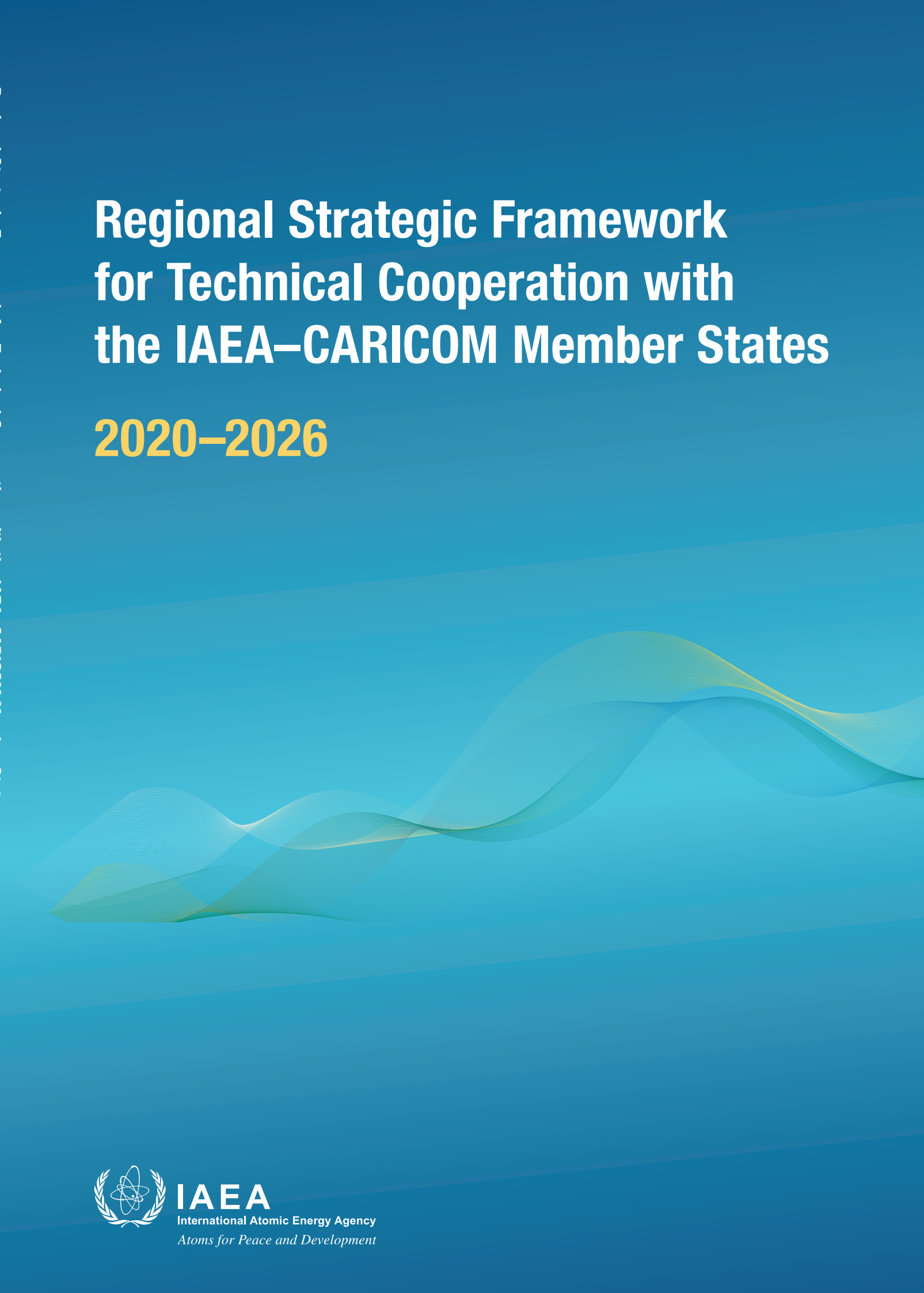
Regional Strategic Framework for Technical Cooperation with the IAEA–CARICOM Member States

2020–2026



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REGIONAL STRATEGIC FRAMEWORK FOR TECHNICAL COOPERATION WITH THE IAEA–CARICOM MEMBER STATES

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REGIONAL STRATEGIC FRAMEWORK FOR TECHNICAL COOPERATION WITH THE IAEA–CARICOM MEMBER STATES

2020–2026

INTERNATIONAL ATOMIC ENERGY AGENCY
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FOREWORD

IAEA Member States belonging to the Caribbean Community (CARICOM) are taking a collaborative approach to furthering the region's development by leveraging the application of nuclear science and technology. This publication presents the Regional Strategic Framework for Technical Cooperation with the IAEA-CARICOM Member States for 2020–2026. It serves as a reference for the preparation of project and programme proposals for future technical cooperation cycles. The framework presents an assessment of the situation in the Caribbean region and is a consensus of Member State experts and CARICOM regional technical institutions relevant to the work of the IAEA. This publication outlines the most pressing needs that can be addressed through the application of nuclear technology in the areas of agriculture and food production, human health, environment, energy, radiation safety and radiation technologies.

This publication provides an avenue to foster a more coordinated approach to the delivery of the technical cooperation programme, as well as greater cooperation among Member States to advance the Caribbean region's development agenda. As the first regional cooperation publication focusing on the Caribbean, it highlights where nuclear sciences and technologies can offer advantages to the region and seeks to facilitate partnerships with other development organizations working in the region. The regional strategic framework identifies opportunities for and the creation of synergies while seeking to ensure improved regional cooperation by communicating more effectively and disseminating information on the impact of technical cooperation projects. This also provides opportunities to attract strategic partners from both in and outside the region thereby developing projects with greater benefit and impact.

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1. SUMMARY

1.1. BACKGROUND

The International Atomic Energy Agency (IAEA) and the group of the Caribbean Community (CARICOM) Member States (MSs) in the IAEA have cooperated closely to prepare a Regional Strategic Framework (RSF) to identify and prioritize the region's most pressing problems and needs that can be addressed using nuclear technologies over the period from 2020 to 2026. This programmatic document further aims to serve as a reference for the promotion and development of cooperation among the Member States of the region, which would also facilitate the planning of regional technical cooperation projects.

The Regional Strategic Framework for Technical Cooperation with the IAEA–CARICOM Member States was drawn up using important regional development documents, such as the United Nations Multi-Country Sustainable Development Framework (UN MSDF) and the Strategic Plan for the Caribbean Community 2015–2019. A sectorial diagnosis was developed using a strengths, weaknesses, opportunities and threats (SWOT) analysis, which helped not only to identify the most acute regional needs and problems, but also to characterize them in terms of their respective baselines, prioritize them, and identify the objectives and goals to be achieved and the indicators by which to measure them.

The needs/problems identified were classified into six thematic areas where the IAEA possesses core competences to assist Member States, thus representing the priority areas within the scope of the RSF: agriculture and food production (food safety and security), human health, environment, energy, radiation safety and radiation technologies. The document also includes important cross-cutting topics, namely communication, outreach, partnership, knowledge management and gender mainstreaming considerations.

In addition to serving as a programmatic reference for the preparation of project and programme proposals both for the CARICOM Member States and the IAEA, it is anticipated that the RSF will help to attract strategic partners, from within the region and outside it, to pursue projects having a larger scope, benefit and impact.

In the preparation of the programmatic framework, account was taken of the important advantages of CARICOM membership which offers, as an intergovernmental agreement, the development of technical cooperation project proposals, the mobilization of national resources, the means to facilitate project implementation, the monitoring and dissemination of the results achieved and the evaluation of the impact of the projects for the Member States of the region. As a starting point for the preparation of this RSF, consideration was given to the following:

a) The current situation regarding nuclear applications in the region, including new technologies in line with the UN MSDF and CARICOM Strategies;
b) Dissemination of the impact and benefits of technical cooperation projects in the region.

The process of preparing the RSF for 2020–2026 began with the drafting of a preliminary document, formulated on CARICOM regional priorities as well as the UN MSDF for the Caribbean. This was followed by two meetings of experts from the region, CARICOM technical organizations[1] and representatives of the Organisation of Eastern Caribbean States (OECS), along with IAEA Programme Management and Technical Officers, comprising the core working group. Both meetings were held in Vienna 26–30 November 2018 and 26–30 August 2019. The draft document resulting from the expert meetings was circulated for comments among IAEA–CARICOM Member States, CARICOM technical organizations, OECS and internally within the IAEA. The consultative process concluded with a final meeting held in Vienna with representatives of IAEA–CARICOM Member States, CARICOM Technical Institutions, OECS and IAEA staff on 18–20 November 2019. The final meeting involved a final review and an endorsement of the document from regional representatives to confirm its importance and applicability to the region.

1.2. OBJECTIVE OF THE REGIONAL STRATEGIC FRAMEWORK

The objective of the RSF for 2020–2026 is to establish a strategic framework for technical cooperation in the Caribbean region based on a detailed analysis of the most pressing problems and needs in the regional context that can be addressed using nuclear science and technology. The framework of cooperation for the RSF will be a programmatic reference of major importance for the preparation of project and programme proposals of the technical cooperation programme in the region. The RSF also serves to guide and improve regional cooperation through better communication and dissemination of the impact of technical cooperation projects, which could help to attract strategic partners from within the region, as well as outside it, to develop projects with greater benefit and impact.

It should be noted that the RSF for 2020–2026 is a dynamic document, and as such, thematic areas that have not been covered may be included as part of its periodic review, provided that they are in line with regional development priorities and the principles and quality criteria of the IAEA's technical cooperation programme.

[1]Caribbean Agricultural Health and Food Safety Agency (CAHFSA), the University of the West Indies (UWI), Caribbean Community Climate Change Centre (CCCCC), Caribbean Disaster Emergency Management Agency (CDEMA), Caribbean Agricultural Research and Development Institute (CARDI), Caribbean Institute for Meteorology and Hydrology (CIMH) in attendance. The Caribbean Public Health Agency (CARPHA), Caribbean Regional Fisheries Mechanism (CRFM) and the Caribbean Centre for Renewable Energy and Energy Efficiency (CCREEE) sent their inputs.

1.3. SCOPE OF THE RSF FOR 2020–2026

To ensure synergy in addressing common problems identified in the various Caribbean national Country Programme Frameworks (CPFs), the RSF includes the following priority sectors for the application of nuclear techniques:

a) Agriculture and food production: food safety and security.
b) Human health: nuclear medicine, radiotherapy, radiodiagnostics, medical physics, radiopharmacy, mosquito control and nutrition.
c) Environment: knowledge and capacity building in atmospheric, terrestrial and marine sciences, as well as in water resources.
d) Energy: capacity building in planning, forecasting and modelling, waste reduction and repurposing (i.e. renewable, fossil fuels, and all other energy sources).
e) Radiation safety: regulatory infrastructure, protection of workers, patients, the public and the environment, management of radioactive wastes and radiological emergency preparedness and response.
f) Radiation technologies: radiation processing technologies (gamma, electron and X-ray), radiotracers, nucleonic control systems, non-destructive testing and analytical techniques for treatment of water, industrial emissions and waste; coastal engineering; advanced materials; medicine; characterization and preservation of cultural heritage; industrial processes; natural resources; and inspection technologies.

1.4. CONTENT OF THE RSF AND THE METHODOLOGY USED

This document establishes a descriptive-analytical profile of the region's most pressing needs and problems, as well as the priority with which they can be addressed using available nuclear technology. The RSF for 2020–2026 has been drawn up based on a sectorial diagnosis with the identification of priority problems and needs taking into consideration the:

a) Regional Cooperation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) Regional Strategic Plan: 2016–2021;
b) Sustainable Development Goals (SDGs);
c) United Nations Multi-Country Sustainable Development Framework in the Caribbean 2017–2021;
d) Strategic Plan for the Caribbean Community 2015–2019;
e) Small Island Developing States Accelerated Modalities of Action Pathway (SAMOA Pathway);
f) CARICOM Policies/Programmes/Plans;
g) Prioritization between sectors;
h) Proposed objectives;
i) Desired results to be achieved in the period.

A group of regional subject experts was formed to develop this RSF, who together with programme managers and technical officers from the IAEA, carried out a SWOT analysis. In the analysis, account was taken on the varying levels of development of the Member States in the region.

The characterization of the need/problem contains the following elements:

a) Justification of the need/problem clearly setting out the situation to be addressed. This justification establishes qualitative and quantitative baselines of the situation diagnosed.
b) An objective at the strategic level that can be achieved during the period 2020–2026 and within the limit of available financial resources, taking into consideration that the IAEA technical cooperation programme works based on two-year technical cooperation cycles.
c) An indicator, along with a baseline and target for the proposed objective outcome(s) to measure performance.

1.5. THEMATIC AREAS

1.5.1. AGRICULTURE AND FOOD PRODUCTION (FOOD SAFETY AND SECURITY)

The Strategic Plan for the Caribbean Community 2015–2019 identified agriculture (food and nutrition security and export development) as a key economic growth driver in building CARICOM's economic resilience. As noted in the SAMOA Pathway outcome on Food Security and Nutrition, small island developing States are primarily net food-importing Member States, particularly vulnerable to the excessive price volatility of food imports [1]. The CARICOM Member States have limited agricultural lands with a total area over 43 000 km^2 [2], and are vulnerable to shocks from external economic factors, natural disasters, particularly hurricanes, water-related extreme events (flood and drought), and invasive species. Global changes in climate bring a more frequent and higher risk of natural disasters that have the effect of reversing several years of economic growth. Supporting the agricultural sector's role as a major food supplier requires overcoming critical challenges regarding both increasing agriculture and food production and preventing the degradation of natural resources. Hence, the urgent need for more adapted technological solutions and sustainable practices to foster sustainable food production from agriculture, stockbreeding and fishing. Nuclear science and technology has been instrumental in developing novel solutions to improve productivity and address threats and challenges in most areas of food and agriculture, playing a crucial role in (i) strengthening crop and livestock production against transboundary pests and diseases; (ii) enhancing the productivity of food, feed and cash crops, and the effectiveness and productivity of livestock; (iii) ensuring the safety and quality of the food supply, safeguarding consumer health and helping to facilitate international trade; (iv) devising environmentally friendly methods for the management of ravaging insect pests; and (v) developing novel soil, water and fertilizer management packages.

In keeping with Priority 2 reflected in the UN MSDF in the Caribbean, as well as with SDG 2, it is anticipated that the implementation of the RSF in support of addressing food security will foster

the development of more efficient agriculture and food systems in the region. This can be achieved through projects with the following objectives:

A1. To improve crop yields and animal productivity, focusing on land and water management and climate-smart agriculture to foster crop and animal production resilience to climate change, including plants and animals (terrestrial and aquatic) of recognized economic importance, reflecting the region's biodiversity.

A2. To reduce the incidence of transboundary animal diseases, including those with zoonotic repercussions.

A3. Inadequate capacity within the region to use isotopic and nuclear-derived technologies for insect pest control to reduce losses to foods of animal and plant origin

A4. To address the inadequate capacity of the region to ensure the safety, and authenticity of foods

1.5.2. HUMAN HEALTH

The Caribbean, like the rest of the world, is impacted by overconsumption. Climate change and non-communicable diseases (NCDs) are the two major causes that affect human health. In the Caribbean, a region with a population of approximately 18 million inhabitants [3], the epidemic of chronic NCDs accounts for 76.8% of deaths – principally, heart disease and cancer [4, 5]. It has been estimated that 40% of NCD deaths occur prematurely in people under 70 and are potentially preventable by applying available knowledge and technologies [6]. To effectively combat the rise of NCDs, it is necessary to implement multi-faceted measures, in addition to timely detection and effective treatment.

In recent years, the frequency of extreme weather events and general changes in climate have impacted health in the region. Health is impacted by natural disasters such as hurricanes and floods, as well as in the changing patterns of vector-borne diseases such as dengue, Zika and chikungunya and in the emergence of infectious disease. Natural disasters also increase the risks of health emergencies. CARICOM Member States have prioritized meeting International Health Regulations (IHR) to prepare for and respond to health risks. Radiation emergencies continue to be the area in which the region is least prepared.

Nuclear technology has been shown to be a powerful tool in the diagnosis and treatment of diseases. Radiology, nuclear medicine and radiotherapy have evolved significantly in recent decades, with advances being made in technological assets, the availability of various radiopharmaceuticals required for diagnosis and treatment, and human resources development. In keeping with UN MSDF priority area 2, SDG 3, and the SAMOA Pathway outcome on health and NCDs, the Caribbean Cooperation in Health Phase IV (CCHIV) and the technical cooperation programme will contribute to addressing these issues. Based on strategic analysis, it has been determined that efforts for the period 2020–2026 should be directed at building resilience in health systems. This entails preparing for, mitigating against and responding to health outbreaks and

emergencies, strengthening national cancer control programmes and improving the safe and standardized use of radiation medicine in the diagnosis and treatment of disease as strategies for solving the identified and prioritized needs and problems in the area of human health. Given the small populations of CARICOM states, it is important that a regional approach is considered in the addressing of these issues, which include mechanisms for sharing human resources, data and information, as well as the use of telemedicine. Regional and national multisectoral partnerships in cancer which facilitate knowledge and resource sharing across and within countries/territories can be pursued through collaborative mechanisms such as the Pan American Health Organization (PAHO) Women's Cancer Initiative, the Healthy Caribbean Coalition Cancer Initiative, the Caribbean Cancer Control Leaders Forum, the International Atomic Energy Agency, and the International Agency for Research on Cancer (IARC)'s Caribbean Cancer Registry Initiative, in collaboration with CARPHA, Centers for Disease Control and Prevention (CDC) and the National Cancer Institute (NCI). This approach requires further strengthening and expansion to effectively support cancer control in CARICOM countries and to address the following:

H1. Lack of availability and access to tertiary and specialized care services in radiation medicine that exist within the region.

H2. Cancer is a leading cause of death in the Caribbean.

H3. Differing levels and standards of quality and safety in the delivery of radiation medicine services within the Caribbean region.

H4. Insufficient human resources in radiology, nuclear medicine and radiotherapy to meet the growing needs arising from the establishment of new centres in the region.

H5. Inadequate systems for life cycle management of medical equipment for radiation medicine (planning, procurement, incorporation, maintenance and disposal).

H6. Emerging and re-emerging infectious diseases, including increasing severity and frequency of mosquito-borne disease outbreak (e.g. dengue, Zika and chikungunya).

H7. Growing childhood obesity in the region and its link to the incidence of non-communicable diseases.

1.5.3. ENVIRONMENT

Member States within the Caribbean region are particularly vulnerable to weather and climate impacts. The latest studies show that the climate in the region is becoming progressively warmer with a notable increase in the number and intensity of hot days and nights [7, 8]. It is further projected to become increasingly warmer and drier over the century, with estimates as high as 30% reduction in rainfall [7, 8]. Increased incidence of severe drought is already being observed across the Caribbean Basin. Indeed, it is projected that the region will have an increased incidence of drought that will erode food and water security, thereby posing a threat to the viability of various

economic sectors. Of particular concern is the impact on farming systems in the Caribbean, which are especially exposed and vulnerable to climate-related shocks, particularly given the sector's heavy dependence on rainfall for irrigation purposes [7]. This also affects the tourism sector, which depends on local farmers to supply the industry.

On the other hand, increased extreme events of high-intensity rainfall has led to severe floods, soil erosion, landslides, siltation, loss of life, livelihood and economic development in Member States across the region in recent years, including Dominica in 2015, Guyana in 2005, Saint Lucia in 2010 and 2013, Saint Vincent and the Grenadines in 2013 and Trinidad and Tobago in 2017, among others [9, 10, 11, 12, 13]. High intensity rainfalls associated with climate variability increases surface runoff that may carry sediment loads containing pesticides, fertilizers and wastes [14]. This may increase siltation, which in turn negatively affects the quality of surface water bodies through periodic impacts on surface water intakes leading to short term water shortages and longer-term impacts from accumulations of agrochemicals transported into lakes and streams [14, 15, 16]. These extreme current events are leading to rapid and significant changes to national and regional ecosystems, which are expected to change in intensity and frequency in the future, leading to a significant decrease in biodiversity and ecosystem functioning of many Member States.

Projected sea level rise associated with climate change will likely result in increased risk of sea water intrusion to coastal aquifers, especially in the presence of higher withdrawals to combat drought and meet the growing water demand from population growth and urbanization [14, 17]. Increasing sea levels will also lead to coastal inundation and exacerbation of both coastal flooding and erosion, especially in the presence of storm surges.

In addition to sea level rise, mean sea surface temperatures are expected to increase, and seawater pH decline (ocean acidification) leading to less dissolved oxygen (hypoxia), which in turn can result in the degradation of coral reefs in many countries [18, 19]. This can also lead to a reduction in seafood species that form part of the staple diet of residents in the region [17, 20]. The net result will be a significant decline in the quality and diversity of coastal ecosystems, especially when coupled with the declining quality of water and sediment discharging into coastal environments.

Poor waste disposal practices continue to be a significant challenge that is accelerating environmental degradation in the Caribbean [21]. In many States, regulations governing waste disposal may exist but are poorly enforced [22]. Engineered municipal landfills and sewage systems where present may be poorly managed. These challenges are leading to a decline in the quality of surface water and groundwater and the quality of discharge to the marine environment [21].

The World Health Organization (WHO) has identified poor air quality as one of the leading causes of premature deaths worldwide [23]. Air quality across the Caribbean is increasingly impacted by unregulated emissions from increasing numbers of vehicles in Member States especially in urban areas, increased construction-related activities (e.g., quarrying, road and building construction),

emissions from factories, increasing occurrences and concentrations of Sahara Dust, and most recently, emissions from decaying Sargassum [24, 25, 26]. Additionally, many States are experiencing decreases in the quality of indoor air. Altogether, this results in higher incidences of persons suffering respiratory distress, which further burdens national healthcare systems and may lead to possible declines in national productivity.

Given the current and future environmental challenges many Member States face or will face, the IAEA supports the region with due consideration as it relates to building environmental resilience, in the context of the UNMSDF priority area 4, the SDGs 6, 7, 11, 12, 13, 14 and 15 and the SAMOA Pathway outcomes on climate change, sustainable energy, oceans and seas, water and sanitation, management of hazardous waste, biodiversity and invasive alien species.

Effective characterization and regular monitoring of the environment is essential for building appropriate regulatory systems pivotal to enhance environmental resilience and sustainability. Unfortunately, many States lack the appropriate technologies, human resources and regulatory frameworks to build and sustain environmental characterization and effective monitoring and enforcement systems. Nuclear technologies are increasingly being adapted to effectively and efficiently support environmental monitoring and characterization. Such applications will be discussed in the section of the RSF focusing on the environment to address the following:

V1. Insufficient capacity to assess the impact and vulnerability of Member States to sources of pollutants (pesticides, persistent organic compounds, heavy metals, microplastics and other pollutants) of anthropogenic origin in terrestrial and marine environments including the region's water resources as well as risks/threats due to climate change and natural hazard events, such as volcanic eruptions, earthquake, hurricanes, flooding, cyclone etc.

V2. Inadequate documentation of each Member States hydrological data/information, characterization (quality and quantity) and assessment of water resources in order to develop long term integrated water resources development plans to support national development.

