BCG Model:

Fostering Sustainable Development in Thai Economy

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BCG Model: Fostering Sustainable Development in Thai Economy

Author: Narong Sirilertworakul, Ph.D.
President, National Science and Technology Development Agency (NSTDA)

Abstract

Bio-Circular-Green Economy (BCG) model was introduced by the Thai Government as a strategy for the national development and post-pandemic recovery (The Secretariat of the Cabinet, 2021). BCG model places emphasis on applying science, technology and innovation to turn Thailand's comparative advantage in biological and cultural diversity into competitive advantage, focusing on four strategic sectors, namely 1) agriculture and food, 2) wellness and medicine, 3) energy, materials and biochemicals, and 4) tourism and creative economy. It aims to promote sustainability of biological resources, strengthen communities and grassroots economy, enhance sustainable competitiveness of Thai BCG industries, and build resilience to global changes (Ministry of Higher Education, Science, Research and Innovation (MHESI), 2021). The model is expected to create sustainability and inclusiveness to Thailand's economy, society and the environment.

Introduction

Thailand was among the United Nations Member States that adopted the 2030 Agenda for Sustainable Development. Since then, the country has been committed to the UN Sustainable Development Goals (SDGs) with some progress and success. In 2020, Thailand was ranked 43rd among 165 countries in SDG Index, a leap from the 55th place in 2017 (Jeffrey D. Sachs, Christian Kroll, Guillaume Lafortune, Grayson Fuller, and Finn Woelm, 2021). While the country has already achieved the target of SDG 1 which is to end the poverty, it is still faced with great challenges with SDG 2 (zero hunger), SDG 3 (good health and well-being), SDG 10 (reduced inequality), SDG 14 (life below water) and SDG 15 (life on land). It is expected that the Bio-Circular-Green Economy (BCG) model, introduced by the Thai Government as a strategy for the national development and post-pandemic recovery, will expedite Thailand to move closer and achieve most, if not all, SDGs in the post-COVID era.

Current Trends of BCG-related Sectors in Thailand

BCG model is fundamentally based on biological resources and linked to Thailand's four strategic sectors, namely 1) agriculture and food, 2) wellness and medicine, 3) energy, materials and biochemicals, and 4) tourism and creative economy. In 2018, a combined value of these four sectors was 3.4 trillion THB, accounting for 21% of GDP, involving more than 16.5 million workers, or half of the total employment.

Agriculture and Food

While one-third of the total employment, or more than 12 million people, work in agricultural sector, this sector contributes only 8% of GDP, or 1.3 trillion THB (45 billion USD). Over 90% of cultivated land are used for 6 crops which are rice, rubber tree, cassava, sugarcane, corn, and oil palm tree – all of which are farm commodities vulnerable to price volatility. This is the main reason for farmers' low income. In 2019, Thai farmers earned an average income of 9,000 USD/household/year, well below the country's average of 1,425 USD/household/year (MHESI, 2020).

Boosting farm productivity requires an increase in resource use, causes more environmental and resource degradation and is unrealistic considering population ageing in Thai farming sector. Therefore, it is necessary to move the farm production from low-price commodity to premium products, i.e., shifting from "more for less" to "less for more" production, by placing emphasis on standards for high quality and safety. Internet of things (IoT) technology enables precision agriculture by allowing farmers to optimize input (water, fertilizer, etc.) application to achieve high crop yields and reduce operational costs. Other farm products, e.g., herbal plants, fruits, seeds, ornamental plants, bamboo, insect and goat, can add diversification to Thai agricultural products and lessen price volatility. Herbal extract and natural products are examples of high-value products derived from farm commodities. Rice extract is sold at 2,400 THB/kg (80 USD/kg) or capsaicin from chili at 30,000 THB/kg (1,000 USD/kg) (MHESI, 2020a).

In 2018, the food and beverage industry contributed 4% to Thai GDP, equivalent to 625 billion THB (20 billion USD). There are 53,642 food processing and beverage factories in Thailand, generating a combined income of 3 trillion THB (100 billion USD), one-third of which were export income. The country is the 11th largest food exporter in the world, and the 2nd in Asia after China, with top export products including rice, canned and processed seafood, fresh and processed fruits, chicken meat and processed chicken and cassava products. Demand for Thai food products overseas continues to rise despite the pandemic due to its reputation for quality and safe food products (MHESI, 2020a).

