP by 2030	• Objective of a strategic plan established NIA • National Research Funding and Investments polices and strategy	• Government and cooperating partners	• Stakeholder engagement to familiarize with all research goals	• Stimulate private sector involvement in financing of academic research activities • Design and implement appropriate dissemination systems for research outputs into communities and industries	• Secure increased government sector investment in university and RIs research and innovation • Improvement of funding of research from internal revenue by Universities and RIs
Increase number of researchers and scientists by 20%	Increase number of researchers and scientists by 20% by 2030	• Action Plan of set Agency	• Government and cooperating partners	• Review National research agenda		• Development of mechanism for providing Incentives and rewarding outstanding researchers and innovators • Development of Research Ethics guidelines
Create a data base for all scientific research in Zambia	Create a data base for all research in Zambia	• This may be included in the new Act in the medium to long term • National Research Policy in the Interim • ZamStats	• Government and cooperating partners			

Appendix 1. Case studies

1. Korea

The Ministry of Science and ICT (MSIT) announced the First Mid- and Long-Term National R&D Investment Strategy (2023-2027) under the President Yoon's administration on March 2023 at the Cabinet Meeting[3]. The First Mid- and Long-Term National R&D Investment Strategy presents the vision of "Becoming one of the top five science and technology powerhouses by 2030" and policy goals of delivering on major national tasks and producing fruitful achievements. The investment goal is to maintain the current R&D expenditure on GDP of 5% by investing KRW 170 trillion for over five years. The technology level of Korea will be raised from the current 80% to 85% compared to the most technologically advanced countries by 2027. Four strategies and 23 tasks will be implemented to achieve the vision and goals.

Korean government established the first National Strategy for technology innovation for 2050 Carbon Neutrality on March 2021. The 2050 carbon neutrality is a challenge to Korea, given the fact that the Korean economy is dependent on coal development and the manufacturing sector. However, the innovation strategy was established recognizing that technology innovation is more important and urgent than anything in reaching the 2050 goals. The vision of the strategy is "Driving the 2050 carbon neutrality goal in Korea through technology innovations" and the 5 action plans were proposed to provide strong life cycle support, including developing key technologies through collaborations of all ministries and creating an innovation environment where new technologies receive commercialization support. The 5 actions are as follow.

① Developing 10 key technologies for carbon-neutral technology innovation

② Planning and promoting R&D projects engaging all ministries

③ Intensive support for the creation of new industries

④ Private-led low-carbon conversion

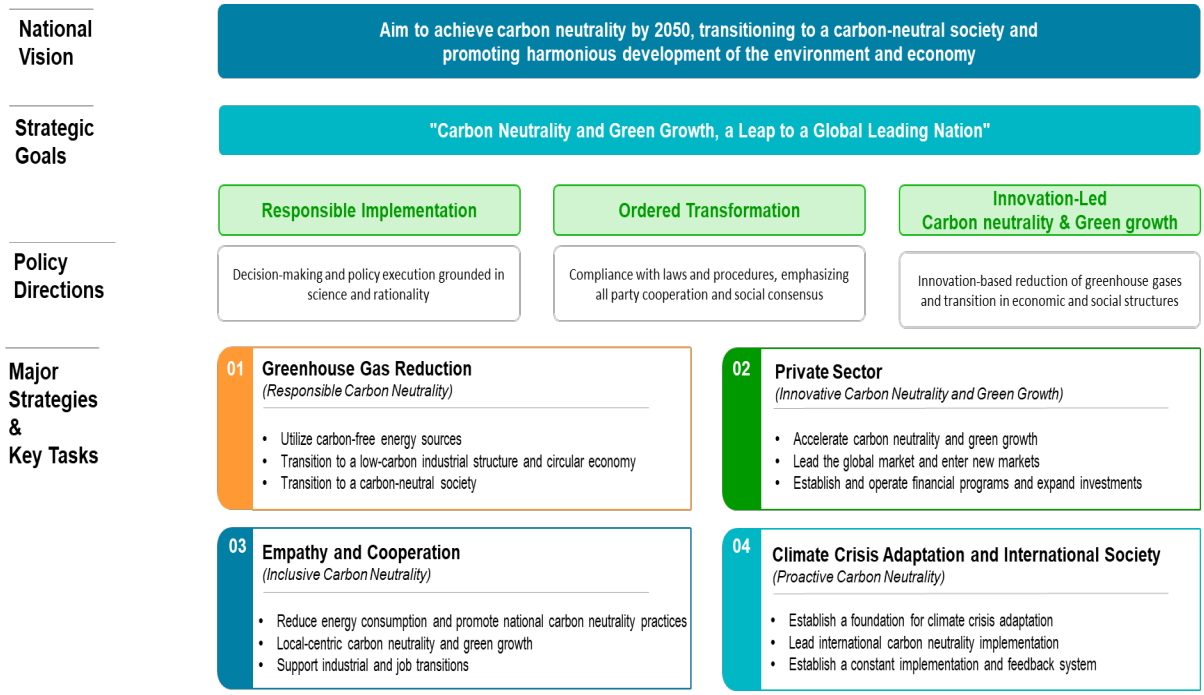
⑤ Sustainable research foundation

The current president Yoon's administration revised the strategy and announced the National master plan for carbon neutrality and green growth in March 2023. The responsible organisation for this plan is the Presidential Commission on Carbon Neutrality and Green Growth. This master plan has two parts, ① national comprehensive strategy, which sets basic policy principles and national policy directions, and ② national basic plan, which identifies specific challenges based on the national

