

Technical Cooperation Report for 2021

Report by the Director General



IAEA

International Atomic Energy Agency
Atoms for Peace and Development

Technical Cooperation Report for 2021

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Preface

The Board of Governors has requested the transmission to the General Conference of the attached Technical Cooperation Report for 2021, the draft of which was considered by the Board at its June 2022 session.

The Director General is also hereby reporting in fulfilment of the request contained in resolution GC(65)/RES/10 on "Strengthening of the Agency's technical cooperation activities".

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Summary

The Technical Cooperation Report for 2021 provides an overview of the Agency's Technical Cooperation (TC) activities during the year, covering actions to strengthen the technical cooperation programme, programme resources and delivery, and programme activities and achievements. Examples of project activities and achievements are listed in Annex 1 according to thematic area, and Annex 2 lists the TC programme Fields of Activity, grouped for reporting purposes. The report responds to General Conference resolution GC(65)/RES/10.

Part A.1 covers the context for the technical cooperation programme in 2021, opening with a section on how the regular technical cooperation programme continued implementation despite pandemic constraints. It also includes a section on support to Member State efforts to address COVID-19.

Part A.2 provides an overview of the Agency's participation in global development dialogue through attendance at key United Nations meetings and international conferences such as the Climate Adaptation Summit, the UN Multi-stakeholder Forum on Science, Technology and Innovation for the SDGs (STI Forum), the UN High-Level Political Forum (HLPF) and the 2021 United Nations Climate Change Conference (COP 26). The Agency's contribution to the fight against cancer was presented at global health events such as the Geneva Health Forum, London Global Cancer Week and the World Cancer Leaders' Summit.

The TC programme delivers support in the form of capacity building and procurement of essential equipment. Part A.2 also provides examples of capacity building, with subsections focusing on PhD and postgraduate support, Postgraduate Educational Courses (PGEC) in Radiation Protection and Safety, and legislative and drafting assistance. The section offers an overview of efforts to address the needs of Least Developed Countries and a wrap up of how the Agency has responded to emergencies in Member States, and closes with a review of efforts to build awareness of the TC programme, through outreach, events and participation in targeted conferences and symposia.

Part A.3 focuses on continuing efforts to enhance the efficiency and effectiveness of the TC programme. It describes activities to ensure that projects are linked with Member States' national development plans and other relevant development policies and goals, including SDGs, where applicable. To maximize programme impact, the Agency works in close partnership with Member States, United Nations agencies, national institutes and civil society. Agreements and Practical Arrangements signed in 2021 to support such partnerships are described in Part A.3. The report then provides an overview of the Agency's activities to improve programme quality in 2021 through workshops, training events and quality reviews and assessments, and the section closes with coverage of the participation of women in the TC programme.

Part B presents a summary of financial and non-financial programme delivery indicators. It reviews the resources received for the TC programme through the Technical Cooperation Fund (TCF) and mobilized through extrabudgetary and in-kind contributions. Payments to the TCF in 2021 totalled €85.3 million¹, or 95.2% of the TCF target set for the year.² New extrabudgetary resources for 2021 came to €23.5 million and in-kind contributions were €0.1 million³. Overall, implementation for the TCF reached 84.1% in 2021. Health and nutrition, food and agriculture and nuclear knowledge development and management⁴ were the top areas of disbursement for the programme.

¹ This figure does not include National Participation Costs, assessed programme cost arrears and miscellaneous income.

² Total payments received in 2021 include €182 023 either of deferred or of additional payments by 11 Member States. Excluding these payments, the 2021 rate of attainment on payments would have been 95.0%.

³ In 2021, China and Malta provided in-kind contributions to support the Agency's efforts to assist its Member States in combating the COVID-19 pandemic, in the amount of €1.842 million and €0.03 million respectively.

⁴ The interregional project INT0098, 'Strengthening Capabilities of Member States in Building, Strengthening and Restoring Capacities and Services in Case of Outbreaks, Emergencies and Disasters', through which the IAEA's support to Member States in addressing COVID-19 was delivered, is classified under the Field of Activity 'Nuclear knowledge development and management'.

Part C highlights programme activities and achievements, and covers assistance to Member States in the peaceful, safe, and secure application of nuclear science and technology. It highlights regional and interregional activities, such as enhancing Member States' preparedness for zoonotic disease prevention through the ZODIAC project, and achievements in technical cooperation in 2021, and presents an overview of the activities of the Programme of Action for Cancer Therapy (PACT).

A brief selection of project examples is presented in Annex 1 according to thematic area, covering health and nutrition, food and agriculture, water and the environment, industrial applications, energy planning and nuclear power, radiation protection and nuclear safety, and nuclear knowledge development and management. The Annex also highlights the activities undertaken to address the challenges of global plastic pollution by integrating various options under NUTEC Plastics. Annex 2 lists the technical cooperation programme Fields of Activity.

The Agency's Technical Cooperation Programme in Figures

(as at 31 December 2021)

2021



146 (34)

Countries/territories receiving support (of which LDCs)

18 Country Programme Frameworks (CPF) signed in 2021

116 CPFs valid as at 31 December 2021

142 Revised Supplementary Agreements (as at 31 December 2021)

Virtual

2526

Participants in training courses

3497

Meeting participants and other project personnel assignments

11

Fellows and scientific visitors

1042

Expert and lecturer assignments

103

Regional and interregional training courses

In Person

372

Participants in training courses

321

Meeting participants and other project personnel assignments

732

Fellows and scientific visitors

644

Expert and lecturer assignments

16

Regional and interregional training courses

€89 558 000

2021 target for voluntary contributions to the Technical Cooperation Fund (TCF)

€145 990 233

TC 2021 year-end budget⁶ (TCF, extrabudgetary resources and in-kind contributions)

95.2% (96.5%)

Rate of attainment on payments (pledges) at the end of 2021

84.1%

TCF implementation rate

New resources for the technical cooperation programme: **€110.0m**

Technical Cooperation Fund, NPC, APC, miscellaneous income: **€86.4m**

Extrabudgetary resources⁵: **€23.5m** In-kind contributions: **€0.1m**



⁵ Includes donor contributions and government cost-sharing. Please refer to Table A.5 of the Supplement to this report for details.

⁶ Year-end budget is the total value of all technical cooperation activities approved and funded for a given calendar year plus all approved assistance brought forward from previous years but not yet implemented.

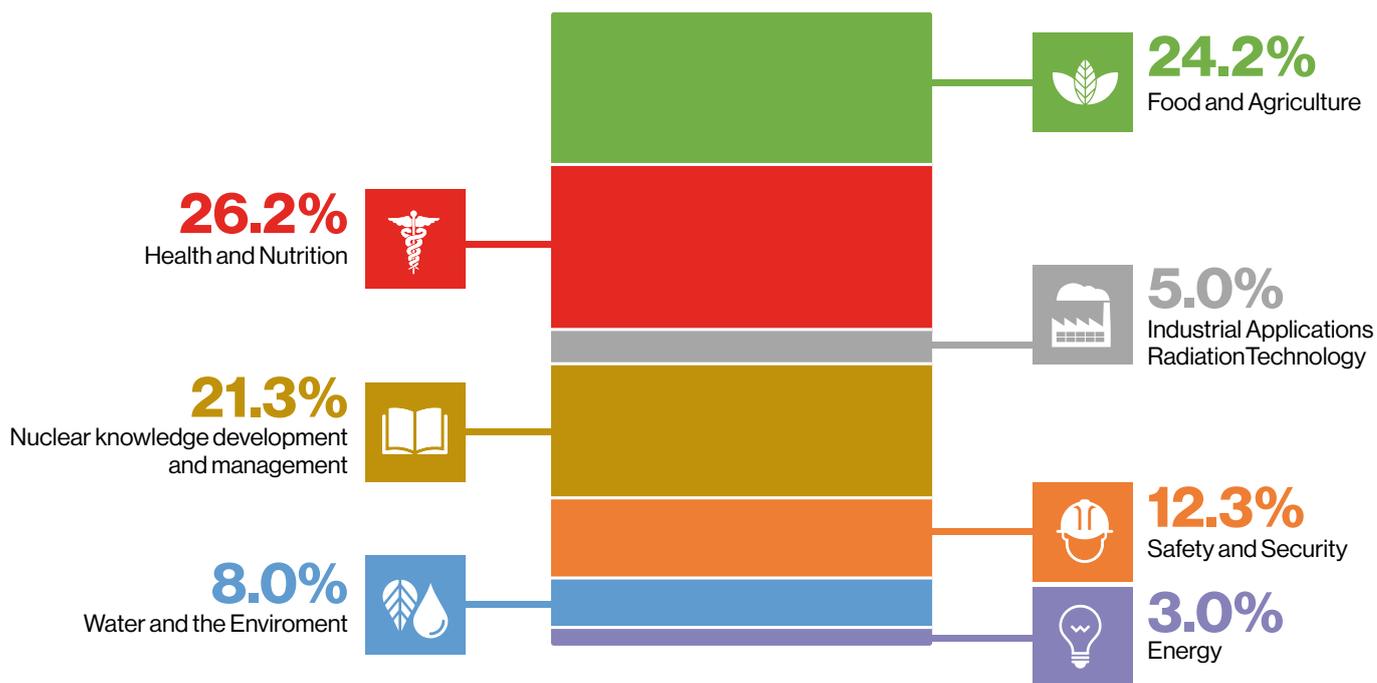


Figure 1: Actuals by technical field for 2021.^{7,8}

⁷ Throughout this report, percentages in charts may not add up to 100% exactly due to rounding. Unless otherwise stated, all figures are denominated in Euros.

⁸ The interregional project INT0098, 'Strengthening Capabilities of Member States in Building, Strengthening and Restoring Capacities and Services in Case of Outbreaks, Emergencies and Disasters', through which the IAEA's support to Member States in addressing COVID-19 was delivered, is classified under the Field of Activity 'Nuclear knowledge development and management'.

Technical Cooperation Report for 2021

Report by the Director General

This document responds to the request by the General Conference to the Director General to report on the implementation of resolution GC(65)/RES/10.

Part A of the report provides an overview of the progress achieved in delivering the technical cooperation programme in 2021.

Part B reports on the management of financial resources and programme delivery at an aggregate level in the calendar year 2021.

Part C reports on regional activities and programme achievements during 2021.

Annex 1 provides examples of project activities and achievements in specific thematic areas.

Annex 2 lists the technical cooperation programme Fields of Activity.

A.

Strengthening the Agency's Technical Cooperation Activities

A. Strengthening the Agency's Technical Cooperation Activities⁹

A.1. DELIVERING THE TC PROGRAMME

In 2021, the implementation of the human resources component of the technical cooperation programme continued to be affected by the COVID-19 pandemic and its concomitant travel restrictions. Implementation of in-person meetings and training courses with a strong hands-on nature, as well as fellowship training and scientific visits, was limited, and the planned programme was adjusted in consultation with Member States to accommodate circumstances and continue uninterrupted programmatic delivery. Many virtual training and meeting events were implemented to continue building capacities as far as possible. Because other in-person training/meeting components were postponed to 2022, a number of projects were extended or integrated into new projects for the 2022–2023 cycle.

The Agency continued its practice of holding bilateral meetings with Member States on the margins of the IAEA General Conference, either in person or via virtual platforms. Meetings of National Liaison Officers (NLOs) and regional cooperative agreement groups were also mostly held virtually.

Supporting Member State efforts to address COVID-19

The Agency continued to support the efforts of Member States to combat the COVID-19 pandemic under interregional project INT0098, 'Strengthening Capabilities of Member States in Building, Strengthening and Restoring Capacities and Services in Case of Outbreaks, Emergencies and Disasters'. In total, 129 countries and territories have requested IAEA assistance, with 305 laboratories and institutions receiving IAEA technical cooperation support. Shipments include RT-PCR and diagnostic kits and related items.

To identify the impact of the assistance and its sustainability, the Agency issued a survey to all laboratories receiving assistance. Of the responding laboratories, 13% had no PCR machine apart from that supplied by the Agency. Around 84% (over 50% of which were in low- and lower-middle income countries) confirmed that the emergency assistance package provided by the Agency could cover the initial gap in testing needs, and 92% acknowledged that Agency support had enhanced their ability to detect COVID-19 and other pathogens, or to provide such services.

Additionally, 92% of laboratories confirmed that they would be able to continue to provide testing beyond the initial Agency assistance. The remaining 8% reported challenges in continuing testing, due to current global difficulties in procuring laboratory reagents and consumables. Estimates from the survey data received indicate that, as of 11 January 2022, the laboratories that received Agency assistance were able to provide testing services to over 30 million people.

In 2021, the Agency continued to liaise closely with competent national authorities to facilitate the clearance and delivery of detection equipment (real time RT-PCR and kits), together with reagents and laboratory consumables, as well as biosafety supplies such as

"In total, 129 countries and territories have requested IAEA assistance, with 305 laboratories and institutions receiving IAEA technical cooperation support."

⁹ Section B responds to section A.4. Technical cooperation programme resources and delivery, of resolution GC(65)/RES/10, Strengthening of the Agency's Technical Cooperation Programme.

personal protection equipment for the safe analysis of samples. Meetings were held with the Africa Centres for Disease Control and Prevention (Africa CDC) to explore partnership and collaboration on COVID-19 and other areas of common interest.



RT-PCR COVID-19 detection kits and equipment provided by the IAEA are unloaded at Pursat Provincial Health Department, following a request by the Minister of Mines and Energy of Cambodia. (Photo: Cambodia Ministry of Mines and Energy)

As part of the UN Crisis Management Team, the Agency worked with the WHO South-East Asia Regional Office (SEARO) to develop a webinar series on applying new tools, data analysis and management, sequencing, public health surveillance, and on global and regional initiatives to strengthen detection of future outbreaks using the One Health approach. The series attracted around 700 participants. In collaboration with the WHO Eastern Mediterranean Regional Office (EMRO), the series was also offered in Arabic.

Samoa, the newest IAEA Member State, was one of the countries that received RT-PCR equipment in 2021, while national centres of the Pacific Islands such as the Fiji Centre for Communicable Disease Control, Belau National Hospital in Palau, and the Nonga Base Hospital in Papua New Guinea also received assistance.

Online material provided by the Agency in the form of webinar recordings and practical videos on sample collection, handling, processing, use of personal protective equipment, RT-PCR use for detection and Standard Operating Procedures (SOPs) have now been viewed over 12,900 times.¹⁰

A.2. TECHNICAL COOPERATION IN 2021: AN OVERVIEW

Global developments in 2021: The context for the TC programme

Global development dialogue

The year opened and closed with an accent on climate: in January 2021, the IAEA took part in the Climate Adaptation Summit with a side event on Nuclear Science and Technology for Climate Change Adaptation, while the 2021 United Nations Climate Change Conference (COP 26) in November saw the IAEA engaged in Glasgow on several fronts, from side events to social media platforms. At this event, the Departments of Technical Cooperation and Nuclear Sciences and Applications collaborated on a side event on climate adaptation, which focused on the role of nuclear science and technology in climate smart agriculture. The Department of Technical Cooperation also collaborated with the Department of Nuclear Energy on several side events on nuclear power and innovation for climate change mitigation, and took part in a side event on sustainable energy transition hosted by the Climate Compatible Growth Programme to present how the IAEA technical cooperation programme supports capacity building in energy planning in Latin America and the Caribbean.

Throughout the year, outreach efforts continued with United Nations (UN) and other international organizations in the context of the 2030 Agenda and of the Building Back Better after COVID-19. An IAEA side event, 'From COVID-19 Emergency Response to Integrated Action to Address Zoonotic Diseases' was organized on the margins of the UN Multi-stakeholder Forum on Science, Technology and Innovation for the SDGs (STI Forum), while a further IAEA side event, 'Nuclear Science and Technology in Support of

¹⁰ Please see documents GC(64)/INF/4, IAEA Support to Member State Efforts in Addressing the COVID-19 Pandemic, GOV/INF/2021/4, IAEA Support to Member State Efforts in Addressing the COVID-19 Pandemic, Progress Update, and GC(65)/INF/7, IAEA Support to Member State Efforts in Addressing the COVID-19 Pandemic, Progress Update II.

"Throughout the year, outreach efforts continued with United Nations (UN) and other international organizations in the context of the 2030 Agenda and of the Building Back Better after COVID-19."

Integrated Actions to Enhance Countries Post-Pandemic Recovery', was held at the UN High-Level Political Forum (HLPF). Together with the World Food Programme and the United Nations Population Fund, the Agency participated in a side event at the 76th session of the United Nations General Assembly on 'COVID-19 Response and Approaches to Strengthen Health Systems'. Here the IAEA described support to Member State efforts to address COVID-19, and underscored the importance of resilient health systems, supported by ongoing technical training and robust supply chains, in ensuring that countries are ready to tackle future pandemics and outbreaks.

The Agency participated in the second open call for Sustainable Development Goals (SDG) Good Practices and Success Stories by the UN Department of Economic and Social Affairs. The Agency formed part of the Inter-Agency Team of experts from 24 UN entities reviewing the submissions of SDG Good Practices, and also submitted seven SDG Good Practices itself, related to the Agency's support to Member States in a variety of areas. All seven SDG Good Practices showcasing the contribution of the Agency's TC programme to SDG implementation are now available on the UN DESA SDG website. Larger efforts to integrate radiation medicine into comprehensive cancer control were among the SDG good practices selected.

The Agency took part at the technical and principal levels in meetings, organized by the Office of the Special Adviser on Africa (OSAA), of the Interdepartmental Task Force on African Affairs (IDTFAA) on promoting a coherent approach to the post-COVID-19 recovery, and leveraging energy for the post-COVID-19 recovery. The Agency also attended the IDTFAA technical level meeting on the impact of energy in SDG implementation in Africa. Dialogue focused on support to the implementation of the AU-UN Framework for the Joint Implementation of Agenda 2030 and the 2063 Agenda to maximize the impact of recovery efforts in Africa, with energy as a key enabler for the achievement of the Sustainable Development Goals.

The Agency also contributed to the Interdepartmental Task force on African Affairs (IDTFAA) Compendium Report 2021, which provides an analytical perspective of the activities of the IDTFAA while showcasing the contributions and knowledge products of IDTFAA members on the specific topics discussed at the strategic level. A technical meeting in December 2021 discussed the preparation of a technology primer on nuclear energy, as a part of a joint plan and programme activities to explore an IAEA-OSAA partnership.

In addition, the Agency participated in virtual seminars organized by the African Commission on Nuclear Energy (AFCON), and the partnership through which the Agency provides support for the development of a Continental Master Plan for energy planning has been strengthened through regular virtual meetings. Partners include the European Union, African Union Development Agency-NEPAD (AUDA-NEPAD), African Power Pools and the International Renewable Energy Agency.

An IAEA presentation, 'Explore the Best Practices in Safe and Sustainable Use of Nuclear Energy: Success Story Finland', on the importance of considering nuclear power to meet energy needs and on IAEA support to Member States for the achievement of the SDGs and the Paris Climate Agreement, was delivered at the Finland pavilion at the World Expo in Dubai, United Arab Emirates.

A keynote IAEA speech at the Arab Nuclear Business Platform Lite 2021 presented the important contribution that clean, nuclear energy can make to the attainment of the SDGs and described Agency support available to Member States. The Business Platform focused on four key themes important to the Arab nuclear market: climate change, regulation, human capacity building and small modular reactors.



IAEA side events at COP26 raised awareness of the role of nuclear science and technology in climate change monitoring, mitigation and adaptation. (Photo: C.Henrich/IAEA)

In December, at the virtual 2nd International Conference on Transboundary Aquifers: Challenges and the Way Forward (ISARM2021) organised by UNESCO, the Agency presented regional capacities for isotope-based assessments of transboundary water resources in Europe and Central Asia.

The Agency also participated in the Eleventh General Meeting between the Caribbean Community (CARICOM) and its Associated Institutions and the United Nations system. The meeting, attended by 130 participants, sought to address ongoing challenges and seize opportunities for enhancing the partnership between CARICOM and Associated Institutions and the UN system. The Agency contributed to the discussions on Advancing the Fight Against Non-Communicable Diseases, HIV/AIDS and Pandemics; Advancing Climate Change Adaptation and Disaster Risk Reduction; and Promoting Food/Nutrition Security and Protecting the Agriculture and Fisheries Sectors.

PACT continued to play a key role in the global dialogue to advocate for improved access for cancer control in low- and middle- income countries (LMICs) through participation in several international forums, such as the Geneva Health Forum, International Childhood Cancer Day, the Economist World Cancer Series, London Global Cancer Week, the launch of WHO's Global Breast Cancer Initiative, World Cancer Day, and the World Cancer Leaders' Summit. PACT also organized several webinars on cancer control assessments.

Building human capacity

The technical cooperation programme is the major vehicle through which the Agency transfers nuclear technology to Member States and builds their capacities in the peaceful use of nuclear science and technology. A One House programme, it brings together skills and expertise from across the Agency to meet Member State needs.

Member States participating in a regional medical imaging project in Africa were the first to apply a staffing algorithm developed by the IAEA to establish a baseline and recommend adequate medical physicist staffing levels for safe and quality imaging services

Nineteen African fellows are being trained in Egypt and Ghana through the very first long-term clinical training for imaging medical physicists as outlined by the AFRA harmonized academic and clinical training syllabus in medical physics. Six candidates continued their long-term fellowship training in radiation oncology, radiation therapy and medical physics, hosted by African institutions. This project complements several national projects accommodating long-term training and qualification of key personnel in radiation medicine. Fourteen candidates continued their group fellowship programme on clinical training in medical physics for imaging, hosted by Ghana and Egypt.

Guidance for Clinical Training of Medical Physicists in Latin America was issued with the endorsement of the Latin America Association of Medical Physics (ALFIM) under the regional project RLA6082 'Strengthening Regional Capabilities in the Provision of Quality Services in Radiotherapy (ARCAL CLXVIII)'. This will strengthen and harmonize the education and training of medical physicists in the region, with a focus on feasibility, sustainability, and cooperation.

A series of IAEA training courses on strategic and business planning for emerging leaders were implemented in 2020 and 2021 through regional project RLA0069, 'Promoting Strategic Management and Innovation at National Nuclear Institutions through Cooperation and Partnership Building - Phase II (ARCAL CLXXII)', equipping young professionals working in national nuclear institutions (NNIs) in 19 Latin America and the Caribbean countries to plan and promote the nuclear and isotopic services they provide. This will help ensure their institutions' sustainability as commercial and research service providers. The course was administered with the support of Argonne National Laboratory and is now available as an e-learning course in CLP4net.

The REMARCO network, which connects 18 countries in Latin America and the Caribbean, focuses on addressing regional challenges and vulnerabilities in the marine and coastal

"The technical cooperation programme is the major vehicle through which the Agency transfers nuclear technology to Member States and builds their capacities in the peaceful use of nuclear science and technology."

environments, including marine pollution, ocean acidification, harmful algal blooms and microplastics. In 2021, supported by TC regional project RLA7025, 'Strengthening Capacities in Marine and Coastal Environments Using Nuclear and Isotopic Techniques,' continued to foster coordinated action, share key data and enhance human and analytical capacities on measuring ocean acidification, eutrophication and marine pollution (microplastics). REMARCO gained visibility through its participation in international forums including the Geo Blue Planet Steering Committee, UN Decade of Ocean Science for Sustainable Development 2021-2030 Regional Working Groups and virtual events such as the Monaco Ocean Week and NUTEC Plastics Roundtable.

PhD and postgraduate support

Important progress was made on human capacity building in the Africa region in 2021. Four radiopharmacists from African Francophone countries were awarded an MSc degree in radiopharmacy within the framework of the IAEA established programme in Morocco. These are the first qualified radiopharmacists in Burkina Faso, Cote d'Ivoire, Democratic Republic of the Congo, and Mauritius. An additional four radiopharmacists, from Ethiopia, Kenya, Uganda and Zambia, completed their academic MSc education in South Africa. The project also supported the establishment of the African Association of Radiopharmacy.