V3. Inadequate risk assessment of the environmental and social impact of hydraulic infrastructure.

V4. Limited knowledge of the main vulnerabilities of low lying coastal and marine ecosystems and their response to expected anthropogenic, natural hazard events, such as volcanic activities and climate change-induced alterations.

V5. Inadequate management strategies for characterization/disposal/reprocessing of waste (solid, chemical and wastewater).

V6. Limited knowledge of temporal and spatial scales of atmospheric pollution.

1.5.4. ENERGY

All CARICOM Member States depend heavily on fossil fuels to supply their energy demand [27]. The CARICOM Energy Policy was approved by a Regional Meeting of Energy Ministers in April 2013. The goal of the policy is the "fundamental transformation of the energy sectors of the Member States of the Community through the provision of secure and sustainable supplies of energy in a manner which minimizes energy waste in all sectors, to ensure access to modern, clean and reliable energy supplies at affordable and predictable prices" [28]. This corresponds with SDGs #7 and 9, the UN MSDF's "A Sustainable and Resilient Caribbean", and the SAMOA Pathway outcome on sustainable energy. The region recognizes a need for a more sustainable pattern of energy supply and end use for the future through greater utilization of renewable, sustainable and cost-effective energy sources, reduced dependence on fossil fuels and greater efficiency and conservation in the use of energy within the context of regional energy security. Energy planning and effective implementation will be vital to achieving these regional goals. In this regard, the IAEA's energy planning tools can play a pivotal role in enhancing energy planning, primarily through data-based scenarios that can support decision making on policies, strategies and implementation. These can be used to address the following needs/problems identified in the RSF in area focusing on energy:

E1. Inadequate capacity within the national and regional institutions tasked with energy planning and decision support.

E2. Inadequate Integrated Energy Planning, as well as Integrated Resource and Resilience Planning, within the Member States.

1.5.5. RADIATION SAFETY

Acceptance in society of the risks associated with radiation is dependent on the net benefit from its various applications. Compliance with radiation safety requirements, in accordance with IAEA Safety Standards, is essential for the application of nuclear technologies and ultimately for the implementation of the main priorities set out in the RSF [29, 30, 31]. Progress has been made in the last five years to strengthen regulatory programmes and radiation safety infrastructure in the Caribbean through efforts implemented under technical cooperation initiatives between the IAEA and Member States. However, action is required to consolidate the results achieved with enactment of legislation and regulations at the national level. Among the needs identified and prioritized in the RSF, are radiation protection of workers, patients, public and the environment as well as the effective implementation of the responsibilities of governments and regulatory authorities for radiation safety, which will assist in addressing the following closely related needs and problems:

R1. Lack of capacity for early warning, risk reduction and management of radiological incidents and emergencies and the potential need for a coordinated regional response.

R2. Insufficient application and implementation among end-users of principles and requirements concerning radiation protection set out in IAEA Safety Standards [29, 30, 31].

R3. Insufficient priority is given to establishing a national, governmental, legal and regulatory infrastructure for radiation safety.

R4. Insufficient coverage by the radiation protection services (individual internal and external monitoring and workplace monitoring) of occupationally exposed workers.

R5. Lack of national policies and strategies for the safe and sustainable management of radioactive waste and disused sources.

R6. Absence of a standardized education and training strategy in radiation, radioactive waste/material transport and waste safety.

R7. Limitations for calibration at the levels of radiation protection, radiotherapy and radiodiagnostics by secondary standards dosimetry laboratories in the region.

1.5.6. RADIATION TECHNOLOGIES

Radiation technologies can be applied in areas such as industry, materials modification, process diagnostics, quality control, sterilization of products and materials, waste processing, the preservation of cultural assets, among others. As the countries in the region increase the use of radiation technologies and become more experienced in their applications, this will redound to the benefit of their economic growth and development. To this end, the RSF seeks to contribute to efforts to address the following:

T1. Inefficient and unsustainable industrial processes lead to low economic growth and the deterioration of natural resources.

2. AGRICULTURE AND FOOD PRODUCTION (FOOD SAFETY AND SECURITY)

2.1. BACKGROUND

The starting point to the SWOT analysis for each thematic area is to determine the needs/problems independently from the application of nuclear techniques. Following an analysis of possible solutions, appropriate nuclear techniques were found to be tools of considerable value in addressing many of these needs/problems, as will be shown below. Regarding agriculture and food production, the subsectors considered in this work are:

a) Mutation induction and genetic improvements of plants;
b) Integrated management of soil, water, plants, fertilizers and environmental protection;
c) Integrated management of plant and animal pests;
d) Animal production and health;
e) Food quality and safety control.

2.2. GENERAL ANALYSIS OF THE REGIONAL SITUATION

Agriculture is a major economic sector in the Caribbean, contributing between 7 to 17% of gross domestic product for countries such as Haiti, Dominica, Guyana and Grenada. It also accounts for a relatively large proportion of employment in some Member States, typically between 10 to 25%, and in the case of Haiti, almost 50% [32]. Agriculture is recognized as a potential driver of poverty reduction in the region, particularly for rural households that benefit less from the growth in tourism, financial services and natural resource extraction [32].

Despite its overall importance to the region's economies, productivity remains low compared to global yields. Productivity of agriculture in the region is limited by factors such as inadequate access to improved varieties and modern technologies, limited access to credit, high labour costs, insufficient monitoring and response to pests and diseases, and inadequate skills and entrepreneurship among farmers [32].

The CARICOM Strategic Plan for 2015–2019 identified agriculture (food and nutrition security and export development) as a key economic growth driver in building CARICOM's economic resilience and in meeting the United Nations SDGs [33]. In this context, it seeks to reposition the regional agricultural and fisheries sector as one economic space for growth and export development [33]. It also seeks to enable food and nutrition security, considering existing strategies to remove key binding constraints and to fulfil the Common Agriculture Policy, the Regional Food and Nutrition Security Policy and the Common Fisheries Policy.

The CARICOM Secretariat continues to work with its Member States and other regional and international stakeholders to design, implement and execute policies, programmes and projects to accelerate the development of this sector. For CARICOM, changing the underlying dynamics of

the agricultural sector by putting in place the necessary technical, infrastructure and incentive frameworks needed to spur innovation and stimulate output continues to be imperative. It should be noted, however, that regional development can bring negative consequences in return. Among these may be highlighted a progressive degradation of arable soils due to intensive use and poor fertilization and irrigation practices; soil erosion; deforestation; the continual reduction of natural woodland to increase the area available for the production of industrial crops for export; overgrazing of grasslands; drought events and desertification; and, in general, a deterioration in the environment reflected in a loss of biodiversity owing to the substitution of native species crops with crops of high commercial value, as well as pollution by agrochemicals used in pest control and postharvest treatment of agricultural products. In addition, extreme weather events, including droughts, seasonal hurricanes and tropical storms, have had a sizeable economic impact in the region, accounting for millions of dollars' worth of damage in the agricultural sector [7]. Consequently, despite advances in the sector, the region must overcome critical obstacles to ensure its viability, including through environmentally friendly agricultural practices and sustainable food production, which will, in turn, contribute to greater economic growth and social welfare.

Ensuring food safety and security for the inhabitants and preserving the environment may translate to increased income for farmers and fishers due to increased production and enhanced management systems. For this development to occur, there is a need to optimise regional agricultural and fishery activities whilst maintaining environmental health and sustainability. Technological change has been recognized as the variable which contributes most to economic growth. In this regard, the use of nuclear techniques can prove to be a significant driver of this growth when applied in areas such as genetic improvement of plants and animals; improvement of soil management and the efficient use of fertilization and irrigation; minimization of land degradation; suppression and eradication of agricultural pests; the early diagnosis of animal and zoonotic diseases; control of food hazards including residues and contaminants, authentication and detection of adulteration or malpractice with respect to high value herbal and organic agricultural products; as well as are high-value marine species that are targeted by illegal fishing. These areas could greatly benefit from the technological advances which can be provided through the application of nuclear technology; such as genetic improvement of agricultural and livestock and aquaculture species, transboundary agricultural insect pests control, good soil and water management practices, non-chemical postharvest treatments and the capacity building for agricultural analysis services.

In light of the discussion in section 2, table 1 summarizes a SWOT analysis for agriculture and food production in the Caribbean.

2.3. SWOT ANALYSIS

TABLE 1. SWOT ANALYSIS FOR AGRICULTURE AND FOOD PRODUCTION (FOOD SAFETY AND SECURITY)

Strengths	Weaknesses
1. The existence of local entrepreneurs capable of adopting innovative technologies in the agricultural sector and in aquaculture. 2. The edaphoclimatic diversity enables the region to be a major world supplier of an extensive range of agricultural products of importance for food and in industry. 3. The region boasts extremely high biodiversity levels and offers the world community new agricultural and aquaculture products of economic potential with a high nutritional or medicinal value (grains, roots, tubers, fruit, fish, shellfish, etc.). 4. The growing increase of national services and subregional agreements for the prevention and control of transboundary pests and diseases, which contribute to the suppression or eradication at the subregional level of agricultural pests, (fruit flies) and livestock diseases (foot-and-mouth disease, botulism, rabies, bovine brucellosis, tuberculosis, etc.), including the New World screw worm (NWS). 5. Public policies in place to promote food security are being implemented in the region.	1. Scientific, government and technological institutions work in isolation and duplicate activities, and it is well known that there is a lack of ongoing networked studies and research at the regional level. 2. An evident lack of continuity in research into the use and spread of technologies owing to the frequent leadership changes in research programmes and in national health services. 3. Low level of involvement of the private sector in initiatives to promote scientific and technological development. 4. Self-sufficiency has not been achieved in the provision of staple foods in some Member States of the region. 5. Inadequate application of international safety and quality standards related to food products for domestic consumption and export is a potential risk to human health and limits access to markets. 6. Significant food losses in the postharvest period owing to a lack of appropriate infrastructure. 7. The appearance of new, resistant agricultural pests and disease due to the inappropriate use of agrochemicals and veterinary medicines and the contamination of the environment and food by these products 8. Poor land management, land degradation, deterioration of soil fertility and desertification.

TABLE 1. SWOT ANALYSIS FOR AGRICULTURE AND FOOD PRODUCTION (FOOD SAFETY AND SECURITY) (cont.)

Opportunities	Threats
1. Development of second-generation biofuels using waste from the harvest of food or industrial crops. 2. Increase in the international market for agricultural and aquatic products. 3. Member States can sign agreements for cooperation in science and technology and local capacity available to develop synergistic agreements between the public and private sectors. 4. Better collaboration and data sharing at the regional and national levels.	1. Introduction and expansion of the range of emerging and re-emerging exotic or endemic diseases and pests in the region (for example, fruit fly, highly pathogenic avian influenza, foot-and-mouth disease, rust), which leads to the excessive use of pesticides for their control. 2. The growing use of food products (soil oil, maize, sugar, etc.) in the production of biofuels. 3. Non-tariff barriers to trade in the region's agricultural and fisheries products. 4. Reduction in agricultural and fishery productivity due to the effects of climate change.

2.4. NEEDS/PROBLEMS

A1. To improve crop yields and animal productivity, focusing on land and water management and climate-smart agriculture to foster crop and animal production resilience to climate change, including plants and animals (terrestrial and aquatic) of recognized economic importance, reflecting the region's biodiversity.

Justification: One way to reduce the food deficit in the region is by increasing animal production and developing improved varieties of crops that are tolerant/resistant to stress factors. In recent decades, genetic improvement of crops and animals has brought about significant increases in productivity, resistance to diseases and pests, tolerance to drought, adaptation to mechanized harvesting practices and uniformity of grains and fruit. Different methods are recognized for the genetic improvement of plants and animals: a) intraspecific and interspecific hybridization; b) mutation induction; and c) genetic engineering. Each method has its advantages and disadvantages, but it is important to bear in mind that they complement each other. Nuclear techniques are used for improvement of animal production to: a) control the reproductive cycle (radioimmunoassay techniques to measure the hormonal status of animals) to shorten the period between pregnancies, and; b) nutritional efficiency using isotopic labelling techniques.

The Food and Agriculture Organization of the United Nations (FAO) and the IAEA's database of mutant varieties shows the vast impact of nuclear technology on crop improvement [34]. There are currently more than 3300 mutant varieties from about 220 plant species, the majority of which (more than 80%) have been developed using gamma irradiation [34]. In the region, limited use is made of this technique, but it holds promise. The need to reduce the vulnerability of domestic crops requires the development of plans for the genetic characterization, conservation and use of these breeds in a manner that would allow the germplasm to be preserved *in situ*, and the identification of the genes that give these populations their adaptive characteristics for the selection of other breeds, improving their productivity levels in specific environments in the region.

In an effort to facilitate better use of reproductive biotechnologies, including programmes for artificial insemination and embryo transfer towards improving strategies for the use of forage resources for animal feeding and mitigation of the greenhouse gas effect, specific measures must be employed to create the basis for the use of genetic markers in the assisted reproduction of species of zootechnical interest in the region and the appropriate use of high genetic merit animals. Essential to achieving this is the use of radiation in the genetic characterization processes for producing irradiated (X-ray) cell hybrid DNA panels for genetic mapping and its use in radioactive labelling processes (^{32}P and ^{33}P) for the synthesis of radioactive DNA probes in the analysis of genome regions. The combined use of these nuclear techniques with other biotechnology techniques fosters a better understanding of the processes that control gene activation in animals that have adapted to the different agro-ecological zones in the region. Once the genes involved in the adaptation process are identified, their expression in different physiological and environmental

conditions can be studied. This can result in useful information for the development of tools for genetic selection of superior animal breeds, as well as appropriate management strategies for these genetic resources.

Agricultural producers in the region at all levels can benefit from the application of these technologies, which can positively impact the earnings of farmers as well as the foreign exchange revenue for countries in the region. It will optimize livestock reproduction and breeding practices that are in line with sustainable development principles.

The use of smart climate agriculture is a beneficial technique to improve agricultural output in addition to obtaining improved varieties of crops that are tolerant/resistant to drought and diseases and increasing animal production. One of the indicators of the level of agricultural technification is based on the effective use of fertilizers. Recently, it has been demonstrated that increasing the content of nitrogen in the soil can result in higher carbon content, which helps to mitigate the greenhouse effect, improves the soil water holding capacity and reduces soil erodibility [35]. Technologies such as direct sowing (zero tillage) [35, 36] and integrated crop-livestock farming systems [37] have the advantage of contributing to the sustainable production of foods over large areas while contributing to the mitigation of the greenhouse effect. In the case of direct sowing and zero tillage, greenhouse gases are reduced through carbon sequestration, whereas for integrated crop-livestock farming, mitigation benefits are reaped through increased land efficiencies from the use of manure for crop production and reduced land area for production of feed crops [36, 37]. In view of the above, there is an urgent need to adopt these technologies, and develop new techniques for the different agricultural areas of the region.

Nuclear techniques offer the best prospects for this. The use of ^{15}N as a tracer is a fast and economical way of producing recommendations for efficient fertilizer management (dose factors, sources, localization, fractionation and application methods). The ^{15}N isotope dilution and ^{15}N natural abundance techniques are also extremely useful for evaluating the efficiency of biological nitrogen fixation in legume production systems, allowing more efficient varieties and inoculants to be selected [38, 39, 40]. Techniques using ^{13}C will make it possible to evaluate the efficiency of the management systems with regard to carbon capture in the soil and its dynamics over time, with a view to promoting the sustainability of the agricultural system [41]. In the same vein, techniques based on ^{137}Cs are valuable tools to quantify soil losses due to erosion or to evaluate the efficiency of production systems in controlling erosion [42]. Water use efficiency by crops can be studied using ^{18}O and ^{2}H isotopes. Furthermore, monitoring of water content in the soil can be conducted using the neutron probe technique [43].

The direct beneficiaries will be large and small farmers who will be able to maintain, or recover the productive capacity of their land, as well as society in general through the availability of a larger quantity of foods of nutritional quality, and the reduction in the risk of environmental degradation, which will have a positive impact on food security.

There is considerable potential for the development of aquaculture due to the extensive coastline and large water basins in the region. Furthermore, the animal protein produced in aquaculture is of high economic and nutritional value; however, some traditional marine fish stock continues to be unsustainably exploited. Aquaculture today is possibly the food production sector growing at the fastest rate globally and accounts for almost 50% of the world's fisheries products used for food [44]. However, for the sector to succeed, it is necessary to take actions, including the appropriate development of structured programmes to control the recurrence of disease problems in cultivated species. The application of new biotechnologies in the selection of species resistant to diseases and molecular diagnostic characterization of different pathogen strains are viewed as beneficial approaches to advance the development of the sector. The results of analyses using these techniques may be utilized to identify the origin and presence of pathogens in animals, water and soils, including the detection of viral diseases in shrimp and bacteria in fish and other aquaculture species. Data from the World Organisation for Animal Health (OIE) indicates a need to establish laboratories with the skills to offer this type of service and implement rules for control of transit of these organisms and their products between Member States [45].

When compared to terrestrial domestic animals, there is limited knowledge about the biology of some of these aquaculture organisms and their pathogens. Given that the collection of 'seed' propagation material in natural populations in the environment is crucial to cultivating various aquatic species of economic importance, cognisance must be taken of the need to establish monitoring and genetic improvement programmes in the region. This will also take account of the propensity of fish and shellfish towards genetic deterioration in intensive cultivation programmes. In addition, the benefit of the use of nuclear technologies in the generation of genome region DNA probes with radioactive (^{32}P and ^{33}P) labelling as well as in gene mapping is recognized. This would result in the availability of accurate and prompt services for monitoring the conditions and production of the water systems for residents located along the coastal areas.

Objective: To increase food production through the improvement of plant varieties, animal breeds, land and water management and aquaculture and agricultural production systems using nuclear, isotopic and nuclear-derived technologies.

Indicator: Number of undertaking plant and/or animal, land and water management and genetic improvement programmes using nuclear, isotopic and nuclear-derived technologies. Number of Member States using nuclear-derived technologies to monitor and manage inputs into their agricultural and aquaculture production systems.

A2. To reduce the incidence of transboundary animal diseases, including those with zoonotic repercussions.

Justification: The Global Framework for the Progressive Control of Transboundary Animal Diseases (GF–TAD), the outcome of an official agreement between the OIE and the FAO, addresses the challenge of combating animal diseases from a regional and hemispheric perspective [46, 47]. As a result, various actions are being taken in the region, which, although still isolated, seek to develop and/or improve epidemiological monitoring and control services for emerging transboundary animal diseases of economic importance, such as foot–and–mouth disease, highly pathogenic avian influenza – H5N–1 and bovine spongiform encephalopathy (BSE) [48, 49, 50, 51, 52]. However, despite the transboundary nature and major relevance of this issue for the regional economy, a wide technology gap exists between the Member States in the region. An outbreak of one of these diseases would lead to incalculable losses and cause irreversible damage to stockbreeding and economic activity in the region due to the economic barriers which would be imposed by importing countries of animal products and derivatives.

It is therefore essential that Member States in the region have the required analytical capabilities for prompt and accurate diagnosis of emerging diseases. This can be achieved through the use of nuclear-derived techniques such as in the development and use of radioactive DNA probes for high sensitivity processes, including DNA and RNA blotting for the detection pathogenic agents in field samples. Subsequently, these can be utilized as a reference against which, other detection methodologies related to the analysis of nucleic acids [53]. Furthermore, the application of nuclear technology involving the use of vaccines and sera which have been inactivated through gamma radiation can support efforts to have an internationally recognized standardization of methods between zones with varying health classification. This would also facilitate the exchange of reference samples among Member States in the region. Additionally, this would result in stronger epidemiological monitoring services with swifter, more accurate and more efficient methods of detecting these types of pathogenic agents, allowing them to verify their technical and managerial competence in the area of animal health. The primary beneficiaries of this work will thus be the economies of Member States in the region, together with countries that import their livestock products, as it regards the prevention and control of emerging diseases. More specifically, livestock farmers will benefit directly since the control of these diseases maintains their commercial capacity at sustainable levels.

Objective: To improve preparation and response to transboundary animal diseases.

Indicator: Number of laboratories across the region with the analytical capability available to provide prompt and accurate diagnosis of transboundary animal diseases

A3. Inadequate capacity within the regional to use isotopic and nuclear-derived technologies for insect pest control to reduce losses to foods of animal and plant origin.

Justification: Fruit flies that include the West Indian fruit fly (*Anastrepha obliqua*), the Caribbean fruit fly (*Anastrepha suspensa*) and various other species of the genus *Anastrepha* are the insect pests that cause the most damage to fruit and vegetable crops in the region. In Member States where there is limited or no control over these pests, they can cause significant losses in production. Moreover, phytosanitary requirements imposed by the international market has restricted exports such as fresh fruits from the region attributed to the presence of this pest. Due to its high mobility and reproductive capacity, the best way to reduce the losses caused by fruit flies is to replace traditional means of control using insecticides from orchard to orchard (with a high risk of product and environment contamination) with the establishment of area-wide integrated pest management systems, leading to the creation of areas of low prevalence or pest-free areas. In order to establish low prevalence or fruit fly-free areas, it is recommended that the phytosanitary approach includes a pest management mechanism that integrates the sterile insect technique (SIT) with other monitoring and suppression methods. The SIT integrated with other monitoring and control methods has proven successful in suppressing and eradicating the New World screw worm (NWS) pest in some parts of the globe. NWS can inflict significant economic damage to livestock production across the Caribbean through high mortality of animals due to myasis. NWS also constitutes a human health problem through the zoonosis caused by the pest. Ultimately, an areawide integrated pest management scheme could benefit Member States greatly in agriculture and food production.

Objective: To strengthen the capacity at the national and regional level to support the development of Integrated pest Management programmes that incorporate the use of SIT.

Indicator: Number of institutions with trained personnel in the principles and application of Sterile Insect techniques in area-wide pest management programmes

A4. To address the inadequate capacity of the region to ensure the safety and authenticity of foods

Justification: The growing application of advanced technology in the region's crop and animal production for local consumption and export has contributed to the widespread use of various types of inputs. These include veterinary medicinal products such as antimicrobials, as well as pesticides and hormones, all of which may have residues that often pose a risk to human health and compromise trade and the economies of the producing countries. This is common with coffee, bananas, pineapple and citrus fruits, as well as products of animal origin, including fisheries and aquaculture. Naturally occurring contaminants such as mycotoxins, toxic metals and natural toxins are also a threat to consumer health and regional and international trade.

The major international export markets for fishery and agricultural products from the Caribbean are the European Union (EU) and the United States of America. However, there are frequent

rejections of large quantities of foods by international markets due to 1) problems with levels of residues and contaminants that pose a health risk and due to 2) the presence of undesirable pests. This affects the economy of the producer countries, where the burden is primarily carried by farmers and fishermen. In addition, The EU, with its new fishery products health conditions programme, and the US's Food Safety Modernization Act have made traceability a top priority and will deny their markets to exporters deemed to lack sufficient food traceability capacity [54]. This involves tracking of food through all stages of production, processing and distribution to identify and address risks and to protect public health, resulting in the swift removal of recalled products from the marketplace. At the regional level, Member States are expected to eliminate existing restrictions on imports and exports of goods of community origin, other than those authorized by CARICOM. This is however, proving to be a serious challenge in determining whether the goods are of community origin or not.

