14 Vigorously Advancing Science, Technology, and Innovation

Chapter 14

Vigorously Advancing Science, Technology, and Innovation

Science, Technology and Innovation (STI) plays an important role in economic and social progress. It is a key driver of the long-term growth of an economy.

Technology adoption allows the country's firms and people to benefit from innovations created in other countries, and allows it to keep up and even leap frog obsolete technologies. This can lead to significant improvements in the productivity of firms in agriculture, industry, and services.

On the other hand, long-term investments in building the local capacity for technology generation can lead to innovations that will give firms a competitive advantage. This can result in the creation of new firms and even entirely new industries that can provide high-quality jobs. Due to the long gestation period for developing this capacity, it is important to start planting the seeds early.

Just as important, STI can lead to the creation of new public goods and services (or new methods of delivering public goods and services) that will help address the needs of society, especially of the disadvantaged, including in the areas of health, education, energy, disaster resiliency, and climate change adaptation, among others.

This chapter discusses the priority strategies and outcomes needed to increase the country's potential growth though innovation, which will build the foundation for a globally competitive knowledge economy.

Assessment and Challenges

There is a low level of innovation in the country brought about by weaknesses in STI human capital, low research and development (R&D) expenditures and weak linkages in the STI ecosystem. In the Global Innovation Index[1] (GII) Report of 2016, the Philippines ranked 74th among 128 economies in innovation[2], garnering a score of 31.8 out of 100. This is a slight improvement from the score of 31.1, ranking 83rd out of 141 economies in 2015.

The country also ranked 5th out of the seven members of the Association of Southeast Asian Nations (ASEAN) in the survey, ahead of Cambodia (95th) and Indonesia (88th), but behind Singapore (6th), Malaysia (35th), Thailand (52nd), and Vietnam (59th).

[1] The Global Innovation Index captures the multi-dimensional facets of innovation in 128 economies. The index is composed on seven pillars namely: institutions, human capital & research, infrastructure, market sophistication, business sophistication, knowledge & technology outputs and creative outputs. It is co-published by Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO).

[2] The overall GII is the simple average of the input and output sub-index scores.

The factors behind the weak performance of the STI sector are as follows:

Weak STI culture. There is a lack of public awareness and interest in STI. Many sectors do not recognize, appreciate, and understand the use of technology and science-based information in their daily activities. Weaknesses in social and professional cultures (i.e., research culture in universities, commercialization of results from public research, and awareness of intellectual property rights) in the research community and the general public persist.

Despite their availability, there are reports that the technologies are not widely used among micro, small, and medium enterprises (MSMEs) and sectors like agriculture and fisheries. This can be attributed to the lack of awareness on the available technology outputs (technologies, processes, or services) derived from public R&D activities, and the various government incentives to support innovation and further spur its growth. Other reasons are weak links between technology generators and users, capacity constraints of users, and inadequate local government unit support.

Low government spending on STI. Investments in R&D are central to enhancing the country's innovation ecosystem. STI monitoring and evaluation of expenditures on R&D and innovation activities, as well as support for human resources development in the various fields of science and technology (S&T) indicates low government spending.

While nominal R&D expenditures increased by 80 percent to P15.92 billion in 2013, the proportion of R&D spending to Gross Domestic Product (GDP) stood at only 0.14 percent. This is substantially below the 1 percent benchmark recommended by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) and the global average of 2.04 percent. It is also low compared to other ASEAN countries, such as Vietnam (0.19 %), Thailand (0.36%), Malaysia (1.09%), and Singapore (2.0%)[3].

The country's relatively low ranking in the GII Report was pulled down by weaknesses in human capital and R&D, with a score of 22.7 out of 100, ranking 95th. This is due to the low public and private expenditure on education and R&D, as well as low tertiary inbound mobility[4].

The bulk of R&D spending (60%) comes from the public sector. This was used for agricultural and industrial production and technology, protection and improvement of human health, control and care of the environment. Most of the R&D activities in the country are concentrated in the National Capital Region (NCR), Region IV-A (CALABARZON), and Region III (Central Luzon).