There are over 100,000 operators of local food and street food in Thailand. This segment requires an improvement in quality and safety. Some operators have turned to health food business. Health food and beverage is a fast-growing sector, with a market value of 200 billion THB (6 billion USD) in 2017. Functional foods that can enhance brain function and improve immune system are in high demand (MHESI, 2020b).

Wellness and Medicine

In 2017, Thailand's healthcare spending was 400 billion THB (13.3 billion USD). This number is expected to reach 1.4 trillion THB (46 billion USD) when the country becomes a fully aged society. Each year, the country imports drugs and pharmaceutical products at a combined value of 100 billion THB (3 billion USD), three-fourths of which are medicine. Local pharmaceutical manufacturing capability is limited to producing generic drugs - 90% of the total volume of drugs manufactured in Thailand - from imported active pharmaceutical ingredients (APIs). The country has 161 GMP-certified pharmaceutical manufacturers but only one is capable of producing biosimilars. As a result, Thailand imports 20 billion THB (600 million USD) worth of biopharmaceuticals such as vaccines, therapeutic proteins and antibodies. To illustrate how expensive and yet necessary these imported biopharmaceuticals are, pembrolizumab is used as an

example. Pembrolizumab is an antibody used in cancer immunotherapy. The drug costs 150,000 THB/treatment (5,000 USD/treatment) in Thailand (MHESI, 2020c).

Thailand medical and wellness tourism is doing remarkably well thanks to high quality medical services and healthcare professionals, and affordable price tags. 70% of foreign patients in Thailand are medical tourists. The country ranked 13th in the wellness tourism destinations by the Global Wellness Institute, generating over 9.4 billion USD income. The International Healthcare Research Center (IHRC) placed Thailand at the 6th position in medical tourism (Thailand Convention and Exhibition Bureau (Public Organization), 2018). These records reflect the strength of Thailand's health service sector. Clinical research is another high potential area for Thailand. In 2015, clinical research activities generated 8.8 billion THB (290 million USD) revenue to the Thai economy. With a good management system, this number can potentially be doubled (MHESI, 2020c).

The growth of medical service sector has contributed to the expansion of medical device industry. In 2019, Thailand achieved medical device trade surplus, with 100 billion THB (3 billion USD) export value against 70 billion THB (2.3 billion USD) import value. The country holds the largest medical device market in ASEAN with an average annual growth of 8-10%, compared to the 5.2% world's average. There are 1,586 medical device manufacturers in Thailand, most of which are joint-venture SMEs with foreign partners. While 84% of export products are medical supplies such as alcohol, surgical masks and safety goggles, import products are mostly medical equipment such as ultrasound machines, x-ray machines and ophthalmology equipment. Top countries of import medical devices are the US, Germany and China (MHESI, 2020d).

The cosmetic market is worth 300 billion THB (10 billion USD). In 2019, Thailand had over 1,800 cosmetic manufacturers. 90% of these companies are SMEs and therefore have multiple disadvantages, including technological capacity, against big or multinational companies. Moreover, local cosmetic companies are faced with challenges in the quality and quantity of domestic herbal plant supply (MHESI, 2020d).

Energy, Materials and Biochemicals

Prior to the 2008 Renewable Energy Development Plan, 60% of total energy consumption in Thailand was imported. This proportion continued to rise, despite the country's high potential in renewable energy. Thailand has abundant biomass, agricultural waste and by-product to produce renewable energy. The volume is sufficient to meet the 30% renewable energy target set by the Alternative Energy Development Plan 2018-2037, up from 16.5% in 2019 (MHESI, 2020e).

An increase in renewable energy production requires highly efficient technologies that can convert a wide range of biomass - municipal, industrial and agricultural waste - to renewable energy such as refuse-derived fuel and biogas. With advancement in renewable energy technologies, a community-based power plant from renewable sources can be established with blockchain-based smart microgrid to efficiently supply electricity to community members and manage the transaction. To promote smart energy networks based on renewable energy, more R&D is needed in the area of energy storage system to stabilize power supply from renewable sources.