Therefore, it is essential, on the one hand, to rationalize the use of agricultural and livestock inputs, particularly those that present risks to health, and, on the other, to develop and adapt integrated methodologies, including analytical methods to control food safety (chemical residues), and biological methods to monitor levels of toxic residues and contaminants in the foods. It is important to note that nuclear isotopic techniques alone or in conjunction with related techniques for chemical analysis offer a solution to mitigating or addressing challenges associated with residues and contaminants. The region would benefit from the implementation of networked programmes with standardized methodologies to ensure the proper use of these techniques.

These safety control programmes will be part of a rigorous risk analysis scheme that would facilitate risk management with the support of certified laboratories. This can be bolstered through the establishment of residue monitoring programmes with appropriate infrastructure (instrumentation) and strengthened training for human resources at a national level. The targeted outcome would be "Improved regional capacity to test, monitor, control food hazards, e.g. veterinary drug and pesticides residues, toxic metals, mycotoxins, etc. according to national, regional or international standards". Thus, farmers, fishermen, the industrial sectors involved in the processing and marketing of agricultural products, as well as consumers, who will have access to safer and better-quality products, will be the primary beneficiaries of these food safety control programmes.

Objective: To ensure the safety and quality of the region's food supplies.

Indicator: Number of competent food safety (residues, contaminants etc.) laboratories and systematic monitoring programmes; to reduce food rejections. Number of regional laboratories upgraded for authenticity testing of identified products using nuclear and isotopic techniques Number of products/ food matrices for which authenticity testing is available. Number of screening methodologies implemented and used to verify food authenticity (presumptive testing). Regional databases of food safety monitoring and authenticity data established and populated.

3. HUMAN HEALTH

3.1. BACKGROUND

For the area of human health, the SWOT analysis identified the priority needs/problems associated with the use of nuclear technology from the regional perspective. These priority needs were the main focus of the goals and objectives of the projects approved and implemented during this period. In this area, the following were considered subsectors within the framework of the RSF:

a) Diagnostic radiology;
b) Nuclear medicine and radiopharmacy;
c) Radiotherapy;
d) Radiation medicine;
e) Nutrition;
f) Infectious diseases, sterile insect technique and nuclear molecular biology.

3.2. GENERAL ANALYSIS OF THE REGIONAL SITUATION

It is recognized that an effective radiation medicine plan benefits from having comprehensive cancer control planning, funding and governance at the country level. The Lancet Oncology has identified several evidence-based strategies to improve cancer prevention and treatment in the small island nations of the Caribbean Community [55]. These strategies include the establishment of a Caribbean Cancer Registry Hub, the development of resource-appropriate clinical guidelines, innovations in delivering special oncology services (e.g., paediatric oncology and palliative care), improving access to opioids, and developing regional training capacity. These developments emphasise the crucial role of public-private partnerships in improving healthcare and demonstrate how fostering strategic collaborations can improve care across the cancer control continuum.

The population of the Caribbean is in a process of demographic and epidemiological transition, exhibiting considerable variation in its health status. This has resulted in a complex situation in which health problems related to underdevelopment (e.g. enteric, communicable and deficiency-related diseases) and, on the other hand, to urban lifestyles and economic development, (e.g. chronic and degenerative diseases, cancer, accidents and mental health problems) coexist. For many Member States in the Caribbean, populations are too small to support particular levels of technology as well as the associated human resources and expertise. There needs to be a certain critical mass to justify investment in some technologies and for experts to maintain skill levels. In addition, it is difficult to retain specialized human resources in the area of health due to the attraction of better opportunities outside the region [56, 57, 58]. An important strategy in this region is to identify existing communities of practice and networks using technology, and to establish collaboration between the countries in the region, where needed. This would support efforts to build resilient and responsive systems around data sharing and protection, human resource mobility and secure record and image sharing to support this. Another factor to consider is climate change and the related extreme weather events in the Caribbean region, which impact

human health directly through injury and disruption of health systems and additionally through outbreaks of infectious diseases, including the emergence and re-emergence of diseases.

Meeting IHR core capacity requirements represent an 'all-hazards' approach to public health events and is a priority for many Caribbean Member States. The conditions for preparing and responding to radiological emergencies is particularly challenging. Many Member States are unaware of the existing sources of radiation or potential threats to human health, and there is little attention paid to waste disposal. PAHO/WHO indicates that "significant challenges remain with the achievement of core capacities to deal with chemical events and radiation emergencies" [59]. This crosscutting area is therefore critical, and CARICOM Member States are encouraged to coordinate with the IAEA and other stakeholders to develop the critical mass necessary to manage such events effectively. Objective and indicators dealing with radiation emergency preparedness and response are described in section 7.

Diagnostic radiology allows for confirmation of diagnosis or suspicion of many health conditions. Many Caribbean states can benefit from improvement in the quantity and competencies of related human resources, including clinically qualified medical physicist, radiographers, radiologists and technicians. Access to appropriate clinical training programmes and continuing professional development is needed in these areas and can be delivered locally. Some hospitals are still utilizing outdated methods in diagnostic radiology, for instance, X-ray films are still being chemically developed in some cases. Consequently, there is a need to improve the equipment and technology for diagnostic accuracy, as well as to minimize exposure and optimize image quality. Additionally, capacity needs to be built across the region to ensure that requisite safety standards are in place for patients and workers in diagnostic radiology.

Furthermore, it is recommended that basic medical imaging equipment is available and accessible to the population. This needs to be complemented with trained human resources and appropriate support systems, including sustainable training programmes offered by regional educational institutions, for example, those courses already at the University of the West Indies and the University of Guyana in the areas of radiography, radiology and medical physics. Additionally, there needs to be structured and supervised clinical training programs in all specialties of medical physics. It is also important to consider the appropriate disposal of waste and consumables, as well as equipment beyond its useful life.

Radioisotope techniques allow for cost effective management of pathologies by enabling early diagnosis and timely appropriate therapy. In recent decades, they have grown in complexity. Efficient and safe implementation of diagnostic and treatment procedures employing open radiation sources requires that the multidisciplinary staff involved are adequately trained on an ongoing basis, as new equipment and radiopharmaceuticals are introduced. It is recommended that basic nuclear medicine equipment is available and accessible to the population. This needs to be complemented with the appropriate human resources and support systems, including sustainable training programmes in regional educational institutions.

Radiotherapy is the non-surgical treatment modality with the highest tumour cure rate, an essential component of comprehensive care. More than half of all patients with cancer will require radiation treatment as part of their care, often in combination with surgery and chemotherapy and, more recently, with biological therapies. In addition, it is an effective option for alleviation and control of symptoms in advanced cancer. In many cases, it replaces supra radical surgery, achieving higher rates of anatomical and functional preservation of organs and improving the quality of life of the cancer patient.

It is important to highlight that the region has experienced a rapid increase in the number of centres established with new equipment using more advanced technology. As a consequence, the deficit in the number of professionals such as clinically qualified medical physicist has been exacerbated by the additional need for training related to new demand and greater complexity. Awareness-raising among medical personnel in various domains, including primary care, is important due to the role, benefits and possibilities that radiotherapy brings in the management of cancer. These include medical physicist and radiation therapy technologist. Additionally, referring doctors including surgeons, internists and oncologists, as well as the nurses who care for them and other members of the team. This can be done through the development and delivery of online short courses and continuing education seminars. There is great need to have medical specialists in the region exposed to new radiotherapy capabilities and to ensure that training opportunities in English are available for physicians in the Caribbean. In addition, the role of clinically qualified medical physicists is vital for an effective, safe and quality delivery of radiotherapy. The Caribbean region's lacks an adequate number of specialists in radiation medicine, as well as training programmes for professionals. It is therefore a priority for the countries within the region to collaborate and put in place measures to remediate this situation. In this context, it would be beneficial to conduct a regional training program for clinically qualified medical physicist along with cancer education. A training needs and gap assessment is required to develop an education and training plan, building on the existing infrastructure and network of hospitals, research centres, and other stakeholders.

The quality of radiotherapy treatment is closely linked to clinical factors (diagnosis, tumour localization, selected treatment strategy, ongoing verification and monitoring of the patient) and physical factors (uncertainty in dose calculation, dose optimization and verification, adequacy of dosimetry, calculation and treatment delivery equipment, inter alia). The level of knowledge and experience of each member of a team significantly affects treatment quality and patient protection. This type of treatment requires a highly complex technological infrastructure which usually includes dosimetry systems for characterization and calibration of radiation beams, simulation systems (conventional, computerised tomography or virtual), computerised planning systems, treatment units (megavoltage and brachytherapy), verification systems and internal networks for managing and transmitting technical and administrative information.

Given that the number of qualified medical physicists is insufficient or non-existent in many centres in the region, the new Basic Safety Standards (approved by the governing bodies of eight

intergovernmental organizations) relating to calibration, dosimetry and quality assurance in radiotherapy are not being met to the detriment of quality service and radiation protection of the patient [30]. The incidence of severe exposure of patients globally, and particularly in the region, indicates that this is attributed to a lack of properly structured and functional quality assurance programmes. In all cases, the initiating events were related to a physical aspect of the process, demonstrating the urgent need for sufficiently thorough training and clinical education for the region's medical physicists, as well as for rigorous work guided by codes of practice and technical guidelines. This is also the situation in diagnostic radiology across the region, Misuse, malfunction or low-quality imaging systems can result in poor quality of images. Poor quality can lead to wrong diagnosis and thus affect the health of many patients and not just one. Imaging modalities must be closely monitored using established quality assurance programs and the use of machines should be tailored to each individual patient's needs with the appropriate quality and radiation dose.

Accelerated technological development in the design and manufacture of imaging systems in the last ten years has led to the gradual integration in the region of more complex technologies in all types of imaging. One of the challenges this trend poses is the general lack of management and planning processes for the incorporation of technology in the region. This usually results in underutilization of imaging systems and, in cases such as digital radiography, multi-slice helical tomography and fluoroscopy-guided intervention systems, an increased risk of unnecessarily high exposure of patients, including children. The availability of digital imaging systems (particularly in radiography and digital mammography) also offers the possibility of using teleradiology as a means of remote participation by radiologists to minimize the problem of accessibility in remote areas, where services are available urban centres. This possibility has already been envisaged by the PAHO. However, in addition to the installation and maintenance difficulties in these regions, the lack of medical physics professionals capable of providing advice and supervision for this type of facility is another factor which makes the implementation of such solutions difficult.

A well-fed population is healthier, has lower mortality rates, enhanced mental development and cognitive capacity, better education, and is therefore a more productive population, which has a positive impact on the development of Member States. However, economic and developmental imbalances have given rise to two realities in the health sphere in the region: malnutrition owing to excess and malnutrition due to deficit [60]. Data on causes of death are an approximate indicator of the type of malnutrition present in the population. As obesity increases, so do deaths due to cardiovascular diseases and cancer. Conversely, where infections are the predominant cause of death, undernutrition tends to be high and obesity low. The pattern of mortality in the Caribbean has been influenced by the demographic and epidemiological transition. As the infant mortality and fertility rates fall, the population ages and the level of chronic non-communicable diseases increase. Currently, chronic non-communicable diseases account for almost two-thirds of all deaths [4]. Improvements are needed in monitoring the nutritional status, growth and development of children and the general population.

The IAEA supports activities to improve nutrition for better health throughout the life course. Through the application of nuclear techniques including stable isotopes, the IAEA supports the Member States to design and evaluate interventions aimed at addressing malnutrition in all its forms with a specific focus on infant and young child feeding; maternal and adolescent nutrition; diet quality; prevention and control of non-communicable diseases (NCDs) and; healthy ageing. Nuclear nutrition techniques can be used for assessing body composition, exclusive breastfeeding, energy expenditure, bone health, vitamin A stores, protein absorption and environmental enteric dysfunction. These technologies, when implemented, can provide excellent data, which can be used to develop healthy nutrition campaigns in the Member States.

Infectious diseases are a significant health problem in the Caribbean. Many infectious agents are emerging or re-emerging every year, increasing the region's economic difficulties and infecting a population already suffering from other social factors. Many efforts are being made at the initiative of the international community to control this problem, but ecological, social and economic factors have an impact on the persistence of such human diseases. The sterile insect technique (SIT) is an insect pest control method involving the mass rearing and sterilization, using radiation, of a target pest followed by the systematic areawide release of the sterile males by air over defined areas, where they mate with wild females resulting in no offspring and a declining pest population [61]. Application of this methodology in mosquito populations can potentially reduce mosquito vector-borne diseases such as Zika, chikungunya, dengue and yellow fever in the region.

Progress in molecular biology and the extensive availability of methods employing nucleic acids have permitted the development of fast and reliable diagnostic methods, as well as genotyping techniques for infectious agents [62, 63]. Application of these molecular techniques in the study and diagnosis of infectious diseases has increased in the past decade and techniques have even been developed for nucleic acid amplification with isothermal incubation for fieldwork [64]. Despite the existence of geographic boundaries, infectious agents and their vectors do not respect such legal borders. Globalization, frequent air transport, migration processes and invasion of other areas have contributed to the spread of many vector species and pathogens in the region. It would be unwise to view health problems as exclusively national and disregard a regional context. Thus, it is beneficial to take a holistic approach through the implementation of a regional plan to control these vectors and diseases.

Following Table 2 summarizes a SWOT analysis in the context of human health in the Caribbean.

3.3. SWOT ANALYSIS

TABLE 2. SWOT ANALYSIS FOR HUMAN HEALTH

Strengths	Weaknesses
1. Capacities for the assessment of nutritional problems in children using isotope techniques have been established in some Member States of the region through IAEA national projects. 2. Available established capacity in highly complex nuclear medicine and imaging services has increased in some of the Member States. 3. Rapid development of established capacity of radiotherapy services with a high technological standard in the region. 4. The University of the West Indies is developing postgraduate programmes for training specialized human resources in all areas of interest: radiotherapy, radiology, nuclear medicine, medical physics and radiopharmacy. 5. Most Member States in the region speak the same language, which facilitates exchanges and ongoing training. 6. Existing regional entities in CARICOM and the Organisation of Eastern Caribbean States (OECS) which can be strengthened and built upon for sharing of human resources, data sharing and support of referral centres, e.g. Caribbean Association of Medical Councils, Eastern Diagnostic Oncology Network, Caribbean Public Health Agency (CARPHA) – International Agency for Research on Cancer (IARC) Cancer Registry Hub. 7. In most of the Member States, information and communications technologies are sufficiently developed for use in virtual and distance learning activities.	1. Shortage of medical physicist and technicians in radiology, radiotherapy and nuclear medicine in some Member States in the region leads to the redeployment of human resources from other sectors (radiology technicians or nurses), affecting the quality of the service provided. 2. The significance of nutrition in the first years of life and its effect on health and development has assumed importance in the global health agenda, but there is little knowledge of the contribution that nuclear and isotope techniques can make in the evaluation of national programmes on nutrition. 3. Inadequate information in the region on the link between nutrition in the first years of life, healthy growth in babies and young children and the risk of developing non-communicable diseases later on in life. 4. Limited knowledge of the benefits of using isotope techniques to study the relationship between food and growth of children in early infancy, and improvement of lifestyles for the prevention of non-communicable diseases. 5. Limited availability and access to diagnostic and therapeutic procedures employing ionizing radiation. 6. Limited knowledge among referring physicians and administrators of health institutes of the specificity and benefits of complex nuclear techniques in diagnostic and therapeutic procedures. 7. Brain drain in highly specialized areas such as medical physics, particularly from Member States with limited resources migrating to more attractive labour markets. This contributes to a shortage of radiographers, radiologists, radiation oncologists, medical physicists in nuclear medicine and radiology services and subsequently delays in diagnosis owing to a shortage of specialists.

TABLE 2. SWOT ANALYSIS FOR HUMAN HEALTH (cont.)

Strengths	Weaknesses
	8. The lack of appropriate undergraduates to follow the postgraduate medical physics courses offered through the University of the West Indies. 9. Inadequate life cycle management of technological resources (procurement, maintenance, safety, quality, national inventory, repair budget, record of prolonged outages and duration of obsolescence, disposal). 10. Shortage of reliable official information in the ministries of health of Member States concerning technological capacity and human resources, as well as requirements to meet the needs of the population. 11. Inconsistency in the structure and application of regulations in force. 12. Deficient mechanisms by the health authorities for monitoring quality assurance programmes in institutions providing health services. 13. Shortage in some Member States of operational and adequately funded national cancer control programmes (NCCPs). 14. Limitations in the follow up of radiotherapy patients and in the research capacity to establish results indicators (no correlation with epidemiology teams). 15. Continued use of adult image acquisition protocols in paediatric patients, which results in children receiving unnecessary radiation doses. 16. Heterogeneous level of development among potential beneficiaries of regional cooperation, which makes it difficult to establish an effective standard for training programmes. 17. Small populations limit the ability to support specialized services in every Member State, necessitating regional approaches.

TABLE 2. SWOT ANALYSIS FOR HUMAN HEALTH (cont.)

Opportunities	Threats
1. Cooperation among international organizations (United Nations Children's Fund, PAHO, WHO) to address the issue of nutrition in early infancy and its influence on the epidemiology of problems affecting the population. 2. Growing awareness among different medical specialists of the advantages of nuclear techniques for diagnosis, treatment and research. 3. Several medical specialities are using new diagnostic and therapeutic procedures for the management of pathologies prevalent in the region. 4. Recognition by health authorities of chronic non-communicable diseases (cancer, cardiovascular disease, diabetes, etc.) as an important public health issue. 5. National professional societies in the region can participate in legislative processes and in the development of public policies relating to the health sector. 6. Technical cooperation involving international organizations and professional societies in the area of training and the availability of quality protocols and guidelines. 7. The possibility of evaluating existing resources and needs of Member States, using international databases, such as the Directory of Radiotherapy Centre (DIRAC). 8. The possibility of improving the performance of nuclear medicine, radiology and radiotherapy services through quality audits organized by international organizations.	1. Economic and working conditions that prevent families from feeding their children properly in early infancy. 2. A decrease in investment in health as a percentage of gross domestic product, which undermines the continuity of programmes and improvement in the quality of health care. 3. Limited administrative and governmental continuity causes instability in the smooth running of related projects. 4. Influence of donor organizations and the media in the reallocation of resources, which leads to changes in priorities previously identified. 5. Speculative overpricing by providers of equipment and inputs, in terms of sale as well as maintenance. 6. Migration of specialized human capital to other sectors or other regions. 7. Lack of adequate recognition of clinically qualified medical physicist.

3.4. NEEDS/PROBLEMS

H1. Lack of availability and access to tertiary and specialized care services in radiation medicine that exist within the region.

Justification: The Caribbean region is comprised of many small island developing States with small and highly variable populations. It is not feasible or advisable for every Member State to have nuclear medicine and radiotherapy services. Instead, it is important to ensure that there is maximized use of national diagnostic radiology services and a broad availability and access to appropriate specialized nuclear medicine and radiotherapy services. The region has existing specialized centres and regional mechanisms that can be strengthened to improve access, including the Caribbean Association of Medical Councils, the Eastern Caribbean Diagnostic Oncology Network and the CARPHA–IARC Cancer Registry Hub. The IAEA has a similar model, e.g. African Radiation Oncology Network (AFRONET), which supported the multidisciplinary virtual tumour board serving several regional needs.

Objective: To strengthen regional mechanisms that improve availability and access to needed radiation medicine services.

Indicator: Number of MS with referral processes for patients from other countries in the region. Number of MS participating in regional collaborative diagnostic/treatment mechanisms, e.g. telemedicine, consultations, tumour boards.

H2. Cancer is a leading cause of death in the Caribbean.

Justification: Recommendations have been made at the international level to ensure appropriate cancer control. These concern the establishment of NCCPs that address various components and include action at different levels related to prevention, early detection, diagnosis, treatment and palliative care. It is important to incorporate some elements of NCCPs at the regional level in order to optimize the use of scarce resources, with actions to be pursued based on information from surveillance, control and research systems. There is a need for information on the disease burden at the national and regional level, which will facilitate the incorporation of novel radiation medicine treatment and evaluate strategies to address the problem at the regional level.

Objective: To reduce the premature mortality due to cancer through planned prevention, early detection, diagnosis treatment and palliative care.

Indicators: Number of MS that have developed/revised robust and funded NCCPs, including the radiation medicine component. Regional strategy and framework of action on cancer control including the radiation medicine component developed.

H3. Differing levels and standards of quality and safety in the delivery of radiation medicine services within the Caribbean region.

Justification: The region is incorporating new technologies at an accelerated rate, and radiation medicine technology is evolving rapidly. It is important that professionals and technical staff are appropriately trained, to produce radiopharmaceutical products of good quality safe for patient use. The relevant protocols for imaging and radionuclide therapy are developed and adopted to meet international standards to obtain the maximum benefit for patients from new technologies. The migration of specialized staff to other sectors and regions remains a threat, but this could be mitigated against by the availability of professional opportunities and appropriate equipment.

Objective: To improve and harmonize quality, safety (for workers, patients and the public), and capacity in the use of radiation medicine technologies for the diagnosis and treatment of diseases.

Indicator: Number of institutions with human resources trained and competent in quality and safety protocols in radiation medicine, including radiopharmacy.

H4. Insufficient human resources in radiology, nuclear medicine and radiotherapy to meet the growing needs arising from the establishment of new centres in the region.

Justification: An internal study was conducted in 2018 by PAHO and the IAEA which quantified the number of staff and equipment available in radiology, nuclear medicine and radiotherapy in the Caribbean [65]. The IAEA and Member States have made efforts to train technical radiotherapy and nuclear medicine staff through regional training courses and fellowships that have been used primarily by personnel currently linked to the services. However, Member States face difficulties in meeting their needs in terms of appropriately trained human resources for new services, and this has not been reflected in the development of sustainable training programmes across the region. It is necessary to find mechanisms to provide training at the highest level for technical staff in the field of radiotherapy and nuclear medicine in the skills required. In nuclear medicine, regional cooperation through the University of the West Indies is planned and can be further strengthened and broadened to include radiotherapy.

The region has noticeably improved its capacity to train medical physicists at the level recommended by international organizations. However, the majority of trained medical physicists have a background in the area of physics and have not been exposed to clinical medicine, including radiology, radiotherapy or nuclear medicine services. The new Basic Safety Standards require medical physicists to support all medical practices because of the complexity of the procedures used [30. This situation is exacerbated by the increase in advanced technologies incorporated in imaging services in the region.

Objective: To increase the number of health professionals in specialized radiation medicine in order to support the needs in the Caribbean region.

Indicator: Number of trained radiation medicine professionals[2] available and working in the region.

H5. Inadequate systems for life cycle management of medical equipment for radiation medicine (planning, procurement, incorporation, maintenance and disposal).

Justification: The capacities of Member States for the evaluation, incorporation and management of technologies and equipment are either weak or absent. This means that the technologies procured are not always appropriate for local conditions. There may be an inefficient geographical distribution of technologies, and limited provision may be made for lifecycle-associated costs (including maintenance, repairs and depreciation), technology is underutilized, and there are shortcomings in the monitoring and evaluation of new technologies. In Member States with small populations, access to centralized specialist services at regional Caribbean centres may be preferable to improve cost efficiency and quality.