Inadequate S&T human resources engaged in STI R&D. Another indicator measuring the capacity for technology generation is the number of S&T human resources engaged in R&D. As of 2013, the country has a total of 36,517 R&D personnel, of which 26,495 are key researchers (scientific, technological, and engineering personnel), and the rest are technicians and support personnel. This means that there are only 270 researchers for every one million Filipinos, which falls short of the UNESCO norm of 380 per million population and the 1,020 researchers per million population average across developing economies of East Asia and the Pacific.

Of the total researchers in the country from the government, higher educational institutions (HEIs) and private non-profit sectors, 14 percent have PhDs, 38 percent have Master's degrees, and 34 percent have Bachelor of Science (BS) degrees up to post-

[3] UNESCO Institute for Statistics. Retrieved from http://data.uis.unesco.org

[4] Tertiary inbound mobility refers to the number of students from abroad studying in a given country, as a percentage of the total tertiary enrolment in that country.

BS degrees. The low number of researchers in the country reflects the propensity of the educational system to produce graduates outside of Science, Technology, Engineering, and Mathematics (STEM) programs, which are the disciplines where R&D flourishes. Nevertheless, the latest GII Report indicates that in terms of graduates in science and engineering, the country garnered a score of 25.5 out of 100, ranking 26th.

Difficulty in increasing employment opportunities and retaining S&T human capital. An assessment of the country's innovation system conducted by the United States Agency for International Development-Science, Technology, Research and Innovation for Development (USAID-STRIDE) Program revealed that the supply of STEM graduates exceeds local demand. As a result, there is an out-migration and underemployment of many skilled, locally-trained scientists and engineers. The report also cited a shortage in training in fields that are critical to innovation, particularly in information technology. This situation makes it difficult for firms to find workers with the required skills.

Brain drain contributes to the problem as researchers, scientists, and engineers, who are the key actors for the innovation ecosystem to flourish, prefer to seek employment overseas where there are better economic opportunities and potential for advancement. Since knowledge and technology are mostly embodied in human resources, the problem stresses the urgency to accelerate the development of R&D human resource.

Absence of a vibrant intellectual property culture. The output of R&D is commonly measured in terms of patents applied and granted to Filipino residents. However, reports show that many universities do not have the expertise to market their patent portfolios for commercial use. Furthermore, technology generators face persisting issues in technology ownership, while researchers are constrained by the "publish or perish" phenomenon. This situation results in a weak technology transfer system in the country.

From 2005 to 2015, there was an annual average of 209 patents, 599 utility models and 598 industrial design applications. In the same period, an annual average of 54 patents, 446 utility models, and 502 industrial designs were granted. In 2016, the World Economic Forum (WEF) ranked the Philippines 86th out of 128 economies in the number of patents filed under Patent Cooperation Treaty per million population. Invention patents granted to local inventors represent the smallest share in the number of intellectual properties granted from 2001 to 2013. Industrial design and utility models consistently comprise the majority of the intellectual properties granted.

The country also needs to catch up in research publications since the number of scientific publications in peer-reviewed journals per million population stands at 55, substantially below that of ASEAN member states Singapore (10,368), Malaysia (1,484), Thailand (478), and Vietnam (105).

Weak linkages among players in the STI ecosystem. The 2009 Survey of Innovation Activities and the 2014 USAID-STRIDE Assessment of the Philippine Innovation Ecosystem show that innovation actors have weak cooperation, partnerships, and trust among them. Most HEIs perceive collaboration with companies as outside their core missions and as potential exploitation of their product or ideas. Firms report that convincing HEIs to collaborate with them is difficult because of resentment, suspicion, and distrust. Hence, firms end up with little technical assistance from the government and research institutions.

Restrictive regulations that hamper the implementation of R&D programs and projects. The tedious government procurement process hampers the immediate acquisition of equipment and other materials for research, which in turn delays the implementation of R&D programs and projects. This was confirmed by the USAID-STRIDE study, which shows that restrictive regulations make the procurement of equipment and consumables for research extremely slow and unnecessarily complex. They decrease research productivity, publication potential, and speed to market innovations. In addition, the report says that government research grants do not compensate universities for the salary of faculty members' research activities. This practice is rarely seen outside the Philippines.

