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**Review Article**

# Observation of the Development of Nuclear Science and Technology as Socio-Economic and Health Problems of Countries

**Cherie Sisay Mekonen**

Department of Nuclear Physics, College of Natural and Computational Sciences, Woldia University, Woldia, Ethiopia

**Email address:**
cheriesisay217@gmail.com

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**Abstract:** The objective of this review paper is to give a comprehensive understanding of the various nuclear techniques in different fields of science, engineering, medicine, agriculture, industry, archology, hydrology, mining, environment, art, space exploration, it contributes in many ways for the development and security in countries worldwide and also it is a roadmap for the developing countries to develop the nuclear technology in different areas. Nuclear techniques essentially utilize the radioisotopes and their decay via a charged particle emission or x-ray/gamma rays. The production and utilization of a selective radioisotope of interest from a nuclear reactor or charged particle accelerator (LINAC, cyclotrons), finds frontier area of research and development in developed/developing countries of the world. It is in this scenario, nuclear research and technology finds a great contribution in socio-economic development of the countries. To develop the importance applications of nuclear science and technology in the developing counties for different aspects and also to increase the socio-economic development in all parts of the world, teaching and researching on utilization of nuclear program should be applicable.

**Keywords:** Nuclear Techniques, Medicine, Food & Agriculture, Industry National Security

## 1. Introduction

Currently, nuclear science and technologies contribute in many (different) ways to the health, development and security in all parts of the worldwide [1, 2]. These nuclear technologies are used daily to find and protect sustainable sources of fresh water, produce energy and food, although providing researchers the tools to study the ocean's past and predict its future technology development [3]. The purpose of this review is understanding of the use of nuclear science and technology in a various aspect of socio-economic development in the countries and also it opens the way to develop nuclear science and technology in different fields of the developing countries around the globe. Nuclear is a dominant energy source to balance the energy security, economic efficiency, and environmental sustainability for the developed world [4] and better opportunity are there to collaborate the developing countries for nuclear program development. Experimental technique for nuclear physics is very important to develop the modern technology for different sectors [5]. Nuclear techniques are used widespread for several purposes in agricultural and environmental sciences [6] that have been used for gauging in different beverage, construction, and transport industries and customs services. This helps countries develop capacity to optimize their use of nuclear techniques to confront and relieve impacts of climate change on agricultural system and food security. This technique also can help to determine the human body's uptake from food and utilization of these nutrients. Nuclear energy technology has special characteristics that affect the way innovation in this domain is conducted [7]. Energy has become the driving force for national infrastructure development, including the socioeconomic development of every society. Socioeconomic development coupled with industrialization and energy demand increase is positively correlated, requiring reliable and sustainable energy supply [8]. The history of nuclear energy is the story of a centuries-old dream becoming a reality [9]. Nuclear is a non-emission clean energy source and it generates power through fission, which is the process of splitting uranium atoms to produce energy [7, 10]. The heat released by fission is used to create steam that spins a turbine to generate electricity without the harmful byproducts emitted by fossil fuels. The aim of fusion research is to design schemes in which light nuclei approach each other frequently down to such small separations that there is a high chance of numerous reactions taking place [14-16].

Nuclear and related technologies can contribute to the productivity, stability, and resilience of food production systems [17]. Radiotracer techniques have been used in research for over a century and their benefits are well demonstrated and recognized in medical, industrial, biological and environmental research. Ionizing radiation is a well-established risk factor for human cancer [18], One of the most important applications to minimize the radiation hazard is application in medicine using nuclear techniques. In all parts of the world with existing nuclear programs need to secure the capacities and human resources necessary to sustain the safe operation of existing installations, including their decommissioning and related programs for spent fuel and waste [19].

Radioactivity is part of everyday life [20] it can defined as spontaneous emission of nuclear transformations in unstable atoms that result in the formation of new elements [21, 22]. Based on the source it can be divide to natural and artificial radioactivity. Natural sources are cosmic rays and the radioactive content of soil and rocks. For the determination of risk assessment this nuclear technique also important aspects [23]. To develop and maintain a strong nuclear knowledge base at the organizational, national, and international levels collaboration and share practical approaches to knowledge management that can be used [24].

## 2. Theories and Computational Methods

The researcher were used all the nuclear science laboratory equipment's depending on the application of medicine, agriculture, industry, space exploration and mining, hydrology and environment, art and archology [12, 13, 20-22, 25-28]. The Joint FAO/IAEA Centre facilitates laboratory networks and cooperation centres to strengthen technical cooperation and partnerships [29].