3 MSIT Press release (2023.9), Establishment of Mission-Centric Strategic Roadmap for Critical and Emerging Technologies.

strategic policy directions. Its time span is next 20 years, from 2023 to 2042, and it will be reviewed and updated every five years. The Objectives of the master plan are to have responsible implementation of carbon neutrality, private-led innovative carbon neutrality and green growth, carbon neutrality with all stakeholders based on their consensus and cooperation, and active leadership in global communities.

Figure 3-6. The 2050 Carbon neutral and green growth strategy of Korea



The National Basic Plan for carbon neutrality and green growth is a national plan for responding to the climate crisis and promoting sustainable development. With annual reduction targets and implementation measures for each sector (e.g., industry and transportation sectors), the Basic Plan will be updated every five years over the next 20 years, from 2023 to 2042. This Basic Plan will facilitate the establishment of subordinate plans (e.g., measures to adapt to the national climate crisis, and basic plans for carbon neutrality and green growth for local cities, provinces, counties, and districts) and a substantial impact on other mid to long-term administrative plans (e.g., the basic plan for supply and demand of electric power, the comprehensive national territorial plan, and the basic plan for resource circulation). The Basic Plan comprises three major parts:

(a) national strategies and visions for conversion to a net-zero society

(b) reduction targets for carbon emissions

(c) policy tools to establish a robust system for implementing the roadmaps to carbon neutrality

The Basic Plan maintains the mid to long-term reduction targets at 40% but adjusts each sector's reduction and absorption/removal targets. In the industrial sector, the current NDC targets decrease

from 14.5% to 11.4%; the reduction contribution for the transition sector from 44.4% to 45.9%; the international reduction sector from 33.5 million to 37.5 million tons.[4]

The Basic Plan establishes a carbon-neutral technology innovation road-map, selects 100 key Korean-style carbon-neutral technologies and develops a comprehensive strategy to foster public-private partnerships in developing climate technology. The Basic Plan also covers the promotion of new green industries such as low-carbon materials, next-generation rechargeable batteries, next-generation semiconductors, recycling and climate impact and adaptation services. In the carbon neutrality sector, investments will be focused on key R&D projects, such as securing technologies directly related to low-carbon transition of carbon-intensive industries, including steel and cement, and developing hydrogen technologies. We need formulate support plans for developing green technologies, fostering new industries, and implementing a just transition, and improvement plans for relevant systems.

2. South Africa

NIS is vital for creating a coordinated, inclusive, and adaptive innovation ecosystem that supports South Africa's development objectives and addresses its socio-economic challenges. The NIS has various implications for South Africa’s sustainable development.

The NIS provides a structured framework for policy-making, monitoring, and evaluation within South Africa’s knowledge and technology environment. This structure is essential for ensuring that different institutions, policies, and organizations interact constructively to achieve common social and economic goals.

The NIS plays a crucial role in driving economic growth and addressing social challenges such as poverty, inequality, and unemployment. By fostering innovation, the NIS helps create new opportunities for economic development and improves the overall quality of life.

The NIS aims to be inclusive, integrating marginalized groups into the innovation process. This inclusivity is not only about increasing diversity but also ensuring that innovation efforts address the needs of the entire population, including the poor and marginalized. This approach helps in transforming the socio-economic landscape of the country.

It is characterized by its evolutionary nature, continuously adapting to new challenges and opportunities. This ongoing evolution is crucial for maintaining the relevance and effectiveness of the innovation system in a dynamic global environment.

Effective innovation often requires collaboration across various sectors, including universities, science

[4] OECD web page. https://stip.oecd.org/stip/interactive-dashboards/policyinitiatives/2023%2Fdata%2FpolicyInitiatives%2F99997402

councils, government agencies, and the private sector. The NIS framework facilitates these collaborations, leading to more robust and impactful innovation outcomes.

Finally, the NIS includes mechanisms for monitoring and evaluating the performance of the innovation system. These mechanisms help in tracking progress, identifying gaps, and making informed decisions to enhance the system's effectiveness.

South Africa established a national development strategy in 2020, “A new pathway 2030: Catalysing South Africa’s NSI for urgent scaled social and economic impact”. The ministry of higher education, science and innovation led to review the landscape of South Africa’s national system of innovation and proposed the national development strategy 2030 based with NSI. The recommended five levers of change for the NSI; values, governance, resourcing, capabilities and coherence.