With growing concern for the environment, biobased products are gaining public attention with worldwide market value expected to reach 487 billion USD by 2024, up from 400 billion USD in 2020. This trend presents ample opportunity for Thailand to create additional value to its commodity crops and biomass. By employing advanced technology and innovation in biosciences and biotechnology, value of crops and biomass can be multiplied. Bagasse worth 1 THB/kg (0.3 USD/kg) can be turned into bioactive compounds for cosmetic application or functional food ingredients worth 260 THB/kg (8 USD/kg). If the bioactive compounds are used in pharmaceutical application, the price can even be driven up to 1,000 THB/kg (30 USD/kg). Another potential utilization of bagasse is as feedstock for bioplastic production. Carbon dioxide emitted from industry or biogas production can serve as a building block to produce chemicals and high value biochemicals (MHESI, 2020e).

Tourism and Creative Economy

Bountiful natural resources and diverse ecosystems make Thailand one of the world's top tourism destinations. In 2019, Thailand's tourism revenue was 3 trillion THB (100 billion USD), two-thirds of which were contributed by 40 million foreign tourists (Ministry of Tourism and Sports, 2020). However, 80% of the revenue was concentrated in only 8 provinces. This could mean that these cities are exceeding their tourism carrying capacity which can lead to environmental destruction and other social problems. It is therefore vital to rehabilitate the damaged environment and resources, and at the same time, develop secondary cities, embrace sustainable tourism and start building tourism based on local identity and the country's strength. New types of tourism such as agrotourism, low-carbon tourism and knowledge tourism have potential to redistribute tourists and income not only to communities, but to other sectors as well, enabling sustainable income throughout the whole system. Tourism management system can be enhanced by technology which can potentially increase tourist spending.

A public payment gateway for tourism businesses is a strategic tool to increase tourism revenue. One payment system offers convenience for tourists to pay for entrance fees, public transportation and other services through a single platform, and at the same time, enables the acquisition of tourist spending insights which can be used for the analysis and planning of tourism management and the design of marketing campaign.

In 2017, Thailand's circular economy amounted to only 100 billion THB (3.3 billion USD), suggesting that the country was at an early stage of circular economy. However, due to escalating demand for resources against limited supply, the global trend is moving towards resource use reduction, waste minimization, and sustainable production and consumption, as a strategy to achieve the Paris Agreement commitment to lower greenhouse gas emissions and at the same time build a new economy. Circularity is expected to contribute at least 400 billion THB (13 billion USD) to the Thai economy, equivalent to 2% of GDP, by 2030 (MHESI, 2020f).

Thailand continues to make a steady progress on green economy. Its Global Green Economy Index (GGEI) rose from the 45th position in 2014 to 38th and 27th in 2016 and 2018, respectively (Dual Citizen, 2021). The country ranked second in the ASEAN region, behind Singapore. Adoption of green economy is a strategy to expand Thailand's international trade dictated by stringent environmental policy and to attract investment from firms committed to green growth.

Investment Climate

Thailand Board of Investment (BOI) – an agency instrumental in promoting industries targeted by the government – currently has around 50 BCG-related business activities eligible for the investment promotion. These include, for instance, the manufacturing of APIs, natural extract, products and services related to modern agriculture, medical food and food supplements, functional ingredients, refuse-derived fuel and biogas. In addition, BOI also rolled out measures to support the development of local economy –strengthening community enterprises, agriculture and food processing businesses and community-based tourism - and technological upgrade to comply with international standards. As BCG model is now a national agenda, BOI is planning to launch more measures and expand business promotion categories to embrace the vast scope of BCG industry.