Inadequate STI infrastructure. The country does not have enough STI infrastructure such as laboratory facilities, testing facilities, and R&D centers. Those that exist need upgrading. The situation contributes to the lack of absorptive capacity in research institutions. The USAID-STRIDE report notes that public institutions failed to provide young researchers, particularly those returning from PhD studies abroad with more advanced research agenda, with the necessary equipment. The Philippines' leading research institutions also remain concentrated in Luzon.

The government continuously engages in technology-intensive research and capacity building projects to improve the quality of its service to the people.

Some successful examples are the following:

Nationwide Operational Assessment of Hazards (NOAH)

- Project NOAH was initiated in June 2012 to help manage the risks associated with natural hazards and disasters. The project developed hydromet sensors and high-resolution geo-hazard maps, which were generated by light detection and ranging technology for flood modelling. It provides timely warning with a lead time of at least six hours during floods.

***Diwata*-1**

- In April 2016, the country launched into space its first micro-satellite called *Diwata*-1. It was designed, developed and assembled by Filipino researchers and engineers, with support from Japanese experts. *Diwata* provides real-time, high-resolution and multi-color infrared images. They are used in meteorological imaging, crop and ocean productivity measurements, and high-resolution imaging of natural and man-made features. It enables a more precise estimate of the country's agricultural production, provides images of watersheds and floodplains for a better view of water available for irrigation, power, and domestic consumption, as well as information on any disturbance and degradation of forest and upland areas.

Intelligent Operations Center Platform

- The Intelligent Operations Center Platform was established through a collaboration between the local government of Davao City and IBM Philippines. The Center resulted in the creation of a dashboard that allows authorized government agencies (i.e., police, fire, and anti-terrorism task force) to use analytics software for monitoring events and operations in real-time.

Establishment of state-of-the-art R&D and testing facilities

The DOST in cooperation with HEIs and research institutions established state-of-the-art facilities that seek to spur R&D activities and provide MSMEs access to testing services needed to increase their productivity and competitive advantage. These include the following:

- **Advanced Device and Materials Testing Laboratories –** equipped with advanced equipment for failure analysis and materials characterization to address advanced analytical needs for quality control, materials identification, and R&D

- **Electronics Products Development Center** – used to design, develop and test hardware and software for electronic products
- **High Performance Computing Facilities** – perform tests and run computation-intensive applications for numerical weather prediction, climate modelling, analytics and data modeling, and archiving
- **Philippine Genome Center** – a core facility that combines basic and applied research for the development of health diagnostics, therapeutics, DNA forensics and preventive products, and improved crop varieties
- **Drug Discovery Facilities** – address the requirements for producing high quality and globally acceptable drugs
- **Nanotechnology Centers** – provides technical services and enabling environment for interdisciplinary and collaborative R&D in various nanotechnology applications
- **Radiation Processing Facilities** – used to degrade, graft, or crosslink polymers, monomers, or chemical compounds for industrial, agricultural, environmental, and medical applications
- **Die and Mold Solutions Center** - enhances the competitiveness of the local tool and die sector through the localization of currently imported dies and molds

Strategic Framework

STI will contribute in the achievement of the overall PDP goal of establishing the foundation for inclusive growth, a high-trust and resilient society and a globally competitive knowledge economy by increasing the country's potential growth. This will be done by promoting and accelerating technology adoption and stimulating innovation. Increasing STI in the agriculture, industry, and services sectors as well as investments in technology-based start-ups, enterprises and spin-offs will result to the promotion and acceleration of technology adoption. On the other hand, enhancing the creative capacity for knowledge and technology generation, acquisition and adoption, and strengthening open collaboration among actors in the STI ecosystem will stimulate innovation *(see Figure 14.1)*.

Targets

Over the next six years, the government will aim to achieve the targets indicated in the following table.