Values are socially shared conceptions of the desirable. It is paramount to strengthen the ethical basis of the NSI by ensuring that there is alignment across the system on what it means to be a public servant, and the imperative to honour the country’s constitution.

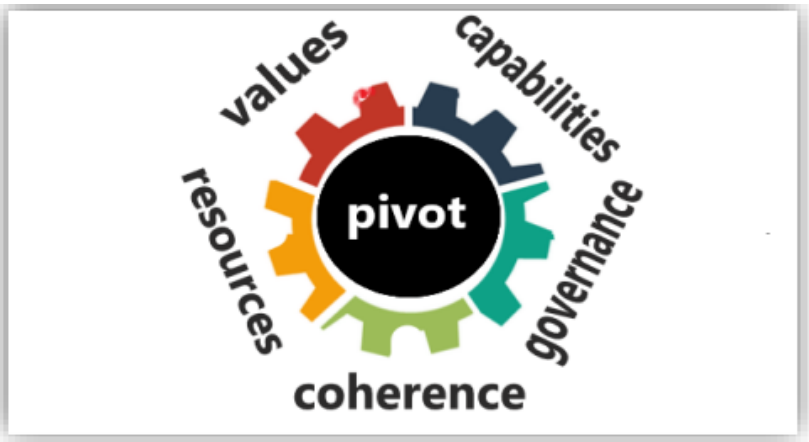
Governance incorporates all aspects of political oversight, strategic management and the advisory support for the NSI. Governance serves as an important lever of change for providing an organising framework for interventions that aim to improve steering and oversight of the NSI.

Resources means recommended actions for the optimisation of financial and other resources available to the NSI.

Capabilities refers to all the necessary capabilities of the institutional landscape that are required to effectively manage the process of converting knowledge and know-how into commercially viable products and services. The recommendations address a range of institutional capabilities essential for innovation.

Coherence encompasses the aspects that are related to forging and maintaining fruitful interactions and partnerships between various actors.

Figure 3-7. The five levers of change for NSI



Source: The HESTIIL Ministerial Committee(2020). A new pathway 2030: catalysing South Africa's NSI for urgent scaled social and economic impact.

According to the report, they proposed the national coordinating framework that will address the fragmentation and incoherence specific to NSI, through high level steering and agenda setting, integrated monitoring and evaluation, and coordinated implementation plans.

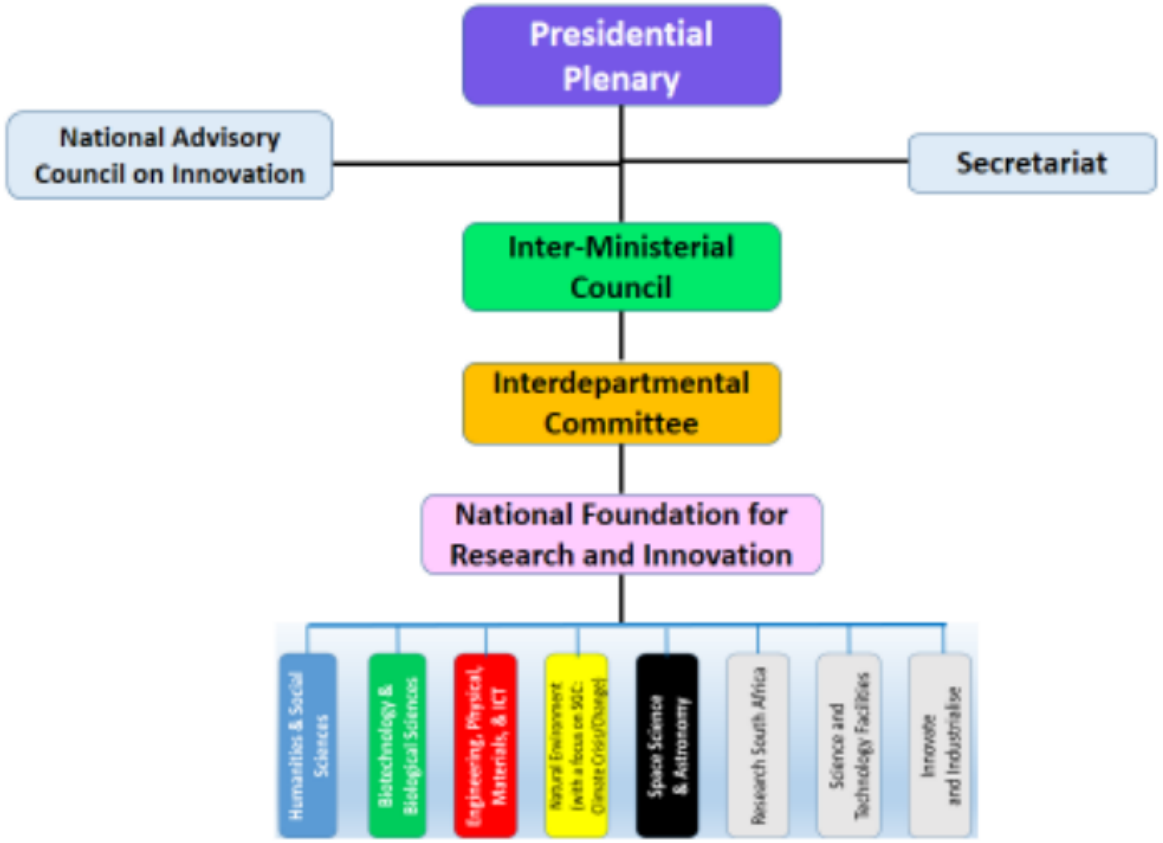
Table 3-9. The national coordinating framework of South Africa