Under a regional project for PhD sandwich programmes, 15 candidates from 15 Member States, of which 10 are least developed countries, pursued fellowship training to carry out their PhD programme in foreign universities. This training complements the PhD coursework in the candidates' home country universities. Ten candidates completed their master's programme in nuclear science and technology from the University of Alexandria, Egypt, and the University of Ghana through the two-year AFRA Masters Programme.

To enhance self-reliance in isotope hydrology expertise, a regional water resources management project for the Sahel region, RAF7019, 'Adding the Groundwater Dimension to the Understanding and Management of Shared Water Resources in the Sahel Region', has awarded 15 PhD sandwich fellowships. Most of the students were able to complete their first period at foreign universities. In addition, the project also awarded the first post-doctoral fellowship under the TC programme.

Discussions were held in 2021 with Tsinghua University on potential cooperation with the University's International Master's Program in Nuclear Engineering and Management (TUNEM) to support long term TC fellowships in the Asia and the Pacific region. Two candidates from Afghanistan were successfully enrolled in TUNEM with the full support of the Chinese Government Scholarship programme.

Supported by RAS0081, 'Supporting Human Resource Development and Nuclear Technology Including Emerging Needs', long-term training in Radiation Disaster Medicine at Hiroshima University for PhD candidates from Iran, Mongolia, and the Philippines continued, and national implementation of fellowships for Indonesia, Malaysia, and Thailand was initiated.

The Master of Advanced Studies in Medical Physics (MMP) is run jointly by the International Centre for Theoretical Physics and the University of Trieste, providing graduates of physics or related fields with postgraduate theoretical and clinical training so that they may be recognised as clinical medical physicists in their home countries. The two-year programme consists of one academic year and one year of professional clinical training in a medical physics department of a hospital in the programme's training network. Through the interregional project INT0095, 'Supporting Member States in Human Capacity Building Related to Nuclear Science and Technology and Quality Management of the Technical Cooperation Programme', 19 fellows completed their clinical training in 2021, and a new cohort of 25 fellows began their academic studies supported by the TC programme. Participation was also supported through national projects, with two fellows supported from January 2020 to December 2021 under national project JAM6014, 'Building Capacity for Cancer Diagnostics and Treatment Services Related to Nuclear Technologies'. Following graduation, both medical physicists have returned to Jamaica where they will

"Under a regional project for PhD sandwich programmes, 15 candidates from 15 Member States, of which 10 are least developed countries, pursued fellowship training to carry out their PhD programme in foreign universities."

help to ensure safety and quality in the diagnosis and treatment of patients in national public sector hospitals.

INT0095 also provides support to students already enrolled in PhD programmes in their home countries, through the ICTP/IAEA Sandwich Training Educational Programme (STEP). In 2021, 10 fellows supported by the TC programme were engaged in periods of research with their co-supervisors in different host institutes, and four more were selected to enter the programme. STEP gives PhD students access to laboratories, research, and training facilities, as well as connections to international networks in their chosen research fields.

Postgraduate Educational Courses (PGEC) in Radiation Protection and Safety

The IAEA's Postgraduate Educational Course (PGEC) in Radiation Protection and Safety has contributed to strengthening the radiation protection and safety infrastructure in many countries in a sustainable manner. Aimed at young professionals, the PGEC is based on a standard syllabus, offered in Arabic, English, French, Portuguese, Russian and Spanish. One hundred and nine courses have been held to date, and 1972 students have graduated. The 6-month course offers the participants the chance to learn about radiation protection and the safety of radiation sources and supports the exchange of information and knowledge among all participants. The PGEC equips young, aspiring regulators, qualified experts and trainers in radiation protection with the technical knowledge and practical experience required to support the protection of workers, patients, the public and the environment from the harmful effects of ionizing radiation.

"The 6-month course offers the participants the chance to learn about radiation protection and the safety of radiation sources and supports the exchange of information and knowledge among all participants."



The IAEA's Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources (PGEC) was provided in Arabic in 2021 with the support of the government of Jordan. (Credit: Jordan Atomic Energy Commission)

In Africa, two Postgraduate Educational Courses (PGEC) in Radiation Protection and the Safety were held in Algeria and Ghana respectively for English and French-speaking countries. Forty-eight young professionals underwent theoretical and practical training in the scientific and technical bases of international recommendations and standards on radiation protection and safety. The training was supported by the regional project RAF9067, 'Sustaining the Establishment of Education and Training in Radiation Safety and Human Resource Development – Phase II (AFRA)'. In Asia and the Pacific, a PGEC was offered in Arabic. Hosted by the Jordan Atomic Energy Commission (JAEC), the course brought together participants from 12 Arabic-speaking countries: Bahrain, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, the United Arab Emirates, Yemen and the territories under the jurisdiction of the Palestinian authority. It was supported by regional project RAS9091, 'Establishing Sustainable Education and Training Infrastructures for Building Competence in Radiation Protection'. Twelve young professionals from Europe and Central Asia also completed the PGEC in 2021, implemented under the ongoing

TC project RER9156, 'Establishing Education and Training Infrastructure in Radiation Protection'. The course was delivered in Russian and was hosted by the International Sakharov Environmental Institute of the Belarusian State University, in Minsk. In Latin America and the Caribbean, a basic course on radiation protection was delivered virtually, and the PGEC was also delivered in a virtual format, to be followed in the future by practical, in-person training. Both courses were supported by the regional project RLA9086, 'Strengthening Radiation Safety Infrastructure'.

Legislative and drafting assistance

In 2021, the Agency conducted several workshops, missions and meetings to raise awareness, advise and train on developing and revising national legislation and adhering to and implementing the relevant international legal instruments.

Seven Member States received country specific bilateral legislative assistance through written comments and advice on drafting national nuclear legislation. As an online alternative to some in-person activities and as a follow-up to reviews of legislation, twelve virtual activities on different aspects of nuclear law were held for Armenia, Botswana, Colombia, Côte d'Ivoire, Croatia, Indonesia, Jordan, Mali, Paraguay, Sri Lanka, Turkey and Viet Nam. Legislative assistance was provided to Member States in the Asia and the Pacific region under TC regional project RAS0085, 'Establishing and Enhancing National Nuclear Legal Frameworks in Member States'.

A virtual sub-regional workshop on nuclear law was carried out for English speaking Member States in the Latin America and the Caribbean region under the regional TC project RLA0067, 'Establishing and Enhancing National Legal Frameworks'. Many of the participating countries are recent IAEA Member States, and they share similar needs and face common challenges in seeking to realise the many benefits of non-power applications. Additionally, they are seeking to establish a sound and comprehensive national nuclear legal framework. Under the regional TC project RAF0057 'Establishing and Enhancing National Legal Frameworks' two virtual sub-regional workshops were held, one for English-speaking Member States and the other for French-speaking Member States in the region. The three sub-regional workshops on nuclear law held in 2021 provided an opportunity to identify Member States' legislative assistance needs, which then resulted in the development of informal bilateral workplans identifying future activities.

In addition, two targeted virtual workshops on nuclear law provided diplomats and officials from permanent missions located in Berlin, Brussels, Geneva, Paris and New York with a high-level overview of international and national nuclear law and the IAEA's role in the development and implementation of nuclear law, including assistance provided through the Legislative Assistance Programme.

Owing to COVID-19 related restrictions, the 2021 session of the annual Nuclear Law Institute (NLI) interregional training event had to be postponed until 2022. Building on a series of interactive webinars on nuclear law held in 2021, Member States also participated in new series of topical webinars on nuclear law. The first four of this eight-webinar series were implemented in 2021. During 2021, planning was underway for the Agency's First International Conference on Nuclear Law: The Global Debate which has taken place at Agency Headquarters, 25-29 April 2022.

Addressing the needs of Least Developed Countries (LDCs)

The Agency continues to address the specific needs of the least developed country (LDC) Member States of the IAEA, which include 27 in Africa, 7 in Asia and the Pacific and one in the Caribbean. The TC programme in these Member States focuses on building capacity in the peaceful uses of nuclear science and technology in food and agriculture, health and nutrition, water and environment, energy, industry, and safety and security. LDC capacity building is supported through short term and long academic programmes to build a critical mass of scientists in these topic areas.

"In 2021, the Agency conducted several workshops, missions and meetings to raise awareness, advise and train on developing and revising national legislation and adhering to and implementing the relevant international legal instruments."

The Agency participated in meetings of the Inter-Agency Consultative Group (IACG) of the United Nations system and international organizations on the Implementation of the Istanbul Programme of Action (IPoA) for the Least Developed Countries (LDCs) on the organization of the Fifth LDC Conference (LDC V), originally planned to take place in January 2022 in Doha, Qatar. The Agency provided inputs on the status on the implementation of the IPoA, focusing on building human and institutional capacities in LDCs.

Responding to emergencies

The IAEA technical cooperation (TC) programme is flexible, allowing it to respond to evolving or unforeseen Member State needs where nuclear science and technology can make a contribution: for example, in emergency situations arising from natural disasters, outbreak of diseases or accidents.

Emergency support in 2021 included expert assistance to Sri Lanka following the fire and subsequent sinking of a container ship off the coast of Colombo. Long-term IAEA capacity building will help Sri Lankan authorities to implement the necessary monitoring and tracking of the contaminants from the sunken ship and the implementation of remedial strategies, which will improve preparedness for similar disasters in the future.

Bangladesh, Cambodia, Indonesia, Myanmar, Nepal, Sri Lanka, Thailand and Viet Nam received assistance to tackle an outbreak of Lumpy Skin disease in cattle. The Agency coordinated assistance with FAO to support identification of the genetic strains of the disease, and to launch an effective response to the disease outbreak.

Agency efforts to assist Lebanon following the 2020 explosion continued in 2021. A series of virtual trainings was carried out on theoretical aspects of non-destructive testing (NDT) and an in-field expert mission was also conducted to support efforts to use NDT to evaluate building integrity and support Lebanon's reconstruction efforts.

The eruption of La Soufrière volcano in Saint Vincent and the Grenadines generated widespread destruction, disrupting critical patient care in hospitals. The Agency provided assistance with the procurement of a CT scanner and equipment for radiation detection, together with support for water quality analysis as well as COVID-19 testing.

Haiti suffered a magnitude 7.2 earthquake in August, which caused widespread destruction and was then followed by extremely heavy rains in southern Haiti, causing flooding in the quake-affected areas. In response to Haiti's request for assistance, the Agency provided four portable x-ray machines to ensure timely diagnosis of patients in affected areas.



Fusarium wilt disease threatens the banana crop throughout Latin America. (Photo: M.Dita/Biodiversity International, Colombia)

Colombia, Guatemala, Honduras and Nicaragua have been significantly affected by hurricanes over the last couple of years, which damaged their health sectors and left some hospitals without equipment for diagnostic medical imaging. In response, the Agency provided necessary support including procuring mobile x-ray machines in 2021 for Colombia, Guatemala, Honduras and Nicaragua to enable the Member States to provide critical care for patients.

In late August 2021, experts and authorities from the Andean Community – Bolivia, Colombia, Ecuador and Peru – reached out to the Agency for support to address Fusarium wilt, Tropical Race 4 (TR4), a banana disease in the region which affects banana plantations and threatens the nutrition and food security of millions of people in the region and banana consumers worldwide. First reported in 2019 in Colombia, it was observed in Peru in early 2021. In partnership with the FAO/IAEA Joint

Centre, the Agency is supporting the Andean Community through a new interregional TC project to prevent and combat the spread of the disease.

Building awareness of the technical cooperation programme

More than 170 web stories on technical cooperation were published in 2021, and coverage of the IAEA's COVID-19 assistance continued. Social media channels remained an important cost-free means of communicating on a wide range of IAEA development activities, and new outreach materials were issued, including *TC Selected Highlights for 2020*.

Two virtual Seminars on Technical Cooperation were held for the diplomatic communities in Berlin, Brussels, Geneva and Paris; and in New York, raising awareness of the TC programme and its contribution to Member State development priorities, including achievement of the Sustainable Development Goals.

Four side events related to technical cooperation were organized on the margins of the IAEA General Conference: 'Enhancing Human Resource Development in Nuclear Science and Technology', 'Technical Cooperation Programme in Asia and the Pacific – Major Contribution to Development', 'Developing Capacity for the Wider Use of Stable Isotopic Techniques for Source Attribution of Greenhouse Gases in the Atmosphere', and the inauguration of the regional chapter of Women in Nuclear (WiN) ARCAL. The hybrid nature of side events at the IAEA General Conference enabled increased attendance.

The virtual side event 'Enhancing Human Resources Development in Nuclear Science and Technology in Africa' showcased the TC programme's contribution to building human capacity for the peaceful use of nuclear technology for socioeconomic development in African Member States. The side event 'The Technical Cooperation Programme in Asia and the Pacific: Major Contribution to Development' formed part of the continuing communication campaign to showcase the Journeys to Success compendium. The event explored how collaboration in nuclear technology has contributed to socioeconomic development in Asia and the Pacific. The side event on TC project INT7020, 'Developing Capacity for the Wider Use of Stable Isotope Techniques for Source Attribution of Greenhouse Gases in the Atmosphere', highlighted how the unique expertise of the Agency combined with the competency of the World Meteorological Organization supports Member States in using stable isotopes to measure greenhouse gas emissions and accurately determine their source in efforts to fight climate change. This is the first time a technical cooperation project is being implemented in partnership with the World Meteorological Organization.

Outreach on technical cooperation in 2021

172 IAEA web articles on technical cooperation

7082 @IAEATC Twitter followers and 464 tweets published (up from 360 in 2020)

2254 @IAEAPACT Twitter followers and 409 tweets

4356 LinkedIn followers

1682 LinkedIn TC Alumni Group members

A.3. BUILDING A MORE EFFICIENT, MORE EFFECTIVE TECHNICAL COOPERATION PROGRAMME¹¹

Revised Supplementary Agreements and Country Programme Frameworks

CPFs signed in 2021	
Burundi	Niger
Djibouti	Palau
Czech Republic	Portugal
Egypt	Saint Vincent and the Grenadines
Ghana	Singapore
Madagascar	Slovakia
Malawi	United Arab Emirates
Mali	Uzbekistan
Marshall Islands	Zambia

By the close of 2021, 18 countries had signed Country Programme Frameworks (CPFs), and the total number of valid CPFs had reached 116. All newly signed CPFs contain a concise and focused medium-term programme plan and are linked with relevant objectives of national and/or sectoral development plans and strategies, the Sustainable Development Goals (SDGs). The CPF preparation process applies a results-based approach to programme planning, implementation, monitoring, assessment and reporting, guided by the TC criterion and the consideration of gender.

The total number of Revised Supplementary Agreements Concerning the Provision of Technical Assistance by the International Atomic Energy Agency (RSAs) is 142.

Maximising programme impact through strategic partnerships

In its efforts to engage with a wide range of new partners to explore complementarities and further enhance the contribution of nuclear science and technology to the sustainable development efforts of its Member States, the Agency concluded a number of new partnerships related to technical cooperation in 2021 and extended an existing one.

IAEA joined the Global Plastic Action Partnership (GPAP) as an affiliate member. Co-founded by partners across the public and private sectors, GPAP harnesses the convening power of the World Economic Forum to bring together governments, businesses and civil society to translate commitments into meaningful action at both the global and national levels to free the world from plastic waste and pollution. In 2021, both organizations rolled out their collaboration for the operationalization of NUTEC Plastics. Interactions with the GPAP regional working group for Africa have identified areas of synergy under NUTEC Plastics, and as an official observer to GPAP the Agency also participated in the Southeast Asia Regional Working Group Kick-off Meeting, paving the way for future partnerships related to NUTEC Plastics.

An agreement between the World Meteorological Organization and the Agency was finalized in 2021 and signed in January 2022. The two organizations pledged to work together in combatting the effects of climate change and pollution in the framework of INT7020, 'Developing Capacity Towards the Wider Use of Stable Isotopic Techniques for Source Attribution of Greenhouse Gases in the Atmosphere'.

The Agency joined forces with the China International Development Cooperation Agency (CIDCA) to scale up action in support of developing countries in the achievement of SDGs, and to strengthen South-South and triangular cooperation. The two entities will pursue cooperation in applied research and development and capacity building, including education and training at the graduate and post-graduate levels. The Agency and CIDCA will exchange expertise and knowledge, and support networking and the placement of training candidates from developing countries. The two organizations will also cooperate in the provision of expertise to support the development of technical infrastructure for the peaceful use of nuclear applications in developing countries. Finally, the agreement is expected to support the implementation of NUTEC Plastics and Zoonotic Disease Integrated Action (ZODIAC).

The Agency and the Pakistan Atomic Energy Commission (PAEC) signed Practical Arrangements enabling regulators and users of nuclear technology to tap into PAEC's long-standing experience in managing nuclear power and application projects.

With a focus on improving access to equitable and quality radiation medicine, the Agency and the City Cancer Challenge Foundation (C/Can) entered into partnership for the benefit of cancer patients in low- and middle-income cities.

In 2021, the Agency signed Practical Arrangements with the Spanish Society of Radiological Protection (SEPR), a scientific and technical association committed to promoting safety in the application of ionizing radiation. Under the terms of the Practical Arrangements, the IAEA and SEPR will work closely together to promote the radiation protection of patients, professionals and the public as well as in radiological emergency preparedness and response (EPR).

Building on the results achieved, the Agency extended its partnership with Empresa Nacional De Residuos Radioactivos (ENRESA) to continue joint work on radioactive waste management.Cs.

Actions under ongoing partnerships

Since 2019, the Agency has coordinated efforts to promote collaboration and triangular cooperation related to the peaceful application of nuclear technologies in Cambodia, the Lao People's Democratic Republic and Viet Nam. As part of these ongoing efforts to support technical cooperation among developing countries (TCDC), the action plan agreed between Cambodia and Viet Nam addresses several priority areas, including radiation applications in the fields of food and agriculture, industry, and non-destructive testing; radiation and nuclear safety; regulatory infrastructure; and others. A series of virtual workshops under the auspices of existing Practical Arrangements were organized in collaboration with the Viet Nam Agency for Radiation and Nuclear Safety (VARANS) and VINATOM in Viet Nam. This included a virtual workshop on radiation protection and nuclear safety inspections, during which VARANS shared its experience with 22 representatives from Cambodia, who learned how regulations are developed for radiation protection, nuclear safety inspections, and law enforcement activities. During a virtual workshop on radiation processing in industry, 27 participants from Cambodia learned about the application of radiation technology in Viet Nam. Finally, 24 participants attended a virtual training course on non-destructive testing (NDT), during which Cambodian experts received detailed information on the qualification and certification of NDT personnel and were given opportunities to participate in visual testing of different methods.

Collaboration with the University of the West Indies (UWI), Mona Campus, continued within the framework of national TC project JAM6014, 'Building Capacity for Cancer Diagnostics and Treatment Services Related to Nuclear Technologies'. The Agency, together with the Ministry of Health of Jamaica and national hospitals, provided targeted training opportunities on radiation safety in medical uses. In 2021, virtual training courses on radiation safety and protection in interventional radiology for radiographers and nurses were hosted by UWI in collaboration with the Agency. The courses strengthened occupational and patient safety by increasing the understanding of potential health hazards associated with the use of radiation in interventional radiology. The courses included a train-the-trainers component to ensure sustainability, providing national professionals with the required skills to replicate the courses in collaboration with UWI in the years to come, and to train new professionals in Jamaica as well as in other IAEA-CARICOM countries.

"A series of virtual workshops under the auspices of existing Practical Arrangements were organized in collaboration with the Viet Nam Agency for Radiation and Nuclear Safety (VARANS) and VINATOM in Viet Nam."

Continual improvement in project design quality and monitoring

In 2021, the Agency conducted a full review of TC projects designed and proposed for the 2022–2023 TC cycle, with the aim of supporting improved project descriptions, logical frameworks and implementation strategies. The review applied the updated TC

Programme Quality Criteria of relevance, coherence, effectiveness, efficiency, sustainability and ownership.

The quality review adopted a country portfolio approach, emphasizing the links between TC project design and Country Planning Frameworks, to align planning and design and reinforce monitoring of outcomes.

Following updates to the tools and guidelines, the submission rate of Project Progress Assessment Reports (PPARs) for the 2020 reporting period increased to 82%, the highest rate achieved so far. The annual PPAR provides a unique opportunity to record progress made by projects towards achieving their outputs and outcomes, and to analyse the extent to which project teams interact efficiently and adapt to changes in a timely manner. The reporting platform promotes the participatory nature of report preparation and emphasizes the accountability of all project team members. Project teams were trained in the use of the TC Reports platform through tutorials, regional workshops and virtual training sessions.

Results-based management continued to be strengthened with the development of monitoring and evaluation tools, frameworks and data dashboards for various projects. Support was also provided to RCA in their efforts to assess the impact of projects in selected thematic areas; and collaborative support in the preparation of bankable documents was analysed.

Processes to improve knowledge management and training were improved in 2021, with the aim of enhancing timeliness and relevance of the support provided to Member States. Improvements were made to processes for staff induction, orientation, hand-over and peer knowledge-sharing, focusing on improving implementation for results, sharing lessons learned and good practices, and building technical or thematic awareness or expertise.

Additionally, practical guidance for counterparts and end-users, reflecting their roles and responsibilities in the TC procurement process, was issued to support procurement efficiency and effectiveness.

The Office of Internal Oversight (OIOS) carried out several evaluations and audits of the work of TC in 2021. All open OIOS recommendations addressed to TC were monitored, and the agreed action plans were tracked closely. This facilitated the timely closure of recommendations. One hundred and thirty-five OIOS recommendations have been addressed since 2019, including 21 recommendations which were closed or implemented in 2021. All recommendations owned by TC issued prior to 2019 have been closed.

Female participation in the TC programme

The Agency strongly encourages the expansion of female participation in the TC programme, and Member States are encouraged to nominate female NLOs, meeting and training course participants, fellows and scientific visitors, and counterparts.

For the second time, in cooperation with the Australian Nuclear Science & Technology Organisation (ANSTO), the Agency held a regional training course on 'Supporting Women for Nuclear Science Education and Communications (W4NSEC)' for women educators in Asia and the Pacific. The course is part of a continuing education programme for female university science teachers and science communication professionals, and includes a new course platform.

To promote greater participation in the nuclear field by women in Latin America and the Caribbean, the Regional Cooperation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) and the Agency have supported the establishment of a new, regional chapter of Women in Nuclear (WiN). The new chapter was inaugurated during the 65th IAEA General Conference and was attended by scientists, policy makers and Agency staff, including IAEA Director General Rafael Mariano Grossi. The chapter is led by a team of 12 women nuclear scientists and policy makers from Latin America, whose specialties range from nuclear medicine and radiotherapy to environmental monitoring and radiation safety.

"The Agency strongly encourages the expansion of female participation in the TC programme, and Member States are encouraged to nominate female NLOs, meeting and workshop participants, fellows and scientific visitors, and counterparts."



Dominique Mouillot, President of WiN Global, speaking at the WiN ARCAL side event. (Photo: D. Calma/IAEA)

The regional chapter aims to strengthen existing WiN National Chapters in Argentina, Bolivia, Brazil, Cuba and Mexico and establish new ones in Chile, Colombia, Costa Rica, Ecuador, Peru, Uruguay and Venezuela. Latin America and the Caribbean reached a key milestone in 2020 and 2021 by officially launching WiN National Chapters in four of these countries: Chile, Colombia, Peru, and Venezuela. In addition to consolidating the various national chapters into a single, overarching network, the WiN ARCAL Chapter will develop and make accessible a regional database to provide information on the participation of women in the nuclear sector, facilitating the future implementation of public policies targeting the gender gap in science. Agency support for WiN ARCAL builds on earlier Agency efforts in the region to prepare young, female professionals for leadership responsibilities and to act as 'nuclear advocates' in their national institutions.