Between 2015-2020, BCG-related projects applying for BOI-investment promotion had a combined value of 600 billion THB (20 billion USD). In 2020, projects received from agriculture and food industry were worth 41.135 billion THB (1.37 billion USD) in total, up 9% from the previous year, while investment in biotech projects was 30.056 billion THB (1 billion USD), doubling the value of the previous year. One of biotech projects was the manufacturing of biobased polymer worth 19,568 billion THB (650 million USD). The first quarter of 2021 saw a surge of BCG investment with total of 90 BGC-related projects worth 40.71 billion THB (1.36 billion UDS), accounting for 58% of the total investment applying for BOI promotion.

Economic Transformation with BCG Model

Thailand's post-COVID sustainable development strategy emphasizes the exploitation of knowledge, technology and innovation to create economic value to its strength and potential in natural resource wealth, cultural diversity and nurturing spirit. BCG model has been introduced to enable sustainable and inclusive growth, in line with the UN Sustainable Development Goals (SDGs) and the Sufficiency Economy Philosophy (SEP) (MHESI, 2021). The model aims at applying the concepts of bioeconomy, circular economy and green economy to develop high value products and services that are eco-friendly and require less resource input, while conserving natural and biological resources.

Turning Challenges into Opportunities

Thailand possesses multiple strengths in terms of food, public health and richness of natural resources and culture, and yet endures several challenges. The country earned 1 trillion THB (33 billion USD) from exporting food products in 2019 with the status of world's top producer of rice, cassava and sugar. Despite high food volume production, 80% of the products are minimally processed, and therefore sold at low prices. While the country's medical and wellness sector performs remarkably well, except during the pandemic, 70% of medicines used in the country are imported. In 2019, Thailand's tourism revenue was 3 trillion THB (100 billion USD), placed 4th in the world, with 40 million international tourists. However, the revenue is mainly concentrated in 8 provinces and majority of the travelers are low budget tourists (MHESI, 2021).

Despite all challenges, there are opportunities for Thailand to thrive. As the world is embracing the idea of balanced and sustainable development, Thailand can promote the production of eco-friendly goods and services to fulfil this significantly expanding market. Consumers nowadays look for quality and safe products and services that meet international standards. Thai food products, especially ready-to-eat meals, are expected to be in high demand in the post-pandemic future, as the country is well recognized for its food quality and safety. New lifestyle leads to market opportunity in health products and services, on which Thailand can capitalize based on its wealth of herbal plants and traditional wisdom.

In view of the strengths, weaknesses and challenges, Thailand can certainly enhance its global competitiveness in the following areas:

1. Hygienic Kitchen of the World. According to the United Nations, the world's population is expected to increase from 7.6 billion in 2016 to 9.8 billion in 2050, driven by growth in developing countries. With this projection, demand for food will increase by 70%. Thailand, therefore, should take this opportunity to strengthen its food quality and safety standards to fulfil this growing market.

2. High Value-added Products from Innovation and Creativity. Thailand is blessed with abundant farm products which can be grown all year round, as well as a large amount of under-utilized agricultural waste and by-product. This biomass can be converted to a wide variety of products. Biobased product market is expected to reach 350 billion USD in 2027 (Grandview Research, 2020), whereas that of biochemicals is projected to increase from 6.5 billion USD in 2016 to 24 billion USD in 2025.

3. Healthy People. The Office of the National Economics and Social Development Council predicted that Thailand would become a fully aged society in 2021 and the elderly would make up one-third of the population by 2040. It is therefore imperative that Thailand develop self-reliance in healthcare.

4. Happy Destination. The next chapter of Thailand's tourism industry will shift towards quality tourism. A new form of tourism will be developed to ensure safety and sustainability, offering fair income distribution to locals and elevating tourist's experience with medical and wellness tourism, as well as culinary tourism.

5. Harmonious and Sustainable Society. The development will focus on creating fair wealth distribution to each and every sector and promoting conservation, rehabilitation and sustainable utilization of resources (MHESI, 2021).

BCG Principles and Strategies

BCG model - aiming to employ knowledge, technology and innovation to create economic value to Thailand's valuable assets, including natural resource and culture - is based on the following principles:

1. Sufficiency Economy Philosophy (SEP). Introduced by His Majesty the late King Bhumibol Adulyadej, SEP is a method of development based on moderation, prudence, and social immunity. The philosophy attaches great importance to human development at all levels and emphasizes the need to strengthen community's capacity to ensure a balanced way of life and resilience, with full respect for the environment. SEP has long been the foundation of Thailand's national development strategy.