	Presidential Advisory Council	Inter-Ministerial Panel	Inter-Department Committee	National Foundation for Research and Innovation
Role	Agenda setting	Steering, monitoring and evaluation	Implementation of NSI agenda	Funding, coordination
Level	Presidency	Ministerial	Director-General	Official
Type	Oversight	Steering	Working group	Agency
Composition	High-level leaders from business, industry, HET, government, civil society and NGOs	Cabinet ministers from relevant ministries	DGs, apex leaders from universities, science councils, business, industry	CEOs of all the reconfigured RDI entities across the whole innovation value chain

Source: The HESTIIL Ministerial Committee (2020). A new pathway 2030: catalysing South Africa's NSI for urgent scaled social and economic impact

The shift towards an idealised HESTIIL (Higher Education, Science, Technology and Innovation Infrastructure Landscape) will be phased over the next ten years. It is recommended that sufficient time is needed for the new entities to be located under the coordination and control of the national foundation of research and innovation.

Figure 3-8. The national coordination framework



Source: The HESTIIL Ministerial Committee (2020). A new pathway 2030: catalysing South Africa's NSI for urgent scaled social and economic impact.

Table 3-10. Indicative implementation roadmap

	PHASE 1	PHASE 2	PHASE 3
	0-2 years	2-5 years	5-10 years
Coordinating mechanism	• Set up Presidential Plenary, Inter-Ministerial Panel and Inter-Departmental Committee	• Governance mechanisms in place and oversee system transformation	• Oversee system review • Approve next decadal plan
National Foundation for Research and Innovation	• Communication and consultations with stakeholders • Set up a transitory coordinating structure	• Initiate legislative processes to establish the NFRI • Coordinating structure is finalised	• Migration of existing entities to the NFRI • Coordinating of entire RDI value chain is complete
National Advisory Council on Innovation	• Initiate legislative process to elevate mandate and strengthen resourcing • Set up transitory arrangements to support new governance protocols	• NACI in place as Advisory and Secretariat to the Presidential Plenary • Migration of NSI evaluation capacity and mandate	• NACI fully functional as advisory council to the system at national level
Grand Challenges	• Consultations and finalisation of the missions • Budgeting and implementing entities outlined	• Full implementation in place • Monitoring mechanisms in place	• System evaluation and review

Source: The HESTIIL Ministerial Committee (2020). A new pathway 2030: catalysing South Africa's NSI for urgent scaled social and economic impact.

From the analysis of NIS of South Africa which was set on 2020, we can draw several implications and meaning of the NIS to the policy makers. It can strengthen the necessity for a more integrated and coordinated approach across various sectors, including higher education, science, technology, innovation, and industry. This involves establishing a new governance framework with mechanisms like the Presidential Advisory Council, Inter-Ministerial Panel, and National Foundation for Research and Innovation (NFRI). The NIS may accelerate investment and resource allocation in research, development, and innovation from both public and private sectors. There is a call for doubling state, business, and industry investments in RDI over the next decade.

As well, the NIS can contribute to expand the RDI enterprise to be more inclusive, diverse, and pluralistic. This includes addressing historical disadvantages and ensuring that innovation efforts benefit all segments of society, especially marginalized communities. We can also expect the enhancing capabilities of institutions and individuals within the NSI to drive high-impact research and innovation. This involves scaling up research capacity, especially in critical areas such as health, digital technologies, and environmental sciences. The policy and governance reforms through the NIS roadmap can be anticipated. We can implement robust governance structures and policy frameworks to steer the NSI effectively. This includes the elevation of the National Advisory Council on Innovation (NACI) to provide strategic guidance and ensure coherence in policy implementation. The NIS roadmap can promote closer collaboration between universities, science councils, industry, and civil society to create a vibrant and interconnected innovation ecosystem. This includes leveraging international cooperation to enhance local innovation capabilities.

3. Cambodia

The NIS roadmap for Cambodia will contribute to achieving Cambodia's Vision 2050 of becoming an upper-middle-income country by 2030 and a high-income economy by 2050, and national goals for sustainable development. The roadmap enhances the governance of STI system by consolidating the roles and responsibilities of various ministries and stakeholders. This ensures better coordination and reduces fragmentation within the system. It focuses on promoting scientific, digital, and entrepreneurial literacy from an early age, thereby developing a new generation of scientists and innovators. This strategic development of human resources is foundational for promoting STI.