In 2021, the Agency also supported the establishment of WiN national chapters in a number of African Member States. The Agency supported the WiN Global side event which took place during the IAEA General Conference, entitled Cooperating with Women in Nuclear: Supporting Talent in the Nuclear Field. The Women in Nuclear global conference was supported by INT0095, 'Supporting Member States in Human Capacity Building Related to Nuclear Science and Technology and Quality Management of the Technical Cooperation Programme'.

"The Agency supported the WiN Global side event which took place during the IAEA General Conference, entitled Cooperating with Women in Nuclear: Supporting Talent in the Nuclear Field."

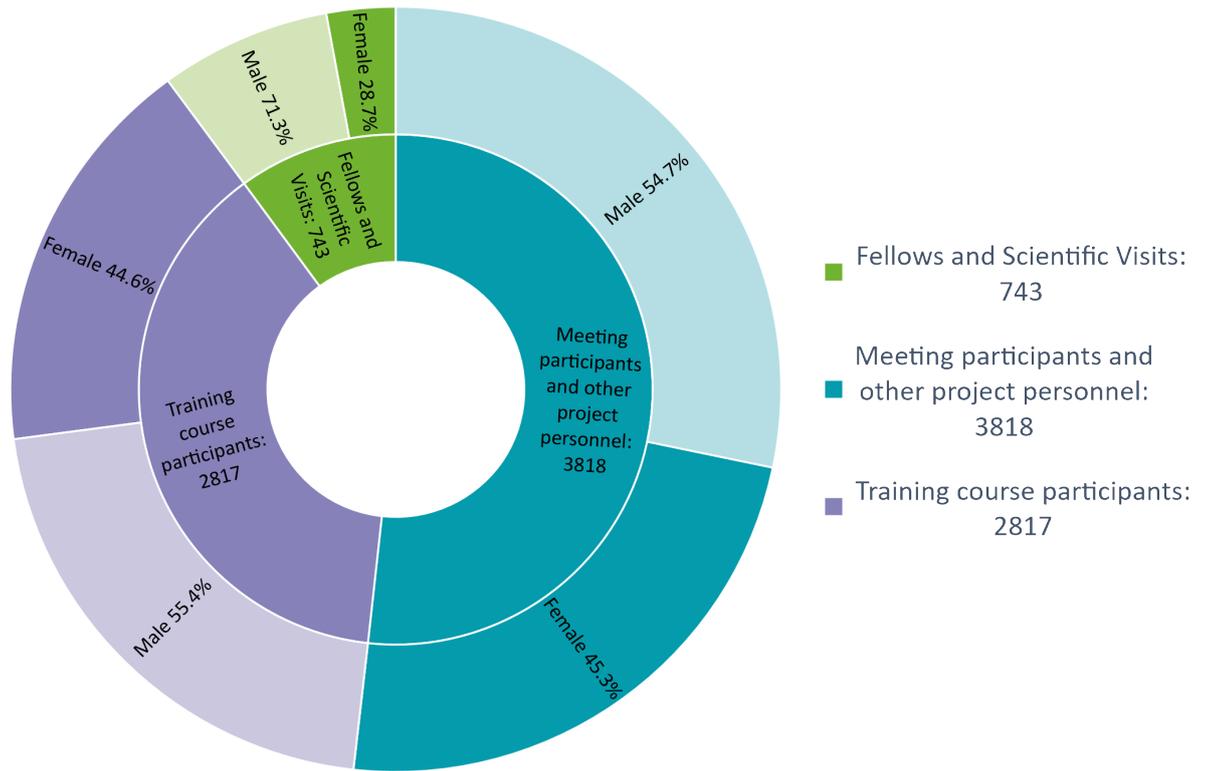


Figure 2: Male/female participation in the TC programme.

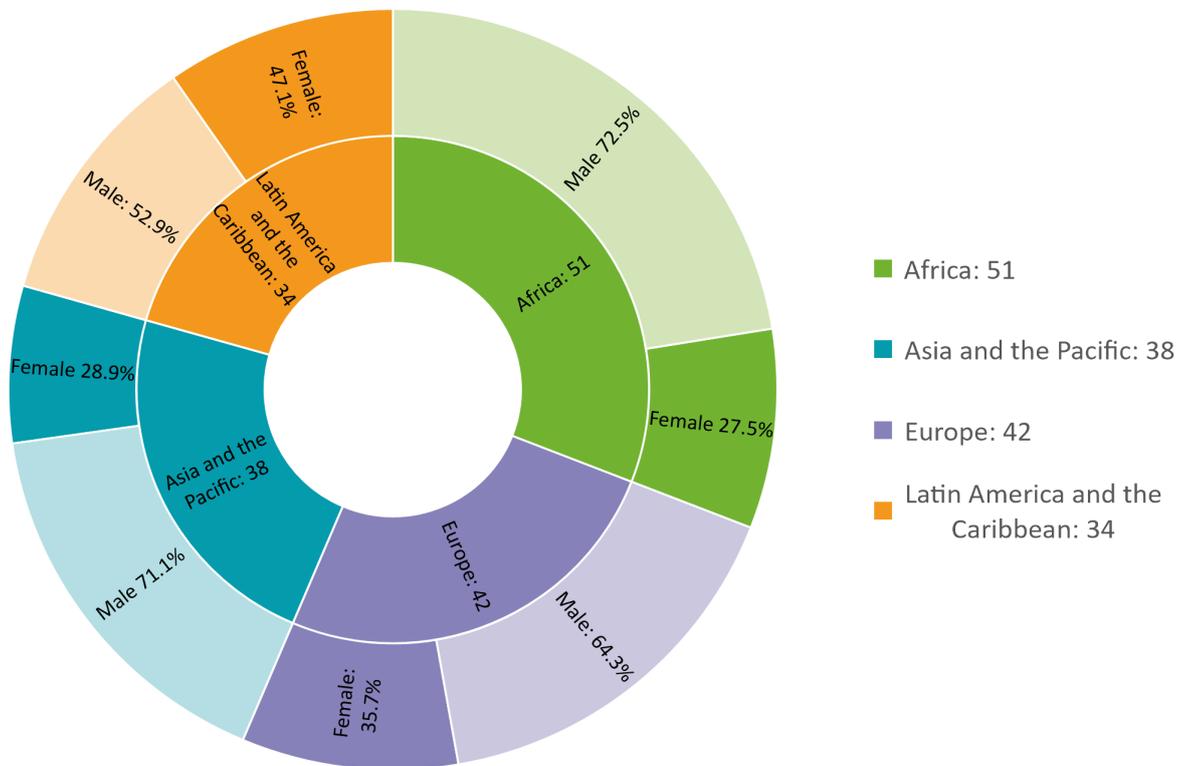


Figure 3: Percentage of male and female NLOs by region.

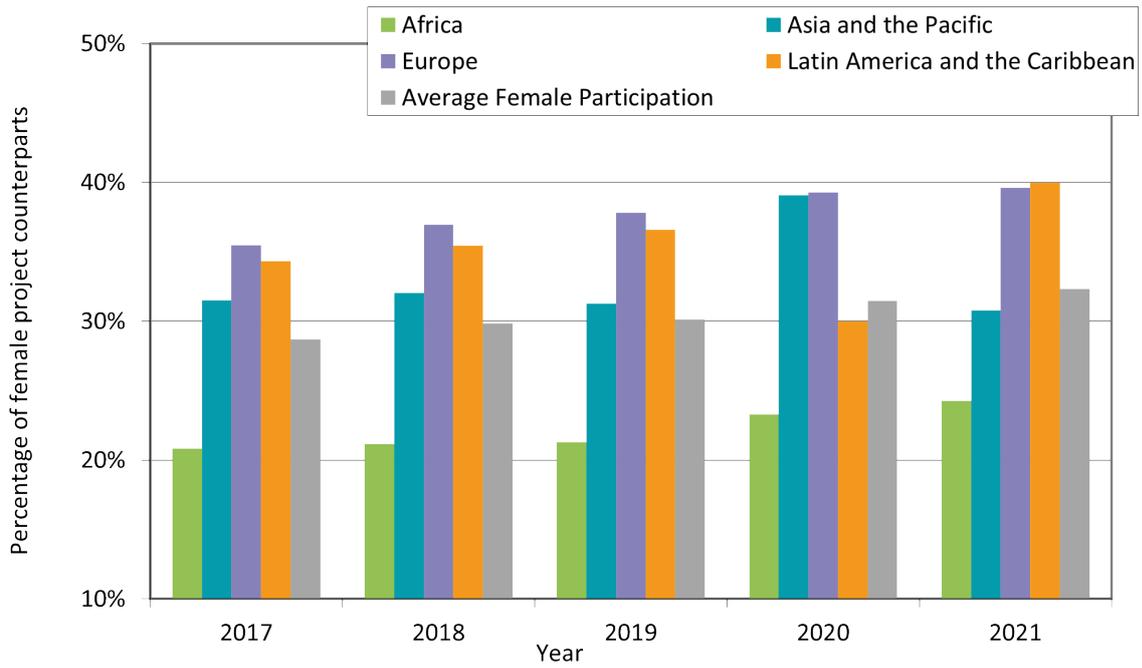


Figure 4: Female project counterparts by region, 2017-2021.

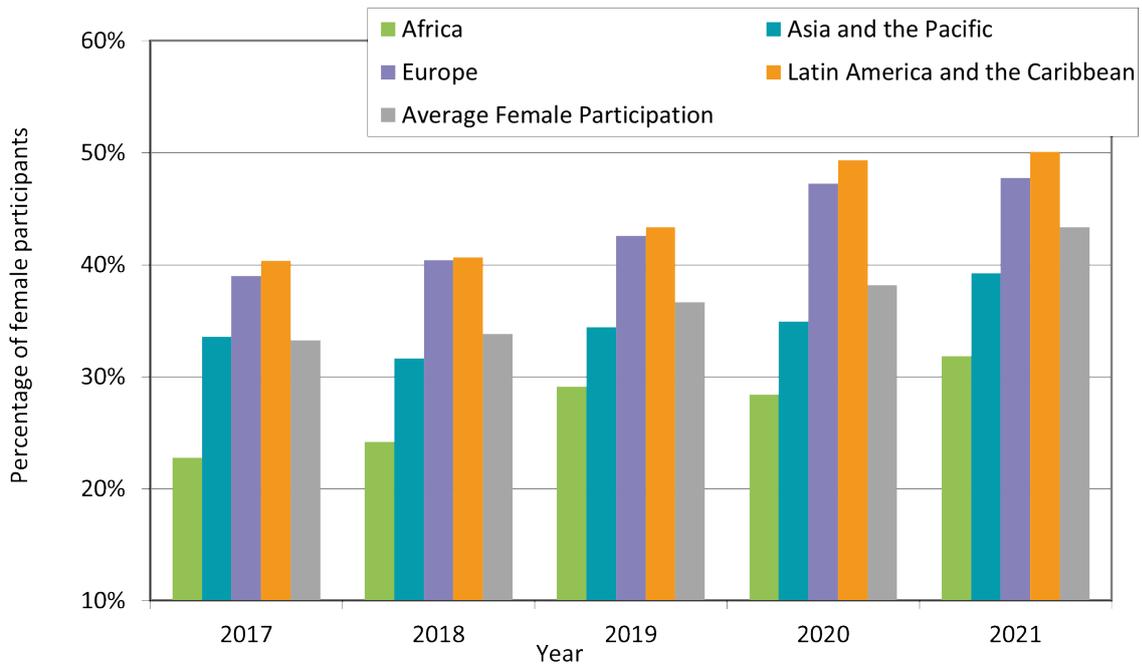
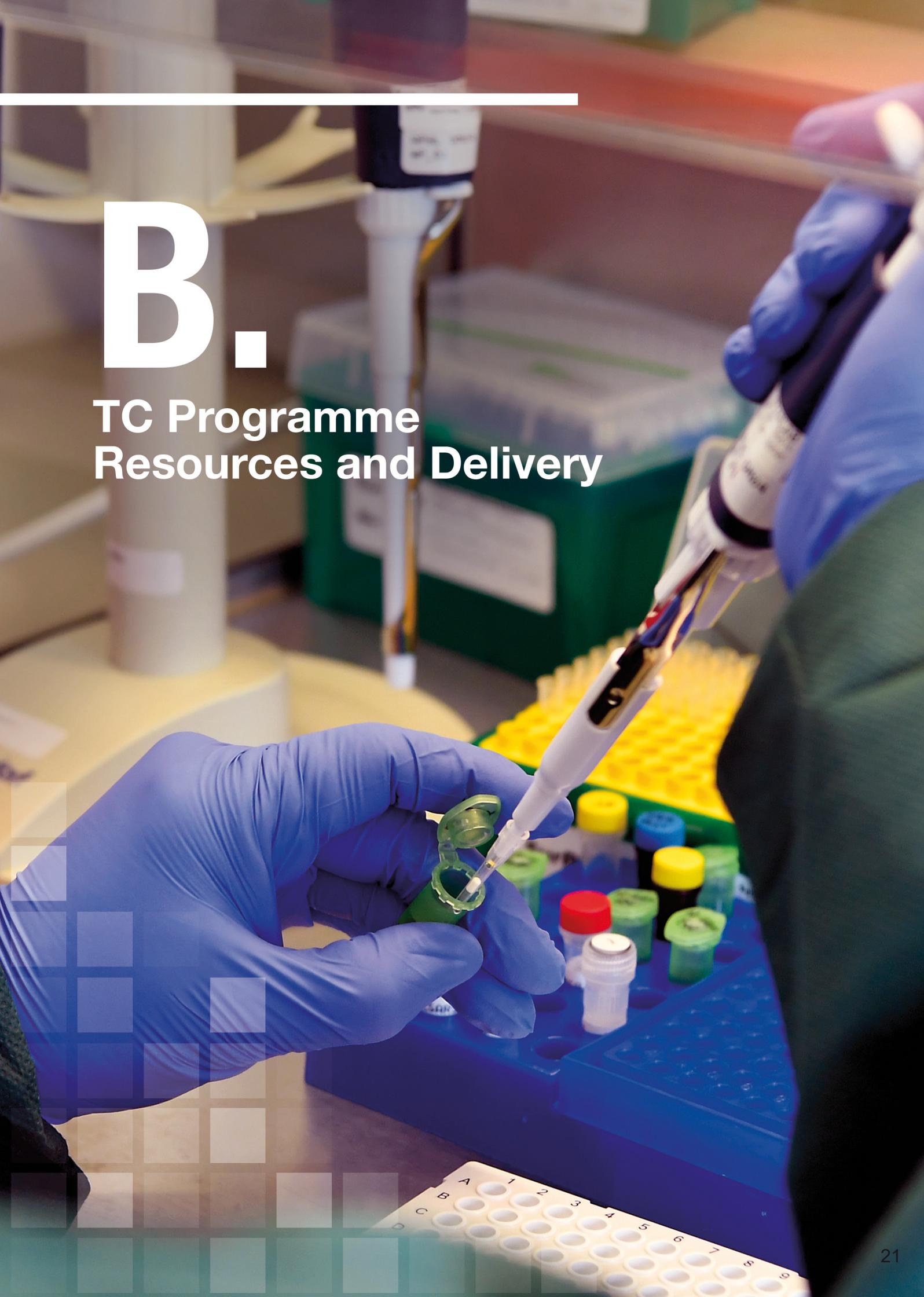


Figure 5: Female participation in training as fellows, scientific visitors, training course participants, meeting participants and other project personnel, 2017-2021.

B.

TC Programme Resources and Delivery



B. TC Programme Resources and Delivery¹¹

B.1. FINANCIAL OVERVIEW

Resources for the technical cooperation programme¹²

At the end of 2021, €86.4 million of the €89.6 million target for the 2021 Technical Cooperation Fund (TCF) had been pledged and €85.3 million in payments had been received. Total TCF resources including National Participation Costs (NPCs), Assessed programme cost (APCs) arrears, and miscellaneous income amounted to €86.4 million (€85.3 million TCF, €0.6 million NPCs, and €0.6 million miscellaneous income). New extrabudgetary resources for 2021 came to €23.5 million and in-kind contributions amounted to €0.1 million. In addition, China and Malta provided in-kind contributions in 2021 to support the Agency's efforts to assist its Member States in combating the COVID-19 pandemic, in the amount of €1.842 million and €0.03 million respectively.

The rate of attainment on pledges as at 31 December 2021 was 96.5% and the rate of attainment on payments on the same date was 95.2% (Fig.6). One hundred and twenty-one Member States, including 17 least developed countries, paid their TCF target in full or partially. Total payments received in 2021 include €182 023 either of deferred or of additional payments by 11 Member States. Excluding these payments, the 2021 rate of attainment on payments would have been 95.0%.

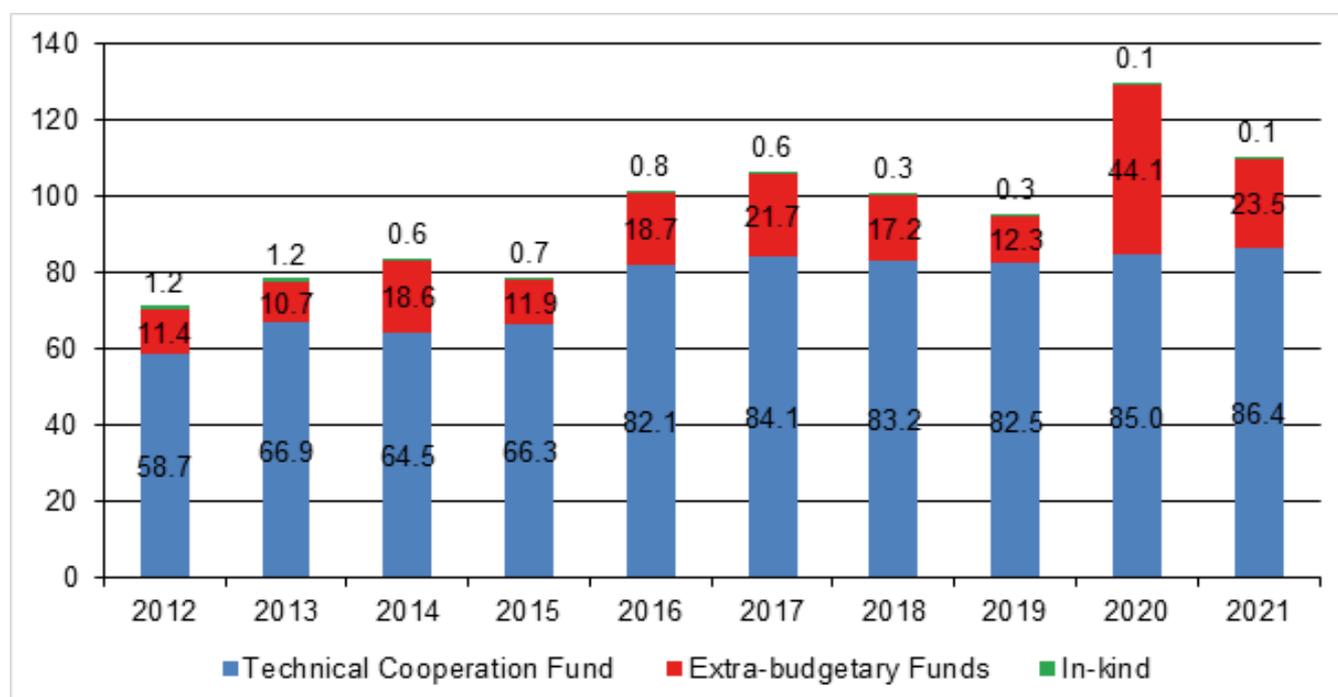


Figure 6: Trends in TC programme resources, 2012–2021.

¹¹ Section B responds to section A.4. Technical cooperation programme resources and delivery, of resolution GC(65)/RES/10, Strengthening of the Agency's Technical Cooperation Programme.

¹² Unless otherwise stated, all figures are denominated in Euros.

Table 1: TC programme resources in 2021

2021 target for voluntary contributions to the TCF	89.6 million
Technical Cooperation Fund, NPC, APC, miscellaneous income	86.4 million
Extrabudgetary resources ¹³	23.5 million
In-kind contributions ¹⁴	0.1 million
Total new resources for the TC programme	110.0 million

Table 2: Payment of National Participation Costs (NPCs) and assessed programme cost (APC) arrears

	Received in 2021	Outstanding payments at end 2021
NPCs	0.6 million	0.5 million
APCs	0 million	0.7 million

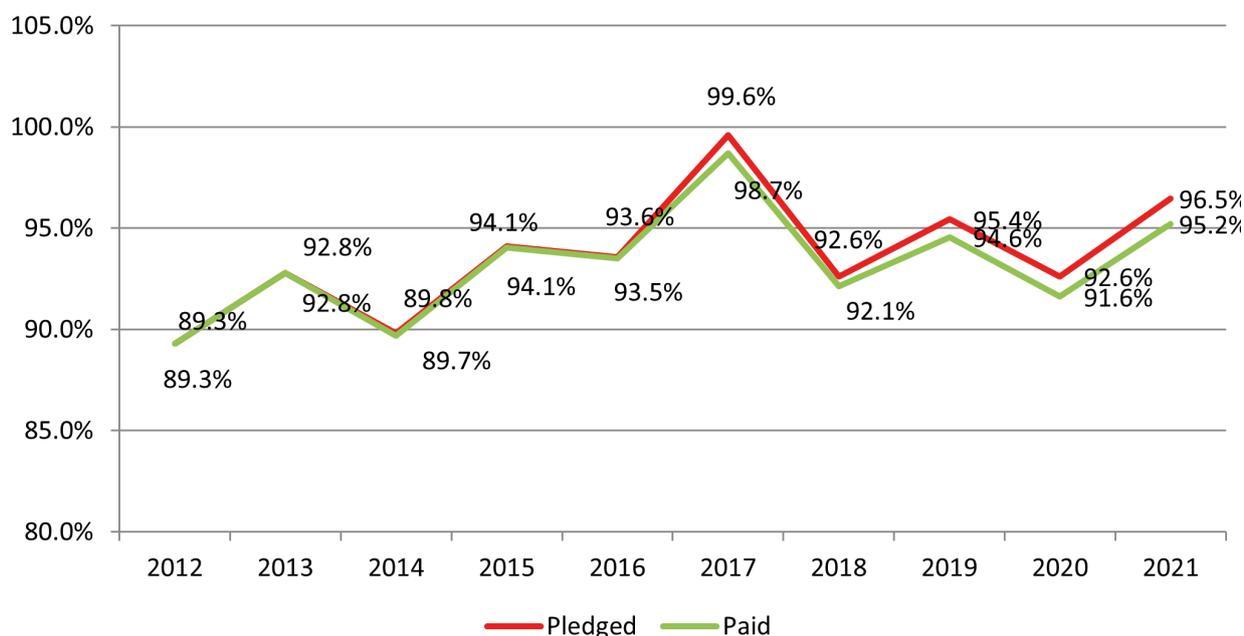


Figure 7: Trends in the Rate of Attainment, 2012-2021.

Extrabudgetary and in-kind contributions

81. Extrabudgetary contributions from all sources in 2021 (donor countries, international and other organizations, government cost sharing) accounted for €23.5 million. The breakdown of the €23.5 million is as follows: €1.8 million funding for activities where the donor is the recipient (commonly referred to as government cost sharing); €21.4 million from donors, of which €15.0 million was received through the Peaceful Uses Initiative mechanism; and €0.3 million from international and bilateral organizations. Fourteen African Member States provided extrabudgetary contributions amounting to €0.3 million for regional technical cooperation projects through the AFRA Fund. More detail is contained in Table 3 (extrabudgetary contributions by donor), Table 4 (government cost sharing) and Table 5 (contributions to PACT). In-kind contributions accounted for €0.1 million.

¹³ Please refer to Table A.5 of the Supplement to this report for details.