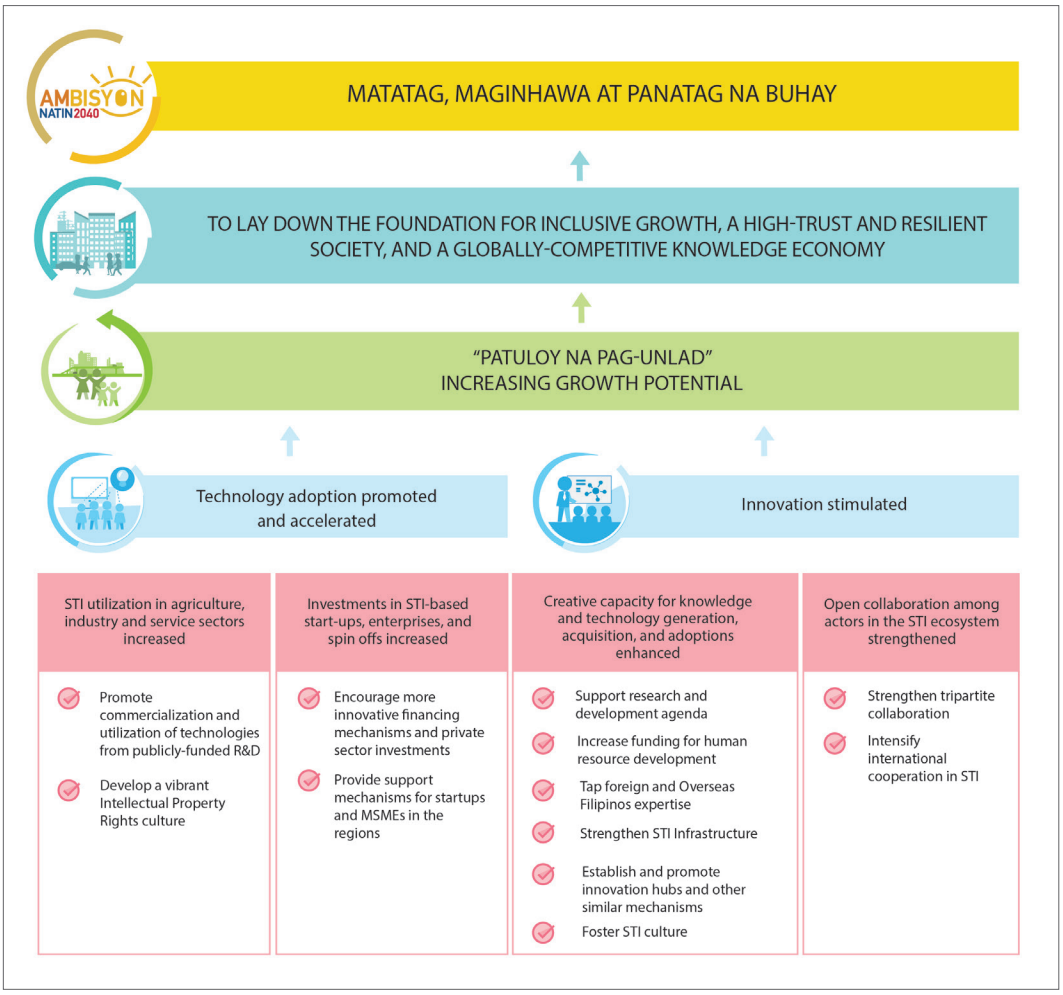
Table 14.1 Plan Targets to Leverage Science, Technology, and Innovation, 2017-2022

INDICATORS	BASELINE		END OF PLAN
	YEAR	VALUE	
Proportion of high-tech agriculture, industry and services value added in sectoral value added_/1		No data	tbd
Share of agriculture forestry and fisheries, and industry & services R&D to sectoral Gross Value Added		No data	tbd
Total number of Filipino patent registered	2016	31	42
Total number of Filipino utility model registered	2016	555	833
Total number of Filipino			
industrial design registered	2016	516	691
Percent of Technology Business Incubations locators that graduated	No data	tbd	tbd
R&D expenditure as a proportion of GDP_/2	2013	0.14	0.50
Researchers (in full time equivalent) per million population_/3	2013	270	300
WEF-Global Competitiveness Report (GCR) Innovation Ranking among ASEAN member countries	2016	5/7	Improved
WED-GCR Technological Readiness Ranking among ASEAN member countries	2016	4/7	Improved
WEF University-Industry Collaboration Index among ASEAN member countries	2016	5/7	Improved
Number of Technology Transfer Agreements	No data		tbd
Number of scientific articles published by Filipino authors	2013		tbd

Strategies

To achieve the sectoral outcomes, the strategies as indicated in *Figure 14.1* will be pursued.