2. Building strength from within and connecting Thailand to the global community. BCG model capitalizes on the country's innate strength which is the diversity of biological resources and culture and applies technology and innovation to convert this capital to high value goods and services. The model also emphasizes capacity building, starting from local communities, expanding to the national level and connecting to the world by being part of the global supply chain, collaborating with international partners to co-create knowledge and innovations and engaging and playing an active role in international initiatives to advance sustainability agenda.

3. Moving forward together and leaving no one behind. BCG model aims to promote growth in all sectors and unlock the potential, while maintaining the identity, of each and every community. Quadruple helix model - engaging public, industry, academia and the society - will be employed as a mechanism to turn comparative advantage in biological and cultural diversity into competitive advantage through the application of science, technology and innovation to build a strong economy ready to compete in the global stage, while at the same time, distributing fair income and wealth to community, reducing inequality, strengthening the grassroots, taking care of the environment and eventually achieving sustainable development.

The 2021-2027 BCG Action Plan sets a vision to create sustainable and quality growth with science, technology and innovation, raising income and quality of life while maintaining a good balance of utilization and conservation of biological and natural resources. The action plan is based on the four strategies (MHESI, 2021):

Strategy 1: Promote sustainability of biological resources by balancing conservation and utilization.

This strategy focuses on applying knowledge, technology and innovation to create a balance between conservation and utilization of biological resources and introduce a paradigm shift from "nature as resource" to "nature as source", reinforcing the perception on nature that it is not just a provider, but a source of all living organisms.

Strategy 2: Strengthen communities and grassroots economy by employing resource capital, identity, creativity and advanced technology.

This strategy aims at understanding and recognizing the potential of each community – resources, culture, and nurturing spirit – and utilizing it to create high value goods and services by employing technology and creativity. Inclusiveness – the concept of leaving no one behind – is also emphasized.

*St*rategy 3: Enhance sustainable competitiveness of Thai BCG industries.

This strategy focuses on enhancing the competitiveness of manufacturing and service industry by employing knowledge, technology and innovation to improve efficiency, reduce waste and enable circularity. Emphasis will be placed on enhancing quality, safety and eco-friendliness of goods and services to meet international standards. Advanced technology will be developed and introduced for commercial use. Examples include plant factory system and personalized medicine.

Strategy 4: Build resilience to global changes.

This strategy aims at creating immunity and building capacity to adapt to global changes, seize opportunity arising from global trends and invest in science and technology and quality infrastructure to support new economic engines and strengthening the grassroots. Science, technology and innovation will be employed to enhance the capacity of local communities and entrepreneurs and enable them to offer products and services to fulfil new market trends and achieve quality growth, as well as to develop a low-carbon society. The strategy also addresses manpower development to support future industry derived from BCG model, as well as frontier research to lessen dependency on foreign technology.

BCG Management and Monitoring Mechanisms

BCG model involves all sectors in the society, including public, private, academia and research, community and international alliance. In the public sector, the work falls under the responsibility of multiple ministries and therefore, cross-ministerial and inter-agency coordination is vital. In addition, BCG model is closely linked to the National Development Plan as set out by the National Strategy, the national reform initiative and others. Based on this interconnection, the mechanism is established in three levels (MHESI, 2021).

1. Policy. The BCG Policy Board has been established to set and drive the policy and promote the integration and cohesiveness among organizations to move in the same direction in order to reach the common goal. The Prime Minister serves as the

board chairman and the National Science and Technology Development Agency (NSTDA) is assigned the role of the board secretariat.

2. *Implementation.* The BCG Implementation Committee is responsible for deploying the policy to the action plan and devising measures and mechanisms to promote BCG development, infrastructure investment, manpower development, ecosystem development, laws and regulations revision to facilitate BCG development, and monitoring and evaluation system. Minister of Higher Education, Science, Research and Innovation is the chairman of the BCG Implementation Committee with NSTDA serving as the committee secretariat. In addition, a number of BCG Implementation Subcommittees, consisting of experts from the public, private and people sectors, are established to drive the work in each target sector.