The roadmap aims to build the capacity of higher education and research systems to conduct high-quality R&D activities of national interest. This includes developing a national research agenda and encouraging collaboration between the academic community and the private sector. By promoting the exchange of ideas across various sectors and domains, the roadmap supports the establishment of intermediary organizations and knowledge broker institutions. This fosters collaboration and

innovation among universities, public research institutions, start-ups, SMEs, large corporations, policymakers, and private investors.

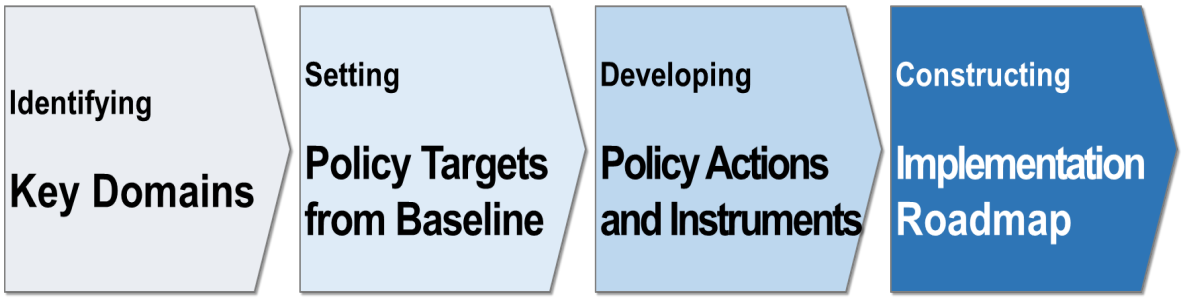
The roadmap aims to enhance the innovation capacities of SMEs and attract investments in STI. This involves supporting technology transfer, promoting domestic technologies, and improving access to finance for innovation activities. The roadmap includes setting up a monitoring and evaluation system to adapt policies based on progress and impact. This ensures that the policies remain effective and are adjusted as necessary to address external developments. The roadmap emphasizes engaging in science diplomacy and international cooperation with high-tech countries to build relationships and cooperation programs in higher education, research, and the private sector.

Science, technology and innovation will be a pivotal driver to shift the economic development pathway from a focus on traditional growth to support for inclusive and sustainable growth. STI will enable and accelerate the structural transformations required to increase national prosperity, peace, security, safety and socioeconomic development and to improve quality of life. The STI roadmap established in 2021 targets five main pillars: governance; education; research and development; collaboration and networking; and enabling ecosystem.

STI governance is a key to restructure of MISTI in 2020. The governance is important to consolidate new structure, while reducing fragmentation and breaking down silos. Teaching science, technology and innovation from very early age will help create a new generation of scientists and innovators. Skills in STEM will need to be promoted in higher education. Strategic development of human resources is the foundation of promoting STI. Building the capacity of the higher education and research system to conduct high quality R&D activities of national interest and in priority sectors is necessary. It requires developing a national research agenda with academic community with private sectors. Intermediary organizations and knowledge broker institutions are essential to facilitate the exchange of ideas. It will be crucial to promote and sustain incubation and acceleration facilities, technological platforms open to private sectors. Supporting innovation capabilities and increasing the absorptive capacities of firms requires financing and promoting intermediary structures that nurture new firms, support technology transfer and promote domestic technologies. The implementation of the five priorities will rely on a partnership between the public sector and the private sector.

The national STI roadmap was established by first identifying key domains, setting policy targets from baseline, developing policy actions and instruments and finally constructing implementation roadmap.