Figure 14.1 Strategic Framework to Leverage Science, Technology, and Innovation 2017-2022



Subsector Outcome 1: STI utilization in the agriculture, industry, and services sectors increased

Promote commercialization and utilization of technologies from publicly-funded R&D. The government will promote and accelerate the dissemination, transfer, commercialization, and utilization of knowledge, technologies, information and processes derived from publicly-funded S&T activities without prejudice to intellectual property rights. Those technologies with high commercial potential shall be given priority assistance. The application of these knowledge, technology, information, and processes to the agriculture, industry, and services sectors will be given priority to improve productivity. This is expected to translate to an increase in incomes and jobs, especially in the countryside. The government will also foster the development of networks and markets, and undertake effective marketing strategies through the extensive use of quad-media and the organization of fora, fairs, and exhibits.

Develop a vibrant Intellectual Property Rights (IPR) culture. The initiative to improve patent applications performance through the Patent Incentive Package will be strengthened. Likewise, the provision of the Philippine Technology Transfer Act of 2009 particularly on ownership and revenue sharing will be institutionalized. Aggressive and sustained advocacy to increase the appreciation and understanding of IPR shall be undertaken in order to leverage intellectual property protection as an essential component of the innovation ecosystem. The government will also conduct information campaigns on the importance of intellectual property rights to strengthen public awareness and create an intellectual property culture among Filipinos.

Subsector Outcome 2: Investments in STI-based start-ups, enterprises and spin-offs increased

Encourage more innovative financing mechanisms and private sector investments. The government will create an investment environment that encourages more private sector participation, including angel investments, venture capital, and crowd fund-sourcing for STI-based startups, enterprises, and spin-offs. The investment provided may be a one-time investment to help the businesses launch or a continuing injection of support fund to help incubate startups during the early stages of their development *(see Chapters 8 and 9 on incentives for prospective investors)*. The government will strengthen programs that provide financing to commercially-viable innovation projects to bridge the gap between R&D and commercialization.

Provide support mechanisms for start-ups and MSMEs in the regions. The government will strengthen the policy and regulatory environment, and introduce new mechanisms to support technopreneurs, start-ups, spin-off companies, and MSMEs. It will provide platforms for technology commercialization such as the establishment of new technology business incubators in the regions in partnership with the private sector and HEIs; promote available technologies; and extend consultancy and other services for productivity improvement. These initiatives are intended to encourage uptake of innovation-based entrepreneurship.

The Small Enterprise Technology Upgrading Program will be expanded to enable more MSMEs to access government assistance for the provision of innovative and cost-effective facilities, provision of technical support for compliance with product and quality standards, packaging and labeling,

as well as training and consultancy services.

Additionally, the Startup Ecosystem Development Program will be pursued to usher in a new breed of businesses that will thrive in an innovation economy. Under the program, support for start-ups will be bolstered through government services, capital, and resources. In addition, a start-up economic zone will be established and assistance in connecting start-ups with industries, including multinational corporations and potential markets, will be provided.

Subsector Outcome 3: Creative capacity for knowledge and technology generation, acquisition and adoption enhanced

Support research and development agenda. The government will invest in building an efficient system of knowledge creation and technology generation. Among others, this will include basic research that needs revitalization, promotion and development through a more rational share in the STI ecosystem budget and infrastructure. As suggested in the Organisation for Economic Cooperation and Development Innovation Strategy 2015, long-term funding for curiosity-driven research must be preserved, as this has been the source of many significant innovations in the past and has high social returns.

Funding support will be provided for the implementation of the Harmonized National R&D Agenda (HNRDA), which defines the country's priorities and guides public investment in R&D. The agenda will consolidate and promote basic and applied research in agriculture, aquatic resources, natural resources, health and nutrition, drug discovery and development, industry, energy, defense and security, and emerging technologies.