## 3. Results and Discussion

### *3.1. Applications of Nuclear Technique in Medicine*

The ultimate significant success story over the past half-century in harnessing radiation to serve modern humanity is in the field of medicine [30]. Nuclear techniques are now a mainstream element of today's medical practice, and will continue to grow as technologies are developed to improve efficiency of production and delivery of isotopes [31]. According to the report of researcher, Cancer and cardiovascular conditions are the leading causes of death in the world. To reduce this leading cause the diagnosis and treatment of Cancer in medical imaging and radiotherapy, the nuclear techniques make a real difference [27]. Nuclear medicine is a technique that are most often used to evaluate the function of any organ or structure in the body and in diagnosing, staging of various diseases and treating certain illnesses [27]. These procedures use radioactive materials and the imaging modalities detects radiation emitted from the administered radiopharmaceuticals, which contains radionuclides. The common radioisotope used in diagnosis inside the body to see how organs or tissue are functioning (for diagnosis) and for treatment is technetium-99 (Tc-99) [30]. Therefore, radioisotopes are an essential part of medical diagnostic procedures [1, 31], those radioisotopes often used in such devices, in addition to Flourine-18, include carbon-11, nitrogen-13, and oxygen-15.

In the developed world to determine anomalies in the heart, brain, kidneys, lungs, liver, breasts, and thyroid glands nuclear diagnostics are now routinely employed. The other disorders like, bone and joint along with spinal disorders, also benefit directly from this routine use of radioisotopes. In a modern diagnostic nuclear medicine, the single photon emission computed tomography (SPECT) and positron emission tomography (PET) are commonly used. Because of inexpensive and utilizes radioisotopes available from nuclear reactors relatively SPECT is used for routine clinical work. Ionizing radiation from decay of unstable nuclei is being routinely applied in diagnostic and therapeutic medical procedures [31]. Significant work is ongoing in medical imaging and the potential for Artificial Intelligence (AI) applications in nuclear nutrition assessments, radiotherapy and education of health professionals is being explored. AI-based tools are being used to facilitate different clinical tasks in imaging such as intra- and inter-modality image registration and fusion, computer-assisted diagnosis in mammography and lung cancer screening programmes, and dose prediction in nuclear medicine procedures [32].

### *3.2. Applications of Nuclear Technique in Food and Agriculture*

Nuclear techniques are used for food and agriculture to enhance livestock growth, reproductive efficiency and disease resistance. For instance, Radioimmunoassay (RIA) methods support diagnose diseases and monitor the effectiveness of disease control and eradication programmes [3]. The most significant technique that can increase crop tolerance to drought, salinity/pests, reduce greenhouse gas emissions and increases carbon sequestration from agricultural system, optimize natural resources management through isotope tracking of soil, water and crops and it provide information essential for assessing ecosystem change and forecast modelling have been used nuclear technique applications [6]. To preserve food, to improves the safety of food and extends the shelf life of foods by reducing microorganisms the growing use of irradiation technology is very important in all parts of the world [33]. The Food and Agriculture Organizations with International Atomic

Energy Agency (FAO-IAEA) Agriculture & Biotechnology Laboratory also plays a major role in the implementation of the work of the Joint Division and assists member countries in the development and adaptation of new and improved agricultural technologies involving radioisotopes and other nuclear applications [34] for ensuring food security, nutrition and public health.

Nuclear scientists and technologist are release the secrets of many agricultural problems, which could not have been possible with conventional methods. Radioisotopes have also been used to develop vaccinations that are effective for certain animal diseases [30] and also used for determining the function of fertilizers in different plants [35]**.** Radioisotopes were used for producing high yielding crop seeds to accelerate the agricultural yield. The use of isotopes and radiation serves as a very effective means of furthering mankind's demand for more and better food throughout the world. These isotope tracer techniques are now widely applied to economically important fields such as fertilizer efficiency, plant and animal nutrition and physiology, insect ecology and pest management systems, or chemical residues in the environment [36].

Radio sterilization freeze out bacteria from our food and extends their shelf life. It also improves the productivity of crops and offers an environmentally friendly alternative to pesticides. Finally, it brings solutions to the global problem of water shortages.