¹⁴ In 2021, China and Malta provided in-kind contributions to support the Agency's efforts to assist its Member States in combating the COVID-19 pandemic, in the amount of €1.842 million and €0.03 million respectively.

Table 3: Extrabudgetary contributions (where the donor is not the recipient) allotted to TC projects in 2021, by donor

Algeria	108 504	Monaco	40 000
Belgium	290 000	Morocco	21 134
Benin	7 662	Nigeria	36 534
Bulgaria	20 000	Norway	353 666
Cameroon	12 061	Philippines	4 120
Chile	8 200	Russian Federation	506 000
Cote d'Ivoire	10 000	Senegal	31 219
Czech Republic	98 344	South Africa	148 823
Democratic Republic of the Congo	50 000	Sudan	14 894
France	150 000	Sweden	328 645
Ghana	5 039	Tanzania	3 080
Japan	6 896 000	Uganda	1 484
Jordan	69 936	United States	12 314 287
Korea, Republic of	160 069	Zambia	1 844
Malaysia	10 000	Zimbabwe	20 000
		Total	21 721 544

Table 4: Funding where the donor is the recipient (Government cost sharing) allotted to TC projects in 2021

Bahrain	1 043 210	Senegal	45 000
Bosnia and Herzegovina	17 000	Slovenia	20 000
Cameroon	508 725	Sudan	21 813
Costa Rica	24 720	Ukraine	359
Morocco	74 950		
		Total	1 755 777

Table 5¹⁵: Extrabudgetary contributions resulting from PACT resource mobilisation efforts, 2021

Member State	Amount
France	100 000
Monaco	40 000
Russian Federation	131 000
Sweden	299 573
United States	4 732 160
Total	5 302 733

¹⁵ Funds presented under Table 5 are already reported in Table 3 above under the respective Donors. Some contributions are made directly to PACT activities and some to activities of regional divisions. In 2021, PACT mobilized in-kind contribution of €89,244 from Varian Medical Systems for cancer control activities to be implemented in 2022.

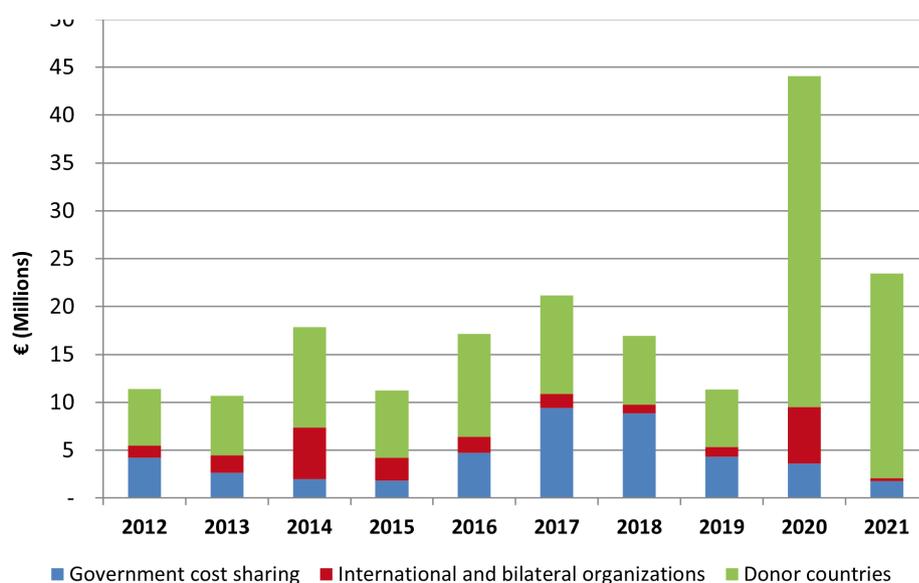


Figure 8: Trends in extrabudgetary contributions by donor type, excluding contributions to PACT, 2012–2021.

B.2. DELIVERING THE TECHNICAL COOPERATION PROGRAMME

Financial implementation

TC programme delivery is expressed in both financial and non-financial terms. Financial delivery is articulated in terms of actuals¹⁶ and encumbrances. Non-financial delivery (i.e. outputs) can be expressed numerically in terms of, for example, experts deployed, training activities, and purchase orders obligated.

Financial implementation for the TCF, measured against the budget for 2021 as at 31 December 2020, reached 84.1% (Table 6).

Table 6: TCF financial indicators for 2019, 2020 and 2021

Indicator	2019	2020	2021
Budget allotment at year end ¹⁷	€123 376 365	€116 306 630	€122 435 851
Encumbrances + actuals	€109 937 361	€93 473 177	€102 940 738
Implementation rate	89.1%	80.4%	84.1%

Unallocated balance

At the end of 2021, the unallocated balance¹⁸ amounted to €1.1 million. €12.9 million were received as advance payments for the 2022 TCF in 2021. Some €0.1 million¹⁹ of cash is held in non-convertible currencies which cannot be used in the implementation of the TC programme.

¹⁶ Actuals are the equivalent of disbursements in line with the terminology in use since the implementation of the Agency-wide Information System for Programme Support (AIPS/Oracle).

¹⁷ 2021 budget allotment at year end includes carry-over from previous years of €7.4 million, already allotted to projects.

¹⁸ Total funds not allocated in 2021 were allocated to TC projects in 2022.

¹⁹ €15,580, rounded to 1 decimal point millions.

Table 7: Comparison of the unallocated balance of the TCF

Description	2020	2021
Unallocated balance	-	1 086 966
Advance payment in 2020 and 2021 for TCF for following year	12 897 556	12 884 788
Non-convertible currencies that cannot be utilized	1 514 657	15 580
Currencies that are difficult to convert and can only be used slowly	223 167	522 890
Adjusted unallocated balance	14 635 380	14 510 225

Human resources and procurement

Human resource and procurement indicators show the non-financial delivery of the TC programme. Regarding procurement, a total of 2 320 purchase orders were issued in 2021.

Table 8: Delivery of outputs: non-financial indicators for 2021

Indicator	in person	virtual
Expert and lecturer assignments	644	1 042
Meeting participants and other project personnel	321	3 497
Fellowships and scientific visitors in the field	732	11
Training course participants	372	2 526
Regional and interregional training courses	16	103

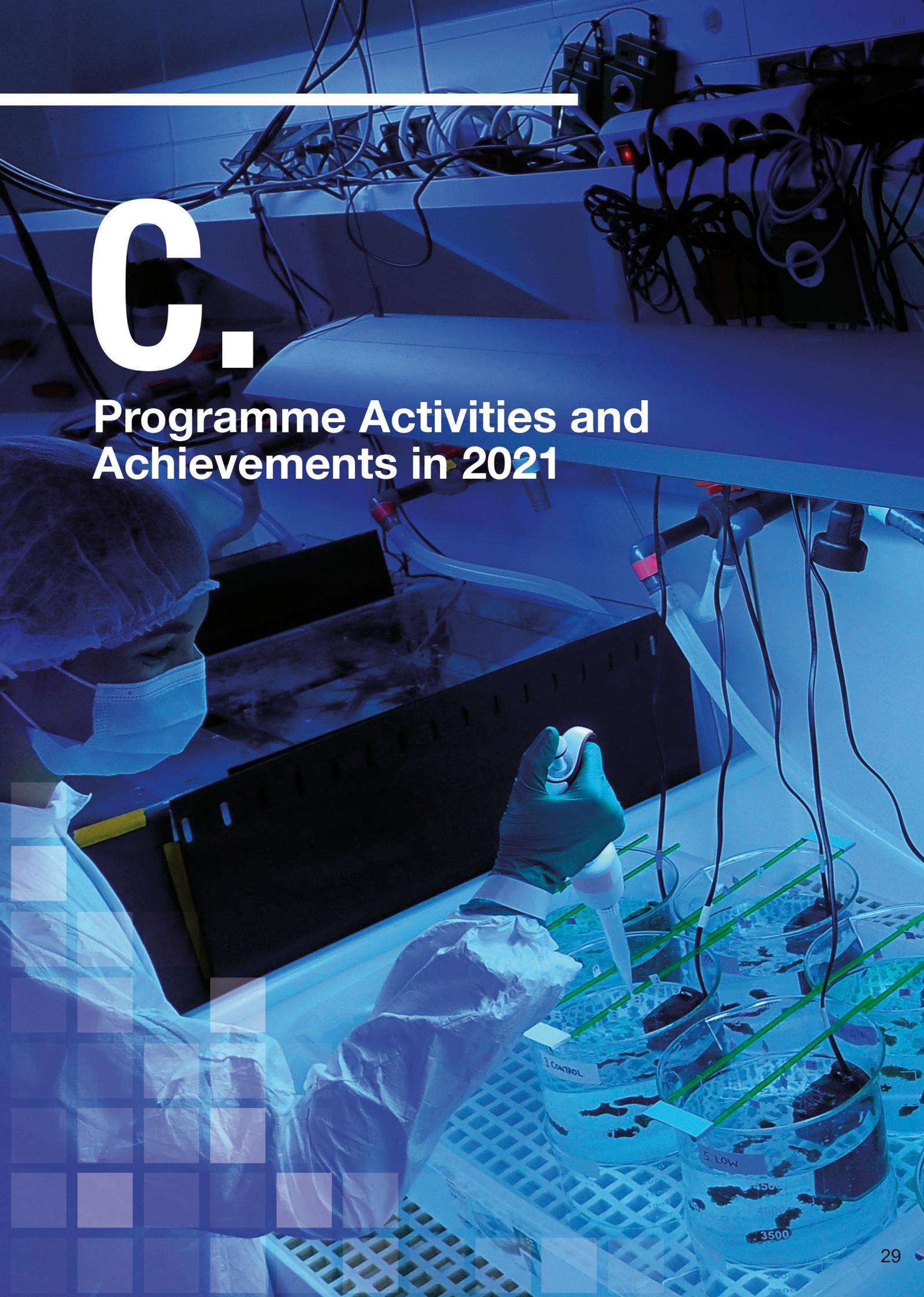
Table 9: TC procurement in 2021

Division	Requisitions	Purchase orders issued	Value of purchase orders issued
TCAF	634	683	19 506 064
TCAP	518	468	12 642 735
TCEU	325	366	9 754 146
TCLAC	460	800	22 208 213
PACT	2	3	48 325
Total	1 939	2 320	64 159 484

At the end of 2021, 973 projects were active, and an additional 445 projects were in the process of being closed. During 2021, 158 projects were closed. Seven projects were cancelled in consultation with the relevant Member State.

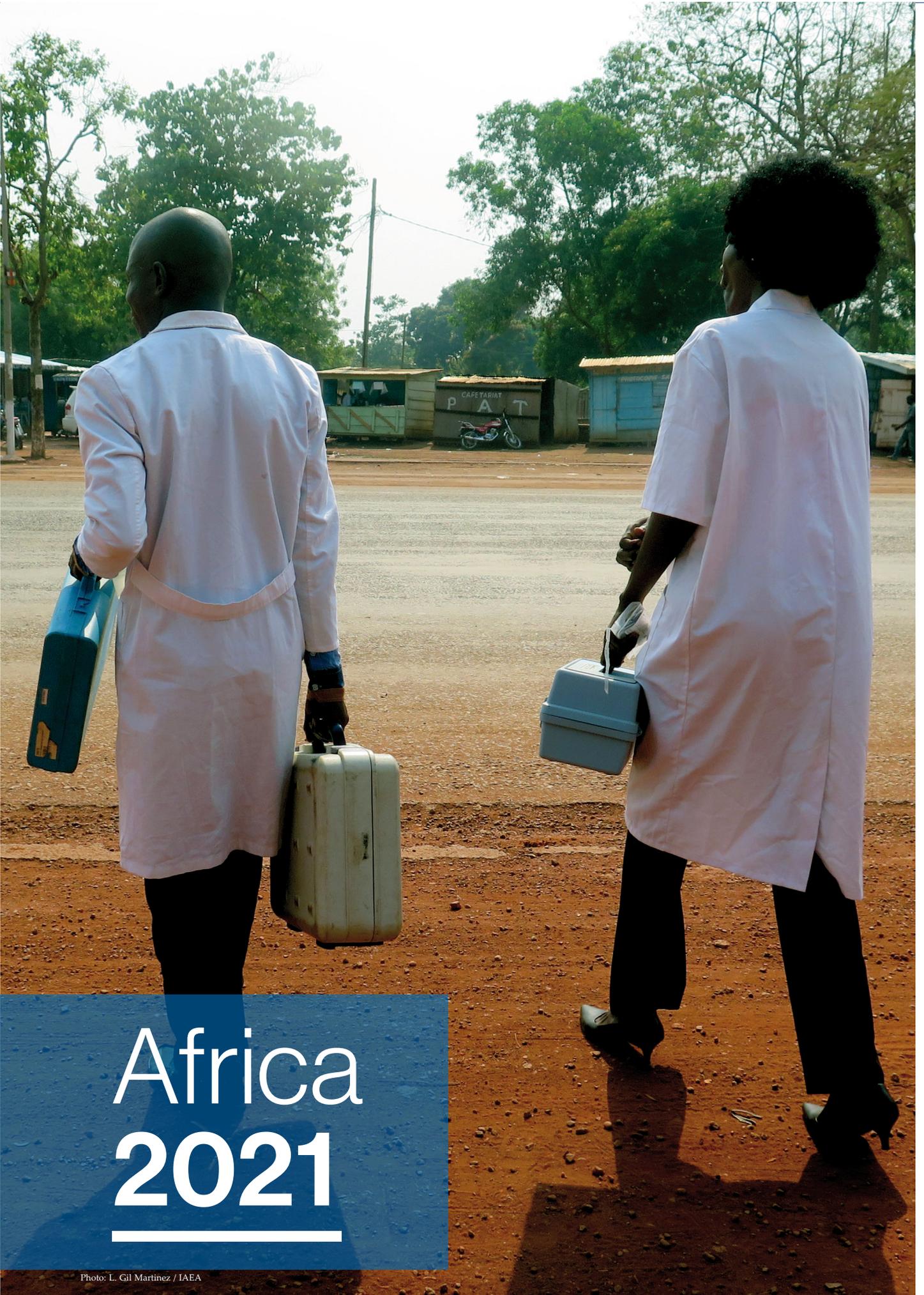
Programme Reserve projects

No Programme Reserve projects were requested in 2021.



C.

Programme Activities and Achievements in 2021



Africa 2021

Photo: L. Gil Martinez / IAEA

C. Programme Activities and Achievements in 2021²⁰

C.1. AFRICA

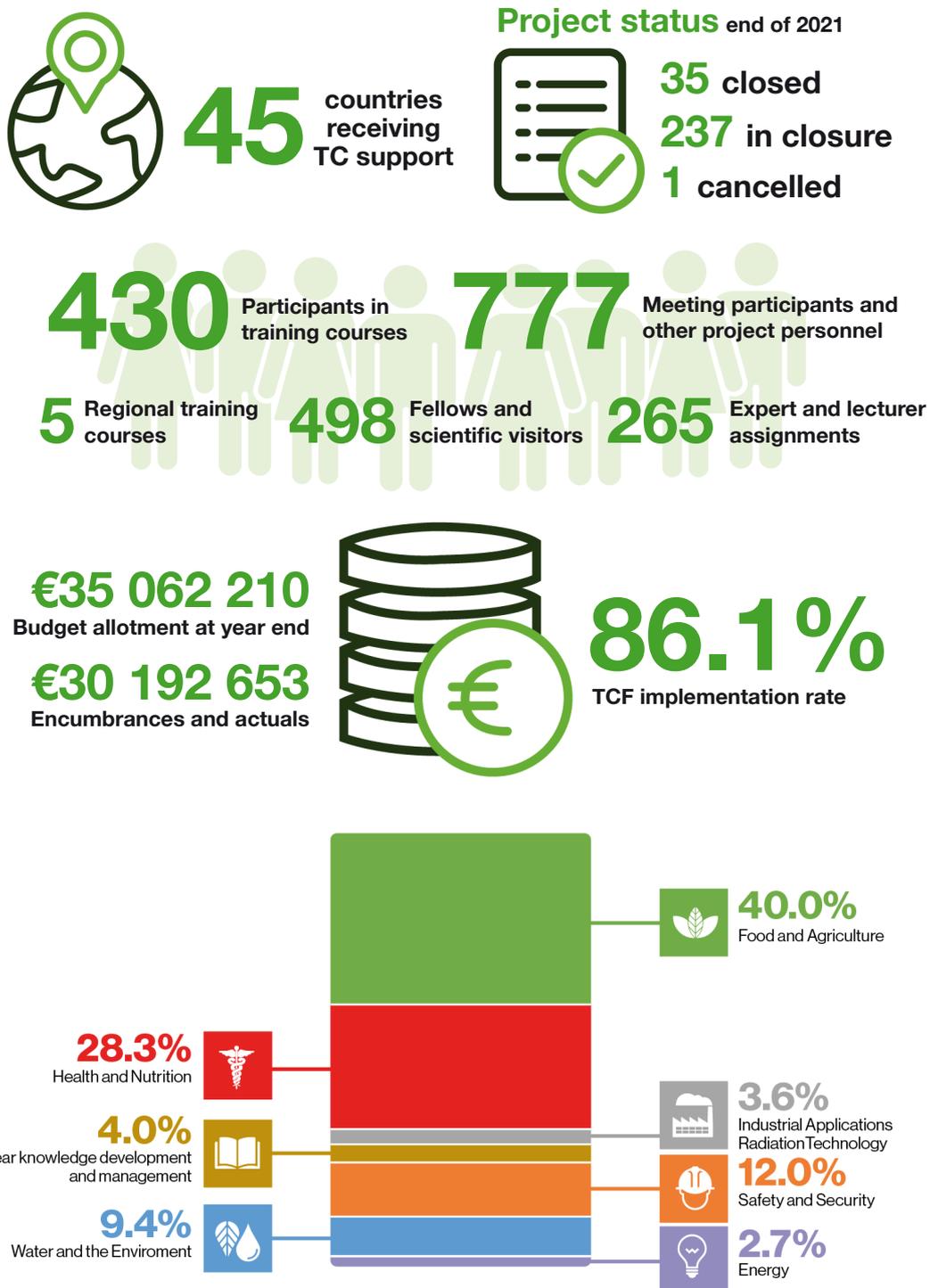


Figure 9: Actuals in the Africa region in 2021 by technical field.

²⁰ Section C responds to section A.1. General, section A.2. Strengthening technical cooperation activities, and Section B. Programme of Action for Cancer Therapy, of resolution GC(65)/RES/10, Strengthening of the Agency's Technical Cooperation Programme.

Regional highlights in Africa

in 2021, 45 Member States in the Africa region, of which 26 were least developed countries, participated in the TC programme through 319 national projects and 48 regional projects. The programme achieved an implementation rate of 86.1%.

Nine Member States signed CPFs in 2021. Rwanda established its nuclear regulatory body during 2021.

The delivery of the programme, especially the human resources component, continued to be affected by the travel restrictions resulting from the COVID-19 pandemic. Many training courses with a strong hands-on nature could not be implemented. As needed, workplans were adjusted. Where possible, fellowships, particularly long-term, continued to be implemented. Virtual meetings and training courses were used to continue capacity building as much as possible.

Close collaboration between Agency personnel and national and regional stakeholders in developing project designs for the 2022-2023 cycle resulted in 181 (163 national and 18 regional) new approved projects.

The annual meeting of NLOs was held virtually in March 2021. Participants considered important regional issues such as the challenges and lessons learned in delivering the programme during the pandemic, promoting women in nuclear science and technology, partnerships in the TC programme in Africa, and strategic aspects of key thematic areas in support of the realisation of the 2030 Agenda.

Two joint UNIDO-IAEA projects on food safety and climate resilient crops have been designed. The two organizations will mobilize resources for their implementation.

Dialogue with the United Nations Office of the Special Adviser on Africa (UN-OSAA), through participation in meetings of the Interdepartmental Task Force on African Affairs (IDTFAA) at the technical and principal levels, has focused on support to the implementation of the AU-UN Framework for the Joint Implementation of Agenda 2030 and the 2063 Agenda to maximize the impact of recovery efforts in Africa, highlighting energy as a key enabler for the achievement of the Sustainable Development Goals.

CPFs signed in Africa in 2021	
Burundi	Madagascar
Djibouti	Malawi
Egypt	Mali
Ghana	Niger
Zambia	

Project highlights

Burundi has been challenged with low livestock productivity due to a high prevalence of transboundary animal and zoonotic diseases, low genetic performances, and inadequate animal feeding. Given the importance of livestock in supporting the livelihoods of farmers and consumers, improving laboratory diagnosis has helped veterinary services in Burundi to develop and maintain safe, effective, and efficient animal health-management systems. Through national project BDI5002, 'Improving Animal Production Through Enhanced Application of Nuclear and Related Techniques', Burundi has upgraded the capacity of the national veterinary laboratory and several technicians have been trained in laboratory diagnostics, laboratory management, and epidemiology. Sample analyses have increased from 1000 samples per year to above 5000 samples per year. During the first outbreak of Peste des petits ruminants (PPR) in Burundi, and within the framework of regional project RAF5082, 'Enhancing Veterinary Diagnostic Laboratory Biosafety and Biosecurity Capacities to Address Threats from Zoonotic and Transboundary Animal Diseases (AFRA)', the laboratory was able to analyse more than 4000 samples in two weeks for post vaccination sero-monitoring.

Niger, under national project NER6006, 'Establishing a Radiotherapy Facility,' established the Centre National de Lutte contre le Cancer, its first ever radiotherapy centre, and began treating cancer patients in November 2021. The country has a high incidence of breast and



Laboratory technicians at the Central Veterinary Laboratory, Burundi (Photo: Canesius Nkundwanayo)

cervical cancers. The new facility will contribute to the improvement of the quality of life of cancer patients in Niger.

With the support of regional project RAF6054, 'Strengthening and Improving Radiopharmacy Services (AFRA)', the first four qualified radiopharmacists from the Francophone countries of Burkina Faso, Cote d'Ivoire, the Democratic Republic of the Congo, and Mauritius were awarded an MSc degree in radiopharmacy within the framework of the IAEA-established programme in Morocco. An additional four radiopharmacists from Ethiopia, Kenya, Uganda, and Zambia completed their MSc degrees in South Africa. The project also supported the establishment of the African Association of Radiopharmacy.

The thirteen participating countries in regional project RAF7019, 'Adding the Groundwater Dimension to the Understanding and Management of Shared Water Resources in the Sahel Region', have, as of December 2021, collected data from 1950 sampling points. Analyses for stable oxygen and hydrogen isotopes have been carried out for all of these points. Selected samples were also analysed for tritium and carbon-14 (C-14) providing further insight into the age of the waters. A tritium map, including data from the 1960s to the present day, was developed to indicate water vulnerability and shared with the UN High Commission for Refugees (UNHCR) as an input to modelling potential future conflict areas in the Sahel. A growing number of samples has been analysed for nitrogen-15 (N-15), giving information on water quality and pollution. The IAEA Water Availability Enhancement (IWAVE) process has been initiated in Mauritania – the ninth participating country to undergo this process. Final technical reports on this phase of the Sahel water project are expected to be completed in 2022.



Radiotherapy treatment services have started in Niger (Photo: Dr Mostafa Malam Abari/CNLC)

Regional cooperation

The 32nd AFRA Technical Working Group Meeting (TWGM) took place in virtual format in July 2021. In accordance with AFRA guidelines and procedures, participants discussed the performance of the AFRA programme and made recommendations to improve its delivery and effectiveness. Among these recommendations, AFRA State Parties were invited to establish human resource development plans for nuclear science and technology, linked to their respective National Development Plan (NDP) and CPF.