STI initiatives for the creative industries, tourism, and other services industries will also be undertaken. Public investments will be channeled to cybersecurity and other technology-related ventures. Furthermore, investments will be made in support of the goal of Self-Reliant Defense Posture, which develops a local defense industry to sustain the material and non-material requirements of the defense forces. Innovation activities on the sectors covered by industry roadmaps will be supported. These roadmaps shall consider the utilization of results of researches and their R&D requirements, which will be made part of the HNRDA.

To keep up with the rapid global technological trends and developments, the Philippines will engage in more collaborative R&D activities and invest in infrastructure buildup to develop its capabilities and maximize the use of the following core and emerging technologies: (a) information and communications technology; (b) biotechnology for industry, agriculture, health, and environment; (c) nanotechnology; (d) genomics; (e) nuclear science for energy, health, agriculture, and industry; (f) artificial intelligence; (g) space technology; and (h) disaster risk reduction and climate change adaptation, and mitigation.

Increase funding for human resource development. Increasing the number and quality of researchers, scientists, and engineers is an essential strategy for the establishment of a vibrant STI ecosystem. The target is to achieve and even surpass the UNESCO norm of 380 researchers, scientists and engineers per million population by 2025 from its current level of 270. This can be achieved by providing continuous support and funding to ongoing S&T scholarships such as the following: (a) Expanded Specialized Science Secondary Education Scholarship; (b) Expanded Undergraduate S&T Scholarships for

Inclusive Development; and (c) Expanded S&T Graduate (Masters/PhD) Scholarships. Strengthening these S&T-based scholarship programs and providing specialized training and incentives will accelerate the development of the S&T human resources that will be tapped to contribute to nation-building. A competitive work environment will be created and research as a career will be promoted to help motivate competent human resources to stay in the country.

Tap the expertise of foreigners and overseas Filipinos (OFs). Mechanisms will be established to encourage overseas-based experts to share their knowledge and specializations with the academe and industry through information and communication technology (ICT), such as videoconferencing. The *Balik* Scientist Program and other related initiatives will be strengthened. The potential role of OFs in developing the country's STI capability will be recognized and pursued by providing opportunities for them. The hiring of foreign scientists and experts will be explored in areas where expertise is not available locally to leapfrog products and process development and build capacity in the field. Institutional linkages through OFs, especially in ASEAN, will also be fostered to encourage more R&D collaboration and capacity building activities.

Strengthen STI infrastructure. STI infrastructure development will be undertaken across the country in order to address region-specific concerns. Niche centers for R&D will be established to equip regional academic institutions and improve industry competitiveness. Moreover, modernization of existing R&D facilities and other STI infrastructures, both in the public and private HEIs, will be pursued to enable them to carry out higher-level R&D activities. The government will also invest in the establishment of product development centers, materials and product testing facilities, and climate and disaster risk reduction facilities.

Improvement of internet connectivity by putting in place a robust ICT infrastructure, particularly the national broadband infrastructure, will be given priority to boost productivity in research and other STI activities. The government is preparing for the rollout of its fiber optic cable network under the "Convergence Program" to link national government agencies in a fiber-optic network and shared resources.

Establish and promote innovation hubs and other similar mechanisms. Innovation hubs will be established in strategic locations in the country to include food innovation centers and shared service facilities. The country will position itself to become the global hub for Disaster Risk Reduction and Climate Change Adaptation and Mitigation. The hub will provide a platform for sharing technologies, lessons and best practices in responding and recovering from natural disasters such as typhoons, floods, and volcanic eruptions.

In addition, an innovation center will be established to promote not only innovation, but also design and creativity, and to provide support for the creation of incubation centers for MSMEs and start-ups. The Department of Trade and Industry will coordinate with the Department of Science and Technology (DOST) and other government agencies, the academe, the private sector, and people's organizations on the necessary investments in scientific and technological research, as well as government support for science and technology parks and local R&D and training.[5]

Moreover, existing services that will be continued and bolstered, such as the following: (a) One Lab (Harmonized Laboratory Testing Services); (b) One Expert; and (c) One Store.