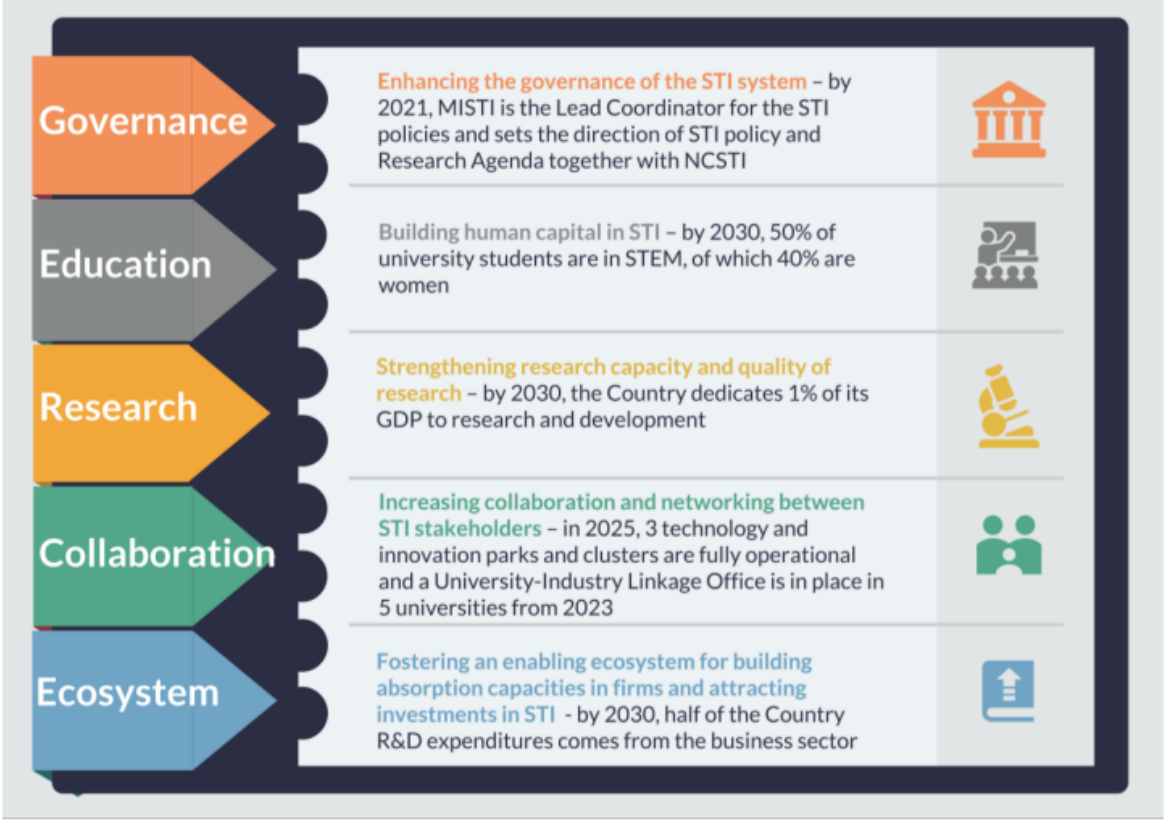
Figure 3-9. The process of designing STI roadmap



Source: Ministry of industry, science, technology and innovation(2021). Cambodia's science, technology & innovation roadmap 2030.

Cambodian government selected five key domains as described above. The policy targets for each domain are shown in the below figure.

Figure 3-10. Summary of the National STI roadmap 2030



Source: Ministry of industry, science, technology and innovation(2021). Cambodia's science, technology & innovation roadmap 2030.

The policy actions and instruments are developed to reach the policy targets set for each domain. For example, education, one of the domains exhibits policy targets of building human capital in STI by 2030 to be 50% of university students in STEM, of which are women. They also present the policy actions and instruments for the targets. There are 15 policy actions in the 4 categories, which are ①

enhancing the scientific culture in the society, ② enhancing technology readiness of youth at primary and secondary school, ③ increasing the attractiveness of STEM curricula and the number of STEM graduates in the higher education system, ④ strengthening the quality of teaching and collaboration with private sector at the TVET institutions.

Table 3-11. Building human capital in STI

Enhancing the scientific culture in the society	1. Promote science fairs, science festival, open days, social media campaigns, science competitions, science museum, involving the private sector, mediatize role models and examples of STI projects.
Enhancing technology readiness of youth at primary and secondary school	2. Introduce science, digital and entrepreneurship in primary and secondary school curricula. 3. Introduce a specific training for schoolteachers on teaching STEM with innovative approaches and techniques of teaching. 4. Equip pupils with computers.
Increasing the attractiveness of STEM curricula and the number of STEM graduates in the higher education system	5. Innovation and entrepreneurship in curricula at BSc, Master and PhD levels. 6. Introduce innovative approaches and techniques to teach STEM. 7. Promote young scientists through competitions, such as an innovation and entrepreneurship competition in STEM. 8. Expand international network and collaboration of STEM departments to attract senior visiting researchers. 9. International mobility of STEM students. 10. Internship and apprenticeship with industry for STEM students. 11. Equip STEM departments with up-to-date testing machines.
Strengthening the quality of teaching and collaboration with private sector at the TVET institutions	12. Develop training the trainers programmes at TVET (in collaboration with industry). 13. Internship and apprenticeship with the industry for TVET students. 14. Equip TVET institutions with up-to-date technology equipment used in the private sector. 15. Mobilize funding to support TVET programmes and STI centres of excellence to both create a critical mass of well-trained professionals as well as to exemplify how a TVET institution should work.

Source: Ministry of industry, science, technology and innovation(2021). Cambodia's science, technology & innovation roadmap 2030.

The policy mix of several policy instruments is provided for education domain. They set time frame as 2 intervals, such as 2021~2022 and 2023~2030. The policy instruments are regulatory, social and

cultural, and financial. The detailed information on this is shown in the following table.