The 32nd Meeting of AFRA Representatives was held virtually and on-site in Vienna at IAEA Headquarters in September 2021, prior to the 65th Regular Session of the IAEA General Conference. The meeting, attended by over 120 high-level representatives of AFRA State Parties, including 21 ambassadors and representatives of the Vienna-based African Group, endorsed the recommendations of the 32nd AFRA TWGM. State Parties were encouraged to identify more regional training centres that can be used to meet the growing training needs of the continent, in line with the objectives of the AFRA Agreement. The AFRA Annual Report for 2020 was approved at the meeting, and Rwanda was endorsed as the host of the 33rd TWGM in July 2022. At the meeting, representatives also approved the composition of the new AFRA management committees, which for the first time will be made up of 60% women. The new committees held their first meeting in November 2021.

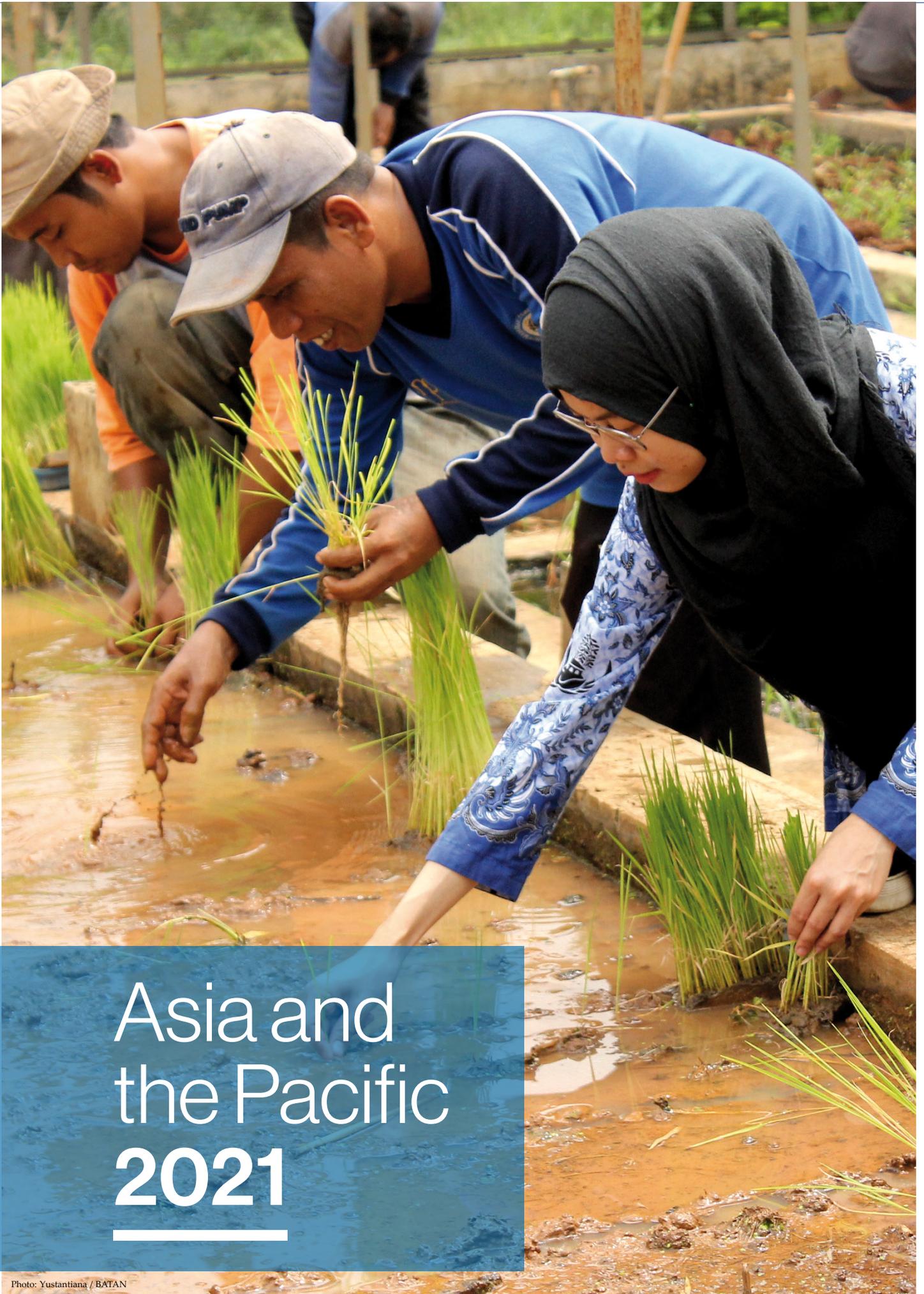
"The meeting, attended by over 120 high-level representatives of AFRA State Parties, including 21 ambassadors and representatives of the Vienna-based African Group, endorsed the recommendations of the 32nd AFRA TWGM."

Contributions to the AFRA Fund

The total contribution of AFRA State Parties to the AFRA Fund came to €348 461, demonstrating the Parties' continued commitment to AFRA activities and regional ownership of the programme. The funding will be allotted to AFRA regional projects in 2022 to support the implementation of unfunded activities.

Table 10: Voluntary contributions to the AFRA Fund for TC activities, 2021

Country	Amount received	Country	Amount received
Algeria	43 504	Senegal	31 219
Benin	7 662	South Africa	148 823
Cameroon	3 244	Sudan	14 894
Cote d'Ivoire	10 000	Tanzania	3 080
Ghana	5 039	Uganda	1 484
Morocco	21 134	Zambia	1 844
Nigeria	36 534	Zimbabwe	20 000
		TOTAL	€348 461



Asia and the Pacific **2021**

Photo: Yustantiana / BATAN

C.2. ASIA AND THE PACIFIC

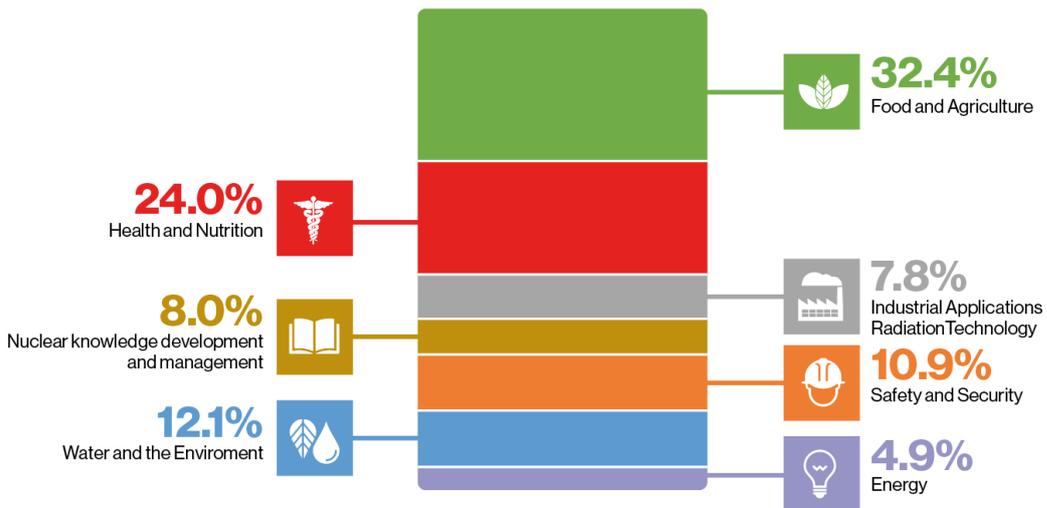
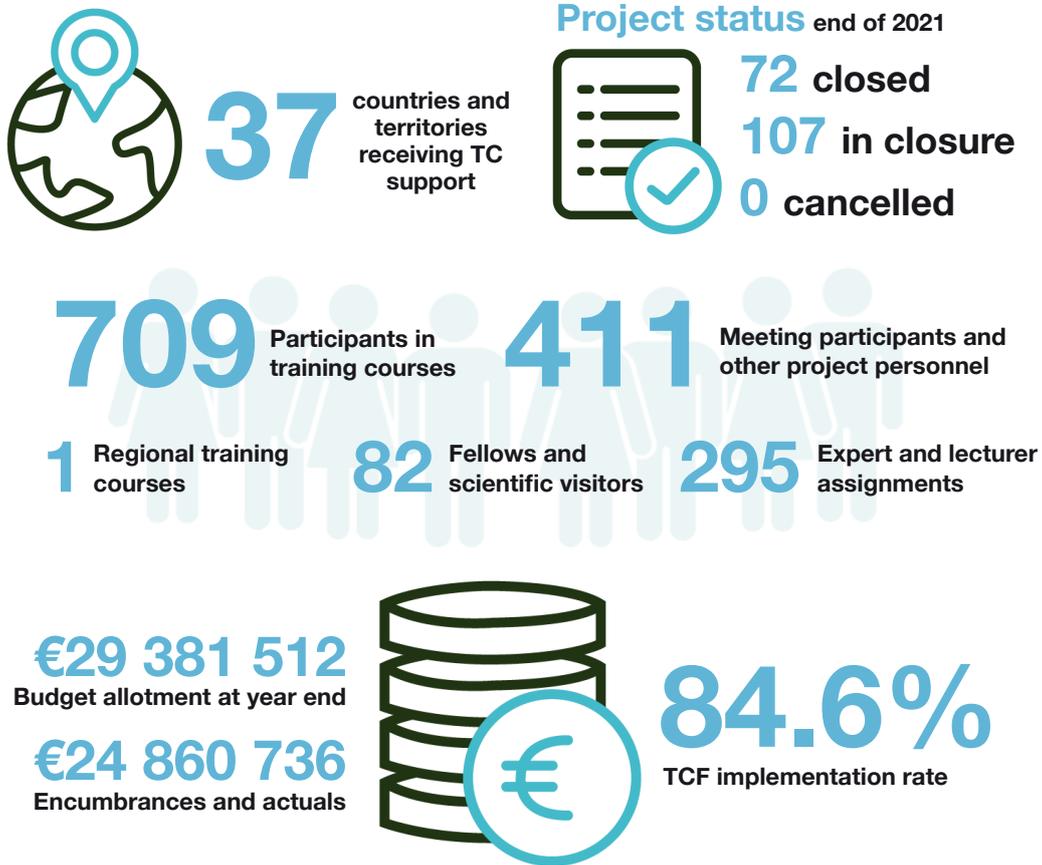


Figure 10: Actuals in the Asia and the Pacific region in 2021 by technical field.

Regional highlights in Asia and the Pacific

In 2021, the TC programme in Asia and the Pacific enhanced the capabilities of 37 Member States and territories, including seven Least Developed Countries and six Small Island Developing States, through 239 national and 59 regional projects. The programme achieved an implementation rate of 84.6% in the region.

Four countries in the region signed CPFs in 2021, and substantial progress was made in the initiation and drafting of CPFs for Fiji, Malaysia, Mongolia, Myanmar, Papua New Guinea, Qatar, Saudi Arabia, Thailand and Viet Nam, to be signed in 2022.

Throughout 2021, the TC programme in Asia and the Pacific focused on the key thematic areas of food and agriculture, human health and nutrition, radiation and nuclear safety infrastructure, and water and the environment.

The Sub-regional Approach to the Pacific Islands (SAPI) was finalized. The programme will be implemented in the 2022–2023 TC cycle as a framework for the delivery of TC assistance within several mutually agreed, high priority focus areas, and will address common capacity building and development concerns in the Pacific Islands. The virtual launch event in December 2021 brought together 30 NLOs, NLAAs and counterparts from the Pacific Islands to discuss the final aspects of the programme, and ensured that SAPI complemented national programmes and would optimize the delivery and impact of the TC programme. SAPI will provide opportunities for partnerships, and will enhance coordination between the islands, providing more efficiency and value for money while still addressing the development needs of all countries. The needs of Small Island Developing States in the Asia and the Pacific region, including Fiji, Marshall Islands, Palau, Papua New Guinea, and Vanuatu, are being addressed through SAPI. The approach will also be used to support Samoa, which became a Member State of the IAEA in 2021.

Project highlights

The TC programme continued to support the Asia and Pacific region in addressing SDG 4 on quality education through several activities under regional project RAS0079, ‘Educating Secondary Students and Science Teachers on Nuclear Science and Technology’. The International Nuclear Science and Technology Academy (INSTA), a regional educational initiative supported by the Agency, was launched, including a pilot programme for a tertiary level 6-month training course, in 2021. The academy facilitates linkages among academic institutions and stakeholders so that resources can be shared and optimized to advance nuclear science and technology (NST) education. INSTA fosters educational programmes and platforms to address current and emerging needs for NST education and organizes

activities to engage and motivate NST educators and stakeholders. The Academy also contributes to global nuclear human resources development through regional and interregional collaboration to empower educators and advance NST education programmes at the tertiary level.

A Virtual Nuclear Science and Technology (NST) Education Exhibition Competition was held in December, also with the support of RAS0079. Thirty-seven schools and institutions of learning in the region took part. Over 200 videos were submitted to the competition, and 20 student and 21 teacher submissions were selected by judges for display at the virtual exhibition. More than 20 000 people from over 100 countries visited the exhibition, part of an extensive online event to encourage secondary school

CPFs signed in Asia and the Pacific in 2021

Marshall Islands

Singapore

Palau

United Arab Emirates



The entry portal for the Virtual Nuclear Science and Technology (NST) Education Exhibition. (Photo: B.Carter/IAEA)

students and teachers to explore the many applications of nuclear science and technology. This competition sparked ideas on how to support adaptation to climate change and other issues of global concern through nuclear applications and helped promote STEM subjects.

Eight educational webinars on NST under RAS0079 took place over the course of 2021 for students, teachers and project counterparts from Asia and the Pacific. The interactive webinars covered topics such as radiopharmaceuticals, history and basics of nuclear science, non-destructive testing (NDT) and radiation safety in industry.

Under regional project RAS5077, 'Promoting the Application of Mutation Techniques and Related Biotechnologies for the Development of Green Crop Varieties', 37 new mutant varieties with desired green traits in different crops have been released. More than 600 advanced stable mutants are undergoing regional multi-location tests prior to release. More than 35 000 mutant lines in M3 generation are under evaluation for desired green traits. Thirteen protocols on mutation induction and screening for target green traits have been developed and circulated for use. More than 120 scientists were trained on the application of mutation techniques and related biotechnologies, which has significantly enhanced the region's capacity to develop crop varieties.

"More than 120 scientists were trained on the application of mutation techniques and related biotechnologies, which has significantly enhanced the region's capacity to develop crop varieties."

Regional cooperation

Despite the challenges of the COVID-19 pandemic, the Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA) programme in 2021 enabled the implementation of regional training courses, meetings and workshops, and expert missions. Two social and economic impact assessments of RCA non-destructive testing (NDT) projects and RCA radiotherapy projects have been finalized. In 2021, the RCA Regional Programme Framework (RPF) for 2024–2029 was finalized. The RPF will be used to guide the formulation and design of future RCA programmes. RCA State Parties agreed to undertake an in-depth feasibility study of the RCA Scholarship Programme, to scope the benefits the programme could bring to strengthening human resources and achieving sustainable development in the region, at the 44th RCA National Representative Meeting in April 2022.

In 2021, ARASIA State Parties adopted a chairmanship selection mechanism, which will be officially reflected in the ARASIA Guidelines and Operating Rules.

The ARASIA Extraordinary Board Meeting was held online and was attended by 40 participants representing all the ARASIA State Parties. The Board also discussed the new TC programme for 2022–2023 and resource mobilization modalities.



Europe 2021

Photo: Scientific Veterinary Institute Novi Sad

C.3. EUROPE



33 countries receiving TC support

Project status end of 2021



21 closed
24 in closure
2 cancelled

602 Participants in training courses

1668 Meeting participants and other project personnel

100 Regional training courses

143 Fellows and scientific visitors

516 Expert and lecturer assignments

€21 274 223
Budget allotment at year end

€17 107 452
Encumbrances and actuals



80.4%
TCF implementation rate

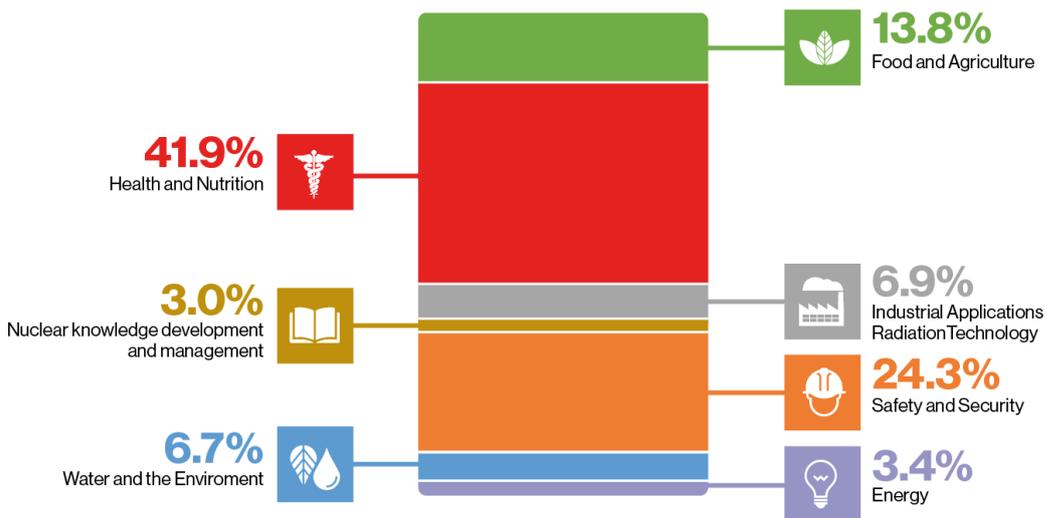


Figure 11: Actuals in the Europe region in 2021 by technical field.

Regional highlights in Europe

CPFs signed in Europe in 2021

Czech Republic	Slovakia
Portugal	Ubekistan

In 2021, the TC programme supported 33 Member States in Europe and Central Asia through 130 national and 39 regional projects. The programme achieved an implementation rate of 80.4% in the region.

Four CPFs were developed and signed in 2021.

In line with Member States' priorities, the TC programme focused strongly on the thematic areas of health and nutrition and nuclear and radiation safety.

Project highlights

While the COVID-19 pandemic meant that most hands-on training courses could not take place, more than 280 medical practitioners in Europe and Central Asia were provided with continuous learning opportunities in the area of radiotherapy through virtual training courses on specialized topics. Courses were offered in partnership with the European Society for Radiotherapy and Oncology (ESTRO) and Inholland Academy. Furthermore, under the financial agreement between the Agency, ROSATOM and the Federal Medical and Biological Agency (FMBA) to support Agency activities through the Programme of Action for Cancer Therapy, the Russian Federation supported four online regional training courses. The courses, held in the Russian language for medical physicists, covered topics such as brachytherapy, intensity modulated radiation therapy, radiobiology and radiation protection and accident prevention in radiation therapy, and were held under regional project RER6036, 'Improving Radiotherapy Practices for Advanced Radiotherapy Technologies Including Quality Assurance and Quality Control'.

In 2021, the Agency supported the implementation of techniques for the detection of designated priority animal and zoonotic diseases under RER5025, 'Improving Early Detection and Rapid Response to Potential Outbreaks of Priority Animal and Zoonotic Diseases'. Online regional training events on advanced molecular techniques for characterization and phylogenetic analysis of bacterial pathogens and on whole genome sequencing platforms and bioinformatic data processing were organized.

CEA Grenoble ARC-Nucléart has supported IAEA technical cooperation activities on cultural and natural heritage in countries around the world for the past 30 years. Under this

"While the COVID-19 pandemic meant that most hands-on training courses could not take place, more than 280 medical practitioners in Europe and Central Asia were provided with continuous learning opportunities in the area of radiotherapy through virtual training courses on specialized topics."



Participants at the cultural heritage preservation workshop in Grenoble, France, visited several museums that use nuclear techniques to conserve and preserve their artefacts. (Photo: IAEA)

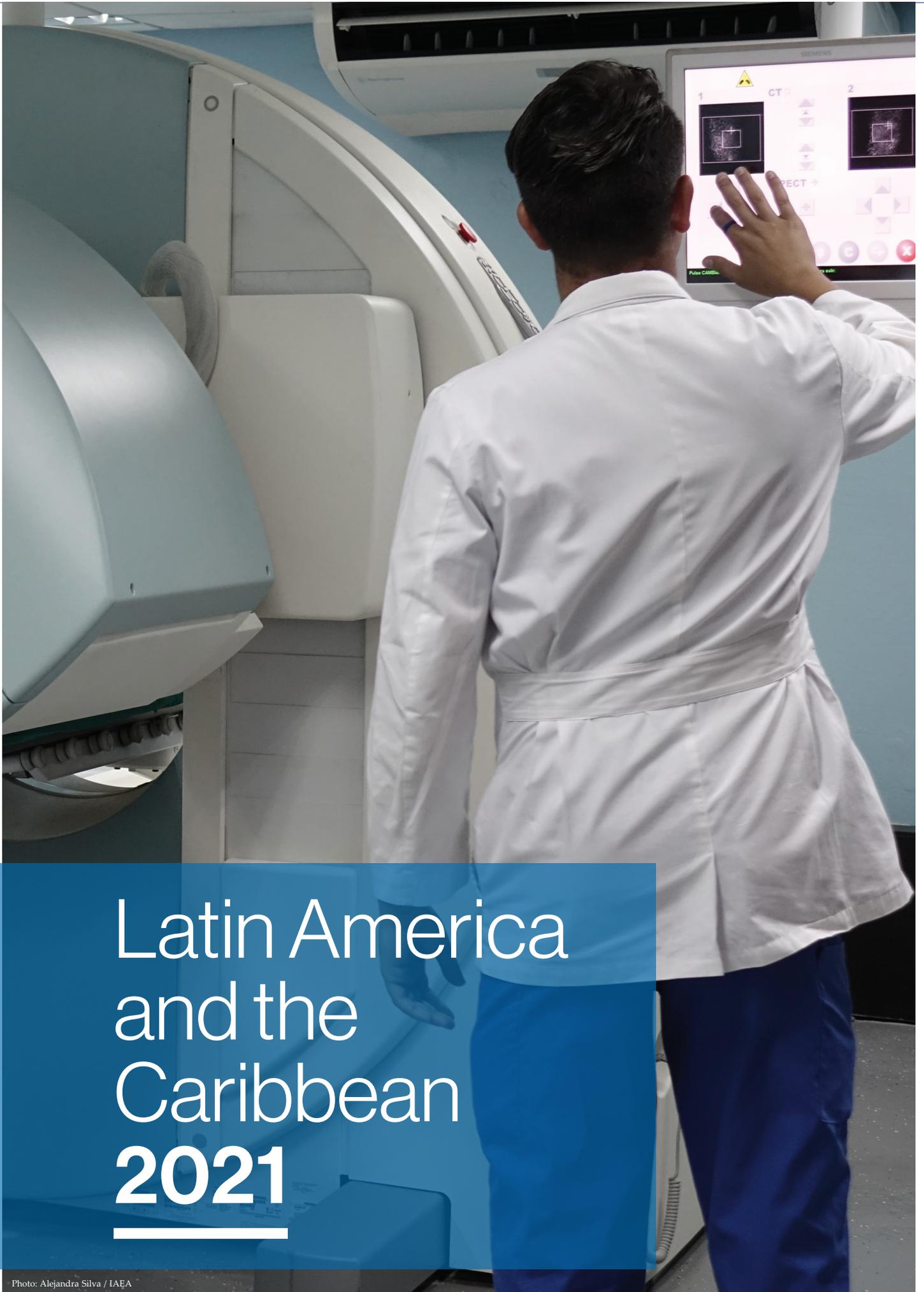
long-standing cooperation, and in conjunction with the 50th anniversary of ARC-Nucléart, a hybrid regional workshop on Radiation Technologies for Cultural Heritage Preservation took place in November, in Grenoble, France. Over 100 participants, including museum curators, conservators and operators of irradiation facilities shared experiences, lessons learned and best practices in the characterization and preservation of cultural and natural heritage artefacts using ionizing radiation. The workshop was organized under RER1021, 'Enhancing the Use of Radiation Technologies in Industry and Environment'.