Objective: To improve the availability, quality and safety of medical equipment needed for delivery of radiation medicine services.

Indicator: Number of MS with life cycle management plan for medical equipment for radiation medicine including facilities and equipment for production of radiopharmaceutical products. Number of MS that have institutions with trained personnel in the maintenance and disposal of equipment for radiation medicine.

H6. Emerging and re-emerging infectious diseases, including increasing severity and frequency of mosquito-borne disease outbreak (e.g. dengue, Zika and chikungunya).

Justification: Infectious diseases are a significant health problem in the Caribbean. Many infectious agents are emerging or re-emerging every year, increasing the region's economic difficulties and infecting a population already suffering from other social factors. From December 2013 to July 2014, the chikungunya outbreak spread to hundreds of thousands of persons in Latin America and the Caribbean. Non-Latin Caribbean countries reported 3676 suspected and 511 confirmed cases [66]. Two years later, the Zika outbreak exposed gaps in public health preparedness and response that had not been adequately addressed following the 2013–2014 chikungunya outbreak [67]. The ease with which these mosquito-borne diseases cross national borders underscores the importance of well-coordinated country and regional responses and containment strategies to avoid the high costs associated with outbreaks. Outbreaks of this nature not only impact human health but also have an economic impact on tourism-dependent economies.

[2] Radiologists, oncologists, radiation oncologists, medical physicists, radiotherapy and nuclear medicine technicians, dosimetrists, nurses

The sterile insect technique (SIT) is a method in which radiation, such as with gamma rays and X-rays, is used to sterilize mass-reared insects so that they cannot produce offspring. The SIT is one potential methodology for mosquito control in the region. It is essential that appropriate research and testing is conducted to determine the effectiveness and potential future use of this technique in the region.

Objective: To decrease the spread and impact of arboviral diseases through radiation related SIT to reduce mosquito populations.

Indicator: Number of MS in the Caribbean piloting sterile insect technology programmes to reduce mosquito incidence.

H7. Growing childhood obesity in the region and its link to the incidence of non-communicable diseases.

Justification: It is estimated that, in the region, between 50% and 60% of adults and between 7% and 12% of children under five, as well as a third of adolescents are overweight or obese [68]. It is recognized that obesity is a determinant in the incidence of non-communicable diseases among the population, such as cardiovascular disease, diabetes and cancer.

Appropriate nutrition during pregnancy and the first years of life is essential for the healthy growth of the child, his or her mental health and resistance to infections. The IAEA supports the use of stable isotope techniques for the appropriate evaluation of public health interventions, including the promotion of breastfeeding, micronutrient supplementation programmes, a healthy diet and more physical activity to prevent and control the double burden of malnutrition and non-communicable diseases. Stable isotope techniques give the most accurate measure of breast milk intake and total energy expenditure.

Objective: To optimize the use of stable isotopes in the measurement of body composition in research for childhood obesity in the Caribbean.

Indicator: Number of MS that have institutions with trained personnel to use stable isotopes for assessment of childhood malnutrition/obesity. Number of studies being conducted. Number of MS with institutions capable of analysing stable isotopes (regional).

4. ENVIRONMENT

4.1. BACKGROUND

This section in the RSF describes the environmental conditions in the Caribbean region and identifies areas for improvement through international cooperation utilizing nuclear-derived techniques, where possible. The focus is on the three elements of the environment: land, water and air as an integrated whole.

4.2. GENERAL ANALYSIS OF THE REGIONAL SITUATION

Caribbean countries are of varying sizes, ranging from Anguilla at 91 km^2 to Cuba at 110 860 km^2. The region is recognized as a biodiversity hotspot with seagrass meadows, mangrove swamps, marshes, rocky coasts and coral reefs, including the second largest global coral reef system off the coast of Belize [69]. The Caribbean islands hotspot represents an important portion of the world's critical biodiversity with diverse terrestrial ecosystems and significant proportion of endemic species. This includes approximately 11 000 plant species of which 72% are endemics; 100% of 189 amphibian species, 95% of 520 reptile species, and 74% of 69 mammals, species assessed [70]. Overall, the Caribbean hotspot covers 2.6% and 3.5% of the world's 300 000 plant species and 27 298 vertebrate species, respectively [70].

The CARICOM region shows a unique interplay between equatorial and tropical features across spatial scales. The North Atlantic Subtropical High is a large-scale feature that shapes together with the Atlantic Warm Pool and the Inter-tropical convergences zone the bi-modal pattern of wet (boreal winter) and dry (boreal summer) season [71]. Rainfall in the Caribbean region is resulting from the passage of moist air masses associated with tropical disturbances including tropical waves, depressions, storms and hurricanes. Guyana represents a unique climatology within the countries discussed as it has two rainy seasons due to its geographic location. There are spatial differences in annual precipitation, mean wind speed and temperatures across the region. Highest rainfall accumulations and cooler temperatures are generally encountered in higher elevations where tropical forests may occur. While the availability of water resources is strongly influenced by precipitation patterns, other factors such as land use, structural geology and stratigraphy influence runoff, river discharge, aquifer recharge and the size and overall water availability in Member States.

The decline in the region's freshwater resources has been attributed to a change in rainfall patterns caused by climate change, among other factors [72]. Declines in seasonal rainfall, along with increasing amounts during rainfall events and increased dry spells, led to decreases in surface water runoff and diminished groundwater recharge within the aquifers of some Member States [9, 14, 73, 74]. The Caribbean region is facing droughts as a threat to water resources but is also prone to flooding, as storms and hurricanes occur frequently [75]. Hence, access and availability of the region's water resources are susceptible to the impacts of these natural hazard events, and furthermore, to volcanic eruptions and earthquakes. This applies in particular to Member States relying exclusively on surface water.

The situation may be exacerbated by sustained and prolonged groundwater withdrawals which may impact the long-term sustainability of aquifers in some Member States, especially when withdrawal rates exceed recharge rates. Contamination of aquifers in some Member States is also a concern with high nitrate levels often occurring due to agricultural runoff and inappropriate and/or inadequate sewage treatment and disposal. In addition to nitrates, agrochemicals are increasingly being observed in aquifers, lakes and river systems [14].

Some Caribbean countries must utilize nearly 100% of their renewable water resources with some States relying exclusively on either surface water or groundwater to meet demand [14, 76]. Several countries have reported emerging deficits between available water resources and demand. Groundwater and surface water represent the largest proportion of water supply across the region, except for countries such as Antigua and Barbuda and the Bahamas, where desalination has become the major water source, as natural supplies are insufficient to meet demand [14, 76]. Similarly, Barbados is currently aiming to increase use of desalinated water to respond to their freshwater deficit [14, 74]. It is expected that the need of the region to adapt to long term climate change coupled with growing demands for potable water for municipal purposes and expanding service industries will result in many islands revaluating their water resources strategies.

The demand for water has increased as a result of demographic growth (particularly in urban areas), changes in lifestyle, expansion of industrial and touristic activity and demand for irrigation [77]. Increased urbanization is a notable concern. As urban areas continue to grow in Member States, the demand for water to meet local needs grows and, in an increasing number of cases, exceeds the capacity of local sources. Addressing this problem often results in water being piped from great distances leading to increased tariffs for consumers or high government subsidisation. In many countries of the region, the inability to locate and mitigate leaks within national distribution systems further compounds the efficient and cost-effective delivery of water to subscribers, with several States reporting estimates of water loss or unaccounted water along distribution systems higher than 50 per cent [75, 78].

Another area of concern relates to the impact of pesticide residues on water and food production for local consumption as well as export. Particular emphasis is placed on meeting sanitary and phytosanitary requirements for export of produce to minimize losses due to delays experienced at

ports of entry in importing countries. One of the measures to be pursued by CARICOM is the development and introduction of a common water framework for the region to address the issue of water quality which directly impacts on food safety standards for local and international markets. This is further intended to protect water resources and facilitate the needs of other sectors. For effective implementation across the region, this will require Members States to integrate the framework into national planning and policy.

Deterioration in the quality of soil due to nitrification, salinization and depletion of nutrients is a significant issue within the region. This is attributable to excessive use of fertilizers, poor irrigation practices and farming techniques, inappropriate sewage treatment and disposal and the overuse of natural resources, all of which may lead to desertification in extreme cases [77]. In Member States engaged in mining activities, including oil and mineral extraction, soil and water contamination may be exacerbated. Cognisance must be taken of the fact that in some mining and mineral operations, naturally occurring radionuclides present in, or released in process material, may be harmful to workers, the public and the environment [79].

Environmental degradation is also impacted by urban population growth, resulting from rural migration to cities, which in turn creates a demand for more land space to accommodate expansion in housing developments. In line with this, environmental management remains vital as it relates to water resource management, sanitation and sewage as well as waste disposal. This can be better ensured through proper urban and rural development planning. Unplanned development such as informal settlements in watershed areas in cities of some Caribbean Member States pose a challenge. Informal settlements which can be densely populated, creates a burden on existing infrastructure, as these tend to lack the prerequisites and appropriate design for water supply, sewerage, stormwater drainage and solid waste management.

Air pollution is a health and environment risk, which in urban areas is strongly associated with energy consumption and generation, as well as transport emissions. Combustion processes release particulate matter and other pollutants (such as lead), which in combination with atmospheric transformations arising from ozone and sulphates, contribute to detrimental emissions for health and air quality [77]. This problem extends to rural areas, as anthropogenic and natural sources of air pollution are produced either locally or in the periphery and are transported over long distances. Air quality is further aggravated in countries where there are no monitoring systems or incentives in place to control or reduce emissions [80]. There is need for air quality monitoring programmes at the national level, which feeds into a regional network. There is no air quality data available for most countries in the region, except for Jamaica [80]. Even so, monitoring stations are only found in the capital city of the country, which is indicative of what it is obtained in Latin American countries [80]. WHO estimates that both ambient and household air pollution are responsible for 138 000 deaths per year in the Latin American and Caribbean [80]. In fact, according to the Pan American Centre for Sanitary Engineering and Environmental Sciences, this may be underestimated, and the actual figure may be much higher, which highlights the severity of this public health issue [81]. Another contributing factor to air pollution relates to vehicle emissions.

This is particularly relevant in densely populated urban centres with public transportation, primarily using combustion engine buses and an increasing volume of privately-owned vehicles, which all contribute to declining air quality. Often, the age and maintenance of the vehicle, type and quality of fuel, and the technologies utilized to control emissions are contributing factors.

In general, the management of solid and liquid urban and industrial waste in the region is of poor quality. The amount of solid waste generated per person has increased, and most of the waste is deposited in open solid waste dumps or partially controlled landfills, with no protection for the environment or prior treatment [82]. Solid municipal waste is made up of organic material, recyclables, dangerous household material, medical and industrial waste and construction debris. The effects of inadequate management and disposal can be observed on the health of the population through the tendency towards certain diseases, and the contamination of soils, water resources/aquifers, air, flora and fauna, and disasters such as flooding [82]. Of growing concern in the region is the dominance of plastics in the marine environment as these materials are comprised of many plastic polymers such as polystyrene and polyethylene which are toxic to humans and animals and can have far-ranging effects, even in small amounts. Larger marine animals have often been found as victims of entanglement, choking, malnutrition and premature death because of their encounters with large debris during feeding and locomotion [83]. It is recognised that single-use plastic products are the largest segment of marine litter recovered and many countries have implemented legislations for the ban of the use and manufacture of these products [84]. Whilst microplastics have been documented in marine environments worldwide, there is very limited information on their concentrations and implications for the region. In addition, there is limited information regarding the presence of pollutants including hormones, antibiotics, natural radioactive emissions and additives amongst the waste and thus their environmental and population-related effect cannot be evaluated [82].

The fishing industry of the Central Caribbean is threatened by overexploitation of valuable species for commercial gain and personal consumption. This is further exacerbated by pollution of the marine environment arising from a high volume of nutrients, organic and solid waste from land-based and marine sources. In turn, this leads to degradation or perturbation of ecosystems through the development of harmful algal blooms (HABs), such as red tides, ciguatera and sargassum super blooms [25]. One of the most significant consequences of HABs is the production of toxins by certain species of algae, which may build up in seafood products and constitute a health risk for consumers, ranging from passing discomfort to long term disease and even death from poisoning syndromes. Additionally, HABs involves significant economic losses, including costs associated with routine programmes to monitor affected resources, temporary or permanent stoppage of fish and shellfish harvesting, declining sales of seafood, and the death of wild and farmed fish, shellfish, submerged aquatic vegetation and coral reefs. This is also detrimental to tourism and associated businesses, driving up the costs to provide medical treatment to the exposed population.

The rapid increase in CO_2 produced from human activity in recent decades further deteriorates the wellbeing of marine ecosystems. Increased CO_2 concentration in the atmosphere has been linked to changes in global temperatures and other significant climatic disturbances, including a rise in sea temperature and levels, and ocean acidification, which is a consequence of a decrease in pH from large quantities of CO_2 captured in oceans. This can adversely impact on coral reefs which are home to significant biodiversity and are highly sensitive to these changes. Molluscs, lobsters, shrimp and several other commercially important species are also threatened by changes in ocean acidity and temperature. Although the full magnitude of the impact of increased CO_2 in the marine environment is yet to be examined, the deterioration of coastal and marine ecosystems, including the decay of coral reefs and loss of biodiversity poses an environmental threat in the region. Moreover, a decline in these populations leads to economic adversities associated with the fall of productivity, abundance and distribution of important marine species, which may also impact ecotourism.

Taking into consideration the various environmental threats the region currently faces, Table 3 summarizes a SWOT analysis regarding the environment in the Caribbean.

4.3. SWOT ANALYSIS

TABLE 3. SWOT ANALYSIS FOR ENVIRONMENT

Strengths	Weaknesses
1. Existence of international conventions and protocols on environment issues, to which Member States in the region are a party, including the Basel Convention, the Stockholm Convention, the Regional Seas Programme and the Environment Ministers Forum, among others. 2. Existence of laboratories with equipment and trained personnel for the quantification of pollutants in environmental samples. Some laboratories use nuclear analytical techniques such as alpha and gamma spectrometry, liquid scintillation, neutron activation analysis, isotope ratio mass spectrometry, inductively coupled plasma mass spectrometry and non-nuclear analytical methods, such as X-ray fluorescence. There are laboratories with quality control systems in place, which is essential for the mutual recognition of analytical results achieved. A few of these laboratories have ISO/IEC 17025 accreditation. 3. Some Member States of the region have experience with standardized protocols for the application of nuclear techniques in some environmental areas, as well as a history of collaboration between groups conducting research on environmental issues and nuclear techniques. 4. Complementarity of the techniques. The availability of various complementary nuclear and non-nuclear methods enables environmental issues to be tackled comprehensively, facilitating a more complete characterization of the samples for analysis. 5. Existence of regional institutions with strong scientific knowledge and implementation capabilities in the region.	1. Low level of continuity in policies applied and in efforts made, especially from the government sector. Environmental issues are contributing factors to severe problems such as hunger, lack of potable water or communicable diseases. In addition, there are shortcomings in networks for long term monitoring, harmonized legislation and policies, political will as well as intra- and interregional control structures. 2. Low level of interaction between environmental protection institutions and those that could provide support for studies using nuclear applications. The relationship between the institutional sector and scientific institutions is limited, leading to insufficient knowledge of the potential and advantages of nuclear techniques. For improved diagnosis and monitoring of environmental issues and mitigation strategies, better communication is needed between the scientific sectors. 3. Limited knowledge of environmental issues and their impacts on the region. This is inclusive of inadequately applied technical research and development as it relates to water resources. There is limited scientific information that could serve as a basis for understanding the environmental problems affecting the region. Many efforts tend to address the symptoms of the problems rather than identifying their causes and ways of mitigating the effects. 4. Weakness or failure of Member States to comply with environmental standards. Lack of data to substantiate the need to monitor pollution problems and to establish proper environmental quality standards. Even where these do exist, limited effort is made to ensure compliance due to a lack of human and technical resources.

TABLE 3. SWOT ANALYSIS FOR ENVIRONMENT (cont.)

Strengths	Weaknesses
	5. Inadequate interaction between agencies of the United Nations system and/or regional entities on topics related to environmental protection. 6. Limited promotion of the scope for the use of nuclear techniques. The characteristics of nuclear techniques make them an ideal, and often the only, tool to support environmental monitoring and toxicology studies. However, their potential is often restricted to the academic field. There is thus a need to raise awareness among the general public and government departments responsible for environmental management. 7. Insufficient specialized and accredited laboratory facilities and personnel trained in the application of nuclear techniques in environmental areas. Although the region has capacity in the field, in many cases, it is insufficient to cope with the magnitude of the task, or the staff needs specific training in the application of the techniques to environmental studies. Moreover, the existing capacity needs to be maintained or upgraded to respond to increasingly demanding quality standards. 8. Disparity in the use of techniques, as well as in the quality of analytical results generated within the region. 9. Inadequate budgetary provision for the effective maintenance and ongoing modernisation of the equipment of facilities and laboratories.
Opportunities	**Threats**
1. Existence of programmes of United Nations agencies and international institutions interested in environmental issues. 2. Strong interest by the region's universities and research institutions in the research and application of nuclear techniques to the environment, where analytical capacities could be built within a Regional Water Research Institution that could provide services to inform each Member State's policy, planning, management, protection and allocation of water resources.	1. Weak commitment from some governments and institutions to the sustainability of outcomes of environmental projects. Long term efforts are needed to solve environmental problems, which are not dependent on any political changes that could affect the region. 2. Negative social perception and a lack of understanding of nuclear techniques. Greater visibility on peaceful applications of nuclear techniques will heighten awareness among the public and in government circles.

TABLE 3. SWOT ANALYSIS FOR ENVIRONMENT (cont.)

Opportunities	Threats
3. Identification of critical problems that affect the environmental situation in the region. 4. Increasing demand from the population to resolve various environmental issues common to all the Member States in the area: this awareness, together with the capacity available, make this the right time to promote the adoption/consolidation of comprehensive environmental management plans, control emissions of pollutants and ensure the appropriate characterization of different environmental compartments. 5. Nuclear techniques are part of the array of techniques demanded by the institutions (inclusive of Regulatory Agencies) responsible for environmental management. These techniques are used in the following activity groups linked to environmental issues: a) Diagnosis and basic studies of the environmental situation in the region; b) National, regional and global programmes and monitoring networks; c) Remediation of environmental problems. 6. Existence of the Coastal - Marine Stressor Research Network for Latin America and the Caribbean (REMARCO), which is a non-profit interdisciplinary research network that uses nuclear and isotopic techniques to address environmental problems of coastal-marine ecosystems in the region.	3. Low level of stability in terms of qualified staff. Retention of qualified staff is critical for sustainability. 4. Inadequate budgetary provision for the effective maintenance and ongoing modernisation of the equipment of facilities and laboratories.

4.4. NEEDS/PROBLEMS

V1. Insufficient capacity to assess the impact and vulnerability of Member States to sources of pollutants (pesticides, persistent organic compounds, heavy metals, microplastics and other pollutants) of anthropogenic origin in terrestrial and marine environments including the region's water resources as well as risks/threats due to climate change and natural hazard events, such as volcanic eruptions, earthquake, hurricanes flooding, cyclone etc.

Justification: The Caribbean has a legacy of pollution that is expressed in many terrestrial and marine environments, including their biota. Moreover, very little urban and industrial wastewater receives any treatment, and most solid waste is managed using sanitary landfills, causing pollution of soils and water sources and affecting human and environmental health. Inadequate knowledge on the distribution of water resources inhibits their protection.

In addition, Member States in the region are faced with problems related to pesticides in food for local consumption and export, exceeding the legal limits in many cases. There are also issues related to contaminants released from mining activities. This is compounded by a lack of adequate information or analytical capacity to determine the pollutants and their impact on human health, flora and fauna.

Objective: To improve source identification, impact assessment and mitigation of pollutants in soil and water, and to develop appropriate adaptation strategies.

Indicator: Number of Member States with trained personnel in the use of specific nuclear techniques for pollutant determination in soil and water. Number of Member States using operating procedures for collection and analysis, including heavy metals testing, in reference laboratories integrating the use of nuclear techniques.

V2. Inadequate documentation of each Member States hydrological data/information, characterization (quality and quantity) and assessment of water resources in order to develop long term integrated water resources development plans to support national development.

Justification: The availability of potable and irrigation water varies greatly in the region, leading to marked water deficits in some cases. The intensive exploitation of water resources causes problems, such as sea water intrusion and exhaustion of water reservoirs.

Objective: To characterize all Member States water resources to achieve the comprehensive management of water resources, to ensure their availability, quality and long-term sustainability.

Indicator: Number of MS which have integrated isotope hydrology information into their water resource management plans, including enhancement of capacities for isotopic techniques. Number of MSs with a monitoring program of isotopes in the hydrological cycle (i.e. groundwater, rivers, precipitation) that supports an IAEA/regional database for water resources assessment, including the impacts of climate change. Number of MSs with analytical capabilities in the use of nuclear techniques for water resources management.

V3. Inadequate risk assessment of the environmental and social impact of hydraulic infrastructure.

Justification: Currently, many Caribbean Member States face significant risks in relation to the age and structural integrity of hydraulic infrastructure. These risks are exacerbated by poor land use management, population settlement patterns and the anticipated effects of climate change. Implications of this will be evident for all sectors, where degradation of hydraulic structures such as dams, water supply intake works and sewerage systems could potentially fail, causing widespread damage and pollution that would negatively impact drinking water systems and result in system outages and costly cleanup efforts.

Objective: Sustainable management and safety of hydraulic infrastructure.

Indicator: Number of Member States conducting risk and vulnerability assessments on key hydraulic infrastructure using nuclear techniques.

V4. Limited knowledge of the main vulnerabilities of low lying coastal and marine ecosystems and their response to expected anthropogenic, natural hazard events, such as volcanic activities and climate change-induced alterations.

Justification:

There are several factors negatively affecting coastal and marine ecosystems and their important services, which in turn undermine the development of Member States, including the potential for ocean economic activities in the area. These include: overexploitation of marine resources; increasing chemical and nutrient pollution caused by coastal growing development of human activities; climate change-related changes (warming waters, ocean acidification, water deoxygenation, rising sea level and current changes); more frequent harmful algal blooms; increase in tourism and maritime transport; outbreaks of invasive species such as the Pacific lionfish; as well as beach and coastal erosion.

Objective: To develop comprehensive data through monitoring programmes, including nuclear techniques that facilitate the sustainable management of coastal resources and preserve the livelihoods of coastal communities and the environmental integrity of the coasts.

Indicator: Number of Member States utilizing nuclear and isotopic techniques to monitor marine and coastal ecosystems. Number of Member States tracking data on coastal and marine ecosystems through monitoring programmes, including nuclear techniques, Number of MS joining an international network which is focusing on marine stressors (and monitoring of these stressors).

V5. Inadequate management strategies for characterization/disposal/reprocessing of waste (solid, chemical and wastewater).