Table 3-12. Policy mix: education

Pilar	Time frame	Regulatory instruments	Social and cultural instruments	Financial instruments
Build the science technology and innovation	2021–2022	• Co-monitor the implementation of the Education Strategy related to STEM • Co-monitor the setting up of digital	• Promote science museums, STI libraries, science fairs, science festivals, open days, social media campaigns, innovation and	• Finance computers for pupils at primary and secondary school • Establish a national

Pilar	Time frame	Regulatory instruments	Social and cultural instruments	Financial instruments
human capital		education at all levels of education • Complete existing curricula, notably STEM curricula at primary and secondary school and innovation curricula at the Bachelor, Master and PhD levels, in collaboration with the private sector • Introduce specific curricula for training on teaching STEM with innovative approaches and technique for schoolteachers, higher education professors and TVET teachers on advanced manufacturing technologies	entrepreneurial-related competitions, mediatize role models and examples of STI projects • Promote "best STEM students" of the year • Set up a network of international academic collaborations with top-ranking research institutions and higher education institutions • Initiate and support stronger collaboration with the private sector • Propose internship and apprenticeship programme to STEM student in the industry • Promote the use of digital technologies and up-to-date technology equipment for teaching and learning how to use robots, censors, imagery and other technologies	programme to equip universities and TVET institutions with technology platforms for teachers and students • Finance Innovation Days and an Innovation Forum • Provide attractive remuneration packages to higher education professors from international top-ranking institutions (Talents Grants In) • Set up the right incentives for students to study abroad and come back to the country to start their professional career (Talents Grants Out) • Mobilize funding (e.g., from the Skills Development Fund) to support, equip and promote five "TVET institutions of excellence"

	2023–2030	• Continue other measures	• Expand science museums and libraries across the country	• Facilitate and support Cambodian students to study abroad

Source: Ministry of industry, science, technology and innovation(2021). Cambodia's science, technology & innovation roadmap 2030.

We can take some implications of the NIS of Cambodia. It helps guide Cambodia's efforts in leveraging science, technology, and innovation for sustainable and inclusive socioeconomic development and lay out a comprehensive plan to strengthen the STI foundation. In addition, we can improve the enabling ecosystem, and enhance the quality of life by fostering innovation across all sectors.

Appendix 2. Discussion and suggestions

Even though the direction of establishing NIS roadmap is suggested after several discussion and joint workshop among Zambia working group and STEPI experts, there remain some issues and points that may be debated intensively. It is recommended to consider these issues at the early stage of establishing NIS roadmap. The relevant stakeholders are able to have an opportunity to understand the background and purpose of NIS roadmap, so that they can stand on the same page to step out together. As well, we can increase the effectiveness of NIS roadmap and enhance the possibility of successful implementation when we fully discuss the potential issues at the beginning of the long journey job.

STEPI team explained 7 issues for NIS roadmap to the Zambia working group. The discussion results are share in the following appendix.

1) Clearly set a vision for NIS roadmap

The NIS roadmap is useful for national level to reach the sustainable growth and climate resilient system. Therefore, it is necessary for all relevant stakeholders agree the direction and vision of it. The tasks at the inception stage is to have a common view on the NIS roadmap. They can discuss why they need NIS roadmap and what they want to achieve with the NIS roadmap at the national level.

2) Role and responsibility of stakeholders

Since various stakeholders involve in the process of setting NIS roadmap and implementing it, it is very critical to distinguish the role and responsibility of them in advance. We have observed in other areas that the NIS roadmap was not productive and effective because the involving parties were overlapped and duplicative. As worse, they worked in silos, resulted in miscommunication and less collaboration.

3) Reality and practicability of time frame

Implementing a roadmap usually takes long time. We should understand the reality and practicality of time that is necessary for full carrying out. Neither too short nor too long time is adequate to the successful NIS roadmap. Every stakeholders need agree the proper time line and frame.

4) Pivoting process and smooth transition

The NIS roadmap is considered as a pivoting process that transfers from “an as-is system” to “a to-be system”. Therefore, we need identify the current status of as-is system and the problems and limitations embedded into it. Also, we are asked to set a vision for the to-be system. Moreover, the key point to understand is how to pivot the current system toward new system, and how to make

the transition as smooth as possible.

5) Consideration on IP issues

The Intellectual property is a driver of technology innovation and growth of a country. It is required for a country to have a well-organized and systematic IP structure for technology promotion and protection. However, for countries in the developing stage, technology adoptions and importation can be efficient strategy for a rapid growth and innovation. In other words, the IP system for more technology promotion than protection is beneficial to the countries. We recommend balancing the technology promotion and protection by applying proper IP system is significant for Zambia's development and growth.

6) Focus more on climate resilient aspect

The climate risk can affect significantly the national growth in various dimensions. When establishing NIS roadmap, it is required to reflect the impact of climate risks on the innovation system including technology transfer and infrastructure. We suggest that we need conduct additional project which focuses on investigating the relationship between climate risks and NIS.

7) International partners

Utilizing external resources such as international organizations, other countries, and multilateral banks and so on in the process of national development is strongly recommended. The international partners can share experience and knowledge, and provide technical advice and financial support. We suggest to form a collaboration system and structure to enhance the partnership.

Based on the above topics, the working group discussed intensively to reflect the result into the NIS roadmap.

