The role of nuclear science and technology (NST) in supporting the implementation of the sustainable development goals (SDGs) in Malaysia

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Abstract. The United Nations 2030 Agenda for sustainable development (2030 Agenda) adopted in 2015 has underlined seventeen sustainable development goals (SDGs). The SDGs are used to chart the actions over the next fifteen years (2016-2030) in areas of critical importance for humanity and the planet towards sustainable development. Malaysia is among the countries that have put the SDGs in its development agenda and is on track to achieve the SDGs. Many countries including Malaysia use nuclear science and technology (NST) to meet their development objectives in various areas including food and agriculture, industry, human health, energy, water management, and environmental protection. The use of NST can help to achieve nine of the seventeen SDGs. This paper aims at highlighting the role of nuclear science and technology in supporting the implementation of the SDGs in Malaysia.

1. Introduction

On 25th September 2015, as part of the United Nations Resolution 70/1, the global leaders have adopted the sustainable development goals (SDGs) at the United Nations Summit [1]. SDGs are a collection of seventeen global goals with 169 targets, which designed to stimulate action over the next fifteen years (2016-2030) in areas of critical importance for humanity and the planet. Countries including Malaysia have committed to undertake appropriate actions to integrate such goals and targets into their national development plans as well as to align policies and institutions behind them [2]. In this connection, the United Nations has highlighted the critical role of science, technology and innovation in achieving the SDGs [3].

In this connection, the International Atomic Energy Agency (IAEA) has emphasised the IAEA’s role in transferring nuclear technology for peaceful uses to developing countries through its technical cooperation programme, to help them achieve their development objectives. The use of nuclear science and technology (NST) contributes directly to nine of the seventeen SDGs namely, SDG 2: Zero hunger, SDG 3: Good health and wellbeing, SDG 6: Clean water and sanitation, SDG 7: Affordable and clean energy, SDG 9: Industry, innovation and infrastructure, SDG 13: Climate action, SDG 14: Life below water, SDG 15: Life on land, and SDG 17: Partnerships for the goals [4]. Malaysia has long benefitted from the use of NST in various sectors including human health, food and...
agriculture, industry, water management and environmental protection. The use NST contributes to national socio-economic development and therefore, could support the implementation of SDGs in the country. This paper aims at highlighting the role of NST in supporting the implementation of the SDGs in Malaysia.

2. SDGs in Malaysia
Malaysia has integrated the SDGs in its development agenda. SDGs were implemented in phases through the national development plans, particularly the Five Years Malaysia Plan. For period of 2016 to 2020, the Eleventh Malaysia Plan and its Mid-Term Review have incorporated the multi-dimensional nature of the SDGs, with the people at the centre of all development efforts. The Shared Prosperity Vision 2030 and the next two Malaysia Plans will further reinforce Malaysia’s efforts to implement SDGs for period of 2021 to 2030. Figure 1 shows the SDGs implementation through the national development plans.

![Figure 1. SDGs implementation through national development plans.](image)

The first phase of the Malaysia Plan roadmap is being developed to provide guidance for the implementation of the seventeen SDGs. The roadmap takes into account the nation’s capacities and capabilities in achieving the identified goals and targets of the SDGs. Mapping of SDGs with the Eleventh Malaysia Plan strategic thrusts was also performed [5].

3. Peaceful Uses of NST in Malaysia
Since the introduction in 1897, NST has steadily progressed and made direct contribution to national socio-economic growth [8]. The progression of NST is demonstrated by the increasing trend of license holders for medical and non-medical activities in Malaysia as shown in Figure 2 and 3, respectively. The NST is utilised in six technical sectors in the country, namely, medical and healthcare, food and agriculture, industry, water and environment, energy, and safety and security [6]. Consequently, the use of NST in those sectors has made positive contribution to national socio-economic growth. A study was carried out by the Malaysian Nuclear Agency (Nuklear Malaysia) in 2010 to assess the impact of nuclear technology to the national socio-economy for 2006 to 2008. The study found the percentage share of nuclear technology to the national Gross Domestic Product (GDP) increased from 0.024 percent in 2006 to 0.032 percent in 2008 [7].