The Republic of Belarus, the Russian Federation and Ukraine are receiving Agency assistance for the long-term remediation and management of Chernobyl-affected areas through regional project RER7010, 'Improving the Remediation and Management of Terrestrial and Freshwater Environments Affected by Radioactive Material of Chernobyl Origin'. In 2021, the Agency supported the drafting of working materials on the development of national strategies for the long-term safe management of radioactive material as well as an analysis and comparison of national and international legislation and regulations. The project focused on the experience accumulated in the three countries on assuring safe living and economic development of the affected areas, and practices regarding public information. Additionally, services for data and other information processing were initiated to improve the information available in the International Chernobyl Research and Information Network web portal.

Regional cooperation

Implementation of activities in close collaboration with Member States were aligned with the Europe Regional Strategy for 2019–2025, the Europe Regional Profile for 2018–2021), and the priorities identified in CPFs. Participants at the annual NLO meeting held on the margins of the 65th IAEA General Conference agreed to begin updating the Europe Regional Profile. This document defines common needs and priorities in the region that can be addressed using nuclear applications and guides the development and implementation of regional projects in the medium term.

"Over 100 participants, including museum curators, conservators and operators of irradiation facilities shared experiences, lessons learned and best practices in the characterization and preservation of cultural and natural heritage artefacts using ionizing radiation."



Latin America and the Caribbean 2021

Photo: Alejandra Silva / IAEA

C.4. LATIN AMERICA AND THE CARIBBEAN

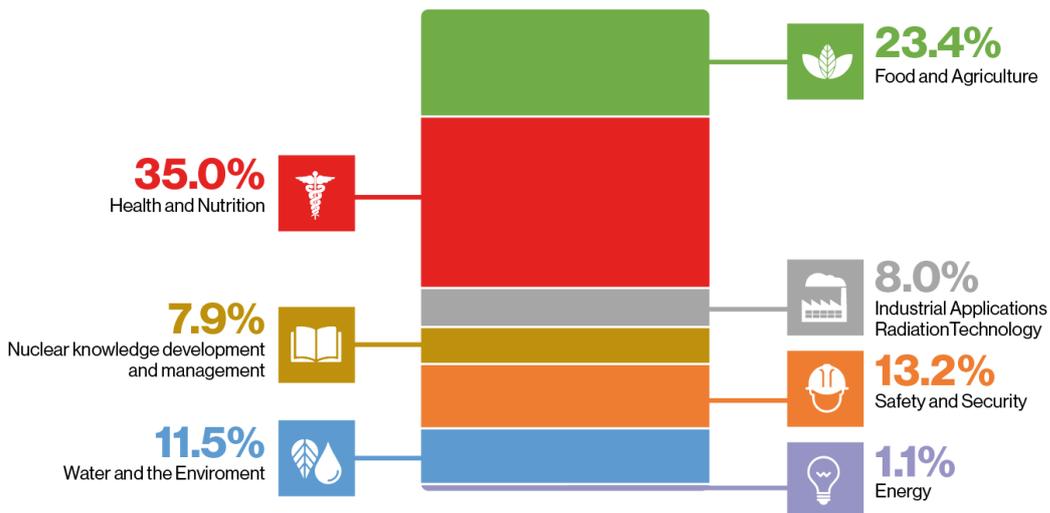
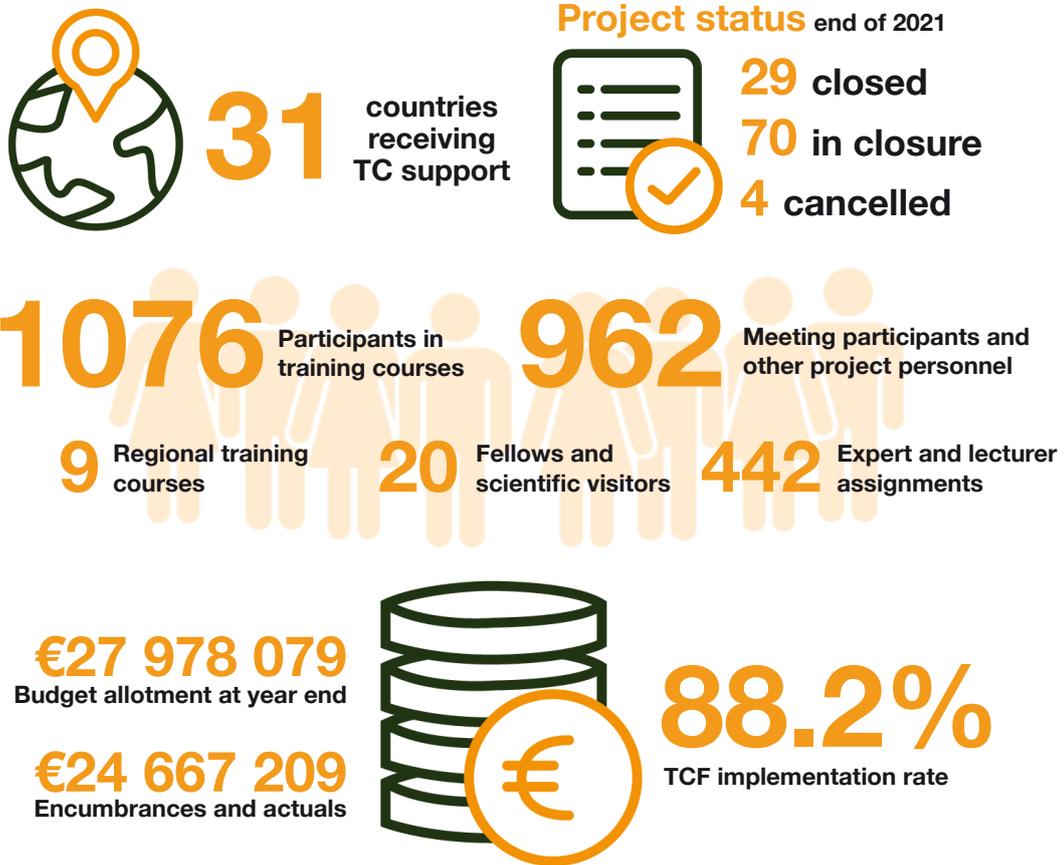


Figure 12: Actuals in the Latin America and the Caribbean region in 2021 by technical field.

Regional highlights in Latin America and the Caribbean

CPFs signed in Latin America and the Caribbean in 2021

Saint Vincent and the Grenadines

In 2021, 31 Member States, including one least developed country (Haiti), were supported through 157 active national projects and 50 active regional projects. The programme achieved an implementation rate of 88.2% in the region.

One Member State signed a CPF.

Project highlights

Within the framework of the regional ARCAL project RLA5068, 'Improving Yield and Commercial Potential of Crops of Economic Importance (ARCAL CL)', Latin American and Caribbean countries are receiving support for the development of climate-resilient and economically viable crops. Mutation breeding techniques rely on radiation to safely accelerate the natural mutation process, leading to the development of new mutant lines and enabling experts to select new crop varieties that meet local needs. National researchers in participating countries have succeeded in using nuclear techniques to develop an herbicide-resistant rice line in Brazil and six improved mutant lines, including tomato in Cuba, quinoa in Peru and potato in Bolivia.



Thanks to nuclear techniques, new tomato varieties were planted and harvested in Cuba in 2021. They have higher yields than the mainstream varieties. (Photos: M.C. Gonzalez-Cepero/INCA)

In Cuba, new improved tomato and soybean varieties (Giron 50 and Cuvin 22) were successfully harvested for the first time in a field trial under RLA5068 in May 2021. They will now be distributed to farmers, along with the 21 other varieties developed earlier by Cuba's National Institute of Agricultural Science (INCA), including rice, green beans and rosellon, a species of hibiscus. The new varieties have been authorized at the national level and subsequently registered in the global database, managed by the Joint FAO/IAEA Center for Nuclear Techniques in Food and Agriculture.

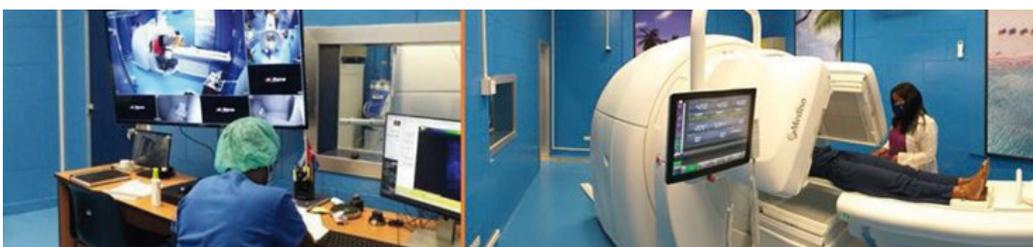
In March 2021, with the support of the Agency under national project BOL5022, 'Reducing Fruit Fly Populations in Different Regions Introducing an Integrated Pest Management Approach Including the Use of the Sterile Insect Technique,' Bolivia launched a pilot project using SIT to suppress and eradicate the Mediterranean fruit fly in selected fruit production sites in the country's lowland valley regions. Bolivia's national agricultural service SENASAG (Servicio Nacional de Sanidad Agropecuaria e Inocuidad Alimentaria) subsequently built a state-of-the-art facility for the packing, holding and release of sterile flies, and counterparts are now receiving follow-up support to expand the use of SIT technology to other fruit producing regions. To support the sustainability of the capacities developed through this project, the Joint FAO/IAEA Centre for Nuclear Techniques in Food



Sterile fly release over commercial peach orchards in Bolivia that are affected by fruit flies. (Photo: SENASAG)

and Agriculture is supporting the drafting and review of manuals on standard operating procedures for the management of fruit flies using SIT.

National project CUB6026, 'Strengthening Capabilities for Non-Clinical and Clinical Evaluation of Radiopharmaceuticals According to Good Practices', led by the Center of Isotopes of Cuba, aims to enhance nuclear medicine diagnosis and therapy services by supporting the production and introduction of new radiopharmaceuticals and molecules in local clinical practice. Under this project, nuclear medicine services have been significantly improved with the procurement and installation of high-tech equipment, including a multi-modality system. The Agency has supported training for staff to support the quality and safety of both non-clinical and clinical research. Standardized operating procedures for non-clinical and clinical research have been created and validated, approved by local scientific committees and implemented in clinical practice. The upgraded facilities and equipment are now being used to evaluate new radiopharmaceuticals. In 2021, medical examinations using hybrid techniques began, and more than 100 patients were treated.



Upgraded nuclear medicine facilities and the new hybrid system in Cuba. (Photo: CENTIS/Cuba)

Isotopic tracing techniques are being applied to improve groundwater management, land planning and land remediation in Argentina with the support of ARG7008, 'Improving Management and Evaluation of Quality and Availability of Water Resources in Certain Regions through the Use of Isotopic Techniques'. Concrete impacts have been achieved in the remediation of mining sites, spatial planning, and the implementation of new tools for water resource management. At Los Gigantes, the site of a former uranium mine, data collected through the project is providing new information on the source of recharge, water age and transit time in the site, groundwater-surface water interactions and dam leakages. This is contributing to engineering designs for the remediation of the site. In the Uspallata-Yalguaraz basins, improved water resource modelling is supporting spatial planning for new activities in the region, including real estate development, agriculture, tourism and mining. A new laboratory equipped with two isotope ratio mass spectrometers and accessories for the measurement of isotope ratios of hydrogen, oxygen, carbon, nitrogen, sulphur and silicon was developed. In 2021, a virtual expert mission took place to support data interpretation in the laboratory and a final review of the project. The facility enables staff to be trained in sampling and measurement of isotope ratios in water bodies, interpretation of hydrodynamic, hydrochemical and isotopic data, and in modelling.

In Brazil, under the framework of national project BRA6029, 'Strengthening Human Resources in Molecular Imaging and Radionuclide Therapy', the Agency procured two mammography units for Navy Hospital Assistance ships, with the goal of increasing much-needed breast cancer screening services for remote Brazilian riverside communities in the Amazon region. The units were installed on Hospital Assistance Ships NAsH (Navio de Assistência Hospitalar) Soares de Meirelles and Carlos Chagas. In October 2021, NAsH Soares de Meirelles started operations as part of the Pink October initiative, focusing on female cancer prevention and successfully performing over 300 mammograms.



The ship Carlos Chagas with a mammography unit on board. (Photo: Navy Nuclear Development Directorate)

Regional cooperation

"In a milestone for the Caribbean, a Steering Committee was established in 2021 to support the implementation of the Regional Strategic Framework (RSF) for 2020–2026 for technical cooperation with IAEA-CARICOM Member States."

In a milestone for the Caribbean, a Steering Committee was established in 2021 to support the implementation of the Regional Strategic Framework (RSF) for 2020–2026 for technical cooperation with IAEA-CARICOM Member States. The Committee will work with the Agency to begin implementing cooperation actions outlined in the RSF in the areas of agriculture and food production, human health, environment, energy, radiation safety and radiation technology. In its inaugural meeting, the Steering Committee adopted a monitoring and evaluation strategy to track the progress of the implementation of the RSF through national and regional projects.

The ten ARCAL projects approved for the 2020–2021 TC cycle continued implementation in 2021. The projects were prepared and adopted by Member States in the region and reflect the shared priorities highlighted in the Regional Strategic Profile for Latin America and the Caribbean for the period 2016–2021. A new Regional Strategic Profile covering the period 2022–2030, titled 'Agenda ARCAL 2030', has been developed for the next phase. During 2021, ARCAL States Parties developed Guidelines for the Implementation of the Agenda ARCAL 2030, which defines all baseline and target indicators for Agenda ARCAL 2030.

At the online XXII Meeting of the ARCAL Technical Coordination Board (OCTA) in May, national ARCAL Representatives discussed actions to implement projects during the pandemic, and issues pertaining to project outreach and impact. The presidency of ARCAL was transferred from Cuba to Peru during the event.

The XXII Meeting of the Board of ARCAL Representatives was held as a hybrid event in Vienna in September and was attended by ARCAL State Party representatives and Spain, as an ARCAL strategic partner, as well by a representative from the African Regional Cooperative Agreement (AFRA). IAEA Director General Rafael Mariano Grossi opened the meeting, highlighting the importance of the Agreement in the achievement of the Sustainable Development Goals in the region and commended its efforts in promoting gender parity. During the meeting, ARCAL representatives endorsed the new projects, which were subsequently submitted to the Board of Governors of the IAEA for approval



Hybrid meeting of Board of ARCAL Representatives (Photo: Dean Calma/IAEA)

C.5. INTERREGIONAL PROJECTS²¹

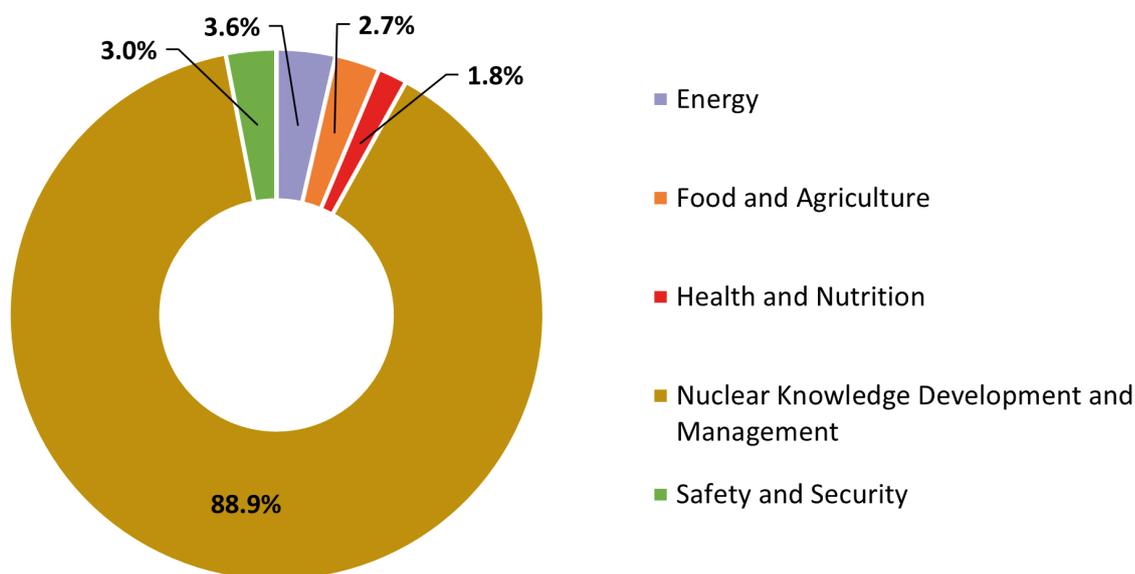


Figure 13: Interregional actuals in 2021 by technical field.

Interregional projects deliver technical cooperation support across national and regional boundaries and address the common needs of several Member States in different regions. In 2021, actuals under interregional projects totalled €14.8 million. Seven interregional projects were in closure status at the end of the year.

Member States around the globe are receiving Agency assistance in creating an enabling environment to facilitate the safe, secure and sustainable introduction or expansion of nuclear power, with the main focus on nuclear infrastructure development and nuclear safety. In 2021, 20 activities were implemented in either virtual or in-person format to share knowledge and experience under INT2021, 'Supporting Member States Considering or Planning to Introduce or Expand Nuclear Power Programmes in Developing the Sustainable National Infrastructure Required for a Safe, Secure and Peaceful Nuclear Power Programme'. Face-to-face events were implemented in collaboration with host institutes in France, Russia and the United Arab Emirates, and 12 virtual events were also supported. Altogether more than 400 participants from countries in Africa, Asia and the Pacific, Europe and Central Asia, and Latin America and the Caribbean were trained under this project in 2021.

Two interregional training activities were organized to build capacity in decommissioning and environmental remediation projects under INT2020, 'Enhancing Capacity Building to Promote Successful Decommissioning and Environmental Remediation Projects'. The first event highlighted the importance of planning and properly managing projects in decommissioning and environmental remediation, including the benefits of applying life-cycle management principles and available project management and planning tools in a transparent manner with appropriate stakeholder engagement. The second activity covered environmental remediation site characterisation and provided an overview of key aspects to support decision-making in the scope of site environmental remediation and management, including elements of design, implementation of data acquisition,

"Altogether more than 400 participants from countries in Africa, Asia and the Pacific, Europe and Central Asia, and Latin America and the Caribbean were trained under this project in 2021."

²¹ The interregional project INT0098, 'Strengthening Capabilities of Member States in Building, Strengthening and Restoring Capacities and Services in Case of Outbreaks, Emergencies and Disasters', through which the IAEA's support to Member States in addressing COVID-19 was delivered, is classified under the Field of Activity 'Nuclear knowledge development and management'.

visualization, and interpretation. The course attendees (26 in total from 18 Member States) came from government organizations, operators and regulators, as well as from academic and research communities.

In 2021, regional kick-off meetings for the Zoonotic Diseases Integrated Action (ZODIAC) initiative began. For a number of laboratories, actions have been initiated to provide equipment packages for serology, molecular diagnostic and Whole Genome Sequencing during the first phase of the project.

At the regional meetings, participants discussed the Agency’s role in addressing zoonotic diseases and examined ways to enhance Member State capacities to predict and prepare for outbreaks. Training including fellowships for Member States receiving genome sequencing equipment as well as group training for those receiving serology and molecular diagnostic equipment are also planned.

Around 150 Member States have designated ZODIAC National Coordinators, and over 120 have designated ZODIAC National Laboratories.

"Around 150 Member States have designated ZODIAC National Coordinators, and over 120 have designated ZODIAC National Laboratories."



ZODIAC National Coordinators Meeting for North, Central, South America and the Caribbean on 25 March 2021 (Photo: O.Yusuf/IAEA)

C.6. PROGRAMME OF ACTION FOR CANCER THERAPY (PACT)

PACT highlights in 2021

In 2021 the Agency, through PACT, supported the efforts of low- and middle-income countries (LMICs) to integrate radiation medicine into national comprehensive cancer control programmes. Activities focused on assessing cancer control capacities, facilitating expert advice for national cancer control planning, assisting with strategic document development and mobilizing resources for cancer-related projects. Inputs were also provided to the design of TC projects for the 2022–2023 cycle, and to twenty-one CPFs under preparation, to link Agency support to comprehensive cancer control efforts.

86 Member States through their Ministries of Health are actively participating in the interregional cancer project INT6064, 'Supporting Member States to Increase Access to Affordable, Equitable, Effective and Sustainable Radiation Medicine Services within a Comprehensive Cancer Control System'. This project facilitates interaction around PACT services through the TC programme. The project allows for targeted interaction with Ministries of Health, in collaboration with WHO and IARC, to understand national cancer control gaps and needs. Counterparts join a community of practice where capacity building webinars on various areas of cancer control and the provision of expert advice are readily accessible.

The 13th International Conference on Cancer in Africa organized by the African Organisation for Research and Training in Cancer (AORTIC) took place in November 2021, bringing together multidisciplinary specialists from the global cancer community and enabling the exchange of ideas between oncology leaders from all over Africa and around the world. The conference offered an opportunity to present the work of the IAEA TC programme with Member States on cancer control related projects. With the support of INT6064, seven scientists from six Member States presented abstracts on advances in integrating radiation medicine for diagnostic or treatment as part of national efforts related to ongoing TC projects.

"86 Member States through their Ministries of Health are actively participating in the interregional cancer project INT6064, 'Supporting Member States to Increase Access to Affordable, Equitable, Effective and Sustainable Radiation Medicine Services within a Comprehensive Cancer Control System'."

imPACT Reviews

The imPACT (integrated mission of PACT) Reviews are designed to support national cancer control planning and decision-making processes along with the mobilization of funds to establish or strengthen cancer services. The imPACT recommendations highlight areas where programmatic interventions to enhance national cancer control systems can contribute, for example, to the establishment of safe radiation medicine practices. In addition to key external partners, the imPACT Review team brings together specialist staff from across the Agency.

In 2021, four Member States received imPACT Reviews (Democratic Republic of Congo, Iraq, Nepal and Uruguay). Reviews were also initiated in Colombia, Syria and Uzbekistan. Conducted upon the request of a country's Ministry of Health, imPACT Reviews draw on the experience and knowledge of the Agency as well as that of international experts nominated by WHO and IARC, covering all areas of cancer control. A hybrid modality is in place for imPACT Review missions, with a virtual component to be complemented by an in-country visit for high-level dialogue and verification where possible.

Honduras and Jamaica received expert advisory support in the follow-up to implementation of imPACT Review recommendations. A multi-disciplinary group of international experts reviewed progress towards the implementation of cancer control recommendations, with the goal of identifying barriers and any additional programmatic

imPACT review missions in 2021

Democratic Republic of Congo	Nepal
Iraq	Uruguay

support required to advance in areas ranging from cancer prevention to palliative care. Additionally, the Agency facilitated support to Sri Lanka in the preparation of a comprehensive radiotherapy plan.

Efforts were deployed to improve the gender balance of experts conducting imPACT Reviews, to strengthen the capacities of experts from LMICs to lead such assignments, and to expand the roster of available expertise. PACT continued its collaboration with the Union for International Cancer Control on imPACT Review activities.

imPACT Review Democratic Republic of the Congo

In 2021, following a request from the Government of the Democratic Republic of Congo (DRC), a team of international cancer experts from the Agency, and nominated by WHO and IARC conducted a virtual imPACT review. Experts visited facilities in four provinces and provided recommendations to increase access to cancer care in the country and lower the annual cancer-related death toll of 34 000 people. As a first step to addressing these recommendations, the government intends to establish a national cancer control programme (NCCP). The implementation of this programme is expected to reduce mortality and improve the quality of life of cancer patients through the systematic and equitable implementation of evidence-based strategies for cancer registration, prevention, safe diagnosis and treatment and palliative care.

imPACT Review Iraq

At the request of the Iraqi Minister of Health, the Agency conducted a virtual imPACT Review in collaboration with WHO and IARC. Over 150 cancer professionals and allied workers, policy makers and academics were interviewed to assess cancer control capacity and identify priority needs across Iraq (in Baghdad, Basra, Najaf, Karbala and Mosul). The discussions with a broad range of Iraqi cancer diagnosis and treatment specialists were especially useful, as these led to regional south-south mentoring and collaboration efforts supported within the framework of the current IAEA technical cooperation project.

imPACT Review Nepal

The Government of Nepal plans to target and tackle childhood cancer, a highly curable disease, as a first step in its broader cancer control efforts. In 2021, Nepal invited the Agency, WHO and IARC and a team of international cancer experts, including those from St. Jude Children's Research Hospital, USA, to provide recommendations on how to increase access to cancer care and lower the annual cancer-related death toll of 14 000 people in the country.