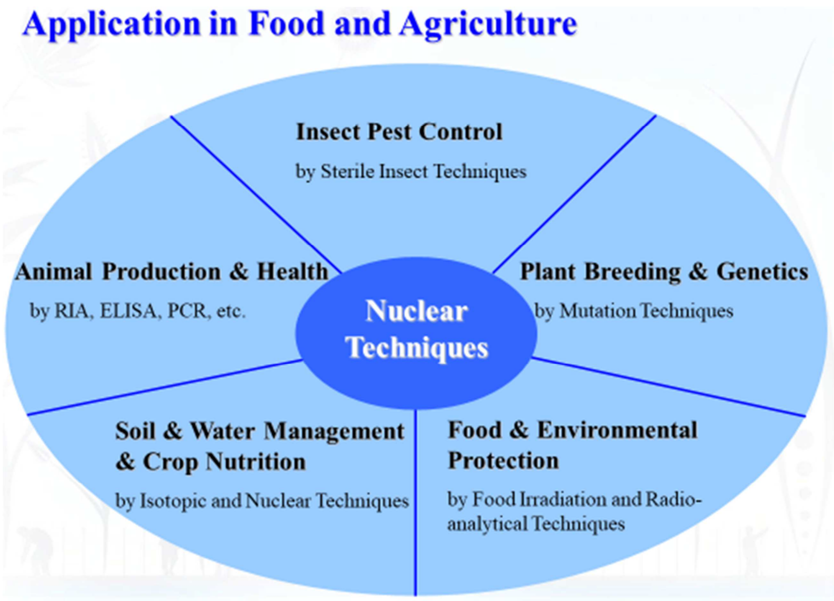


***Figure 1.*** *The application of nuclear technique, IAEA goal is food security, food safety and sustainable agriculture joint program FAO/IAEA [6].*

### *3.3. Applications of Nuclear Technique in Industry*

World Nuclear Association is the only organization with a global mandate to promote nuclear energy and represent the companies that constitute the worldwide nuclear industry program [37]. The first thrust for the development of peaceful applications of use of nuclear power was technological innovation [38]. Radioisotopes are used by manufacturers as tracers to monitor fluid flow and filtration, detect leaks, and gauge engine wear and corrosion of process equipment.

Nuclear technique, as a means of material alteration or processing, is realized through chemical, physical and biological effects, which are created by interaction between ionizing radiation and the material. The techniques used depend on radioisotope X-ray fluorescence and preferential absorption techniques. Technology transfer of nuclear techniques to the mineral industry involves different aspects, either introduction of the technology and its regular applications in the mineral industry and or indigenous production of the systems and technique/services. Mineral and coal processing operations can be controlled more economically if materials in various process streams can be rapidly analyzed on-line [39].

One of the earliest applications of radiation to industry was to measure engine wear within the automotive industry usage [30]. Radiation has the ability to penetrate matter, industrial measurements can be made using radioisotopes without the need for direct physical contact of either the source or sensor. The coal industry, which currently accounts for well over half of the world’s supply of electricity, benefits directly from using neutron gauges to measure and control the moisture content in coal and coke. Further, gamma sources are used to assay the ash content, as well as the combustion gases that go up the stack. A practical applications of nuclear energy is nuclear reactor which is a device used to carry out a controlled chain reaction, i.e. the continuous acquisition of energy from the fission of U-235 or Pu-239 nuclei [40]. The operation of the reactor is based on the controlled fission reaction (chain reaction). Typical nuclear reactor consists of a core, neutron reflector and biological shields. The core itself comprises fuel rods, control rods, safety rods, moderator, cooling channels and test channels [11, 41-43]. The Pressurized Water Reactor (PWR) is the most common nuclear power reactor technology in the world today [44].

### *3.4. Applications of Nuclear Technique in Hydrology and Environment*

Nowadays, environmental pollution has become a worldwide concern. Recently, it has been used to control environmental pollution using nuclear techniques. Ionizing radiation provide a fast and reliable means of sewage water and sludge treatment than the conventional methods [45]. Nuclear technique in environment also improve healthy environment through quality monitoring protocol and enhance waste treatment strategies especially radioactive waste. Hydrology indicates the identification of potential water resources and sedimentation rate through isotopic tracer techniques [46]. In advanced economies, nuclear has long been the largest and the second-largest source of low-carbon electricity. Nuclear power and hydropower form the backbone of low-carbon electricity generation.