The earliest application of nuclear technology in Malaysia was applied in the field of medicine with the first used of x-ray machine in Hospital Taiping in February 1897 [8]. Since then, the application of radiation in medical has expanded and has now become one of the most important techniques used for diagnosis, therapy and palliative of various medical conditions in Malaysia, particularly cancer. Besides that, NST is also applied in nutritional studies using stable isotope techniques to monitor situations and interventions for promoting infant, young child and adolescent nutrition.

In food and agriculture sector, the application of NST covers the complete plant life-cycle [9]. The acute and chronic gamma irradiations are used to produce beneficial new mutant plant varieties. Research activities in mutation techniques for crop improvement was also conducted, especially in producing new mutant varieties with desired characters such as high yield, resistance to abiotic and
biotic stress, and improved quality traits. The use of nuclear and related techniques involving isotopic and elemental fingerprinting was also performed in determining the geographical origin of various food products and is currently being explored for traceability of Malaysian agricultural produce [10]. Other applications of NST include the food irradiation and food safety.

![Figure 2: License Holders for Medical Activities from 2009 – 2016 [11]](image1)

![Figure 3. License Holders for Non-Medical Activities from 2009 – 2016 [11]](image2)
In industrial sector, NST is widely used for diagnostic and testing purposes in various industries such as oil and gas, conventional power generation, processing plants, transportation, aerospace and manufacturing. Such applications include non-destructive testing, nuclear and radiation gauges, radiotracer technology, plant assessment, and sealed sources technology. These applications have helped to optimise industrial productivity and operations as well as producing high quality goods. Radiation processing is also being used in many economic sectors in the country including for sterilisation, polymer cross-linking, rubber vulcanisation, and irradiation of certain food products for hygienisation and phytosanitation.

NST also plays an important role in water and environment sector, especially in the management of water resources. The use of environmental tracers and isotope hydrology techniques have helped to characterise ground and surface water resources to determine various factors and processes, including sources and history of water, past and present rainfall conditions, recharge of aquifers, mixing and interactions of water bodies, evaporation processes, geothermal resources and pollution processes. The nuclear and related techniques are also used for radiological monitoring, climate change studies, soil erosion and marine contamination studies.

4. The role of NST in supporting the implementation of the SDGs in Malaysia
The use of NST contributes directly to nine of the seventeen SDGs namely, SDG 2: Zero hunger, SDG 3: Good health and wellbeing, SDG 6: Clean water and sanitation, SDG 7: Affordable and clean energy, SDG 9: Industry, innovation and infrastructure, SDG 13: Climate action, SDG 14: Life below water, SDG 15: Life on land, and SDG 17: Partnerships for the goals. Based on our assessment using the selected publicly available publications related to the sectorial uses of NST in Malaysia, we summarised and mapped the utilisation of NST in related sectors in Malaysia with the SDGs as shown in Table 1.

4.1. Food and agriculture
The National Agrofood Policy developed in 2010 has put the main focus on improving the efficiency of the agro-food industry in the country [13]. Presently, Malaysia is still a net importer of rice with self-sufficiency level (SSL) hover between 60 to 70 percent [14]. Also, a research performed by the Khazanah Research Institute in 2019 to assess the status of paddy and rice industry in Malaysia has found that the nation recorded slow release of new rice varieties, which stand at less than 50 varieties for the past 50 years. The figure is lower than other countries in the South East Asia region such as the Philippines and Thailand which released more than 200 and 80 new rice varieties, respectively, over the same period [15]. Hence, Malaysia is targeting to achieve 80 percent SSL in rice by 2022 as well as to increase the release of new rice varieties [16]. On this note, the NST can play a role in helping the nation to achieve those targets. This argument is justified based on the development of NST in the country. For example, Nuklear Malaysia has started research on mutation breeding of rice since 2008 and has successfully developed two new rice mutants namely NMR 151 and NMR 152 [17]. These rice mutants were developed from gamma-irradiated seeds and have high tolerance to flooding and aerobic conditions as well as high yield. Apart from rice, the mutation breeding technology is also used to develop new varieties of fruits and vegetables including banana and mushroom.
## Table 1. The summary and mapping of the utilisation of nuclear science and technology in related sector in Malaysia with the SDGs