Justification: The management and disposal of solid, chemical and liquid waste from various sources such as the oil/gas, mining and agricultural sectors, remains a challenge in the region. Both disposal and management of chemical and liquid waste continue to elude most environmental regulators primarily due to an inability to identify the constituents of such wastes, which is collected over years and mixed in holding tanks. Another contributing factor is the absence of procedures for handling, storage and disposal of this waste, as well as a lack of access to suitable disposal methods (denaturation, chemical conversion to less harmful forms, etc.). This has led to a build-up of chemical waste in hundreds of schools, laboratories and manufacturing spaces across the region. While environmentally friendly systems have been designed and implemented across Member States to manage organic wastes, there has been little success in the management of chemical waste.

Objective: Effective strategies, processes and procedures to support the safe disposal of highly hazardous waste.

Indicator: Number of Member States which have completed characterization and classification of waste using nuclear techniques.

V6. Limited knowledge of temporal and spatial scales of atmospheric pollution.

Justification: The majority of the region's population lives in cities. The increase in the number of motor vehicles is adding to serious atmospheric pollution problems. Rural areas are also exposed to anthropogenic and natural emissions. In all cases, the sources of the emissions may be local, regional or transboundary. High levels of particulate matter in the air have been associated with different ailments and constitute a risk to human health. In fact, poor air quality has been identified as the leading cause of premature deaths in the world. Chemical characterization not only provides information on the concentration of various elements in the atmospheric particulate matter but also identifies the sources.

Objective: Improve the management of air quality using nuclear analytical techniques for the chemical characterization of particulate matter in monitoring studies.

Indicator: Number of Member States monitoring systems for chemical characterization of particulate matter and aerosols in the atmosphere.

5. ENERGY

5.1. BACKGROUND

The Caribbean has varied energy resources, ranging from fossil fuels (oil and gas), geothermal and renewable sources (wind, solar and hydro). This section in the RSF outlines the status of the region's energy landscape, including diversification of energy sources as well as enhancing human resources and institutional capacities through the use of IAEA's energy planning tools and methodologies.

5.2. GENERAL ANALYSIS OF THE REGIONAL SITUATION

Most of the countries in the region are net importers of fossil fuels for electricity generation and transportation [85]. All are extremely vulnerable to the effects of volatility of the international oil market, natural disasters and climate change and, with the exception of Belize, Guyana and Suriname, there is no ability for transboundary interconnection for the supply of electricity. As such, most energy planning is better conducted at the national level. However, the interconnection between the islands and mainland territories is being considered by the region.

In order to improve the security and sustainability of their respective energy sectors, the CARICOM Member States defined an overarching energy policy with the goal of fundamentally transforming the energy sector through the provision of secure, sustainable, reliable and efficient supplies of energy, to facilitate economic growth. Priorities include the diversification of energy resources through increased usage of renewable energy in a manner that assures optimal integration with other sectors, encouragement for greater efficiency, demand-side management and the undertaking of necessary reforms in a timely manner to encourage greater investment in the energy sector. Key strategies were defined and geared towards building and strengthening human and institutional capacities within the region to encourage research and development; set and achieve regional and national targets for the reduction of greenhouse gas emissions; and to implement appropriate mitigation actions.

The overarching regional energy policy shares the intent of energy policies in some Member States regarding their goals to increase and optimise the use of renewable or alternative energy sources; promote energy efficiency and demand-side management and improve local expertise in energy planning. However, few have undertaken the required studies on energy demand projections and supply options to inform such planning, leading to uncertainty and inhibiting potential investments in the energy sector. Coming out of this policy, CARICOM launched a programme called the Regional Building Energy Efficiency Programme (BEEP) to improve the use of energy in buildings across the region in 2017 [86]. The BEEP aims to address the dependence on fossil fuels and economic vulnerability as a result of the inefficient energy use in buildings in the Community.

The IAEA can support the Member States of the region in strengthening national capabilities in energy system analysis and planning so that countries can independently analyse and elaborate energy plans, strategies, and policies without relying extensively on external consultants. The agency capacity building programme includes the development and maintenance of IAEA's energy system assessment tools, user support, various types of trainings and workshops, multi-lingual approach, and technical assistance for elaboration of sustainable energy strategies, including the achievement of modern, efficient, diversified and environmentally sustainable energy sectors. These activities are aimed to build and sustain local expertise as well as to support decision and policy making in countries by transferring modern energy planning tools and methodologies to national teams, increasing knowledge, and reinforcing their skills.

The IAEA has also experience and tools for the implementation of these interdisciplinary studies, which analyse the interrelationships between the different resource systems referred to as a Climate, Land, Energy and Water (CLEW) framework.

Based on the discussion in section 5, Table 4 summarizes a SWOT analysis on the area of energy considering the identified areas that could benefit the region.

5.3. SWOT ANALYSIS

TABLE 4. SWOT ANALYSIS FOR ENERGY

Strengths	Weaknesses
1. Relatively low demand for energy. 2. Established overarching policy framework: CARICOM Community Energy Policy (2013) and Member States energy policies. 3. The establishment of a new CARICOM specialized agency in energy, Caribbean Centre for Renewable Energy and Energy Efficiency (CCREEE). 4. Availability of energy planning tools and methodologies (climate, water, land and energy nexus) to address the achievement of SDGs 7and 13 and Nationally Determined Contribution optimization. 5. CARICOM and its Member States have overarching energy policies that support and optimize the use of indigenous energy resources.	1. Over-reliance on fossil fuels. 2. Small, unreliable and inefficient grids. 3. Varying circumstances, laws, regulations and procedures in individual Member States. 4. Lack of integrated plans that create uncertainty and lack of investment in development/upgrade of national energy grids to facilitate renewable energy integration. 5. Lack of institutional capacity and trained personnel to support energy planning and decision making. 6. Lack of a comprehensive CARICOM policy regarding tariffs on energy efficiency components.
Opportunities	**Threats**
1. Proper energy planning will allow for the introduction of different energy sources to the grid. 2. The trend towards diversification of the energy mix with a view to improving the security of the energy supply. 3. Regional university networks to develop curricula in energy planning. 4. Availability of IAEA energy planning tools and capacity building programme. 5. There is potential for the inclusion of renewable /alternative energy sources, including solar, wind, hydro and geothermal sources and in limited cases biofuels and energy from waste.	1. Increasingly volatile cost of fossil fuels. 2. Greenhouse gas emissions and local pollutants. 3. Adverse weather and climate events which are capable of disrupting energy supplies and grids.

5.4. NEEDS/PROBLEMS

E1. Inadequate capacity within the national and regional institutions tasked with energy planning and decision support.

Justification: There is a general low level of awareness, knowledge and skills among users, planners and service providers related to energy system analysis and planning (including renewable technologies and how they can be integrated). Additionally, there is limited data available on the region's extent of energy use, efficiency or conservation efforts.

Objective: To strengthen capacities at national and regional levels to support medium and long-term sustainable energy planning for enhanced efficiency, effectiveness and sustainability of Member States energy sectors' development.

Indicator: Number of Member States with human resources trained using IAEA energy assessment tools and methodologies to support medium and long-term sustainable energy planning (e.g. energy demand projections, technology options for energy supply, including the integration of renewable and alternative energy sources).

E2. Inadequate Integrated Energy Planning, as well as Integrated Resource and Resilience Planning, within Member States.

Justification: Countries in the region have strong interlinkages between energy, water use and climate systems (through vulnerabilities related to climate change). At the same time, there are no national development plans in the region that explicitly contemplate such an integrated and comprehensive analysis. Thus, developing and strengthening capacities for making integrated assessment of different resource systems (climate, water and energy) would be an asset for the countries' teams and would contribute to the development of coherent policies related to the SDGs, mainly those associated with: Clean water and sanitation; Clean and affordable energy; and Climate Action defined in the 2030 agenda.

Objective: To develop and enhance capacities for elaboration of energy planning studies, plans and strategies based on Integrated Resources and Resilience approach.

Indicator: Number of Member States with capacities built for integrated assessments of Climate, Land, Energy and Water (CLEW) to support policy formulation and planning.

6. RADIATION SAFETY

6.1. BACKGROUND

For the use of nuclear technology in facilities and activities to be considered justified, the benefits that it yields must outweigh the radiation risks that it poses. Radiation safety aims to protect workers, the public, patients and the environment from the harmful effects of ionizing radiation and ensure adequate protection of current and future generations from any activity that involves exposure to ionizing radiation.

The IAEA, in accordance with Article III A.6 of its Statute, is authorized to establish standards of safety for protection of health and minimization of danger associated with the application of ionizing radiation to life and property and to provide for the application of these standards. IAEA safety standards cover nuclear safety, radiation safety, transport of radioactive material, safety of radioactive waste and emergency preparedness and response. The Fundamental Safety Principles stipulate that States have a national system for effective control of all radiation sources, including a regulatory body with clear responsibilities and powers, and access to resources that allow it to fulfil its mandate of regulation, authorization, control and sanction, as well as to ensure compliance with international commitments set by international agreements, arrangements, protocols or conventions [87]. It is important for States to also have the necessary arrangements so that, if needed, a capacity for intervention and mitigation in the event of accidents exists.

In the area of radiation safety, the RSF for the period 2020–2026 uses information provided by the IAEA as a reference point, such as the Radiation Safety Information Management System (RASIMS), expert missions, reports from evaluation missions, information from international meetings and congresses, Member State reports presented on regional coordination meetings, Member State CPFs for the technical cooperation programme, surveys and other sources of information.

Based on the needs identified by the Member States in the region and now captured in the RSF, the IAEA has been managing technical cooperation projects that have contributed to improving the regulatory infrastructure, occupational radiation protection, radiation protection of patients and the public, radiological emergency preparedness and response, education and training in radiation safety, safety of radioactive waste and safety of transport of radioactive material. It has been noted in multiple meetings that Member States of the region need access to adequate technical support services and sufficient number of qualified human resources to fulfil their regulatory functions and responsibilities for radiation safety.

6.2. GENERAL ANALYSIS OF THE REGIONAL SITUATION

Under its technical cooperation programme, the IAEA has recently embarked on the implementation of a series of projects aimed at strengthening the nuclear regulatory infrastructure in its CARICOM Member States. Analyses of the countries' project outcomes indicate that there is limited regulatory infrastructure in place, with only one Member State having a fully operational regulatory body with the attendant legislation and regulations. This said, additional technical cooperation projects are expected to be implemented in the future to support other Member States further develop and strengthen previous gains made in the region. However, decisive action is required by all parties to sustain the results achieved as good international practice in the radiation safety area.

The new IAEA safety standards, General Safety Requirements (GSR Part 1- GSR Part 7) clearly reflect the responsibilities of governments and regulatory bodies in the development and application of regulatory infrastructures and systems [29, 30, 31]. The IAEA thus encourages the governments of Member States to enforce the safety requirements set out in the IAEA safety standards to ensure the establishment of efficient and sustainable regulatory and radiation safety infrastructures. The current evaluation of the status of radiation safety in Member States in the Caribbean indicates the following:

a) Despite the achievements of previous regional projects in implementing all aspects associated with the creation and/or improvement of radiation safety infrastructure, there remain elements that need to be addressed to ensure that the regulatory bodies are independent, have sufficient resources, competence, knowledge, and are free from political influence. This includes the existence of an appropriate national structure safeguarded by effective and sustainable regulatory bodies to guarantee the safety of radiation sources.
b) There is an inadequacy of suitably qualified regulatory staff readily available, which leads to inadequacies in undertaking the core regulatory functions for authorization, inspection and enforcement, among others. This situation also has implications for end-users and technical services in the area of radiation protection.
c) Orphan and disused sources are identified hazards which could potentially cause radiological incidents and emergencies. This points to the need for measures to ensure detection and timely safety action.
d) Not all occupationally exposed workers receive the individual monitoring required under international recommendations and national regulations. Dosimetry calibration laboratories are not sufficient to meet the region's needs.
e) Single national registers of all occupational doses are not available in all Member States.
f) Technical support services to regulatory bodies (such as equipment calibration, dosimetry services, environment monitoring, technical analysis, specialized training, etc.) are not always available at the national level. Individual external dosimetry services are currently

offered through the International Centre for Environmental and Nuclear Sciences. However, the provision of other technical services at the regional level -should be explored.

g) In most of the Member States in the region, no action has been taken to identify existing exposure scenarios associated with industries that involve naturally occurring radioactive material (NORM) and to assess their impact. Furthermore, an effective regulatory framework to address this area has not been developed.
h) There is weak planning, reporting and coordination in the region to respond to radiation emergencies, particularly with respect to identification and classification of risks.
i) There is a lack of capacity to recognize the adverse effects of ionizing radiation exposure, including the provision of medical care to those affected.
j) There are continued inadequate national strategies and policies for the management of radioactive waste, compounded by the absence of human resources with necessary technical expertise, and deficiencies in the application of the concepts of exemption and clearance.
k) The majority of regulatory bodies do not have enough human and financial resources to fulfil all their designated responsibilities under applicable legislation and regulations.
l) There is a clear shortage of management systems of regulatory authorities that are in line with the competencies assigned under the legal framework.
m) Safety assessments and the promotion of a safety culture in the area of radiation safety is not properly promoted or implemented. It is important for regulatory bodies and end-users to be knowledgeable about good safety practices.
n) The governments of some Member States in the region still do not have sufficient knowledge of the need and role of the regulatory body, and this could adversely affect the sustainability of the national radiation safety system.
o) Documented experience and information on the infrastructure for the safe transport of radioactive material is not available in the majority of Member States, and problems associated with the denial of shipments of radioactive material arise.
p) There is a shortage of national strategies for education and training in radiation safety.
q) There is insufficient training on programmes for optimization of radiation protection in all practices, particularly in medical applications, with emphasis on new technologies (digital techniques — multi-slice computed tomography — hybrid systems single photon emission computed tomography (SPECT) – positron emission tomography–computed tomography (PET-CT) and advanced techniques in radiotherapy).
r) There is also insufficient training for medical and paramedical staff in radiological protection programmes for diagnosis or treatment therapy of children and pregnant women in specialities with high radiation risks, such as radiotherapy and interventional procedures.

Table 5 summarizes a SWOT analysis in the context of radiation safety in the Caribbean, taking into account the previous discussion.

6.3. SWOT ANALYSIS

TABLE 5. SWOT ANALYSIS FOR RADIATION SAFETY

Strengths	Weaknesses
1. Cultural identity and language that (particularly among the English-speaking Members) facilitate the exchange of experience, information and professional support, helping to bring Member States to the same level in various areas relating to safety. 2. Existence of professionals trained in all fields of Occupational, Environmental Health and Safety with experience that can collaborate within a bilateral framework. 3. Recognition by Member States of the need for authorized centralized storage facilities for radioactive waste and disused radioactive sources. 4. Existence of organizations for conventional emergency management that can assist in the event of radiation emergencies. 5. Skill and preparation levels of some regulatory authorities have increased. 6. Existing national inventories of radiation sources, radioactive sources, radioactive waste and disused radioactive sources. 7. Increased awareness among the private sector for the need to ensure the safe use of radiation sources and the promotion of a safety culture. 8. Existence of basic technical services to determine occupational exposure and aspects of radiation measurement in the event of unintentional releases of radioactive material to the environment and the need for emergency response. 9. Public opinion in favour of the protection of the public and the environment.	1. Insufficient high-level governmental commitment to the creation of a regulatory infrastructure. 2. Protracted time frame to develop and promulgate nuclear laws and regulations. 3. Most regulatory bodies have limited capacity in terms of infrastructure and trained human resources to meet their responsibilities according to international standards. 4. Regulatory bodies do not have the financial resources necessary to fulfil all their designated legislative responsibilities. 5. Low pay and incentive to work in the public sector, leading to high attrition of specialized human resources in radiation safety and a lack of staff renewal. 6. Lack of knowledge management necessary to maintain an institutional memory on radiation safety issues. 7. Low level of independence of existing and potential regulatory bodies in most Member States where the regulatory body is also an operator of practices that need to be regulated or the regulatory body is dependent on the specialized knowledge of the operators. 8. Absence, or limited dissemination, of formal programmes for the development and promotion of a safety culture among users and the regulatory body. 9. Insufficient external personal dosimetry coverage to encompass all workers and all types of radiation to be measured. Difficulties concerning beta and neutron dosimetry. 10. No laboratories in the region providing internal dosimetry services, which makes it impossible to provide broad coverage for all exposed workers who require it. 11. Limited services and equipment available to monitor the workplace (measurement of radiation beams and contamination of surfaces).

TABLE 5. SWOT ANALYSIS FOR RADIATION SAFETY (cont.)

Strengths	Weaknesses
	12. There are no dosimetry calibration laboratories in the region to calibrate the equipment for workplace monitoring. 13. The absence of unified national records for occupational dose in the majority of Member States. 14. Lack of clarity regarding the meaning, need and scope of national policies and strategies pertaining to radioactive waste management, which makes safe and sustainable implementation in this area difficult. 15. Limited information on the existence of NORM, technologically enhanced naturally occurring radioactive material and identification of exposure scenarios that exist in the Member States and a lack of identified industries that may be part of 'positive list' of NORM related industries. 16. Lack of clarity concerning the regulation and practical application of the concepts of exemption and clearance. 17. Absence of national strategies for education and training in radiation safety. 18. Most Member States in the region have yet to become State Parties to the convention on Early Notification of a Nuclear Accident, and on Assistance in Case of a Nuclear Accident or Radiological Emergency, the Joint Convention and support the Code of Conduct on the Safety and Security of Radioactive Sources and its Supplementary Guidance Documents. 19. Variability in the level of upkeep and maintenance of radiation equipment and in some medical applications. 20. Inadequate level of awareness of radiation protection programmes and ~~best~~ good practices in the application of radiation safety standards among end-users. 21. Limited healthcare resources (human and equipment) in the region to identify, advise and treat those injured in nuclear and radiological accident and emergencies. 22. Limited use by Member States of tools developed by the IAEA, such as the Self–Assessment of Regulatory Infrastructure for Safety (SARIS) and the Radiation Safety Information Management system (RASIMS). 23. The region is essentially dependent on external financing for the development of capacities to respond to nuclear and radiological emergencies. 24. There is no mechanism for official reporting or documenting of radiation accidents, nor systematic analysis is performed of the accidents that have occurred in the region.

TABLE 5. SWOT ANALYSIS FOR RADIATION SAFETY (cont.)

Opportunities	Threats
1. Possibilities to access specialized international and bilateral cooperation aimed at supporting the development of radiation safety infrastructure in Member States. 2. Access to legal assistance to assess the existing legal framework of the Member States to regulate ionizing radiation and to accelerate the development of new nuclear laws. 3. Enhancing capacity in Member States of the region for training of trainers. 4. Adhesion to international conventions on safety and emergency response. 5. Access to regional projects and plans of action that help to find solutions to the problems. 6. Expansion of Programme for Postgraduate Courses in Radiation Protection offered by the University of West Indies (UWI). 7. Capitalising on available training packages developed by the IAEA allowing standardisation of the information imparted in training. 8. Use of updated IAEA international standards concerning radiation safety. 9. Utilisation of tools (software) that serve as a basis for the preparation of personnel and other activities in the area of radiation safety. 10. Utilisation of available guidance for establishing requirements in terms of qualification and recognition of different categories of workers and practices associated with the area of radiation safety. 11. Utilisation of IAEA advisory services for evaluating the radiation safety infrastructure and the legislative and regulatory framework (Integrated Regulatory Review Service, Emergency Preparedness Review, Occupational Radiation Protection Appraisal Service, etc.). 12. Utilisation of existing international programmes for the conditioning and repatriation of disused radioactive sources. 13. Use of a database that reflects the current radiation safety situation of Member States of the region (Radiation Safety Information Management System (RASIMS)). 14. Use of the benefits of international conventions concerning emergencies and knowledge of other safety conventions. 15. An open and ongoing exchange of professional experience, training, regulatory documents, etc. in the area of radiation safety through networks. 16. Training programmes implemented and provided by the IAEA.	1. Changes in national priorities which may affect the establishment of emerging infrastructure and the continuity of national regulatory projects and programmes. 2. Economic instabilities affecting the establishment or improvement of infrastructure. 3. Weak governmental commitment to support, strengthen and establish infrastructure and regulatory programmes concerning radiation safety. 4. Lack of multiplier effect with respect to knowledge (knowledge transfer) acquired at specific courses provided by international organizations. 5. Lack of awareness on radiation safety issues among professionals working with ionizing radiation and the general public. 6. Potential hazard of orphan sources in the region due to a lack of regulatory infrastructure and effective strategies to regain control of orphan sources as well as the absence of authorized long term storage facilities.

6.4. NEEDS/PROBLEMS

R1. Lack of capacity for early warning, risk reduction and management of radiological incidents and emergencies and the potential need for a coordinated regional response.

Justification: Ministries of Health in the Caribbean region have committed to meet IHR as noted from outcomes and presentations at the recent CARICOM Council for Human and Social Development meeting held in Washington, DC in September 2018, and the OECS Council of Health Ministers meeting held in Grenada in October 2018. All evaluations show that the region is weak in meeting the radiological safety aspects of IHR. In 2016 and 2017, Member States were encouraged to join the IAEA for support in this area. In addition, radiation sources widely used in industrial applications and research in the Caribbean require adequate institutional and national mechanisms to respond to potential incidents and emergencies, in close cooperation with the organizations mandated to deal with disaster management. There are capacities in the region (plans, procedures, human resources) that can be strengthened and used in the event of an emergency situation, and which, if appropriately coordinated through official mechanisms (e.g. IAEA Response Assistance Network (RANET)), could be made available to the Member State concerned. In most Member States, shortcomings have been identified in the evaluation of threats for planning and response to radiological and nuclear emergencies, taking into account aspects associated with mitigation of the potential consequences of the emergency itself and the response. Healthcare resources in the region for those injured in emergency situations are not properly identified, and there are not enough experts to provide guidance on the medical response in the event of nuclear and radiological emergencies. Although actions have been taken to improve the knowledge and infrastructure of the first responders, they need to be strengthened further in the majority of Member States. No systematic analysis has been performed on the accidents that have occurred in the region. A number of Member States in the region are still not party to conventions on radiological and nuclear emergencies.

Objective: To increase the capacities for planning, recording and responding to emergencies.

Indicator: Number of Member States with documented progress level of preparedness for responding to radiological and nuclear emergencies.

R2. Insufficient application and implementation among end-users of principles and requirements concerning radiation protection set out in IAEA Safety Standards.

Justification: Increased radiation protection of patients, workers and the public is essential in view of the universality and magnitude of radiation exposure to the population due to medical conditions, as well as in other applications. It is also important to ensure compliance with internationally recommended radiation protection requirements [29], in particular concerning the application of the principle of justification and optimization programmes. In addition, a lack of awareness of radiological risk and the lack of safety culture development can lead to unnecessary exposure.

Objective: To ensure the safe use of radiation sources and the protection of workers, patients and public to avoid unnecessary exposure.

Indicator: Percentage of institutions within MS with radiation protection and optimization programmes implemented at end-user facilities.

R3. Insufficient priority is given to establishing a national, governmental, legal and regulatory infrastructure for radiation safety.