The expert team recommended that the health system for childhood cancer be strengthened in the areas of data registration, diagnosis and treatment services, as well as palliative care. The implementation of these recommendations will lead to long-term improvements in the cancer control programme in Nepal, reducing fatalities, government officials said.

imPACT Review Uruguay

Together with the Ministry of Health and 20 national experts, the Agency, in collaboration with WHO and IARC conducted an imPACT Review in Uruguay to find ways to strengthen cancer control capacities and reduce mortality, which remains high despite the medical expertise available in the country and technological investments made in recent years.

During the in-country mission, the expert team consulted with nearly 100 national stakeholders, including oncology physicians, nursing staff, hospital and laboratory technicians and public administration officials. They visited seven public and nine private



Al-Amal National Oncology Hospital (Photo courtesy of the hospital)

cancer facilities in both urban and rural parts of the country. The expert team recommended that national health authorities focus on the promotion of comprehensive public cancer centres and the regulation of medical practices for the quality control and standardization of services.

imPACT Review Webinars

A webinar held with WHO and IARC brought together IAEA National Liaison Officers and representatives from Ministries of Health to review progress made following imPACT Reviews in a number of countries. The event, held in five UN official languages, allowed country representatives to learn how imPACT Reviews helped national authorities to reprioritize screening programmes (Kazakhstan), initiate a strategic plan for addressing childhood cancer (Sri Lanka), and establish the first independent national nuclear regulatory body in the English-speaking Caribbean (Jamaica). Recent imPACT Reviews also served as a reference for resource mobilization and a planning tool to scale up cancer treatment services (Paraguay), resulted in the establishment of a technical working group for cancer control (Zambia), and helped monitor and evaluate progress in cancer control (Senegal).

imPACT Review experts met in December to discuss the updated imPACT Review methodology and linkages to global cancer initiatives. The group brainstormed ways to further strengthen imPACT Review data collection, data analysis and report development. The experts also discussed the joint assessment tool of IAEA, IARC and WHO, which is a new digital tool for imPACT Review self-assessments. It covers the entire cancer control continuum and can be tailored to country contexts.

Development of strategic documents

PACT assisted Member States in developing bankable documents that can enable them to mobilize resources from international financial institutions (IFIs) and partners. Bangladesh, Liberia, Mozambique, Sierra Leone and Tanzania were supported with a comprehensive technical review for the development, finalization or follow-up of bankable documents. The Agency, together with WHO and IARC, contributed to the midterm review of Iran's national cancer control programme, including radiation medicine components, to strengthen country-level implementation.

Ten Member States (Benin, Burundi, Chad, Ecuador, Guyana, Paraguay, Senegal, Sierra Leone, Zambia and Zimbabwe) began receiving expert advisory support from the Agency, WHO and IARC to develop comprehensive NCCPs in 2021. A modality for virtual advisory services to prepare NCCPs was developed to ensure continuation of this service during the COVID-19 pandemic. An NCCP is part of the blueprint that national health authorities use to reduce cancer incidence and mortality while improving the quality of life of cancer patients. The three organizations work in close cooperation and make available technical expertise to countries to develop their cancer control plans. These experts provide advice to Ministries of Health for the design of realistic and effective NCCPs, tailored to national needs.

International experts supporting countries in developing their NCCPs convened in April and October for workshops to share good practices and challenges, including advancing NCCP advisory support by virtual means. These workshops are part of a larger effort by PACT to strengthen South-South cooperation on cancer control, create a knowledge-sharing community across regions, and expand the base of expertise available to support LMICs in cancer control planning.



Experts from the IAEA, the WHO and IARC reviewed Uruguay's cancer services to provide advice to the government on how to tackle the country's growing cancer burden. (Photo: G. Saporiti/IAEA)

"An NCCP is part of the blueprint that national health authorities use to reduce cancer incidence and mortality while improving the quality of life of cancer patients."

Advocacy, partnership building and resource mobilization

Partnership building and outreach

Practical Arrangements were signed with the City Cancer Challenge Foundation (C/Can) to improve access to quality radiation medicine for cancer patients in LMICs. The partnership aims to increase the sharing of expertise, skills and resources for greater impact in the application of radiation medicine as part of cancer care. The Agency continued to collaborate with the Global Access to Cancer Care Foundation (GACCF), UICC and UNAIDS.

Under the Women's Cancers Partnership Initiative, a bankable document from Uzbekistan, with support from the IAEA, was submitted to the Islamic Development Bank (IsDB) for financing a project in the amount of approximately €71.2 million. The project will improve access to and quality of oncology services in several regions of Uzbekistan and will build on findings from the imPACT Review to the country. In 2021, the second Call for Innovation to find and reward solutions for strengthening national health systems in breast and cervical cancer prevention and control was launched under the initiative.

A bankable document from Chad, developed with IAEA technical assistance, was submitted to the Kuwait Fund for Arab Economic Development for financing a project in the amount of approximately €19.6 million. The project will focus on the establishment of the first radiotherapy facility in Chad.

PACT contributed to strengthening the formal coordination mechanisms on cancer control with WHO and IARC. The Agency participated in the virtual 2021 meeting chaired by IARC. PACT also organized detailed discussions with all six WHO regional offices and multiple WHO country offices, with a view to reinforcing coordination on cancer control, including the provision of assessments and planning support through a hybrid modality due to the COVID-19 pandemic.

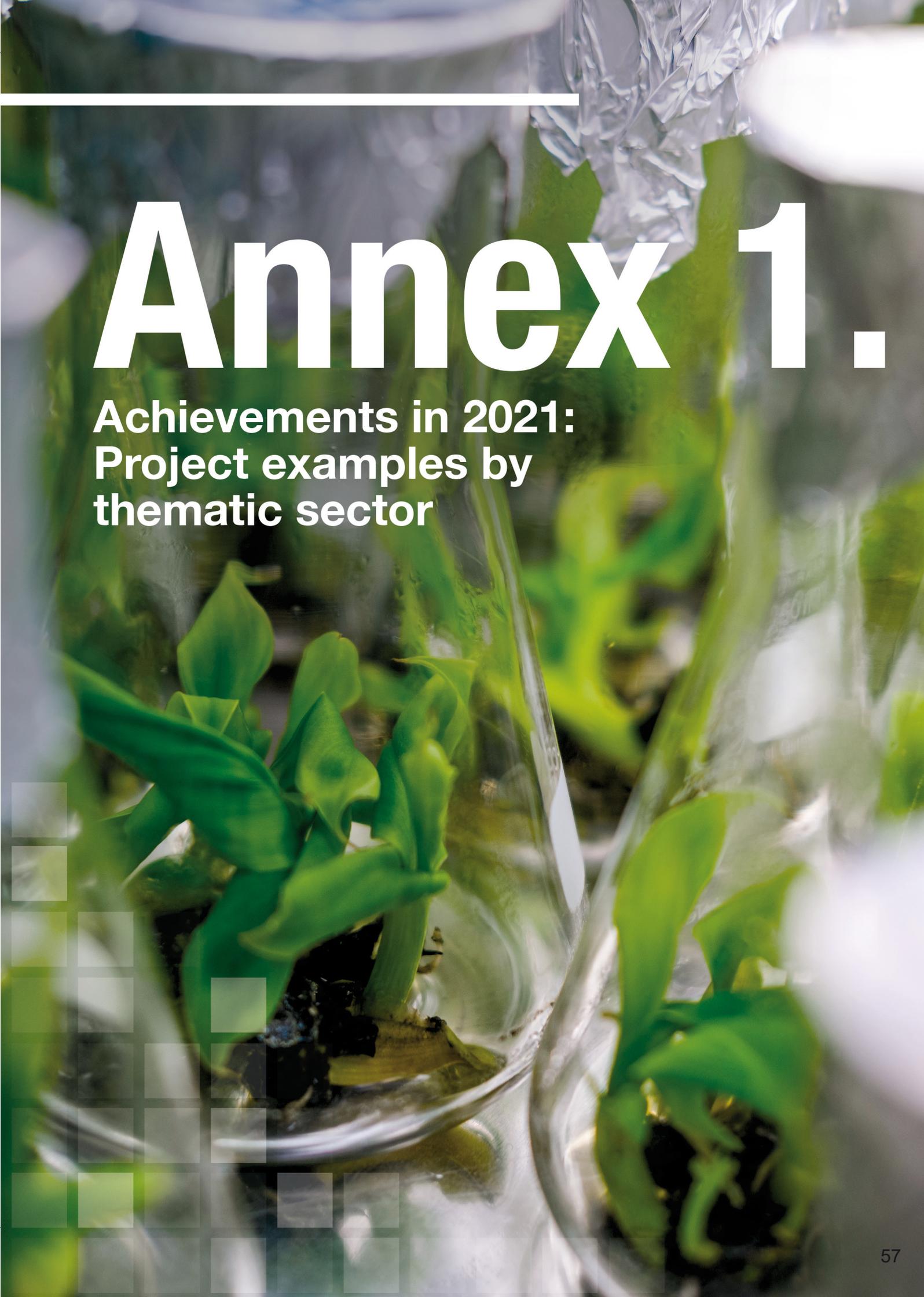
Resource mobilization

Member States continued to show support for the Agency's cancer control activities in 2021. A total of €5 302 733 was mobilized by PACT in 2021 from France, Monaco, the Russian Federation, Sweden and the United States. From this total, €658 257 was directly contributed to the interregional project INT6064, 'Supporting Member States to Increase Access to Affordable, Equitable, Effective and Sustainable Radiation Medicine Services within a Comprehensive Cancer Control System', under which national cancer control planning advisory support and imPACT Reviews are conducted. The remaining €4 644 476 is to support technical cooperation cancer-related projects. An in-kind contribution was received from Varian Medical Systems to support cancer control activities for further implementation in 2022.

There is an estimated shortfall of over 5 600 radiotherapy machines in low- and middle-income countries, and by 2035, these countries will need an additional 80 000 radiotherapy technologists, among other specialists in radiation medicine. Key supporters and advocates of PACT's work joined forces to discuss IAEA cancer activities and outstanding funding needs at a roundtable in June. The roundtable was attended by representatives of Australia, Belgium, Bulgaria, Canada, the Czech Republic, France, Israel, Japan, Monaco, New Zealand, Norway, Republic of Korea, Russian Federation, Spain, Switzerland, the United Kingdom and the United States of America.

List of frequently used abbreviations

AFRA	African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology
Agency	International Atomic Energy Agency
APCs	assessed programme costs
ARASIA	Co-operative Agreement for Arab States in Asia for Research, Development and Training related to Nuclear Science and Technology
ARCAL	Regional Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean
CPF	Country Programme Framework
FAO	Food and Agriculture Organization of the United Nations
IAEA	International Atomic Energy Agency
IARC	International Agency for Research on Cancer
LDC	least developed country
NLA	National Liaison Assistant
NLO	National Liaison Officer
NPCs	National Participation Costs
NPP	nuclear power plant
PACT	Programme of Action for Cancer Therapy
RCA	Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology
SIDS	small island developing States
SIT	Sterile insect technique
SDG	Sustainable Development Goal
TC	technical cooperation
TCF	Technical Cooperation Fund
UICC	Union for International Cancer Control
WHO	World Health Organization



Annex 1.

**Achievements in 2021:
Project examples by
thematic sector**

Annex 1. Achievements in 2021: Project Examples by Thematic Sector

Health and Nutrition

REGIONAL HIGHLIGHTS

The TC programme in Africa supports Member State efforts to address cancer, cardiovascular diseases and malnutrition using nuclear and nuclear-related techniques. In 2021, assistance was provided through the programme for radiotherapy treatment, nuclear medicine, diagnostic imaging projects and related medical physics, as well as for nutrition centres and human resource development.

Assistance for health and nutrition in the Member States of the Asia and the Pacific region ranged from procurement of essential equipment for radiology to enhancing cancer treatment capabilities and conducting human resource activities, to developing the knowledge of medical workers and strengthening national practices.

Education and training of medical professionals has been identified as one of the priorities in Europe and Central Asia in the progress towards effective and safer use of new technology in radiation medicine. Despite the constraints of the COVID-19 pandemic, efforts were made throughout 2021 to ensure that continuous training opportunities were offered to Member States where possible through virtual formats.

Human health and nutrition is also a priority in the Latin America and the Caribbean region, where many countries are affected by both communicable and non-communicable diseases. In 2021, the Agency helped Member States expand access to their cancer services through the procurement of equipment for radiotherapy, nuclear medicine and diagnostic imaging for public hospitals across the region.



RADIATION ONCOLOGY IN CANCER MANAGEMENT

In February 2021, Kenya opened its second public radiotherapy centre at Moi Teaching and Referral Hospital, Eldoret. The establishment of the centre was supported by the Agency with advisory services and the procurement of equipment.

With Agency support provided through project NER6010, 'Supporting the Establishment of a Radiotherapy Centre', Niger inaugurated its first ever radiotherapy centre in March 2021, and the first cancer patient was successfully treated in November. The new centre is expected to provide radiotherapy services to around 600 cancer patients each year, from Niger and neighbouring countries in West Africa. The radiotherapy services will improve the quality of life of cancer patients and reduce mortality rates.

In April 2021, Burkina Faso opened its first radiotherapy centre. Personnel employed at the centre have been trained by the Agency.

Under project NAM6013, 'Expanding Radiotherapy Services', a new orthovoltage unit, procured with government cost-sharing, has been installed and commissioned at the Windhoek Radiotherapy Department in Namibia. The new unit will enhance care for more than 600 patients per year, primarily with skin cancers, by delivering treatment with less damage to underlying tissues. Use of the new orthovoltage unit will free up the capacity of the single Co-60 teletherapy machine for patients with deeper seated cancers such as cervical carcinoma. This could potentially enable the treatment of an extra 300 patients per annum in Namibia.



Commissioning the new orthovoltage unit at the Windhoek Radiotherapy Department (Photo: Wilfred Midzi)

"A new computed tomography (CT) scanner was installed at the Sir Anthony Mamo Oncology Centre (SAMOC), replacing Malta's only public health sector scanner, an ageing 10-year-old machine."

A new computed tomography (CT) scanner was installed at the Sir Anthony Mamo Oncology Centre (SAMOC), replacing Malta's only public health sector scanner, an ageing 10-year-old machine. Following IAEA-organized virtual and on-site training courses, the first patient was scanned using the new CT machine on 18 August. Ongoing Agency support through MAT6009, 'Establishing Linear Accelerator Based Radiosurgery and Adaptive Radiotherapy and Needs Assessment for the Provision of Brachytherapy Services', is expanding access in the country to advanced radiotherapy technologies.

Moldova has been receiving Agency assistance to build capacity in the use of new technologies and improve quality assurance in nuclear medicine, radio-diagnostics and radiotherapy for the past 15 years. Under a recently completed project, MOL6010, 'Establishing a Radiotherapy Department at the Balti Municipal Clinical Hospital', the Oncology Institute in Chisinau, the only public centre providing radiotherapy services, was equipped with a new linear accelerator (co-financed by the Government of Moldova which was commissioned in 2021. IAEA-supported training on its operation was also provided. Together with the equipment received earlier (including a CT-simulator, new Cobalt-60 source, upgraded record and verify system, updated treatment planning system and new radiotherapy immobilization devices), the new linear accelerator will significantly improve access to quality cancer diagnosis, treatment and care for all people in the country.

The Government of Romania is implementing a national programme to upgrade national radiotherapy infrastructure with the financial support of the World Bank and the technical support of the Agency under ROM6020, 'Establishing a National Training Facility to Improve the Safety and Quality of Radiotherapy Services'. A number of radiotherapy units (medical linear accelerators and brachytherapy units) have been installed and commissioned with this assistance in radiotherapy centres across Romania. Romania has received IAEA technical support to assess radiotherapy services at the Regional Institute of Oncology in Iasi (North-East region of the country), as well as the readiness of the recently constructed satellite radiotherapy facility to receive a high energy medical linear accelerator. The closest radiotherapy centre outside of Iasi is located in the city of Bacau, 130 km away. With Agency support for the technical justification, the Romanian government has been able to secure the second phase of the cooperation project with the World Bank to upgrade its national infrastructure across all of Romania (including the North-East of the country) with modern radiotherapy units.

A linear accelerator has been procured and installed at the newly constructed and licenced bunker of the State Cancer Centre of Chihuahua, Mexico. The procurement was supported through the national TC project MEX6011, 'Strengthening Capacities for Cancer Management,' and with an extrabudgetary contribution from the United States of America. Staff from the Centre were trained in September, and the linear accelerator went into operation in October.

The Agency's support to Peru in the area of radiation medicine focuses on supporting the implementation of the national Plan Hope ('Plan Esperanza'), which aims to decentralize and strengthen national cancer services and create more access to treatment services for patients outside Lima. Support is being provided to health centres in Arequipa, Huancayo and Piura to strengthen and increase access to quality diagnosis, treatment and care. In addition to the strengthening of physical infrastructure, capacity building activities supported in 2021 focused on building knowledge in advanced radiotherapy techniques and in paediatric radiotherapy.

Under TC project RLA6081, 'Strengthening Human Capacities of Caribbean countries in Radiation Medicine', assessments on the current status of radiation medicine in the region as well as staffing of medical physicists in radiology and nuclear medicine were conducted among English-speaking Member States. The two resulting reports will inform future activities to be implemented on a national and regional basis.

NUCLEAR MEDICINE AND DIAGNOSTIC IMAGING

A staffing algorithm developed by the Agency to establish a baseline and recommend the adequate medical physicist staffing levels for safe and quality imaging services has been applied for the first time in a study carried out with the support of RAF6053, 'Enhancing Capacity Building of Medical Physicists to Improve Safety and Effectiveness of Medical Imaging (AFRA)'. The study was conducted at the regional scale, involving 212 imaging departments in Africa, and the findings showed that only 26.8% of the institutions employ an adequate number of medical physicists. The project RAF6053 is addressing this challenge and has launched the first long-term clinical imaging training for medical physicists as outlined by the AFRA harmonized academic and clinical training syllabus in medical physics. Nineteen African fellows are being trained in Ghana and Egypt.



Training of long-term fellows in medical physics for clinical imaging at the National Cancer Institute, Cairo University (Photo: Cairo University)



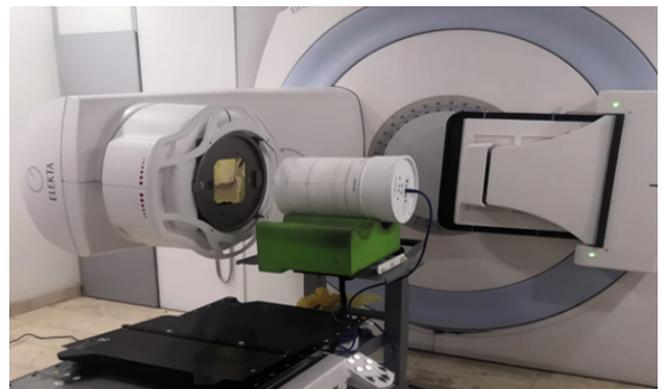
The first group of long-term fellows undergoing training in clinical imaging medical physics at the Korle Bu Teaching Hospital, Accra (Photo: Francis Hasford)

Furthermore, with support through RAF6053, the African region has become the first region to develop a regional harmonized quality control programme based on Agency guidance for the effective implementation of quality assurance. The harmonized protocol provides a practical guide for the execution of quality control tests and offers a common basis for data collection, analysis and the comparison of results, as well as supporting the sharing of issues, challenges and experiences. Quality control equipment was procured under the project to support participating Member States in the implementation of the protocol.

Under TC project PLW6003, 'Upscaling the Delivery of Radiology through Local and Teleradiology Services', a portable ultrasound for general imaging for radiology and vascular applications for Palau's Belau National Hospital was procured. Support was also provided for the procurement of a Picture Archiving and Communication System, to be provided in 2022. As a result, a detailed checklist to evaluate and identify the right specifications for a tailor-made system for the counterpart was developed.

In Iraq, under IRQ6018, 'Strengthening Radiotherapy and Nuclear Medicine', the procurement and delivery of a digital colour doppler ultrasound system has increased the diagnostic capabilities of the local hospital, created opportunities to train doctors, and reduced the need for patients to travel abroad.

In November 2021, Paraguay's first public sector PET/CT scanner was inaugurated at the Research Institute for Health Sciences, National University of Asuncion. The PET/CT scanner will support



Installation of multidimensional detector array with trolley & quality assurance software to provide higher quality of treatment and advanced techniques of radiotherapy. (Photo: Dr. Mussab Alabbodi)



In November, Paraguay inaugurated a PET/CT-scanner received through the IAEA's technical cooperation programme. (Photo: Regulatory Authority for Radiology and Nuclear/Paraguay)

improved, more effective cancer diagnosis, which will in turn help to reduce the mortality rate. The PET/CT scanner was procured through Paraguay's national TC project PAR6017, 'Providing Patients from the Public Sector with Early and Effective Diagnosis of Cancer through Positron Emission Tomography Technology'. Training was provided for the personnel using the scanner through the project.

RADIOISOTOPES, RADIOPHARMACEUTICALS AND RADIATION TECHNOLOGY

In Hungary, the Agency strengthened capacities to conduct quality assurance/quality control (QA/QC) measurements at the National Public Health Centre Department of Radiobiology and Radiohygiene and the National Institute of Oncology through the delivery of diagnostic radiology equipment under project HUN6004, 'Implementing a Formal Quality Assurance Programme in Diagnostic Radiology at End User Level'. The items delivered included multimeters, phantoms and accessories. In addition, with the support

of the Hungarian Society for Medical Physics, the Quality Control Guidelines for major pieces of diagnostic radiology equipment were reviewed, and a methodology for their implementation was developed.

Capacities for the development of different and new radiopharmaceuticals labelled with F-18 used in clinical practice have been strengthened in the Nuclear Diagnostic Centre Foundation (FCDN) in Argentina. Under the project ARG6018, 'Strengthening Capacities for the Development and Clinical Applications of Radiotracers Labelled with Fluorine-18, Different from Fluorodesoxyglucose,' both radiopharmacy and medical personnel have been trained through fellowships, scientific visits, expert missions, and participation in national meetings. The enhanced capacities will contribute to improve the diagnosis in cancer patients.

"Under regional project RAS6087, 'Enhancing Medical Physics Services in Developing Standards, Education and Training through Regional Cooperation', the number of medical physics educational programmes has increased in the region, notably in India, Indonesia, Japan, Korea, the Philippines, and Thailand."

DOSIMETRY AND MEDICAL PHYSICS

Under regional project RAS6087, 'Enhancing Medical Physics Services in Developing Standards, Education and Training through Regional Cooperation', the number of medical physics educational programmes has increased in the region, notably in India, Indonesia, Japan, Korea, the Philippines, and Thailand. Clinical training programmes in all specialities in medical physics have been sustained during COVID-19 in RCA States Parties and are continuing in many countries, such as Bangladesh, Indonesia, Malaysia, Philippines, Singapore, and Thailand. A virtual clinical training review process and a supervisors' clinical training course have been developed successfully. Advanced Medical Physics Learning Environment (AMPLE) software has been improved to include the tracking of resident progress to assist coordinators in progress review and clinical training. Under project RAS6087 developed and emerging countries support developing countries in medical physics MSc education. For example, Thailand supports Myanmar and Laos, Indonesia supports Syria and the territories under the jurisdiction of the Palestinian authority, and Malaysia supports Cambodia.