(Discussion Group 1)

1) Vision for NIS roadmap

Fostering development in which science technology and innovation are the driving force in developing an environmentally sustainable and climate resilient economy

2) Role and Responsibility of stakeholders

Government through Ministry of Technology and Science - The Lead institution in developing enabling STI Policy, allocation of funds as well as coordinating the formulation and implementation of Zambia's NIS roadmap

Line ministries - Developing R & D in respective ministries and mainstreaming STI into their respective policies

Private sector - Investment and enterprise development as well as provide technical and industry specific advice in the NIS implementation

Developmental partners and donors- to share technical assistance, capacity building, investments, best practices

Academia and Researchers - Conduct research and provide technical backstopping in STI research. Provide skills development technical and enhance technical development.

Civil Society and Community - Advocacy awareness and Beneficiaries of climate smart technologies and policies

3) Reality and Practicability of time frame

5 years (Review of Policy and legislation; Setting up of appropriate Governance structures; Setting up of a system to collate all STI in Zambia; Development of implementation plans) 2025 to 2029

4) Pivoting process and smooth transition

Assessment of current NIS system, implement incremental changes while continuously monitor and adjust, engage stakeholders to ensure needs are addressed, necessary skills and resources to support transition process, create strong strategic partnerships to leverage expertise and resources

5) Consideration on IP (Intellectual Property) issues

Develop IP regimes that promote innovation as well as technology transfer and adoption to support growth of a climate resilient economy based on the key sectors of national focus

6) Focus more on Climate resilient aspect

Encourage R&D in climate resilient technologies and practices

Support climate focused entrepreneurs and startups

Ensure policy environment supports and gives incentives to climate resilient investments and innovations

Funding for incubation facilities to support innovations

Promote dissemination and adoption of climate resilient innovations and best practices

7) International partners

bilateral, multilateral and international organizations: to provide support through technology transfer, capacity building, funding and collaborative research

Strategic affiliation to regional (COMESA) and continental (Africa Continental Free Trade Agreement) partnerships.

(Discussion Group 2)

1) Vision for NIS roadmap

"Contributing to achieving Zambia's vision of becoming a Prosperous Middle Income Nation and Transitioning to building a green economy by 2030"

2) Role and Responsibility of stakeholders

Government	**Industry/Private Sector/civil society**	**Academia/Research Institutions**
Providing policy oversight Provide funding and resources Set research agenda Coordinate research efforts	Provide funding and resources Identify research needs & applications Apply research findings Advocate for research based policies Disseminate research findings	Conduct research & innovations Build human capital & research capacity Skills transfer Technology transfer Ensure research integrity

3) Reality and Practicability of time frame

Time frame to be revised up to 2030 so that it is aligned with Vision 2023 and Green Growth Strategy

GOAL TYPE	KEY RESULT AREAS
Short-Term Goals (1-3 years)	Establish foundational policies, create initial funding mechanisms, and launch pilot projects
Medium-Term Goals (3-5 years)	Expand infrastructure, strengthen industry-academia collaboration, and scale successful pilot projects
Long-Term Goals (5-10 years)	Achieve widespread adoption of innovation practices, foster global competitiveness, and ensure sustainable development

4) Pivoting process and smooth transition

Ensure the vision is phased into short, medium and long-term intervals

KEY ASPECTS TO CONSIDER	RECOMMENDED ACTIONS
1. Formulate flexible Policies:	•Implement adaptable policies that can evolve with changing circumstances and emerging technologies.
2. Continuous Monitoring:	•Regularly assess progress and make data-driven adjustments to the NIS roadmap.
3. Stakeholder Engagement:	•Maintain open lines of communication among all stakeholders to address challenges and leverage opportunities.
4. Capacity Building:	•Provide training and resources to stakeholders to facilitate smooth transitions.

5) Consideration on IP (Intellectual Property) issues

• IP policies should not be too rigid: Ensure the country benefits from inward technology transfer, while promoting outward technology transfer;

• Need to strengthen IP Laws: Enhance intellectual property laws to protect innovators and encourage investment.

• Awareness and Education: Educate stakeholders on the importance of IP rights and how to protect their innovations.

• IP Support Services: Provide support services such as patent filing assistance and legal advice.

• Collaboration with International IP Bodies: Align with international IP standards and practices.

6) Focus more on Climate resilient aspect (tech transfer, infrastructure)

This could be attained by aligning the NIS to the GGS which focus on;

• Renewable energy,

• Sustainable agriculture,

• Ecotourism,

• Green infrastructure,

• Forest conservation,

• Climate change resilience

• Waste reduction and recycling,

• Green Economy skills development and

• Inclusive growth

7) International partners

Establish strong relations with international partners

• Bilateral and Multilateral Agreements: Establish agreements with countries and international organizations to support innovation initiatives.

• Funding and Grants: Secure funding and grants from international bodies such as the World Bank, UN, and other donors.

• Knowledge Exchange: Participate in international forums and networks to share knowledge and best practices.

• Capacity Building Programs: Partner with international institutions to offer training and capacity-building programs for local stakeholders.

• Joint Research Initiatives: Engage in joint research projects with international universities and research institutions.

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