Justification: The vast majority of Member States in the region have no legally established regulatory body. However, for those who do have or will soon establish, this does not guarantee in all cases the existence of a sustainable national regulatory system for radiation safety that provides the regulatory body with sufficient resources to fulfil its responsibilities concerning regulation, authorization, inspection and enforcement. In addition, the level of commitment of governments to support, strengthen and implement regulatory programmes for radiation safety can be improved. The majority of Member States have limited competent human and financial resources to fulfil all their designated responsibilities under the legal framework. In some cases, workers are not financially incentivised enough and lack motivation and the tenure of staff of regulatory bodies might not always be guaranteed, which puts at risk institutional memory and knowledge management.

Objective: To protect workers, patients, the public and the environment from the adverse effects of ionizing radiation.

Indicator: Number of Member States with a basic regulatory infrastructure in line with IAEA Safety Standards.

R4. Insufficient coverage by the radiation protection services (individual internal and external monitoring and workplace monitoring) of occupationally exposed workers.

Justification: There are few technical services for external dosimetry in the region resulting in a lack of coverage, particularly concerning neutron and beta dosimetry. Due to the lack of internal dosimetry services in most of the Member States, it is not possible to evaluate the occupational exposure of those working in nuclear medicine and the production of radionuclides. Furthermore, the services and equipment available to monitor radiation beams and contamination of surfaces in workplaces remain limited. Quality systems in these services have not been implemented in most Member States, and technical competence has not been recognized by the body concerned. The majority of Member States do not have centralized national records of occupational dose and often do not have information on levels of exposure associated with different practices; actions for optimization are not promoted.

Objective: To protect workers from the adverse effects of ionizing radiation and monitor occupational exposure at the workplace.

Indicator: Number of Member States with national registries of occupationally exposed workers. Percentage of coverage of occupationally exposed workers in external dosimetry within Member States.

R5. Lack of national policies and strategies for the safe and sustainable management of radioactive waste and disused sources.

Justification: None of the Member States currently has national strategies and policies approved by the government for the safe and sustainable management of radioactive waste, including the conditioning and safe storage of radioactive waste and disused sealed radioactive sources, and for the tools necessary for clearance. There are metal recycling industries where orphan sources have appeared, and if such sources are not detected and properly managed, they may result in the exposure of the public and industrial workers, leading to costly economic losses. In most of the Member States in the region, no action has been taken to characterize NORM residues or effluents that might contain relevant amounts of natural radionuclides or to identify existing exposure scenarios (i.e. NORM), and to evaluate their radiological impact with a view to adopt the appropriate regulatory measures. Additionally, no solutions have been identified for the final disposal of radioactive waste and disused sealed radioactive sources.

Objective: To protect the public and the environment through the safe and sustainable management of radioactive waste and disused sources.

Indicator: Number of Member States with established national policies and strategies for the safe and sustainable management and disposal of radioactive waste and disused sources. Number of Member States with a sufficient capacity of authorized storage facilities in operation.

R6. Absence of a standardized education and training strategy in radiation, radioactive waste/material transport and waste safety.

Justification: There is an absence of sustainable national strategies for education and training in radiation safety to build and maintain competence commensurate with all practices according to the national requirements, including the basic and postgraduate levels. There is also a shortage of human and financial resources for the establishment of sustainable national education and training programmes in occupational radiation protection for facilities and activities, in particular, medical practice.

Objective: To build a workforce to satisfy the fulfilment of safety requirements in the Caribbean region.

Indicator: National training strategies developed. Number of qualified safety professionals in the region fulfilling their intended functions.

R7. Limitations for calibration at the levels of radiation protection, radiotherapy and diagnostic radiology by secondary standards dosimetry laboratories) in the region.

Justification: Services for the calibration and verification of equipment in the secondary standards dosimetry laboratories in the region are not sufficient to meet the needs of the end-users in terms of levels of radiation protection, radiotherapy and diagnostic radiology with photon radiation. In addition, problems often arise at customs concerning the transfer of equipment between the Member States.

Objective: To ensure safety, accuracy and traceability in the measurement and delivery of doses.

Indicator: Percentage of institutions within Member States with their calibration needs covered.

R8. Absence of regulatory oversight of transport of radioactive material and insufficient knowledge of requirements by stakeholders (users, carriers, other authorities with responsibilities in the control of transport and radioactive sources)

Justification: Transport of radioactive material by land, water or air inherently presents a risk of accidents with the potential for radiological exposure that could impact the safety of people, property and the environment. There is an absence of transport safety regulations to guide governments, regulators, carriers, users of radiation sources and cargo-handling personnel, to ensure the safe transport of radioactive materials. There is also limited knowledge among stakeholders within the Member States regarding the correct application of regulatory requirements and international safety standards; hence problems associated with the rejection of shipments of radioactive material arise.

Objective: To ensure safety of workers and public when the radioactive material is in the public domain.

Indicator: Number of Member States establishing transport regulations and stakeholders trained on transport requirements of IAEA regulations.

7. RADIATION TECHNOLOGY

7.1. BACKGROUND

The use of radiation technology to improve quality of life has several applications in different fields which address a wide range of development issues in the areas of water resources, the environment, coastal engineering, medicine, industrial processes and production, natural/agricultural resources, and inspection technologies.

The activities recommended to be addressed using nuclear science and technology began with a review of the validity of the needs/problems set out in available CPFs. The needs of the region were identified in the areas of the environment, treatment of emissions and waste, coastal engineering, medicine, industrial processes, natural resources and inspection technologies, considering the use of the following nuclear techniques:

a) Radiation processing
b) Radiotracers
c) Nucleonic control systems
d) Non-destructive testing
e) Analytical techniques

7.2. ANALYSIS OF THE REGIONAL SITUATION

The applications of radiation technologies are continuing to grow. They are developing in areas including the exploration and the efficient use of natural resources, mining, the mineral processing industry, metallurgy, development of advanced materials, characterization and preservation of cultural heritage, the environment and protecting coasts from erosion. With the increase in experience and confidence in the technology, the use of radiation technologies can have a pivotal role to play in bringing about significant improvement in the Member States of the region and as an important contributor to the national economies. This can be achieved with specific radiation techniques, depending on the field in which it will be applied. Radiotracers and nucleonic gauges are used to optimize processes and for quality control, e.g. drinkable water and wastewater treatment plants, mining, cement, petrochemical refineries, etc. This is also used in coastal engineering to study sediment transport dynamics which is the main cause of erosion of coastlines, lakeshores and riversides, and also to study sediment deposition in ports that affects dredging work, interfering with harbours activities.

Non-Destructive Techniques (NDT) are used as an inspection technology when it relates to quality control of a material during its production/construction and use, for example: metals, welding, pipework, energy plants, oil and gas, aerospace industry, etc. It is also broadly applied in civil structures to evaluate concrete, roads, bridges, buildings, and after specific emergency events, such as earthquakes, blasts, hurricanes. For NDT, it is important to have trained and licensed personnel under ISO standards to perform these tests.

Given the regional needs, possibilities and capacities, the group identified the following areas in which the use of radiation technologies could be beneficial.

Water (treatment):

a) Treatment of water for reuse or discharge;
b) Treatment of sludge;
c) Optimization of water treatment processes;
d) Measurement of precipitation;
e) Areas of protection for hydrographic basins.

Environment (treatment of emissions and waste):

a) Treatment of gaseous effluents;
b) Discharge from industries (mining and petroleum);
c) Sediment transport.

Coastal engineering:

a) Protecting coasts from erosion;
b) Ports and dredging work, optimization and administration.

Medicine:

a) Sterilization of medical products;
b) Sanitization of recipients;
c) Hydrogels (cosmetics, medicines, etc.);
d) Irradiation of blood;
e) Irradiation of biological tissues (human and animal);
f) Production of radioisotopes for medicine and industry.

Industrial processes:

a) Optimization of processes;
b) Quality control;
c) Modification and improvement of products.

Natural resources:

a) Food:
   - Quarantine treatment and preservation using irradiation;
   - Quality control;
   - Optimization of processes;
   - Reduction of pests using the Sterile Insect Technique (SIT).
b) Agriculture:
   - Sterilization of soils;
   - Plant growth promoters (using natural polymers);
   - Super water absorbers (using natural polymers);
   - Biocides (using natural polymers);
   - Soil erosion studies;
   - Studies of fertilizer and pollutant transfer;
   - Sanitization of animal feed;
   - Sanitization of agricultural products – flowers, wood, tobacco, seeds, etc.;
   - Disease resistance, nutrient improvement and increase production;
   - Animal production and health

c) Mining:
   - Exploration;
   - Processing.

Inspection technologies:

a) Metals, welding, pipework, energy plants, oil and gas, aerospace industry, etc.;
b) Concrete, roads, bridges, buildings, etc.;
c) In-service inspection of power plants, in particular, nuclear power plants;
d) Harmonization of training and certification of operators;
e) Digital training of operators.

Table 6 summarizes a SWOT analysis in the context of radiation technologies in the Caribbean considering the identified areas that could benefit the region.

7.3. SWOT ANALYSIS

TABLE 6. SWOT ANALYSIS FOR RADIATION TECHNOLOGIES.

Strengths	Weaknesses
Water 1. Water is recognized as a strategic resource in all Member States. 2. Existing experience in various Member States of the region. **Environment** 3. Existence of dedicated institutions with common interest across the region to protect the environment. **Coastal engineering** 4. Existence of dedicated agencies for coastal management in several Member States in the region. 5. Use of radiation technology already exists in some Member States. **Medicine** 6. Regional institutions and professional staff willing to use the technology. **Industrial processes and production** 7. Currently, in some Member States of the region, radiotracer techniques and nucleonic process control systems are in use. **Natural resources** 8. Existing products on the market in Asia, which have been developed through IAEA projects, can be used as a frame of reference for the Caribbean. **Inspection technologies** 9. Common interest in certified products and improvement in quality and safety. Existing network of service providers and end-users of the technology. 10. Advanced Member States can facilitate regional cooperation.	**Water** 1. Development of technology for radiation treatment is in its infancy in the region. 2. Potential actors have limited information about the technologies. 3. Few facilities are available to demonstrate the technology. **Environment** 4. High setting up costs for new radiation processing facilities. 5. There are no providers of systems ready for use. 6. Few facilities to demonstrate the technology. **Coastal engineering** 7. Limited availability of radiotracers. 8. Public concern. 9. Weak regulatory infrastructure. **Medicine** 10. Most Member States do not have appropriate irradiation facilities. 11. Low compliance in the region with international standards. 12. Significant investment required for new facilities (in some cases), which is greater than the application of non-nuclear techniques. **Industrial processes and production** 13. Limited availability of radiotracers. 14. Weak regulatory infrastructure. **Natural resources** 15. Demonstration of the technology will take time. 16. Groups need to be established for a long time for the development of capacity (sustainability). 17. The need to standardize processes and products (for commercial use). **Inspection technologies** 18. Certification of staff training is not harmonized.

TABLE 6. SWOT ANALYSIS FOR RADIATION TECHNOLOGIES (cont.)

Opportunities	Threats
Water 1. Municipalities are recognizing that wastewater from human and industrial activities needs to be addressed and is one of the main challenges for the region. 2. Regional recognition of the need to improve the quality and availability of water resources. 3. Technology and techniques are expanding to reduce waste and clean up the environment. **Environment** 4. Industrialization increases the release of pollutants, and as a result, there is a growing demand for technologies to reduce them. **Coastal engineering** 5. Better understanding of the effects of climate change on the costs increases the need for coastal management. 6. The need to better understand the effects of population growth and activities near the coast. 7. Improved sediment management to counter the effects of deforestation on soil erosion. 8. The increase in foreign trade generates a need to develop, improve and manage port infrastructure. 9. Better coastal management has indirect effects on tourism and also eases harbour activities **Medicine** 10. Member States of the region are considering irradiation facilities. 11. Ability to meet increased demands of the irradiation of medical implements is necessary. 12. The technology is respectful of the environment. 13. Strong demand for sterilization of medical instruments and irradiation of blood.	**Water** 1. Public acceptance of the radiation treatment of water is low. **Environment** 2. Alternatives are available for the reduction of specific pollutants. **Coastal engineering** 3. The existence of alternative technologies. **Medicine** 4. There are non-nuclear techniques for sterilization processes. **Industrial processes and production** 5. Perception of risk among possible end-users regarding the benefits of the technology. **Natural resources** 6. Perception of risk among possible end-users regarding the benefits of the technology. **Inspection technologies** 7. Increase in the cost of disposal.

TABLE 6. SWOT ANALYSIS FOR RADIATION TECHNOLOGIES (cont.)

Opportunities	Threats
Industrial processes and production 14. Industrial development requires increased use of technologies. 15. Common interest to improve the efficiency of production processes. **Natural resources** 16. Economic incentives have created high interest in using the technologies whereby some Member States have already made progress and others are exploring possibilities. 17. Potential collaboration with other international organizations. 18. The region is rich in natural resources (agriculture, marine products, minerals, hydrocarbons).	

7.4. NEEDS/PROBLEMS

T1. Inefficient and unsustainable industrial processes lead to low economic growth and the deterioration of natural resources.

Justification: A clear baseline concerning the specific and strategic opportunities and challenges in the region is essential for the future development and application of radiation technologies in the region itself. Furthermore, dissemination and promotion of information concerning how these technologies can be used in different fields are important not only for the development of the technologies but also to meet needs associated with natural resources, industrial processes and production, and inspection processes. Regional industries, such as mining, processing and production, and food and agriculture industries face several problems, including relatively low competitiveness, the impact of their activities on the environment, poor quality of finished products, inefficient energy consumption and scarcity of strategic minerals. For example, radioactive tracers and nucleonic control systems can assist in addressing the above-mentioned problems and minimize their impact, from their origin through to their elimination. Radiation technologies can contribute in an efficient, affordable and straightforward manner to promote the use of the region's natural, renewable and non-toxic resources. These technologies can be utilized for the preparation of products derived from or based on natural polymers or wastes that could be used in areas such as healthcare, agricultural applications, food conservation, cosmetics, water purification or environmental remediation. The preparation of a regional reference plan would make it possible to update the status of the use of radiation technologies in the region, identify opportunities and propose a plan of action that is disseminated and implemented by interested parties to determine the impact of the programme at the end of the cycle.

Objective: To use radiation technologies to increase wellbeing, generate socioeconomic benefit and protect the environment.

Indicator: Regional reference on beneficial uses of radiation technology developed and disseminated.

8. CONNECTIONS WITH REGIONAL DOCUMENTS

As mentioned in section 1.4, the RSF takes into consideration the most relevant documents existing in the region that pertain to sustainable development. All of the needs/problems highlighted in the RSF can be addressed through the safe use of nuclear science and technology, which the IAEA is in a position to support. It is also important to highlight each need/problem with its corresponding priority areas in the Caribbean region. In Table 7, all needs/problems have been linked with their associated priorities by thematic area according to two development/vision documents in the region; the UN MSDF [88] and the Strategic Plan for the Caribbean Community 2015–2019 [33].

TABLE 7. ALIGNMENT OF RSF NEEDS/PROBLEMS WITH PRIORITIES REFLECTED IN UN MSDF AND THE CARIBBEAN COMMUNITY STRATEGIC PLAN

RSF Need/Problem	Related UN MSDF Priority Area	Related CARICOM Strategic Plan Priority[3]
Agriculture and Food Production (Food Safety and Security)		
A1. To improve crop yields and animal productivity, focussing on land and water management and climate smart agriculture to foster crop and animal production resilience to climate change, including plants and animals (terrestrial and aquatic) of recognized economic importance, reflecting the region's biodiversity.	PA2: A Healthy Caribbean PA4: A Sustainable and Resilient Caribbean	ECN 4: Build Competitiveness and Unleash Key Economic Drivers to Transition to Growth SOC 3: Advance Initiatives for Health and Wellness ENV 1: Advance Climate Adaption and Mitigation ENV 3: Enhance Management of the Environment and Natural Resources
A2. To reduce the incidence of transboundary animal diseases, including those with zoonotic repercussions.	PA2: A Healthy Caribbean PA4: A Sustainable and Resilient Caribbean	SOC 3: Advance Initiatives for Health and Wellness ENV 3: Enhance Management of the Environment and Natural Resources
A3. Inadequate capacity within the region to use isotopic and nuclear-derived technologies for insect pest control to reduce losses to foods of animal and plant origin	PA2: A Healthy Caribbean PA4: A Sustainable and Resilient Caribbean	SOC 3: Advance Initiatives for Health and Wellness ENV 1: Advance Climate Adaption and Mitigation ENV 3: Enhance Management of the Environment and Natural Resources
A4. To address the inadequate capacity of the region to ensure the safety, and authenticity of foods	PA2: A Healthy Caribbean PA4: A Sustainable and Resilient Caribbean	SOC 3: Advance Initiatives for Health and Wellness ENV 1: Advance Climate Adaption and Mitigation ENV 3: Enhance Management of the Environment and Natural Resources

[3] ECN refers to Economic, SOC to Social, and ENV to Environmental priorities, as presented in the CARICOM Strategic Plan.

TABLE 7. ALIGNMENT OF RSF NEEDS/PROBLEMS WITH PRIORITIES REFLECTED IN UN MSDF AND THE CARICOM STRATEGIC PLAN (cont.)

RSF Need/Problem	Related UN MSDF Priority Area	Related CARICOM Strategic Plan Priority
Human Health		
H1. Lack of availability and access to tertiary and specialized care services in radiation medicine that exist within the region.	PA2: A Healthy Caribbean PA3: A Safe, Cohesive and Just Caribbean	SOC 3: Advance Initiatives for Health and Wellness SOC 4: Enhance Citizen Security and Justice ENV 2: Advance Disaster Mitigation and Management
H2. Cancer is a leading cause of death in the Caribbean.	PA1: An Inclusive, Equitable and Prosperous Caribbean PA2: A Healthy Caribbean	SOC 3: Advance Initiatives for Health and Wellness
H3. Differing levels and standards of quality and safety in the delivery of radiation medicine services within the Caribbean region.	PA1: An Inclusive, Equitable and Prosperous Caribbean PA2: A Healthy Caribbean	SOC 3: Advance Initiatives for Health and Wellness
H4. Insufficient human resources in radiology, nuclear medicine and radiotherapy to meet the growing needs arising from the establishment of new centres in the region.	PA2: A Healthy Caribbean PA3: A Safe, Cohesive and Just Caribbean	SOC 3: Advance Initiatives for Health and Wellness
H5. Inadequate systems for life cycle management of medical equipment for radiation medicine (planning, procurement, incorporation, maintenance and disposal).	PA1: An Inclusive, Equitable and Prosperous Caribbean PA2: A Healthy Caribbean	SOC 1: Advance Human Capital Development: Key Skills, Education Reform and Youth Development SOC 3: Advance Initiatives for Health and Wellness
H6. Emerging and re-emerging infectious diseases, including increasing severity and frequency of mosquito-borne disease outbreak (e.g. dengue, Zika and chikungunya).	PA2: A Healthy Caribbean PA3: A Safe, Cohesive and Just Caribbean	SOC 3: Advance Initiatives for Health and Wellness ENV 3: Enhance Management of the Environment and Natural Resources
H7. Growing childhood obesity in the region and its link to the incidence of non-communicable diseases.	PA1: An Inclusive, Equitable and Prosperous Caribbean PA3: A Safe, Cohesive and Just Caribbean	SOC 2: Mainstream inclusiveness in Public Policy: Gender, Persons with Disabilities, Age SOC 3: Advance Initiatives for Health and Wellness

TABLE 7. ALIGNMENT OF RSF NEEDS/PROBLEMS WITH PRIORITIES REFLECTED IN UN MSDF AND THE CARICOM STRATEGIC PLAN (cont.)

RSF Need/Problem	Related UN MSDF Priority Area	Related CARICOM Strategic Plan Priority
Environment		
V1. Insufficient capacity to assess the impact and vulnerability of Member States to sources of pollutants (pesticides, persistent organic compounds, heavy metals, microplastics and other pollutants) of anthropogenic origin in terrestrial and marine environments including the region's water resources as well as risks/threats due to climate change and natural hazard events, such as volcanic eruptions, earthquake, hurricanes, flooding, cyclone etc.	PA2: A Healthy Caribbean PA4: A Sustainable and Resilient Caribbean	SOC 3: Advance Initiatives for Health and Wellness ENV 1: Advance Climate Adaption and Mitigation ENV 2: Advance Disaster Mitigation and Management ENV 3: Enhance Management of the Environment and Natural Resources
V2. Inadequate documentation of each Member States hydrological data/information, characterization (quality and quantity) and assessment of water resources in order to develop long term integrated water resources development plans to support national development.	PA2: A Healthy Caribbean PA4: A Sustainable and Resilient Caribbean	SOC 3: Advance Initiatives for Health and Wellness ENV 1: Advance Climate Adaption and Mitigation ENV 2: Advance Disaster Mitigation and Management ENV 3: Enhance Management of the Environment and Natural Resources
V3. Inadequate risk assessment of the environmental and social impact of hydraulic infrastructure	PA2: A Healthy Caribbean PA4: A Sustainable and Resilient Caribbean	SOC 1: Advance Human Capital Development: Key Skills, Education Reform and Youth Development ENV 1: Advance Climate Adaption and Mitigation ENV 2: Advance Disaster Mitigation and Management ENV 3: Enhance Management of the Environment and Natural Resources

TABLE 7. ALIGNMENT OF RSF NEEDS/PROBLEMS WITH PRIORITIES REFLECTED IN UN MSDF AND THE CARICOM STRATEGIC PLAN (cont.)

RSF Need/Problem	Related UN MSDF Priority Area	Related CARICOM Strategic Plan Priority
Environment		
V4. Limited knowledge of the main vulnerabilities of low lying coastal and marine ecosystems and their response to expected anthropogenic-, natural hazard events, such as volcanic activities and climate change-induced alterations.	PA2: A Healthy Caribbean PA4: A Sustainable and Resilient Caribbean	ENV 1: Advance Climate Adaption and Mitigation ENV 2: Advance Disaster Mitigation and Management ENV 3: Enhance Management of the Environment and Natural Resources
V5. Inadequate management strategies for characterization/disposal/reprocessing of waste (solid, chemical and wastewater)	PA2: A Healthy Caribbean PA4: A Sustainable and Resilient Caribbean	SOC 3: Advance Initiatives for Health and Wellness ENV 1: Advance Climate Adaption and Mitigation ENV 2: Advance Disaster Mitigation and Management ENV 3: Enhance Management of the Environment and Natural Resources
V6. Limited knowledge of temporal and spatial scales of atmospheric pollution.	PA4: A Sustainable and Resilient Caribbean	ENV 1: Advance Climate Adaption and Mitigation ENV 2: Advance Disaster Mitigation and Management ENV 3: Enhance Management of the Environment and Natural Resources
Energy		
E1. Inadequate capacity within the national and regional institutions tasked with energy planning and decision support.	PA1: An Inclusive, Equitable and Prosperous Caribbean PA4: A Sustainable and Resilient Caribbean	SOC 1: Advance Human Capital Development: Key Skills, Education Reform and Youth Development ENV 1: Advance Climate Adaption and Mitigation ENV 3: Enhance Management of the Environment and Natural Resources

TABLE 7. ALIGNMENT OF RSF NEEDS/PROBLEMS WITH PRIORITIES REFLECTED IN UN MSDF AND THE CARICOM STRATEGIC PLAN (cont.)