Foster an STI culture. The culture of inventiveness and creativity (*see also Chapter 7 on advancing "pagkamalikhain" or creative excellence*) will be promoted in all

[5] Banatao, D. (2016). Creating an Innovative Mindset and Ecosystem. Manufacturing Summit 2016.

sectors and as early as possible. Programs to boost the interest of young students to pursue STEM courses and the creative arts as viable career options will be pursued. Communicating STI through various media and in partnership with different stakeholders will be carried out to increase public awareness and interest on the importance of STI in daily life.

An STI culture that fosters more effective decision making will be promoted among policy makers and government officials and employees. Being major users and consumers of products and services, government offices will also serve as showcase and promoter of innovative and STI-based solutions. The government will also support LGU-led innovation activities.

Sub-sector Outcome 4: Open collaboration among actors in the STI ecosystem strengthened

Strengthen tri-partite collaboration. Collaboration in R&D based on the triple helix model, which involves the coordination and cooperation of university, industry, and government, will be strengthened. It will be facilitated through the elimination of institutional bottlenecks for joint research activities, such as burdensome processes and administrative procedures, particularly in public higher education and research institutions. The government will also leverage public R&D grants, tax, and other incentives to increase productivity.

Intensify international cooperation in STI. International cooperation will be pursued more aggressively to enhance the flow and benefit of a wide range of existing knowledge and technologies from other countries. Existing fora such as the ASEAN, Asia-Pacific Economic Cooperation and other similar platforms for dialogue and collaboration will be utilized.

Public and private STI institutions will be encouraged to participate and collaborate with international partners in research platforms that seek solutions to common regional concerns such as food security, climate change, disaster risk reduction, resiliency and preparedness, and conservation of resources and biodiversity. These research platforms necessitate specific and strong support for policies that can: (a) facilitate the mobility of S&T experts, researchers, academics and students and other highly skilled human capital; and (b) advance cross-border education and inter-university collaboration in order to foster innovations in solving common regional concerns.

Legislative Agenda

To strengthen the effectiveness of the strategies, legislative action is needed on the following:

Table 14.2 Legislative Agenda to Leverage Science, Technology, and Innovation, 2017-2022

LEGISLATIVE AGENDA	KEY REFORMS
Sector Outcome 1: Promoted and accelerated technology adoption	
An Act Establishing the Science for Change Program	Aims to achieve a higher standard of S&T, by prescribing the basic policy requirements for the promotion of S&T and comprehensively and systematically promoting policies for the progress of S&T.
An Act Strengthening the National Measurement Infrastructure System amending RA 9236, also known as the National Metrology Act of 2003 and for Other Purposes	Aims to establish a National Metrology Institute under the DOST; provide capacity building programs through competency training to strengthen the local metrology authorities at the local level; and set up a Metrology Training Program to undertake proficiency testing, advocacy education and training on metrology.
Subsector Outcome 2: Stimulated Innovation	
An Act Adopting Innovation as a Vital Component of the Country's Development Policies to Drive Inclusive Development, Promote the Growth and National Competitiveness of MSMEs, and for other Purposes	Intends to generate and scale up action in all levels and areas of education, training, research and development towards promoting innovation and internationalization activities of MSMEs as a driver of sustainable and inclusive growth.
An Act Strengthening the Balik Scientist Program and Appropriating Funds Thereof	Seeks to strengthen the scientific and technological human resources of the academe, public institutions, and domestic corporations, through the promotion of knowledge sharing and accelerate the flow of new technologies into the country.
An Act Creating the Philippine Space Agency	Seeks to legislate a Philippine Space Development and Utilization Policy and create a Philippine Space Agency that would be tasked with providing the country's space technology-related need from weather imaging to telecommunications.
An Act Providing for a Comprehensive Nuclear Regulation, Creating for the Purpose the Philippine Nuclear Regulatory Commission (PNRC), and Appropriating Funds Therefor	The bill seeks to legislate an independent regulatory framework that will decide on issues affecting public health and safety, protection of the environment and nuclear security and safeguards, beyond the reach of entities with self-motivated interests. The resolution of issues within an autonomous regulatory structure will generate a higher level of trust and confidence in the application of nuclear technologies. The PNRC shall exercise authority over all aspects of safety, security involving nuclear materials and other radioactive materials, facilities and radiation generating equipment.