3. *Evaluation and Monitoring.* To ensure that the implementation proceeds according to the action plan and timeframe to reach the target, each BCG Implementation Subcommittee is to submit a quarterly report to BCG Implementation Committee. Data and information will also be reviewed and analyzed for performance improvement. As part of the national strategy, outputs, outcomes and impact of BCG will be monitored and evaluated through the Electronic Monitoring and Evaluation System of National Strategy or eMENSCR implemented by the Office of the National Economic and Social Development Council (NESDC).

BCG Policy Recommendations

To warrant the success of BCG model, the government's role needs to be re-defined and a policy needs to be clearly set to facilitate an integrated approach for the implementation.

The paradigm shifts in the government's approach to BCG implementation are proposed as follows (MHESI, 2021):

1. Change from publicly led investment to enterprise-led investment by creating an ecosystem to boost private investment portion. Improvement on ecosystem can be achieved through revising impeding laws and regulations and streamlining product registration processes, for instance.

2. Change from cash-aid policy to investment policy. Solutions such as farm subsidy is short-term. A more sustainable and long-term solution would be to invest in research, innovation and implementation of research outputs to a wider scale.

3. Change from an annual funding to a multi-year funding. Development of technology and innovation takes time and requires funding continuity which is difficult to achieve with the current budgeting system that approves funding year by year.

4. Change from funding individual projects to integrated projects - encompassing the whole process from research, to development, innovation and manufacturing - that will advance research to market. Public research fund mostly stops at the lab-scale technology, leaving the financial burden of upscaling to the private sector. Upscaling of technology to industrial production is an expensive step and can cost as high as 1 million USD – the amount that most SMEs cannot afford (National Science and Technology Development Agency, 2019).

5. Change from traditional industry to s-curve industry, enabling Thai industry to rely less on comparative advantage in labor cost and resources and earning more with innovation.

6. Change from externally dependent growth to strengthening the local economy and connecting to the global economy. Thai economy is highly dependent on foreign tourism revenue and imported technology and materials, and the wealth gap is very large. Economic development must therefore focus on strengthening the grassroots economy and technological self-reliance.

7. Change from individual actions to collective actions, employing the quadruple helix model that engages all sectors - government, industry, academia and people.

The following policy measures are proposed for public-private partnership implementation:

1. Create digital repository of bioresources, cultural capital and local wisdom.

• Develop a database system for collecting and integrating qualitative and quantitative data of various assets and capitals – ranging from genetic and ecosystem information, to products and services, as well as culture and traditional knowledge.

• Employ big data analytics for the planning and management of conservation, restoration and utilization program to strengthen a local economy and tourism industry.

2. Replenish national resources through quadruple helix approach.

• Establish a program offering carbon credit to enterprises engaging in the forestry carbon projects on the government's land.

• Accelerate research and development in plant and animal breeding and resource monitoring and management.

3. Develop BCG corridor.

• Build a regional economic corridor in each part of the country by connecting regional demand and supply.

• Employ BCG approach - modern agriculture, processing, tourism, trade and investment and linkage between domestic and global economy - to develop and improve products and services.

4. Transform agricultural system.

• Focus on premium and safe products by emphasizing plant breeding research, safety and quality standards, good farm management and logistics management system.

• Raise agricultural GDP by diversifying agricultural products with options such as seed, fruits, ornamental plants, timber, insects, herbal plants and livestock.

• Increase farmers' access to knowledge and technology.

• Promote sustainable agriculture through BCG approach.

5. Improve quality and safety of street food and local food.

• Promote food machinery and Good Hygiene Practices (GHP) compliance.

6. Build a biobased economy by employing advanced technology to develop and manufacturer high-value products such as functional ingredients, functional food, biochemicals such as oleochemicals, biomaterials such as carbon-based materials, drugs and vaccines.

7. Create demand for innovative goods and services derived from BCG model.

• Implement the government procurement program such as requiring public hospitals to procure medical devices on the Thai Innovation List.