| SDG No. | IAEA TCP thematic areas | Related fields | Utilisation of nuclear science and technology in Malaysia in respective areas |
|---------|-------------------------|----------------|---------------------------------------------------------------------------------|
| 2       | Food & agriculture      | Food production, safety, security and sustainable agricultural practices | • Mostly used nuclear technique such as mutation breeding to produce new varieties of plants and crops with enhanced resilient to climate including rice, banana and mushroom. <br>• Food irradiation mostly for spices and herbs. <br>• Research in enhancing food safety including food traceability and authenticity. |<br>• Used in nutritional studies including assessment of energy expenditure, assessment of body composition, breastfeeding study and bone health study. |
| 3       | Health & nutrition      | Nutrition      | • Used in nutritional studies including assessment of energy expenditure, assessment of body composition, breastfeeding study and bone health study. |<br>• Applied in cancer management as well as production of medical radioisotopes. <br>• Sterilisation of healthcare products by irradiation. <br>• Research in controlling Aedes mosquito population using Sterile Insect Technique (SIT). |
| 6       | Water & environment     | Water resource, quality and management | • Radiochemical and radioactivity contamination analysis including for food and drinking water. <br>• Used in management of water, local natural resources and environment conservation and climate change studies. |
| 7       | Sustainable energy      |               | • Education and training, and hands-on learning of the research reactor operation and nuclear reactor engineering. |
| 9       | Industrial application & radiation technology | Industry productivity and efficiency | • Radiation processing for sterilisation, polymer cross-linking, and rubber vulcanisation. <br>• Used in determining and improving quality of material and structure such as non-destructive testing, radiotracer and sealed source technology. <br>• Nuclear gauge widely used in various industrial applications. |
| 13      | Water & environment     | Climate change monitoring, mitigation and adaptation | • Climate change studies using light stable isotope. <br>• Soil erosion and environmental studies using nuclear and radioisotopic techniques. |
| 14      | Water & environment     | Ocean, seas and marine protection | • Used in marine, ocean and coastal studies. |
| 15      | Water & environment     | Management of water and environment | • Soil erosion studies and analysis. <br>• Groundwater and natural resources studies. <br>• Environmental monitoring. |
| 17      | International cooperation |               | • Numerous bilateral and multilateral platforms were established which enable sharing and building capacity in NST. |

Thematic areas are classified based on the IAEA Technical Cooperation Programme (IAEA TCP) [12].

Malaysia as a trading nation involved in exports of food commodities to the international market. In this regard, the use of gamma irradiation for exported food commodities can be intensified to improve safety and extends the shelf life of foods by reducing or eliminating microorganisms and insects. The amount of irradiated food commodities from 1997 to 2014 in Malaysia is shown in Table 2 [18]. Research on the NST was also actively conducted in the country to study plant nutrition and soil fertility, manage insect pests, food safety and authenticity, and to promote soil and environmental...
preservation. The use of NST in this sector can help to support the implementation of SDG 2 in the country.

Table 2. The amount of irradiated food commodities from 1997 to 2014 in Malaysia [18].

| Year     | Metric Ton |
|----------|------------|
| 1997-1999| 100        |
| 2005     | 475        |
| 2006     | 800        |
| 2007     | 728        |
| 2008     | 691        |
| 2009     | 826        |
| 2010     | 785        |
| 2011     | 602.4      |
| 2012     | 567.8      |
| 2013     | 530.6      |
| 2014     | 984.1      |