RSF Need/Problem	Related UN MSDF Priority Area	Related CARICOM Strategic Plan Priority
Energy		
E2. Inadequate Integrated Energy Planning, as well as Integrated Resource and Resilience Planning, within Member States.	PA4: A Sustainable and Resilient Caribbean	ENV 1: Advance Climate Adaption and Mitigation ENV 3: Enhance Management of the Environment and Natural Resources
Radiation Safety		
R1. Lack of capacity for early warning, risk reduction and management of radiological incidents and emergencies and the potential need for a coordinated regional response.	PA2: A Healthy Caribbean PA3: A Safe, Cohesive, and Just Caribbean	SOC 3: Advance Initiatives for Health and Wellness SOC 4: Enhance Citizen Security and Justice ENV 2: Advance Disaster Mitigation and Management
R2. Insufficient application and implementation among end-users of principles and requirements concerning radiation protection set out in IAEA Safety Standards	PA2: A Healthy Caribbean PA3: A Safe, Cohesive, and Just Caribbean PA4: A Sustainable and Resilient Caribbean	SOC 3: Advance Initiatives for Health and Wellness SOC 4: Enhance Citizen Security and Justice ENV 2: Advance Disaster Mitigation and Management
R3. Insufficient priority is given to establishing a national, governmental, legal and regulatory infrastructure for radiation safety.	PA2: A Healthy Caribbean PA3: A Safe, Cohesive, and Just Caribbean	SOC 3: Advance Initiatives for Health and Wellness SOC 4: Enhance Citizen Security and Justice
R4. Insufficient coverage by the radiation protection services (individual internal and external monitoring and workplace monitoring) of occupationally exposed workers.	PA2: A Healthy Caribbean PA3: A Safe, Cohesive, and Just Caribbean	SOC 3: Advance Initiatives for Health and Wellness SOC 4: Enhance Citizen Security and Justice

TABLE 7. ALIGNMENT OF RSF NEEDS/PROBLEMS WITH PRIORITIES REFLECTED IN UN MSDF AND THE CARICOM STRATEGIC PLAN (cont.)

RSF Need/Problem	Related UN MSDF Priority Area	Related CARICOM Strategic Plan Priority
Radiation Safety		
R5. Lack of national policies and strategies for the safe and sustainable management of radioactive waste and disused sources.	PA2: A Healthy Caribbean PA3: A Safe, Cohesive, and Just Caribbean PA4: A Sustainable and Resilient Caribbean	SOC 3: Advance Initiatives for Health and Wellness SOC 4: Enhance Citizen Security and Justice ENV 2: Advance Disaster Mitigation and Management
R6. Absence of a standardized education and training strategy in radiation, radioactive waste/material transport and waste safety.	PA1: An Inclusive, Equitable and Prosperous Caribbean PA3: A Safe, Cohesive, and Just Caribbean	SOC 1: Advance Human Capital Development: Key Skills, Education Reform and Youth Development SOC 4: Enhance Citizen Security and Justice
R7. Limitations for calibration at the levels of radiation protection, radiotherapy and radiodiagnostics by secondary standards dosimetry laboratories in the region	PA2: A Healthy Caribbean PA3: A Safe, Cohesive, and Just Caribbean	SOC 3: Advance Initiatives for Health and Wellness SOC 4: Enhance Citizen Security and Justice
Radiation Technologies		
T1. Inefficient and unsustainable industrial processes lead to low economic growth and the deterioration of natural resources.	PA1: An Inclusive, Equitable and Prosperous Caribbean PA2: A Healthy Caribbean PA3: A Safe, Cohesive, and Just Caribbean PA4: A Sustainable and Resilient Caribbean	ECN 4: Build Competitiveness and Unleash Key Economic Drivers to Transition to Growth SOC 1: Advance Human Capital Development: Key Skills, Education Reform and Youth Development ENV 1: Advance Climate Adaption and Mitigation ENV 3: Enhance Management of the Environment and Natural Resources

9. STRATEGY FOR THE IMPLEMENTATION OF THE RSF FOR 2020–2026

The RSF for 2020–2026 provides a basis for a strategic implementation of priority needs/problems in each thematic area. It is important to mention that the RSF is an overarching framework meant to guide future development of regional project designs and implementation. Therefore, the implementation plan is envisioned to act as a flexible guidance document for regional support. For the achievement of the long-term results of the RSF, outcomes, indicators, baselines, targets, means of verification, indicative outputs and timelines are formulated based on updated guidelines facilitating the establishment of goals to be achieved through the IAEA technical cooperation programme. It should be noted that there is a lack of adequate data across the region to inform establishment of suitable baselines and targets to measure indicators outlined in Table 8. It is acknowledged that some baselines and targets will need to be established early in the implementation of the RSF through ongoing technical cooperation projects. Consideration will also be given to the need for appropriate human and financial resources for the implementation period of the RSF over 2020–2026.

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS

Need/Problem	Objectives	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Agriculture and Food Production (Food Safety and Security)									
A1. To improve crop yields and animal productivity, focusing on land and water management and climate-smart agriculture to foster resilience to climate change, including plants and animals (terrestrial and aquatic) of recognized economic importance, reflecting the region's biodiversity	To increase food production through the improvement of plants varieties, animal breeds, land and water management, aquaculture and agricultural production systems using nuclear, isotopic and nuclear-derived technologies	Increased use of nuclear, isotopic and nuclear-derived technologies in plant, animal, land and water management, as well as aquaculture breeding programmes and in climate-smart agricultural production systems	Number of MSs undertaking plant, and/or animal, land and water management and genetic improvement programmes using nuclear, isotopic and nuclear-derived technologies Number of MSs using nuclear-derived technologies to monitor and manage inputs into their agricultural and aquaculture production systems	1 1	4 3	Bilateral cooperation agreements with regional centres Annual reports Food and Nutrition Cluster meeting reports	Reference centres able to provide services and expertise to other Member States are established in the region Programmes to improve plant varieties and animal production and better soil resources (terrestrial and aquatic) using nuclear-derived technologies implemented Agronomic practices using nuclear products in agricultural production systems are employed	Q4 2025 Q4 2024	Regulatory infrastructure in place Requisite radiation safety requirements are in place The centre will have the capacity to accommodate MS requests Interest among Member States Transboundary movement of irradiated materials within the region can be facilitated

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objectives	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Agriculture and Food Production (Food Safety and Security)									
A2. To reduce the incidence of transboundary animal diseases, including those with zoonotic repercussions	To improve preparedness and responses to transboundary animal diseases	Improved detection and emergency response competencies established across regional laboratories	Number of laboratories across the region with the analytical capability available to provide prompt and accurate diagnosis of transboundary animal diseases	2	3	Inter-laboratory competence reports	3 regional laboratories equipped to facilitate rapid detection of animal diseases	Q4 2024	Interest and commitment among regional laboratory partners and competent authority
A3. Inadequate capacity within the region to use isotopic and nuclear-derived technologies for insect pest control to reduce losses to foods of animal and plant origin	To strengthen the capacity at the national and regional level to support the development of Integrated pest Management programmes that incorporate the use of SIT	Increased regional capacities to control pests and diseases of animals and plants using cost effective and environment friendly nuclear, isotopic and nuclear-derived technologies	Number of institutions with trained personnel in the principles and application of Sterile Insect techniques in area-wide pest management programmes	0	1	National agro-production data FAO agro-production data	Operational area-wide management programmes in Member States Capabilities available in in Member States to apply nuclear, isotopic and nuclear-derived technologies in the control of plant and animal diseases	Q4 2026	Interest among Member States to implement programmes

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objectives	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Agriculture and Food Production (Food Safety and Security)									
A4. To address the inadequate capacity of the region to ensure the safety and authenticity of foods	To ensure the safety and quality of the region's food supplies	Improved nuclear/isotopic regional capacity to test, monitor and control food hazards (e.g. veterinary drug and pesticides residues, toxic metals, mycotoxins, radionuclides etc) according to national/ regional or international standards;	Number of competent food safety (residues, contaminants etc) laboratories and systematic monitoring programmes; to reduce food rejections	0	5	Commissioning and operational reports Proficiency test/Method validation reports; Country monitoring program reports; Rejection reports for exported food	Fully equipped and functional laboratories Food Safety Monitoring programs implemented	Q4 2024	Buy-in of national and regional stakeholders, including agreement by labs with scope expansion Sufficient Lab infrastructure and human resources to accommodate expansion in testing scope National/Institutional mechanisms for handling and disposal of radioactive material Chemical makers are available for authentication
		Improved regional capacity in food authenticity and identification of adulterants using nuclear and isotopic techniques	Number of regional laboratories upgraded for authenticity testing of identified products using nuclear and isotopic techniques	0	3	Test reports			
			Number of products/food matrices for which authenticity testing is available	0	3	Biannual reports/ application audit			
			Number of screening methodologies implemented and used to verify food authenticity (presumptive testing)	0	2				
			Regional databases of food safety monitoring and authenticity data established and populated	0	1				

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Human Health									
H1. Lack of availability and access to tertiary and specialized care services in radiation medicine that exist within the region	To strengthen regional mechanisms that improve availability and access to needed radiation medicine services	Caribbean patients can receive needed radiation medicine services through an improvement in the availability of, access to, capacity, efficiency, effectiveness, quality and regional distribution and collaboration of radiation medicine services in the Caribbean and integrated into robust and funded national cancer control plans (NCCPs)	Number of MSs with referral processes for patients from other countries in the region Number of MSs participating in regional collaborative diagnostic/treatment mechanisms, e.g. telemedicine, consultations, tumour boards	2 (Caribbean Countries) 0	3[4] 4	Periodic Assessment done in collaboration with PAHO Reports from participating centres	Regional radiation centres have clear algorithms and referral processes for patients from other Caribbean countries Collaborative regional mechanisms being used to improve cancer diagnosis and treatment, e.g. tumour boards, diagnostics, etc. using telemedicine, etc.	Q4 2024	Buy-in from regional centres (especially private centres) Political buy-in for regional cooperation and collaboration. These centres have the capacity to share beyond the national needs. Risks are different quality/ modes and technology

[4] Antigua and Barbuda, Bahamas, Barbados, Guyana, Jamaica, Trinidad and Tobago.

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Human Health									
H2. Cancer is a leading cause of death in the Caribbean	To reduce the premature mortality due to cancer through planned prevention, early detection, diagnosis treatment and palliative care	Caribbean countries increased capacities to offer quality nuclear imaging and radiotherapy services within comprehensive NCCPs	Number of MSs that have developed/revised robust and funded NCCPs, including the radiation medicine component	2	5	Copy of NCCPs	Qualified staff and required infrastructure in place for delivery of quality nuclear imaging and radiotherapy services	Q4 2026	Countries will make resources available for the development and implementation of national cancer control plans (NCCPs)
			Regional strategy and framework of action on cancer control including the radiation medicine component developed	No strategy and framework of action in place	Strategy and framework of action completed	Copy of strategy and framework of action	Strategy and framework of action on cancer control being adopted by MSs	Q4 2023	Countries will contribute to the development and implementation of regional strategy and framework of action on cancer control

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Human Health									
H3. Differing levels and standards of quality and safety in the delivery of radiation medicine services within the Caribbean region	To improve and harmonize quality, safety (for workers, patients and the public), and capacity in the use of radiation medicine technologies for the diagnosis and treatment of diseases	A culture of safety and quality in the use of radiation medicine technologies as per international standards	Number of institutions with human resources trained and competent in quality and safety protocols in radiation medicine, including radiopharmacy	18	24	Report from MSs or training certification of persons working in radiation medicine	Human resources[5] are trained and up to date with standards and protocols Protocols in place for production of safe and quality radiopharmaceutical products and imaging procedures and operations in radiation medicine	Q4 2026	Buy-in from policy makers and availability of required infrastructural, human and financial resources to implement standards Availability of suitable persons for training Mitigation: Use of virtual platforms where applicable Sensitize of policymakers and ensure appropriate national budgeting for implementation and plan for financing

[5] Physicians, nutritionists, researchers, medical physicists, radiographers, imaging technicians, biomedical technicians/ engineers, radio pharmacists, nuclear physicians, oncologists, radiotherapists, radiologists, technicians and nurses.

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Human Health									
H4. Insufficient human resources in radiology, nuclear medicine and radiotherapy to meet the growing needs arising from the establishment of new centres in the region	To increase the number of health professionals in specialized radiation medicine in order to support the needs in the Caribbean region	Adequate medical professional density and distribution for radiation medicine in the Caribbean in keeping with international guidelines	Number of trained radiation medicine professionals[6] available and working in the region.	609[7]	625	Reports from Ministries of Health and radiation medicine facilities or training certificates	An increase in suitably trained specialists in radiation medicine in the Caribbean	Q4 2026	Availability of suitable personnel to be trained along with access to appropriate training programmes and effective measures for staff retention

[6] Radiologists, oncologists, radiation oncologists, medical physicists, radiotherapy and nuclear medicine technicians, dosimetrists, nurses.
[7] Excluding data for The Bahamas and Haiti

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Human Health									
H5. Inadequate systems for life cycle management of medical equipment for radiation medicine (planning, procurement, incorporation, maintenance and disposal)	To improve the availability, quality and safety of medical equipment needed for delivery of radiation medicine services	Improved equipment uptime due to effective life cycle management of medical equipment for radiation medicine (maintenance and disposal)	Number of MSs with life cycle management plan for medical equipment for radiation medicine including facilities and equipment for production of radiopharmaceutical products.	4	6[8]	Copy of life cycle management plans	Improved maintenance of medical equipment for radiation medicine	Q4 2024	Buy-in by radiation medicine facilities through consistent maintenance of medical equipment Countries have robust planning and procurement procedures The availability of finances for procurement
			Number of MSs that have institutions with trained personnel in the maintenance and disposal of medical equipment for radiation medicine.	9	12	Reports from radiation medicine facilities	Increased number of persons trained in the maintenance and disposal of medical equipment	Q4 2024	The availability of sufficient and competent biomedical staff training

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Human Health									
H6. Emerging and re-emerging infectious diseases, including increasing severity and frequency of mosquito-borne disease outbreak (e.g. dengue, Zika and chikungunya)	To decrease the spread and impact of arboviral diseases through radiation related SIT to reduce mosquito populations	Sustained reduction in mosquito populations due to deployment of SIT leading to reduced arbovirus transmission and disease outbreaks	Number of MSs in the Caribbean piloting sterile insect technology programmes to reduce mosquito incidence	0	1	Pilot programme completion reports	Establishment of the agreements Technical capacities for SIT production and dissemination developed (proof of concept) Capacity to reliably measure mosquito indices developed	Q1 2023	SIT will prove technically and politically feasible to use in the region, as well as accepted by the public and will be successful in significantly reducing *Aedes* mosquito populations, and lower mosquito populations result in reduced transmission of arboviruses and fewer outbreaks
H7. Growing childhood obesity in the region and its link to the incidence of non-communicable diseases	To optimize the use of stable isotopes in the measurement of body composition in research for childhood obesity in the Caribbean	Increased capacity at appropriate regional institutions to assess childhood malnutrition/obesity using stable isotope to contribute to ending childhood obesity (SDG 2.2)	Number of MSs that have institutions with trained personnel to use stable isotopes for assessment of childhood malnutrition /obesity	1	4	Training reports and certificates	Studies conducted on childhood obesity using stable isotopes	Q4 2023	Uptake of stable isotope technology for studies in childhood obesity
			Number of studies being conducted	3	8	Number of studies with ethical approval	Results of studies used to inform decision-making	Q4 2024	Countries are willing to undertake research in this area
			Number of MSs with institutions capable of analysing stable isotopes (regional)	1	3	Report from participating institutions	Increased regional capacity for nutrition-related analysis using stable isotope		

[8] Antigua and Barbuda, Belize Barbados, Guyana, Jamaica, Trinidad

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Environment									
V1. Insufficient capacity to assess the impact and vulnerability of Member States to sources of pollutants (pesticides, persistent organic compounds, heavy metals, microplastics, and other pollutants) of anthropogenic origin in terrestrial and marine environments including the region's water resources as well as risks/threats due to climate change and natural hazard events, such as volcanic eruptions, earthquake, hurricanes flooding, cyclone etc.	To improve source identification, impact assessment and mitigation of pollutants in soil and water, and to develop appropriate adaptation strategies	Strengthened capacities to carry out environmental assessments to develop appropriate adaptation strategies	Number of MSs with trained personnel in the use of specific nuclear techniques for pollutant determination in soil and water.	0	4	Reports from MSs or training certificates	Increased regional capacity in specific nuclear techniques to assess water resources and to determine pollutants in soil and water	Q1 2026	Buy-in by relevant national stakeholder and availability of suitable personnel for IAEA training Standard operating procedure (SOPs) are implemented by Member States
			Number of MSs using operating procedures for collection and analysis, including heavy metals and nutrients testing, in reference laboratories integrating the use of nuclear techniques.	0	4	Country reports	Network of reference laboratories that collaborate with CARICOM members established	Q4 2026	Member State resource commitments realized (including accreditation of laboratories)

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Environment									
V2. Inadequate documentation of each MS hydrological data, characterization and assessment of water resources in order to develop long term integrated water resources development plans to support national development	To characterize all MS water resources to achieve the comprehensive management of water resources, to ensure their availability, quality and long-term sustainability	Enhanced capacities in the use of isotope hydrology techniques to support integrated water resource management in the region	Number of MSs which have integrated isotope hydrology information into their water resource management plans including enhancement of capacities for isotopic techniques	0	3	Copy of completed water resource management plans and report from water resources body	Improved capacity for water resource management using isotopic techniques	Q4 2024	Commitment by decision-makers and operational stakeholders to develop and implement the plan Data sharing agreements amongst States to support data integration
			Number of MSs with a monitoring programme of isotopes in the hydrological cycle (i.e. groundwater, rivers, precipitation) that supports an IAEA/regional database for water resources assessment, including the impacts of climate change	0	5	Reports from MSs on participation in monitoring programs like IAEA-GNIP	Improved regional monitoring capacities in the application of nuclear and isotopic technologies for water resources management	Q4 2026	Buy-in by CARICOM and Member States
			Number of MSs with analytical capabilities in the use of nuclear techniques for water resources management	1	3		Improved analytical capacities of laboratories in the use of nuclear techniques (stable isotopes of water). Regional expert laboratory for isotope hydrology established.		

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Environment									
V3. Inadequate risk assessment of the environmental and social impact of hydraulic infrastructure	Sustainable management and safety of hydraulic infrastructure	Enhanced sustainability and safety of hydraulic infrastructure using nuclear and isotopic techniques	Number of MSs conducting risk and vulnerability assessments on key hydraulic infrastructure using nuclear techniques	0	3	Risk assessment reports from MSs	Member States capacities to conduct risk assessments integrating the use of nuclear techniques strengthened	Q4 2023	Buy-in of national stakeholders for implementation of appropriate measures to address aging critical hydraulic infrastructure Risk: Inappropriate land use and conservation practices around hydraulic infrastructure
V4. Limited knowledge of the main vulnerabilities of low lying coastal and marine ecosystems and their response to expected anthropogenic, natural hazard events, such as volcanic activities and climate change-induced alterations	To develop comprehensive data through monitoring programmes, including nuclear techniques that facilitate the sustainable management of coastal resources and preserve the livelihoods of coastal communities and the environmental integrity of the coasts	Improved availability of regional data in marine and coastal management through the application of nuclear and isotopic techniques	Number of MSs utilizing nuclear and isotopic techniques to monitor marine and coastal ecosystems Number of MSs tracking data on coastal and marine ecosystems through monitoring programmes, including nuclear techniques Number of MSs joining an international network which is focusing on marine stressors (and monitoring of these stressors)	1 0 0	5 2 6	Country reports Reports from MSs Network Membership	Strengthened capacities of MSs to use nuclear and isotopic techniques to monitor marine and coastal ecosystems Network of reference laboratories established.	Q4 2023 Q4 2024 Q4 2026	Commitment of national stakeholders to sustain training, expertise and provision of equipment Integration of data generation initiatives involving various international partners Commitment of MSs to implement monitoring programme on a consistent basis

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Environment									
V5. Inadequate management strategies for characterization/ disposal /reprocessing of waste (solid, chemical and wastewater)	Effective strategies, processes and procedures to support the safe disposal of highly hazardous waste	Improved capacities to provide reliable and accurate data on elementary composition of wastes to facilitate proper management for disposal and reprocessing in line with international standards	Number of MSs which have completed characterization and classification of waste using nuclear techniques	0	3	Expert mission reports, project reports, SOPs completed	Institutional capacities strengthened to conduct waste characterization using nuclear techniques Standardized processes using nuclear techniques for waste disposal management in line with international standards	Q4 2023	Adoption of SOPs in daily operation by MSs along with availability of suitably trained staff Buy-in by national stakeholders at facilities managing hazardous waste
V6. Limited knowledge of temporal and spatial scales of atmospheric pollution	Improve the management of air quality using nuclear analytical techniques for the chemical characterization of particulate matter in monitoring studies	Strengthened capacities of Member States to use nuclear and isotopic techniques to monitor air quality	Number of MSs with monitoring systems for chemical characterization of particulate matter and aerosols in the atmosphere	0	3	Copy of monitoring programme document and country reports	Reference laboratories capacities on specific nuclear techniques to monitor air quality developed.	Q4 2024	Policy and budgetary support in place for implementation of monitoring system

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Energy									
E1. Inadequate capacity within the national and regional institutions tasked with energy planning and decision support	To strengthen capacities at national and regional levels to support medium and long-term sustainable energy planning for enhanced efficiency, effectiveness and sustainability of Member States energy sectors' development.	Improved capacity for energy planning in the region for optimized use of alternative/renewable energy sources	Number of MSs with human resources trained in the use of IAEA energy assessment tools and methodologies to support medium and long-term sustainable energy planning (e.g. energy demand projections, technology options for energy supply, including the integration of renewable and alternative energy sources).	1	3	Certificates of training, training reports, end of mission reports	Trained personnel in energy system analysis and planning, including energy demand projections and options for energy supply, using IAEA's energy system tools and methodologies. National energy studies using IAEA methodologies and tools	Q4 2024	Availability of suitable technical staff to participate in trainings and use of new knowledge gained in MSs
E2. Inadequate Integrated Energy Planning, as well as Integrated Resource and Resilience Planning, within MSs	To develop and enhance capacities for elaboration of energy planning studies, plans and strategies based on Integrated Resources and Resilience approach	Developed and enhanced capacity for energy planning studies, plans and strategies based on Integrated Resources and Resilience approach	Number of MSs with capacities built for integrated assessments of Climate, Land, Energy and Water (CLEW) to support policy formulation and planning	0	1	Certificates of training, training reports, end of mission reports	Member States' capacity for integrated energy planning and assessment improved. National integrated assessment study based on CLEW framework using IAEA's methodology and tools	Q4 2026	Buy-in and active participation of regional and national bodies

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Radiation Safety									
R1. Lack of capacity for early warning, risk reduction and management of radiological incidents and emergencies and the potential need for a coordinated regional response	To increase the regional/national capacities for preparedness and response to emergencies (all-hazards approach)	Regional/National capacity for preparedness and response to radiological emergencies strengthened	Number of MSs with documented progress level of preparedness for responding to radiological and nuclear emergencies through EPRIMS EPRIMS updated	0 0	5 6	Emergency Preparedness and Response Information Management System (EPRIMS) Self–reporting PAHO IHR Tool) Joint External Evaluations for some countries	Approved/drafted Regional/ National Radiological Emergency Plan based on: a) hazard assessment performed, b) protection strategy established c) national/regional coordination mechanism recognised-defined d) interim response capability in place - First responders: Receive basic training and equipment. -Emergency planners trained on methods to develop arrangements for EPR. EPRIMS updated	Q3 2025	Governments continue to be committed and provide sufficient funds to enhance response capacities Countries will designate EPRIMS Country Coordinators, who will provide information to the system First responders are available to participate and cooperate Access to specialized equipment for early response to emergency situations is available Outcome impacts IHR (2005) Radiation Emergencies.