• Offer tax and investment incentives to industry and people sectors to promote products and services on the Thai Innovation List

• Establish BCG-related labeling such as carbon footprint labeling, green labeling and environmental labeling.

• Introduce instruments such as carbon pricing and polluter pays principle.

• Deregulate energy trading.

8. Promote sustainable and green tourism.

• Launch new tourism campaign such as Happy Model.

• Develop sustainable and green tourism with BCG concept and carbon neutrality.

• Form tourism clusters of primary and secondary cities.

• Establish a one payment system to support tourism database for analysis and future planning.

9. Promote the development and manufacturing of sustainable goods and services by employing green technologies and circular concept.

10. Raise the standards of products and services to comply with international requirements by investing in infrastructure.

- R&D infrastructure.
- Translational research infrastructure such as pilot plants.
- Quality infrastructure system to support standardization, testing, certification and accreditation of products/services such as organic products, biochemical products, drugs, vaccines, and medical devices and supplies.
- Revise laws and regulations.

11. Support BCG startups.

- Improving technological and business skills of entrepreneurs.
- Increase access to technology, innovation and government infrastructure
- Provide access to government experts and financial sources.

12. Develop manpower to support BCG model in all levels.

- Communities and grassroots.
- SMEs.
- Deep tech.
- Startups and tech entrepreneurs.

13. Promote international collaboration in all facets, including knowledge creation and talent mobilization.

- Establish research, trade and investment networks at the national, regional and global levels.
- Enrich Thailand’s innovation ecosystem with measures such as incentive to attract foreign investment and international talent and SMART visa program.

Expected Outcomes of BCG Model

It is envisaged that BCG model will make significant impact in four aspects.

• *Sustainability of resources and the environment.* BCG model will reduce natural resource consumption by one-fourth, cut down greenhouse gas emissions by at least 20% and add at least 0.5 million ha of forest area. These improvements correspond to SDG 12 (responsible consumption and production), SDG 13 (climate action)), SDG 14 (life below water), SDG 15 (life on land) and SDG 17 (partnerships for the goals).

• *Socioeconomic prosperity.* BCG model aims to improve income inequality of 10 million people, reduce the proportion of undernourished population to 5%, increase health inequality of at least 300,000 people and increase the number of energy self-sufficient communities by 20%. This aspect is connected to SDG 1 (no poverty), SDG 2 (zero hunger), SDG 3 (good health and well-being), SDG 6 (clean water and sanitation), SDG 7 (affordable and clean energy), SDG 8 (decent work and economic growth) and SDG 10 (reduced inequality).

• *Sustainable economic growth.* BCG model is expected to raise economic value of the BCG industries by 1 trillion THB, increase the proportion of high-value products and services at least by 20% and generate at least 50% more income to the grassroots. This impact will contribute to SDG 1 (no poverty), SDG 3 (good health and well-being), SDG 6 (clean water and sanitation), SDG 8 (decent work and economic growth) and SDG 10 (reduced inequality).

• *Self-reliance.* BCG model sets to improve skill of at least 1 million workers, create additional 1,000 startups and innovation-driven enterprises (IDEs), improve negative technology balance of payment by at least 20% and reduce imports of medical and health supplies by at least 20%. The enhancement will contribute to SDG 8 (decent work and economic growth) and SDG 9 (industry, innovation and infrastructure) (MHESI, 2021).

BCG model is an essential engine to drive the economic and social development, enabling Thailand to become a developed country by capitalizing Thailand's strength in biological and cultural diversity and employing science, technology and innovation.

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สถาบันระหว่างประเทศเพื่อการค้าและการพัฒนา (องค์การมหาชน)
อาคารวิทยพัฒนา ชั้น 8 จุฬาลงกรณ์มหาวิทยาลัย
ซอยจุฬา 12 ถนนพญาไท แขวงวังใหม่ เขตปทุมวัน
กรุงเทพฯ 10330

อีเมล : info@itd.or.th
เว็บไซต์ : www.itd.or.th
โทรศัพท์ : 66+ (0) 2216 1894-7
โทรสาร : 66+ (0) 2216 1898-9

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