Plastic pollution is frequent in aquatic environments and its potential impacts to wildlife and humans present a growing global concern. Radiotracer techniques have been used in research for over a century and their benefits are well demonstrated and recognized in medical, industrial, biological and environmental research. Another important advantage of radio tracing method is the ability, in some cases, to monitor the fate of radiotracers in vivo, in a non-destructive manner [47]. Environmental risks are arising especially from the long-lived radioactive isotope Iodine-129, which is released from nuclear facilities and shows increasing concentrations in the environment [48].

### *3.5. Applications of Nuclear Technique in Space Exploration*

There is the quality of space applications for radioactive materials, both on spacecraft and on launch vehicles range from power generation to the use of radioactive sources or neutron activation analysis for radiation measurement references, instrument calibration, irradiation experiments, electronic circuit components, or for structural purposes [49]. Nuclear propulsion systems can enable robust exploration to Mars and beyond and is crucial for fast deep space crewed interplanetary missions [50]. The role of nuclear propulsion in space, we see that both nuclear rockets and nuclear electric-propulsion systems offer substantial advantages in the exploration of solar system [51]. Nuclear power sources have allowed spacecraft to fly into regions where sunlight is dim or virtually nonexistent. Nuclear power sources have enabled spacecraft to perform extended missions that would have been impossible with more conventional power sources (like, photovoltaics and batteries) [52]. Interactions between cosmic rays and spacecraft materials are of interest for electronics & human radiation exposure. Nuclear reactors have also been used in space [53]. Nuclear propulsion is again coming to the fore in space just as a new generation of terrestrial nuclear power plants started to be introduced in 2003. Nuclear science as an enabling technology, [54]. Protecting the planet from asteroids According to current physics knowledge, the only power source option for some classes of space missions is Nuclear Power source for Space (NPS) [55]. The country in the worldwide like Europe, has successfully used nuclear power sources for space exploration missions. The general use and power level range of these nuclear power sources for space were discussed by the researcher [55]. Fusion (combing two light nuclei) power is the key to scaling up space exploration into the multi-MW level, allowing larger payloads to reach destinations faster and powering industrial-scale settlements and operations [56]. The applications of nuclear physics for space have been receiving increasing attention and funding and also National Aeronautics and Space Administration (NASA) looks to enhance existing capabilities to achieve additional scientific objectives as well as develop new technologies and possible crewed missions to Mars [57]. Using radioisotope power systems there is the process to generate electrical power by converting heat released from the nuclear decay of radioactive isotopes into electricity [58].

### *3.6. Applications of Nuclear Technique in Mining*

Nuclear techniques and instrumentation are contributing to the investigation of minerals and their efficient breeding or extraction and processing methods [59]. For this applications Neutron Activation Analysis (NAA) techniques are usually employed in fundamental geochemical investigations in which high accuracy, precision and sensitivity are required [60]. Nuclear techniques have been used to solve earth science problems in the field, not just in the laboratory, for over 40's years. However, much of the earlier work was related to oil and gas exploration in which the possible merit of the use of nuclear techniques were recognized and implemented long before their use in mining was seriously considered as the researcher reported [61]. Nuclear analytical techniques have great potential to improve the efficiency of raw materials delving, extraction, and advancing, with savings in energy and materials [59]. Mineral raw materials form the basis for energy production and the manufacturing industry are also very important.

Nuclear and radiation technologies play a crucial role in power sector, starting from fossil fuels exploitation, their transport and distribution and finally power generation [62]. The coal industry, which currently accounts for well over half of the world's supply of electricity, benefits directly from using neutron gauges to measure and control the moisture content in coal and coke [30]. The other applications of nuclear techniques reviewed, concern the oil industry, oil field recovery, transportation pipelines and refineries. mining leads to degradation of the environment, especially affects ground and surface waters and may lead to degradation and contamination of water reservoirs. Uranium materials occur in nature in ores can be extracted and chemically converted into uranium oxide ($U_3O_8$) or other chemical forms usable in industry. Uranium-238 undergoes radioactive decay into a long series of 13 different radionuclides before finally reaching a stable state in lead-206 [22, 63].

### *3.7. Applications of Nuclear Technique in Art*

Nuclear techniques are useful tools in the preservation and of the highest importance to study the objects of tangible cultural heritage in the country [64, 65]. From these the investigations of cultural heritage non-destructive and non-invasive methods are key importance. This technique also contributes to archaeometry mainly by non-invasive cultural heritage investigations objects with ion and neutron beams. These nuclear techniques is useful on our cultural heritage objects, focuses on making use of the production and detection of X-rays as a tool for micro analysis [66]. Among our cultural heritage, whether in archaeology or in museum's science overall, glass and ceramics play a major role. Cultural heritage conservation activities used to include examination, preventive care, documentation, stabilization treatment, restoration and any act that could contribute to the perception, appreciation and understanding of the cultural property [67].