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Radiation Safety									
R2. Insufficient application and implementation among end-users of principles and requirements concerning radiation protection set out in IAEA Safety Standards	To ensure the safe use of radiation sources and the protection of workers, patients and public and environment to avoid unnecessary exposure	Improved compliance with the IAEA Safety Standards for safer practices involving radiation sources	Percentage of institutions within MSs with radiation protection and optimization programmes implemented at end-user facilities	Baseline about the number of institutions to be established following assessment	Target on institutions to be determined based on the baseline	Country reports	Capacities improved to design and implement radiation protection programmes at end-user facilities Awareness of senior management on the requirements for radiation protection and optimization increased.	Q1 2024	Commitment of medical staff and senior management
			Percentage of institutions within MSs with integrated management systems for safety established	RASIMS TSA 2 status; No country in medium and high progress	RASIMS TSA2 status: medium or high progress	RASIMS status and expert mission reports	Integrated management systems for safety established		

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Radiation Safety									
R3. Insufficient priority is given to establishing a national, governmental, legal and regulatory infrastructure for radiation safety	To establish a National Regulatory Programme in the region to ensure that radiation sources are used in a safe manner from the adverse effects of ionizing radiation	Improved regulatory framework and control of radiation sources within the region	Number of MSs with a basic regulatory infrastructure in line with IAEA Safety Standards	1	6	Reports from countries and RASIMS Reports from Advisory Missions	Operational regulatory bodies with effective leadership, management systems, equipment and trained staff to carry out regulatory functions Regional capacity in regulatory infrastructure developed through international cooperation as well as knowledge sharing among regulatory bodies in the region Regional Technical and Scientific Service Desk established, serving as a knowledge platform for expert advice and access to Technical Support Organizations available in the region and in neighbouring countries	Q4 2026	Buy-in from high-level national authorities to approve and implement nuclear laws and regulations. Trained staff remains available in the regulatory bodies and available to provide regional services Regional organization cooperates in the establishment of a regional service desk

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Radiation Safety									
R4. Insufficient coverage by the radiation protection services (individual internal and external monitoring and workplace monitoring) of occupationally exposed workers	To protect workers from the adverse effects of ionizing radiation	Occupational exposure is measured and registered for all the practices in the countries of the region	Number of MSs with national registries of occupationally exposed workers	Baseline about the number of institutions to be established following assessment	12	National Reports	Enhanced system for identification of occupationally exposed workers	Q4 2024	Dosimetry services are available for the countries of the region (either through own resources or as contracted service)
			Percentage of coverage of occupationally exposed workers in external dosimetry within MSs	Baseline about the number of institutions to be established following assessment	80% of coverage	Reports from responsible body	Enhanced system for monitoring of occupationally exposed workers Adequate and accessible dosimetry services identified and available to end-users in the region	Q4 2024	Buy-in from decision-makers, regulatory body and end-users

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Radiation Safety									
R5. Lack of national policies and strategies for the safe and sustainable management of radioactive waste and disused sources	To protect the public and the environment through the safe and sustainable management of radioactive waste and disused sources	Improved control over radioactive sources through the establishment and implementation of national policies and strategies	Number of MSs with established national policies and strategies for safe and sustainable management and disposal of radioactive waste and sources	0	2	Policy and strategy documents	Approved Policy and strategy documents Updated source inventories Licensed and operational storage facility	Q4 2024	Commitment of policy makers, including provision of required budget for implementation Availability of required human resources and physical infrastructure to ensure the safe and secure management of Sealed Radioactive Sources (SRS) /Disused Sealed Radioactive Sources (DSRS)
			Number of MSs with national strategies implemented for safe and sustainable management of radioactive waste	0	2	National strategy document			
			Number of MSs with sufficient authorized storage facilities	0	1	Licensing document of storage facility		Q4 2026	Approved national strategy document being implemented
			Number of MSs that are providing for the development of a national disposal programme for disused sources	0	4	Plan for national disposal programme			

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Radiation Safety									
R6. Absence of national education and training strategies in radiation, radioactive waste/material transport and waste safety	To build a workforce to satisfy the fulfilment of safety requirements in the Caribbean region	National strategies for education and training in radiation transport and waste safety developed and implemented	Number of MSs with National education and training strategies	0	2	Copy of training Programme on Radiation Safety, aligned with regulatory requirements	National education and training strategies document	Q4 2023	Educational and academic institutions, and regulatory bodies in the region cooperate in the development and implementation of the strategies
			Number of qualified safety professionals with safety competences recognized by the regulatory bodies and/or end-user institutions in the region fulfilling their intended functions	Baseline to be established following regional assessment	Baseline to be established following regional assessment	Certification documents and report from regulatory bodies	Increased competence in radiation transport and waste safety within the region	Q4 2023	Countries recognize certification by relevant body

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Radiation Safety									
R7. Limitations for calibration at the levels of radiation protection, radiotherapy and diagnostic radiology by secondary standards dosimetry laboratories in the region	To ensure safety, accuracy and traceability in the measurement and delivery of doses	Calibration and dosimetry solutions identified for the region	Percentage of institutions within MSs with plans in place to cover their calibration needs	Baseline to be established following regional assessment	Target to be defined following establishment of baseline	Assessment report document	Plans developed to address calibration needs of end-users and regulatory bodies	Q3 2026	Availability of data from national stakeholders to facilitate analysis Buy-in of policy makers and end-users, including provision of required budget for implementation
R8. Absence of regulatory oversight of transport of radioactive material and insufficient knowledge of requirements by stakeholders (users, carriers, other authorities with responsibilities in the control of transport and radioactive sources)	To ensure safety of workers and public when the radioactive material is in the public domain.	Radioactive material is transported safely	Number of MSs establishing transport regulations and stakeholders trained on transport requirements of IAEA regulations.	0	3	RASIMS evaluation	Regulations on safe transport of radioactive material	Q3 2026	Commitment of national authorities to address the regulatory oversight of transport of radioactive material Availability of required human resources and commitment to transfer the acquired knowledge

TABLE 8. PRIORITIZATION OF NEEDS/PROBLEMS WITHIN THEMATIC AREAS (cont.)

Need/ Problem	Objective	Outcome	Indicator	Baseline	Targets	Means of verification	Indicative Outputs	Timeline	Assumptions/ Risks/Mitigating Strategies
Radiation Technology									
T1. Inefficient and unsustainable industrial processes lead to low economic growth and the deterioration of natural resources	To use radiation technologies to increase wellbeing, generate socioeconomic benefit and protect the environment	Opportunities for the increased use of radiation technology in human health, agriculture, industry, and civil infrastructure identified and promoted among the different sectors	Regional reference plan on beneficial uses of radiation technology developed and disseminated	No plan in place	One reference plan disseminated to 12 MSs	Copy of reference plan	Improved awareness for more targeted development interventions utilizing of radiation technology in the various sectors	Q4 2024	Buy in and acceptance of the technology by policy makers, users and the public

10. COMMUNICATION, OUTREACH AND PARTNERSHIPS

A crucial element for ensuring the success of future IAEA technical cooperation programme cycles in the region is the development of effective communication, outreach and partnership building activities. The IAEA encourages open and transparent collaboration between Member States and regional organizations through information sharing and exchange, as well as fostering active communities for learning and research. Through positive public awareness campaigns, nuclear science and technology can be better understood by policymakers and the general public. The following is a list of possible avenues through which effective communication, outreach and partnership building can be developed over the 2020–2026 period:

a) Sensitize policy makers (including Ministers of Government), technocrats and the public on the impact (economic, environmental, social welfare, health), benefits and relevance of the use of nuclear technologies;
b) Introduce industry, public and private businesses (i.e. farmers and processors) to new/advanced approaches utilizing the safe and secure use nuclear science and technology;
c) Create synergies between national, regional and international entities for communication, knowledge creation and transfer;
d) Develop and implement communication and stakeholder engagement programmes to raise awareness on use of nuclear technologies;
e) Disseminate scientific and technical information among key players.

10.1. SENSITIZATION

To ensure sensitization of the broadest cross-section of key stakeholders who are essential to the success of the technical cooperation programme at the national and regional levels the following mechanisms will be employed:

a) Workshops
b) Newsletters/pamphlets
c) Media (social media and mainstream)
d) Public forums
e) Shows/tradeshows
f) Heads of Government (presentations)
g) Farmer field schools
h) Consumer/producer interface
i) Brand ambassadors
j) Outreach campaigns
k) Targeted presentations
l) Youth STEM promotion

10.2. STAKEHOLDERS

Stakeholders are the engine that will drive and therefore determine the success of the technical cooperation programme to be delivered in the region. In fact, the very nature of the IAEA's support which is demand-driven, requires that the stakeholders be at the centre of communication. In line with this approach, the following key stakeholders have been identified:

a) Member State Steering Committees
b) Researchers
c) Farmers
d) Consumers
e) Policymakers
f) Technocrats
g) Academia
h) Media/communication experts
i) Producers/processors
j) Retailers/distributors
k) Other key stakeholders

10.3. PARTNERSHIPS

To maximize the communication efforts in reaching the widest stakeholder groups that are integral to the success of the technical cooperation programme, it will be crucial to engage and partner with key national and regional institutions in support of their own efforts to bring awareness to the application and benefits of nuclear science and technologies, including among decision-makers, academia and to bring awareness to the population of the region as a whole. The following avenues will be utilized:

a) Websites
b) Training programmes
c) Existing outreach initiatives
d) Existing communication strategies

11. GENDER MAINSTREAMING

The United Nations Sustainable Development Goal #5 'Gender Equality' is a priority in the United Nations system and around the world. Gender equality and mainstreaming in science produces more effective outcomes and stronger teams. Member States with limited human resource capacity would be positively impacted by educating and empowering more women to take leading roles in the scientific community. As such, the aspect of gender mainstreaming deserves an important role in the development, and ultimate implementation of the Regional Strategic Framework for the Caribbean. Appropriate representation of both genders in all areas, including leadership is important to ensure a gender balance throughout. Thus, focus will be on the following areas when implementing the RSF to achieve gender parity:

a) Mainstream a gender perspective in programme planning and implementation;
b) Report on gender-related programmatic results based on sex-disaggregated indicators, as feasible;
c) Raising awareness to develop the interest of both genders at the national level to develop the interest and possibilities of careers in science;
d) Identify opportunities to strengthen gender equality (specific roles, positions in the region, reported data–UN, Academia or regional perspective);
e) Promotion of women in leadership roles in the nuclear field and create the Women in Nuclear Caribbean Chapter.

12. KNOWLEDGE MANAGEMENT

The development and availability of appropriate expertise is of paramount importance to advance programmes in nuclear science and technology. The practice of building, collecting, transferring, sharing, preserving and maintaining essential knowledge can be made possible through effective knowledge management.

In the Caribbean region, there is a need to promote a culture of knowledge sharing through formal and informal means including, continuing education, platforms and online information courses. Knowledge transfer can be achieved through succession planning, transition/ handover processes and thorough documentation of processes and procedures. Other aspects to consider during the implementation of the RSF include:

a) Development and optimization of operational tools to share data and capacities amongst governments, regional organizations and universities to generate further partnerships;
b) Development of accredited programmes of study at regional universities to develop well-rounded professionals;
c) Optimization of existing channels of communication for linkages and promotion of different technologies in key sectors (health, agriculture, environment, radiation safety and technologies);
d) Development and linking of hubs and professional networks to create information sharing networks;
e) Translation of scientific knowledge to key players through technology transfer programmes and activities;
f) Establish regional data repositories on nuclear technologies;
g) Integrate regional databases with available technical experts;
h) Demonstrate through research the tangible benefits of nuclear science and technology, and its comparative advantage to conventional science and technology, and/or its complement to conventional science and technology;
i) Publications on the state of the adoption, use and benefits of nuclear technologies in the Caribbean region.

13. MONITORING AND EVALUATION

Monitoring of the RSF will be carried out using a combination of meetings and existing tools, including reports and Member State visits. Monitoring reports will include the Project Progress Annual Reports, which are required by the IAEA. Mission reports submitted by IAEA Programme Management Officers and Technical Officers as well as external experts will be shared with the relevant national counterparts based on Member State visits and expert assignments to complete specific tasks.

Individual project reports will also be submitted by the designated counterparts for national projects and the Designated Team Leader for regional projects, providing a status update to track biannual progress on project implementation. Ad hoc reports will also be provided by the Designated Team Members and Counterparts of the regional projects as needed. Reports from Coordination Meetings for regional projects will also be utilized by project counterparts to provide information on the progress of project implementation, which will then be fed into the monitoring mechanism for the attainment of the objectives of the RSF.

The RSF will be monitored through a Regional Steering Committee comprised of National Liaison Officers, representing IAEA–CARICOM Member States, CARICOM technical organizations relevant to the RSF thematic areas, and the IAEA. The Committee will meet biennially to review and update the RSF as required, and annually to assess progress in achieving stated outcomes and take corrective actions as required towards ensuring successful implementation of the RSF 2020-2026. The terms of reference for the establishment and operation of the Steering Committee have been endorsed by the National Liaison Officers, regional organizations and the IAEA and are presented in Annex 2: Terms of Reference for the Regional Steering Committee of the Regional Strategic Framework for Technical Cooperation with the IAEA–Caricom Member States 2020–2026.

As per the endorsed Terms of Reference, the strategy for the monitoring and evaluation presented in Annex 3: Monitoring and Evaluation Strategy, will be comprised but not limited to: the design of surveys to monitor RSF indicators and aligned with Project Progress Annual Report (PPAR) and Project Achievement Report (PAR) requirements; agreement on a customized monitoring tool; NLO support to providing PPAR reports and high response to monitoring surveys based on RSF indicators; compiling relevant information for the RSF in coordination with regional stakeholders and counterparts of national and regional projects and the IAEA Secretariat; RSF Regional Steering Committee to receive recommendations on RSF progress and corrective measures; RSF progress to be tracked by the RSF Regional Steering Committee and the IAEA Secretariat through a customized monitoring tool; RSF Regional Steering Committee deciding on and incorporating the feedback in the RSF during the biennial meetings.

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ANNEX 1: LIST OF REGIONAL INSTITUTIONS FOR PARTNERSHIPS IN THE IMPLEMENTATION OF THE RSF

To ensure the successful implementation of the RSF, it is important to continue strengthening strategic partnerships with regional institutions, some of which have signed Practical Arrangements with the IAEA. The following are the main institutions for partnerships under the RSF:

a) Caribbean Community (CARICOM) Secretariat

b) Caribbean Agricultural Health and Food Safety Agency (CAHFSA)

c) Caribbean Agriculture Research and Development Institute (CARDI)

d) Caribbean Centre for Renewable Energy and Energy Efficiency (CCREEE)

e) Caribbean Community Climate Change Centre (CCCCC)

f) Caribbean Disaster Emergency Management Agency (CDEMA)

g) Caribbean Institute for Meteorology and Hydrology (CIMH)

h) Caribbean Public Health Agency (CARPHA)

i) Caribbean Regional Fisheries Mechanism (CRFM)

j) Organisation of Eastern Caribbean States (OECS)

k) Pan-American Health Organization (PAHO)

l) University of Guyana (UG)

m) University of the West Indies (UWI)

ANNEX 2: TERMS OF REFERENCE FOR THE REGIONAL STEERING COMMITTEE OF THE REGIONAL STRATEGIC FRAMEWORK FOR TECHNICAL COOPERATION WITH THE IAEA–CARICOM MEMBER STATES 2020–2026

I. Background

The International Atomic Energy Agency (IAEA) and the group of the Caribbean Community (CARICOM) Member States (MSs) in the IAEA cooperated closely to prepare the Regional Strategic Framework for Technical Cooperation with the IAEA–CARICOM Member States to identify and prioritize the region's most pressing problems and needs that can be addressed using nuclear technologies over the period from 2020 to 2026.

The Regional Strategic Framework for Technical Cooperation with the IAEA–CARICOM Member States 2020-2026 (RSF 2020-2026) was drawn up using important regional development documents, such as the United Nations Multi-Country Sustainable Development Framework (UN MSDF) and the Strategic Plan for the Caribbean Community 2015–2019. A sectorial diagnosis was developed using a strengths, weaknesses, opportunities and threats (SWOT) analysis, which helped not only to identify the most acute regional needs and problems, but also to characterize them in terms of their respective baselines, prioritize them, and identify the objectives and goals to be achieved and the indicators by which to measure them.

The needs/problems identified were classified into six thematic areas where the IAEA possesses core competences to assist Member States, thus representing the priority areas within the scope of the RSF 2020-2026: agriculture and food production (food safety and security), human health, environment, energy, radiation safety and radiation technologies. The document also includes important cross-cutting topics, namely communication, outreach, partnership, knowledge management and gender mainstreaming considerations.

In addition to serving as a programmatic reference for the preparation of project and programme proposals both for the CARICOM Member States and the IAEA, it is anticipated that the RSF 2020-2026 will help to attract strategic partners, from within the region and outside it, to pursue projects having a larger scope, benefit and impact.

II. Objective of the RSF 2020-2026

The objective of the RSF 2020-2026 is to establish a strategic framework for technical cooperation in the Caribbean region based on a detailed analysis of the most pressing problems and needs in the regional context that can be addressed using nuclear science and technology. The framework of cooperation for the RSF 2020-2026 will be a programmatic reference of major importance for the preparation of project and programme proposals of the technical cooperation programme in the region. The RSF 2020-2026 also serves to guide and improve regional cooperation through better

communication and dissemination of the impact of technical cooperation projects, which could help to attract strategic partners from within the region, as well as outside it, to develop projects with greater benefit and impact.

III. Mandate of the Regional Steering Committee[9]

1. To assess progress in achieving the RSF 2020-2026 stated outcomes and take corrective actions on the delivery of RSF outputs as required towards ensuring its successful implementation; and,
2. To review and update the RSF 2020-2026 as required.

IV. Composition and Management of the Regional Steering Committee

1. The Regional Steering Committee shall be comprised of National Liaison Officers, representing IAEA–CARICOM Member States, CARICOM technical organizations relevant to the RSF thematic areas, and the IAEA.
2. The Regional Steering Committee shall appoint a Chairperson, which shall be elected biennially and rotate among the members of the Regional Steering Committee.
3. The Regional Steering Committee shall appoint a Deputy Chairperson, which shall be elected biennially and rotate among the members of the Regional Steering Committee. The Deputy Chairperson shall help the Chairperson in managing the Regional Steering Committee, as well as to ensure the substitution of the Regional Steering Committee Chairperson whenever the Chairperson cannot attend to the meetings.
4. The IAEA shall act as the Secretariat for the Regional Steering Committee, with due regard to the specific requirements of the meetings as communicated by the IAEA-CARICOM Member States, and provide an annual monitoring report on the RSF 2020-2026 implementation progress to the Regional Steering Committee members.
5. The Regional Steering Committee members shall meet, biennially to review and update the RSF 2020-2026 as required, and annually to assess progress in achieving stated outcomes and take corrective actions as required towards ensuring successful implementation of the RSF 2020-2026.
6. The Secretariat shall organize the meetings and prepare the draft agenda as proposed during the previous meeting. A written invitation and draft agenda, as well as reports for discussion, shall be sent to the Regional Steering Committee members in adequate time, to the extent possible, before the meeting is scheduled to take place.
7. Formal minutes of the Regional Steering Committee meetings shall be kept by the Secretariat and shared with the Regional Steering Committee members.

[9] In line with 'Chapter 13: Monitoring and Evaluation' of the Regional Strategic Framework for Technical Cooperation with the IAEA–CARICOM Member States 2020–2026

8. The Regional Steering Committee shall take decisions by consensus. In the absence of a consensus, decisions will be deemed adopted if supported by a majority of three quarters of the Members of the RSF Regional Steering Committee.

VI. Functions of the Regional Steering Committee

The functions of the Regional Steering Committee are as follows:

1. Reviewing the draft agenda proposed for the upcoming Regional Steering Committee meeting.
2. Preparing for the biennial meetings and drafting related documents to be circulated, with the support of the IAEA.
3. Holding the meetings which are needed to coordinate RSF 2020-2026 activities in the interval between the biennial meetings.
4. Nominating countries that shall be responsible for undertaking and coordinating specific activities and/or areas of cooperation.
5. Coordinating the drafting of recommendations and activities proposed to IAEA-CARICOM Member State representatives in the Regional Steering Committee for consideration.
6. Reporting from Member States and relevant CARICOM technical organizations on synergistic activities being implemented in the region in line with the RSF 2020-2026 Outcomes.
7. Tracking progress on the RSF implementation and taking corrective actions on the delivery of its outputs
8. Updating the RSF during the biennial meetings
9. Considering the *Guidelines for the Planning and Design of the IAEA Technical Cooperation Programme* to propose regional projects in line with RSF Thematic Areas
10. Providing guidance on the design and implementation of Technical Cooperation regional projects

VII. Validity of the Terms of Reference

1. The Regional Steering Committee members can agree to modify the present Terms of Reference.
2. The Terms of Reference of the Regional Steering Committee shall be valid until the 31 of December of 2026, in accordance with the validity of the RSF 2020-2026.
3. The Terms of Reference shall become effective upon adoption by members of the Regional Steering Committee.

These Terms of Reference were endorsed by the RSF Regional Steering Committee on 28 September 2021.

ANNEX 3: MONITORING AND EVALUATION STRATEGY

- Design of surveys to monitor RSF indicators
- Agreement on a customized monitoring tool to track annual progress and outcomes' results.
- Monitoring surveys aligned with PPAR and PAR requirements.
- NLO support to providing PPAR reports and high response to monitoring surveys based on RSF indicators
- Compiling relevant information for the RSF in coordination with regional stakeholders and counterparts of national and regional projects and the IAEA Secretariat
- RSF Regional Steering Committee to receive recommendations on RSF progress and corrective measures
- RSF progress to be tracked by the RSF Regional Steering Committee and the IAEA Secretariat through a customized monitoring tool
- RSF Regional Steering Committee deciding on and incorporating the feedback in the RSF during the biennial meetings

This monitoring and evaluation strategy was endorsed by the RSF Regional Steering Committee on 29 September 2021.

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