4.2. Health and nutrition
Cancer constitutes an enormous burden on societies globally, including Malaysia. Cancer is the fourth most common cause of death in Malaysia, with approximately 37,000 cases reported every year [19]. A study conducted by the Malaysia Ministry of Health in 2015 found that a total of 103,507 new cancer cases were diagnosed in Malaysia from 2007 to 2011 [20]. On top of that, the National Health and Morbidity Survey 2015 unveiled an alarming concern regarding the number of Malaysians suffering from Non-Communicable Diseases (NCD) [21]. In this connection, the NST is used in cancer management areas such as diagnostic radiology, radiotherapy and nuclear medicine as well as prevention or control of NCD. Production of medical radioisotopes is also conducted at a few medical facilities that operate cyclotron. Medical facilities equipped with nuclear technology-related equipment were established throughout the country to provide cancer-related services. Besides, Malaysia also participated in the IAEA Programme of Action for Cancer Therapy (PACT) which has helped Malaysia to develop its national cancer control plan. In the area of nutrition, NST has played a role in nutritional studies including assessment of energy expenditure, assessment of body composition, breastfeeding study and bone health study. These studies have contributed to the prevention and control of nutritional deficiency among the people. The use of NST in this sector can help to support the implementation of SDG 2 and 3 in Malaysia.

4.3. Water and environment
Malaysia has always put environmental and climate change issues in its development agenda. The alarming trend of climate change and environment has made the Government to take necessary measures to tackle the issues. In addition, Malaysia also faced challenges in surface and groundwater resources, in terms of deteriorating quality and quantity due to several factors, including rapidly growing populations, increasing agricultural demands, and threat of pollution in the surrounding areas. In this regard, NST can play a significant role in climate change monitoring, mitigation and adaptation as well as management of water, local natural resources and environmental conservation. Such applications include the mitigation of sedimentation, determination of atmospheric and marine pollutants, and groundwater studies. The environmental tracers and isotope hydrology techniques are
widely used to characterise ground and surface water resources in Malaysia. Consequently, it helped to improve the management of water resources across the country. The use of NST in this sector can help to support the implementation of SDG 6, 13, 14 and 15 in the country.

4.4. Sustainable energy
Presently, the nuclear power industry is non-existent in Malaysia. Thus, in this sector, focus a more towards developing national capacity and capability in nuclear science and nuclear reactor engineering. For this purpose, the only research reactor in the country, the TRIGA PUSPATI Reactor, is used for education and training on the operation of research reactor as well as nuclear physics and nuclear reactor engineering. Since the nuclear power is non-existent in the country, the use of NST is centred at education and training and therefore, will have minor role in supporting the implementation of SDG 7 in the country.

4.5. Industrial application and radiation technology
Manufacturing and services remain as the main driver of growth in Malaysia, recorded 78.3 percent share of national GDP in 2018 [22]. This sector has a long history in utilising NST. In manufacturing sector, nuclear and radiation gauges are widely used for measuring and monitoring of product and process parameters such as thickness, density, moisture or fill level.

Radiation processing is a technology that offers clean and additive-free method for preparation of value-added novel materials based on renewable, non-toxic and biodegradable natural polymers, and natural polymer waste. Research on this technology is extensively conducted in the country focusing on polymer and natural polymer [23]. Commercial processing technology such as radiation cross-linking is also maturely developed in Malaysia for the production of cross-linked cables and wires. The cables and wires exhibit enhanced properties and are used in automotive and machinery industries. In addition, radiation technology is also used for sterilisation of health care products in the country. All of these usages have made direct contribution to national socio-economic development.

Malaysia is among the largest producer of natural rubber globally. Rubber industry contributed RM 40.36 billion to national exports, with sixteen percent coming from natural rubber [24]. In Malaysia, nuclear technology such as radiation vulcanisation of natural rubber latex, or RVNRL is used to initiate vulcanisation, a process that chemically bonds molecules to produce rubber elasticity and strength. This technology has replaced the use of a sulphur-based process and produces a material with remarkable qualities such as low cytotoxicity, absence of sulphur and zinc oxide, and high transparency and softness. This technology has proved that RVNRL can provide a technically and economically viable alternative to the existing vulcanisation process, thus benefit the rubber industry [25]. The use of NST in this sector can help to support the implementation of SDG 9 in the country.

5. Conclusion
Since its introduction, NST has long benefitted various key sectors in the country and has been an integral part of the country’s economic development. In tandem with the Government’s commitment to achieve the targets set in the SDGs, NST can play a role in achieving nine SDGs. Most of the NST used in the country has reached a mature phase and is commercially available. As NST undergoes advancement, it will continue to support national socio-economic growth and ultimately, towards sustainability.

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