To improve the characterization and preservation of cultural heritage artefacts with special emphasis on gamma irradiation treatment, including insect eradication and disinfection in various cultural heritage materials and consolidation of degraded materials with radiation-curing resins this technique is very useful.

One of the standard methods for multielement analysis since the 1950s has been Neutron activation analysis (NAA) [60]. It is an analytical method which plans the determination of the concentration of a large number of inorganic elements in a wide range of archaeological materials. Neutron activation analysis (NAA) of archaeological materials started in the early 1980s, and has found continuous interest in general [68]. Then, nuclear archaeology is based on nuclear forensic analysis of samples taken at former production facilities [69]. Conventional X-radiography is a non-destructive technique that used for studying some of the internal structure of paintings in cultural heritages [70].

### *3.8. Applications of Nuclear Technique in National Security*

National security policies on the applications of nuclear materials were first developed by the United Kingdom and the United States in the 1940s and then by other countries [25]. The International Atomic Energy Agency has established a Nuclear Security Programme and instituted a series of publications on nuclear security to provide recommendations and guidance that States can use in establishing, implementing and maintaining their national nuclear security regime [71]. It is important to understand that nuclear security related information may have value (possibly of different natures and magnitudes) to any of the State, the component of authorities, the media and the public. The International Atomic Energy Agency (IAEA) supports States for its Nuclear Security Programme, to maintain, establish and sustain an effective nuclear security regime [72].

There is a possibility for radioactive material or nuclear that could be used for despiteful purposes for the that cannot be ruled out in the current global situation. Use nuclear safety, nuclear security target to protect people, property, society and the environment from harmful effects of ionizing radiation. The security assessment principles apply to assessments of security arrangements defined in security plans as well as the control of Sensitive Nuclear Information (SNI) held on and off nuclear facilities [73, 74]. The IAEA safety standards for nuclear installations, radiation protection and safety, radioactive waste management programmes were set up to coordinate the development of standards covering the different areas of each subject and the transport of radioactive material were historically developed in four separate programmes [75, 76]. Nuclear energy as a cornerstone of national security to ensuring geopolitical leadership abroad are recognized. For prevention and detection also response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities. So, using the nuclear technique for national security play a role for the worldwide.

## 4. Conclusion

This review set out to discuss the important application of nuclear technique and the peaceful use of nuclear science and technology in different fields around the worldwide. Nuclear technique and radiation methods, including radioisotopes analysis and applications, stable isotopes analysis, are applied for safety and process control, including environment impact assessment in coal mining and oil exploitation. The peaceful use of the nuclear fission process not only play a role in nuclear power generation but also in non-electric and non-power applications in medical agricultural and industrial sectors that can boost socio-economic development. The application in food and agriculture have been insect pest control, animal production and health, soil and water management & crop nutrition and perseveration and protection of food and agriculture.

As nuclear science and technology is highly regulated, world also needs to develop robust infrastructures for the national nuclear program through energy mix, nuclear education, non-energy applications and others. Nuclear physics is having a strong impact on medicine: in the application of radioisotopes directly, as well as accelerators and other research instrumentation. Radioisotope techniques helps the environment to keep clean, safe and reliable that we sometimes take for granted. Developing nuclear power, clear energy is the importance of mankind and the interest in non-electric applications of nuclear energy is growing, driven by environmental, economic, security and other reasons. To promote the safe, reliable and sustainable development of the potential use of nuclear energy beyond electricity generation work together and supply are likely to find increasing application of nuclear technique in the future.

Nuclear education has been developed for the importance application of nuclear technology in different aspects: like medicine, energy mix, industry and to study & preserve the national heritages in the developed world. So, in the developing country it is better to work together/collaborate with the national, international, regional organizations for growing the most significant use of nuclear energy, non-energy applications, food & agriculture and for development of nuclear science and technology. To increase the socio-economic development in all parts of the world the nuclear program could be one of pillars for peaceful use, teaching and researching on utilization of nuclear energy in agriculture and other fields. Energy security emerged as a concept in the first half of the twenty century as political and military leaders showed concern over available fuel supplies for armed forces.

# ORCID

https://orcid.org/0000-0002-4374-104X

# Conflicts of Interest

The authors declare no conflict of interest.

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