Food and Agriculture

REGIONAL HIGHLIGHTS

In 2021, food and agriculture accounted for the highest disbursement of funds in the IAEA technical cooperation programme for Africa. Member States received assistance for the peaceful applications of nuclear and related technologies, with the goal of contributing to sustainable agricultural development and global food security.

In the Asia and the Pacific region in 2021, TC projects in the food and agriculture sector ranged from crop mutation induction to the development of food safety laboratories and the monitoring of drug residues in foods.

In Europe and Central Asia, the production of food and agriculture continued to play an important role. In 2021, Agency support helped to increase productivity in major food crops (legumes, cereals and other important food crops) and to build their resilience to unfavourable environmental conditions caused by climate change. The support provided also included the use and integration of the sterile insect technique (SIT) in area-wide insect pest management, to address the spread of vector-borne diseases due to climate change.

Food and agriculture continued to be of pivotal importance in the Latin America and Caribbean region. In 2021, the TC programme supported e-learning opportunities for the staff of food safety laboratories in the region. The Agency also partnered with international organizations to launch a regional effort to fight pests that pose a threat to human health and agriculture. This effort included building national capacities in the use of the sterile insect technique (SIT) as part of area-wide insect pest management. In 2021, SIT was used in Brazil, Cuba and Ecuador to reduce vector-based diseases effectively.



CROP PRODUCTION

A new cassava mutant line has been developed in Sierra Leone under TC project SIL5021, 'Improving Productivity of Rice and Cassava to Contribute to Food Security'. Preliminary results show resistance to both Cassava Mosaic and Cassava Streak viruses.

In Sri Lanka, under TC project SRL5050, 'Supporting Genetic Improvement of Tea', tea varieties have been developed with the help of single cell induced mutagenesis, an irradiation method involving a radioactive source and single plant cells. This project has been key in supporting Sri Lanka's tea industry to thrive despite climate change, as tea is the leading foreign exchange earner in the country, and 10% of the population is directly or indirectly employed in the tea industry.

In Kuwait, homogeneous seeds were developed for mutation induction and mutant screening for salt tolerance under TC project K UW5005, 'Implementation of Mutation Induction to Improve Barley Production under Harsh Environmental Conditions – Phase III'. The mutant screening process will be performed in January 2022.

For Europe and Central Asia, developing tolerant genotypes in key agricultural crops, including legumes and cereals to overcome the negative impact of unfavourable environmental conditions on plant productivity is a strategic priority. Member States received training on plant mutation breeding and efficiency enhancing techniques under RER5024, 'Enhancing Productivity and Resilience to Climate Change of Major Food Crops in Europe and Central Asia', to increase resilience to climate change and enhance understanding and research laboratory capacities in basic aspects of crop mutation breeding. Several countries have subsequently requested additional training on mutation breeding and combined biotechnologies, including on olive breeding.



Researchers at the Tea Research Institute of Sri Lanka are developing new lines of tea to improve quality and resilience to disease and climate change. (Credit: Tea Research Institute of Sri Lanka)

Honduras is one of the largest coffee producing countries in the world, exporting seven to ten million 46-kilogram bags per year, making this crop a critical national priority. Project HON5009, 'Improving Genetic Resistance of Coffee to the Coffee Leaf Rust through Mutation Breeding', aims to contribute to the enhancement of the economic, social and environmental welfare of coffee farmers in the rural areas of Honduras through the cultivation of certified coffee mutants resistant to coffee leaf rust. The project counterpart, the Honduran Coffee Institute (IHCAFE) is developing new varieties of coffee resistant to coffee leaf rust, a fungus that is devastating for coffee producers. Under the project, IHCAFE had received laboratory and greenhouse equipment, as well as coffee seeds that were irradiated in the Agency laboratories in Seibersdorf. 2021 was a key year for the successful improvement of greenhouses for the germination of mutant coffee varieties.



Germination trays with mutant coffee varieties
(Photo: Juan Lopez/IHCAFE)

AGRICULTURAL WATER AND SOIL MANAGEMENT

Personnel in Malaysia received online training on the installation and use of cosmic ray neutron sensors (CRNS) for stationary soil moisture assessment under project MAL5032, 'Strengthening National Capacity in Improving the Production of Rice and Fodder Crops and Authenticity of Local Honey Using Nuclear Related Technologies'. Virtual training was also provided on agricultural water productivity for 19 participants, and sampling activities and analysis were carried out in the Selangor Study site. The CRNS was installed and validated with guidance from Agency experts.

In Iraq, human resource capacity in climate-smart irrigation and nutrient practices was further developed under TC project IRQ5022, 'Developing Climate-Smart Irrigation and Nutrient Management Practices to Maximize Water Productivity and Nutrient Use Efficiency at Farm Scale Level Using Nuclear Techniques and Advanced Technology'. Also in Iraq, local staff were trained to utilize nuclear techniques to develop high yielding drought tolerant (and some disease resistant) varieties of legumes to contribute to food security under TC project IRQ5023, 'Utilizing Nuclear Technology to Improve Key Legume Crops for Climate Change Adaptation'.

Thirteen countries in Latin America and the Caribbean have implemented a case study comparing a traditional production strategy with one that contributes to climate change adaptation with the support of regional project RLA5077, 'Enhancing Livelihood through



Installation, calibration and validation of cosmic ray neutron sensor at Kulim Pineapple Farm. (Photo: Selangor Study Site)



Rice paddy fields with irrigation canal. (Photo: Selangor Study Site)

Improving Water Use Efficiency Associated with Adaptation Strategies and Climate Change Mitigation in Agriculture (ARCAL CLVIII)'. Italian zucchini, corn, tomato, wheat, marandu grass, barley, rice, potato, soy and beans were studied, and the results were compared using AquaCrop to assess water use efficiency under both management practices. In addition, stable isotopes of water extracted from the soil were used to estimate evapotranspiration partitioning into transpiration (water used by plants) and evaporation (water lost to the environment). A number of countries also used N-15 labelled fertilizer to determine nitrogen use efficiency under certain management practices. The study demonstrated that the AquaCrop model effectively simulates the yield and biomass of different crops, and is a useful tool to create awareness of the benefits related to more efficient water use. In 2021, five virtual training courses were held for over 150 participants on topics such as nutrient and water management in crops, AquaCrop simulation modelling, evapotranspiration estimation and partitioning, cost/benefit analysis for the selection of optimum agriculture practices, and remote sensing for water use efficiency.

The Agency continued to support Haiti's Ministry of Agriculture, Natural Resources and Rural Development with assistance to enhance crop productivity and strengthen capacities to monitor food contaminants. The Ministry implemented a sampling campaign and soil samples were shipped to the Agency laboratories in Austria to assess soil loss and quantify erosion using nuclear techniques.

LIVESTOCK PRODUCTION

Zimbabwe has established a new bull station and expanded artificial insemination services for improving cattle breeds and productivity with Agency assistance under ZIM5024, 'Establishing an Artificial Insemination Center to Enhance the Rebuilding of the National Herd'. The Mazowe Bull Centre and semen production laboratory is now operational following installation and commissioning of new equipment.

The Agency has contributed to the revitalisation of veterinary teaching at the Milton Margai College of Education and Technology (MMCET) with training and provision of laboratory equipment provided under SIL5019, 'Strengthening Capacities for the Diagnosis and Control of Zoonosis to Improve Public Health Services and Livestock Production'. The college, which is currently being transformed into Milton Margai Technical University (MMTU) in Freetown, Sierra Leone, has established two laboratories for disease diagnosis and is contributing to enhanced animal health and production. The institution is also an active participant in the National Antimicrobial Resistant Campaign. MMTU is now running a diploma course to train diagnostic laboratory technicians, with the first group of technicians completing their studies during 2021

Foot and Mouth Disease (FMD) vaccine technology was developed and formally registered on the drug registration list of Mongolia in 2021, following capacity building activities under TC project MON5023, 'Enhancing Livestock Production Through the Improved Diagnosis and Prevention of Transboundary Animal Diseases'. The industrial production of the vaccine was accelerated by the construction and operationalization of a formulation facility with capacity to produce 50000 doses of vaccine per shift. A commercial contract with the facility to supply 500 000 doses of FMD vaccine annually was signed



Implementation of a case study to compare productions systems in Ecuador. (Photo: Yamil Cartagena)



A technician at work in the newly established Mazowe Bull Centre (Photo: Mazowe Bull Centre).

in 2021. This achievement contributes directly to supporting Mongolia in addressing transboundary animal diseases, and thereby to enhancing food security in the country.

A nation-wide serosurvey of hepatitis E virus (HEV) infection in pigs from all regions of Bulgaria (including wild boars and domestic pigs from commercial farms and backyards) has been undertaken with the support of TC project BUL5017, 'Enhancing the National Diagnostic Capabilities for Detection of Hepatitis E Virus in Pigs and Pig Products'. An



Laboratory technicians and analysts undergoing national training in diagnosing and monitoring animal diseases at the MMTU. (Photo: MMTU)

expert mission helped to elaborate a concept for the integration of diagnostic techniques in the national control plan and to design an epidemiological survey to detect the presence and the prevalence of HEV among the pig population, as well as to identify critical risk points for human infections. A virtual national training course on analysing disease data was provided, and several group fellowships were organized in the region. As a result, there is a better understanding of the epidemiology of the disease and capacity to identify people most exposed to the risk of infection.

The first case of African Swine Fever (ASF) was discovered in domestic pigs in the Dominican Republic on July 28, 2021 – the first confirmed case in the Americas. ASF is a contagious viral disease that affects domestic and wild pigs, and while it does not present a risk to human health, it is currently the most serious threat to pig farming in the world. Assistance to combat the spread of ASF was provided through TC project DOM0006, 'Building and Strengthening the National Capacities and Providing General Support in Nuclear Science and Technology', in the form of emergency provision of laboratory equipment and consumables for the Central Veterinary Laboratory (LAVECEN), and capacity building for technical staff. A hybrid national training course on laboratory diagnosis of ASF was held in October at LAVECEN in Santo Domingo. Educational videos in Spanish, showing the use of the nuclear technique and handling of samples in the laboratory, have been developed jointly by the VISAVET Health Surveillance Center of the Complutense University of Madrid, Spain, which is the International Organization for Animal Health (OIE) Reference Laboratory for ASF.

INSECT PEST CONTROL

The construction of the fruit fly mass rearing facility at Agadir, Morocco, has been completed with assistance from the Agency through TC project MOR5038, 'Strengthening the Use of the Sterile Insect Technique'. This is a major step towards establishing capacity to integrate the sterile insect technique (SIT) as a component of the integrated pest management control strategy for Medfly (*Ceratitis capitata*) in the Souss Massa and Moulouya regions.

In South Africa, activities undertaken under SAF5017, 'Assessing the Sterile Insect Technique for Malaria Mosquitoes – Phase III' have moved from laboratory scale to 'field pilot trial' scale. The first production, sterilization, and release of an African malaria vector

was carried out in November 2021. The success of the weekly releases will determine the development of SIT as an alternative vector control method to complement the existing malaria vector control strategies of the National Malaria Control Programme (NMCP). The release trials not only showed that the various SIT components are 'ready to use' at field scale, but also that sterile males already had an impact on the fertility rates of wild population's eggs after a few releases. Other significant achievements include optimizing mass-rearing techniques, streamlining operations for mass production, and extensive community engagement.

Following receipt of an extrabudgetary contribution for TC projects in Fiji, FIJ5003, 'Implementing Pesticide-Free Suppression and Management of Fruit Flies for Sustainable Fruit Production', and FIJ5004, 'Establishing a Food Safety Laboratory for Analysis of Pesticide Residues in Fresh Fruits, Vegetables and Root Crops', procurement and capacity building activities have been initiated. For FIJ5003, laboratory equipment for Post Entry Quarantine (PEQ) laboratory for the Biosecurity Authority of Fiji was procured. This included fruit fly adult cages, incubator for rearing, stereomicroscope for fruit fly identification, a freezer for fruit fly samples, magnifying lens, entomology kits for general use in the laboratory and a quarantine station. In addition, field surveillance and suppression materials for fruit fly management including fruit fly attractants, traps and Male Annihilation Technique (MAT) block and protein bait were provided.

In Turkey, the Agency continued to supply materials and equipment under TUR5026, 'Conducting a Pilot Program on Integrated Management of Aedes Aegypti Including Sterile Insect Technique', to support progress in capacity building at the local level for the adoption of SIT to control Aedes aegypti. The mass-rearing laboratory was upgraded with new equipment and consumables for rearing activities. In addition, virtual expert mission and training courses helped to develop and enhance knowledge regarding different components of the SIT package such as mosquito mass-rearing, irradiation, and field monitoring.

In Cuba, controlling mosquito species Aedes aegypti is a national priority which may be addressed using SIT. Activities under project CUB5021, 'Demonstrating the feasibility of Sterile Insect Technique in the Control of Vectors and Pests in Cuba', are led by the Institute of Tropical Medicine Pedro Kourí (IPK) in collaboration with other national institutions. Under this project, a facility for mass production of sterile insects was developed. The scientific team was trained through training courses, workshops, scientific visits, fellowships and expert missions. Several trials were carried out in order to optimize the technological steps of SIT including mosquito's colony maintenance, mass rearing, sex sorting, irradiation, packing and the development of devices for the maturation and release of sterile insects. At the same time, a social communication campaign, backed by community leaders and family doctors, was conducted, directed at the general population in field study sites, schools, vector control workers and social organisations. A successful SIT open field pilot study was carried out in a suburb of Havana city where data clearly indicated a significant suppression of the wild target population. In 2021, mark-release-recapture (MRR) trials provided relevant data regarding the performance of irradiated males in the field, including survival, dispersion, diffusion and competitiveness. For the first time in Cuba, the relative abundance of wild population of Aedes aegypti was assessed using MRR, guaranteeing high accuracy of results. The project has provided new information about the monitoring tools for the evaluation of vector control methods.

Under project ECU5031, 'Enhancing the Application of the Sterile Insect Technique as Part of an Integrated Pest Management Approach to Maintain and Expand Fruit Fly Low Prevalence and Free Area', Ecuador has reported very successful results following the application of SIT. The country has reduced the prevalence of fruit flies in crops such as tomato, pitahaya, and blackberry, allowing these crops to access new markets for exportation. The counterpart institution, AGROCALIDAD, has carried out significant work to achieve these results in partnership with the Agency, enabling new opportunities to export goldenberry and other non-traditional fruits to the international market.

"The success of the weekly releases will determine the development of SIT as an alternative vector control method to complement the existing malaria vector control strategies of the National Malaria Control Programme (NMCP)."

Through national project ECU5032, 'Building Capacity for Mass Rearing, Sterilization and Pilot Release of *Aedes aegypti* and *Philornis downsi* Males', the Agency has been supporting capacity building efforts in Ecuador to apply the sterile insect technique to eradicate mosquitos and an invasive fly species from the Galapagos and Inbabura regions. *Aedes aegypti* is responsible for transmitting dengue, chikungunya and Zika virus leading to thousands of medical cases of these life-threatening illnesses in Ecuador every year. Meanwhile, the non-native *Philornis downsi* fly continues to threaten at least seven bird species in the Galapagos Islands by carrying parasites that kill bird hatchlings. In 2021, to combat the environmental and health risks associated with both pests, the Agency worked with local institutions to establish SIT in the affected regions, including setting up pilot locations for SIT, establishing laboratory capacity to process relevant data, and training personnel in procedures related to SIT.

FOOD SAFETY

Under regional project RAS5081, 'Enhancing Food Safety and Supporting Regional Authentication of Foodstuffs through Implementation of Nuclear Techniques', the Agency supported Member States in raising awareness of food fraud and its potential to impact on



*Strengthening capacities for the establishment of the sterile insect technique in Ecuador: Equipment and established *Aedes aegypti* colonies in Galapagos and Imbabura. (Photo: INSPI/ Ecuador)*

food safety, including capacity building for research organisations to engage with relevant stakeholders such as government officials, regulators, the food industry, and consumers. The project supported the establishment of a preliminary database for authentic rice samples in Asia and the Pacific Member States, forming the basis for future studies on the origin of important rice varieties such as Thai Jasmine rice, Thai Hom Mali rice, and Indian and Pakistani Basmati rice. The studies will lead to control systems that will facilitate trade and protect consumers and honest traders from fraud. Online resources, including e-learning modules on software to carry out multivariate analysis for food authenticity interpretations, were prepared under the project. Training courses under project RAS5081 have helped strengthen the regional capacity to detect food fraud and determine the origin and authenticity of added value food products. Using stable isotope analysis, Philippine scientists detected fake vinegar and widespread adulteration of honey. The results of the vinegar studies were submitted to the Food and Drug Administration (FDA) to serve as a basis for the development of new vinegar standards for the Philippines.

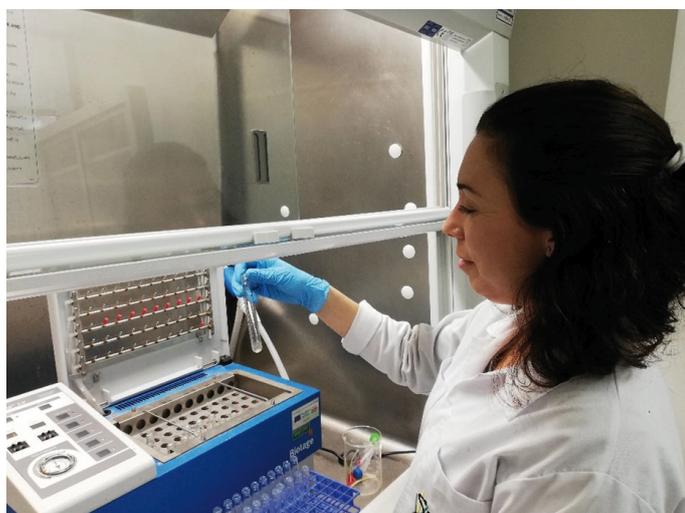
Georgia is receiving Agency assistance to enhance national programmes for testing and monitoring food contaminants. In 2021, the Agency, with government cost sharing, supported the enhancement of the analytical capabilities of the Laboratory of the Ministry of Environment Protection and Agriculture (LMA) through the procurement of an ultra-high performance liquid chromatography-mass spectrometry and laboratory instrumentation for the confirmation of residues and related contaminants. Expertise and training on antifungal

residue analysis were also provided under GEO5001, 'Enhancing National Programmes for Testing and Monitoring Food Contaminants and Residues', and the enhanced laboratory infrastructure is contributing significantly to food safety and boosting trade in foodstuffs.

Under the framework of a regional technical cooperation project RLA5080, 'Strengthening Regional Collaboration Between Official Laboratories to Face New Challenges Related to Food Safety (ARCAL CLXV)', an e-learning course on Food Safety Risk Assessment was created to transfer basic to intermediate knowledge in dietary risk assessment and to familiarize participants with practical applications using a dedicated software. The e-learning course is accessible free of charge through the Agency's learning management system CLP4Net. For national food safety authorities to be able to apply risk assessment tools, access to high-quality and current data sets is essential. For this purpose, the project has collaborated with the Latin American Network of Analytical Laboratories (RALACA), focusing since 2019 on data-sharing, including the establishment of monitoring programmes. Expert technical support for the establishment of the RALACA Data-Sharing Committee (RALACA-DSC) was provided through the project. In 2021, the official framework document of RALACA-DSC was developed with significant stakeholder involvement by national food safety authorities, laboratories and other institutions. The framework document includes the provisions for data exchange, collection, verification and the use of data, which will be coordinated by representatives of official analytical food safety laboratories in the framework of RALACA-DSC. The project has received continued collaboration from regional and national organizations, such as the Inter-American Institute for Cooperation on Agriculture, the International Regional Organization of Agricultural Health, the Agency for Food Safety and Quality of Chile and the European Food Safety Agency, and was presented at the Latin American Risk Assessment Symposium in October 2021, as well at the LXVI Meeting of the Technical Commission for the International Regional Organization of Agricultural Health in March 2021.

Within the framework of the regional project RLA5081, 'Improving Regional Testing Capabilities and Monitoring Programmes for Residues/Contaminants in Foods Using Nuclear/Isotopic and Complementary Techniques (ARCAL CLXX)', regional partners in the Latin American and Caribbean region have exchanged expertise on the analysis of residues and pollutants using complementary nuclear and isotopic techniques. In 2021, targeted training activities focused on veterinary drug residue monitoring programmes to share expertise and experience with regional participants in residue surveillance planning, risk-based monitoring programmes, and the implementation of international regulations to ensure market access and commercial growth.

A regional assessment is being carried out to identify the presence, concentration and exposure to persistent organic pollutants in human milk, cow milk, water and soil samples under project RLA5069, 'Improving Pollution Management by Persistent Organic Pollutants to Reduce Impact on People and the Environment'. In 2021, an e-learning course and a virtual training course on the elaboration of risk maps took place, with a final coordination meeting in November 2021 to present national results. All countries shared their data in an access-restricted regional database. The countries have defined the sampling areas and have made strategic alliances to carry it out. Likewise, Member States have negotiated authorizations with national ethics committees according to WHO recommendations to facilitate studies on biological material (mother's milk). In relation to analytical measurements, several new methods were developed by the laboratories and validated for human and cow milk, and soil and water samples.



Food safety laboratories in the LAC region generate valuable analytical data on chemical contaminants in food which can be used for evidence- and risk-based decision making and the formulation of sustainable agricultural practices. (Photo: LANASEVE, SENASA, Costa Rica)

Water and the Environment

REGIONAL HIGHLIGHTS



In Africa, the Agency supports efforts to integrate the use of isotope hydrology into national water infrastructure and programmes, emphasizing the characterization and monitoring of groundwater. The IAEA Water Availability Enhancement (IWAVE) approach is being mainstreamed into projects and planning and has been implemented under the regional programme in Benin, Cameroon, Ghana, Mali, Niger, Nigeria, Senegal and Togo. The approach has now been expanded to include Mauritania. A tritium map was developed in these nine countries to indicate areas of water vulnerability in the Sahel.

Projects throughout the Asia and the Pacific Region regarding water and the environment focused primarily on environmental monitoring and on examining groundwater characteristics.

In Europe and Central Asia, the TC programme continued its efforts to support Member States in enhancing their competencies in coastal management and environmental monitoring. In the area of public and environmental protection, the Agency supported activities to improve national capabilities to conduct environmental monitoring and impact assessments in different exposure situations in accordance with international requirements and guidelines.

The coastal population is increasing in the Latin America and the Caribbean region and many who live there depend on the ocean for their income and for sustenance. However, changes in water temperature and increased ocean acidification and deoxygenation could have a significant impact on local communities. Isotopic tracing techniques can be used to monitor the impacts of ocean acidification and other ocean stressors and help identify the sources of pollution in the water. Findings can facilitate the scientific community and policy makers in making informed decisions to protect vulnerable ecosystems.

The Agency has been assisting Member States to address the challenge of global plastic pollution both on land and in the marine environment. In this regard, NUClear TECHNOlogy for Controlling Plastic Pollution (NUTEC Plastics) was launched, which consolidates and builds on the IAEA portfolio around plastic recycling using radiation technology, and monitoring and impact assessment of marine microplastics using isotopic tracing techniques. In 2021, the Agency hosted a series of roundtable discussions with high-level officials and experts from industry, academia and international organizations for the Africa, Asia and the Pacific, Europe and Central Asia, North, Central, South America and the Caribbean regions to discuss ongoing efforts, innovative solutions and partnerships to tackle plastic pollution using nuclear technologies.

The first roundtable, for Asia and the Pacific, entitled 'Atoms Contributing to the Search for Solutions to Plastic Pollution' took place in May. The proceedings have been published in Summary Report: NUTEC Plastics Roundtable for the Asia and the Pacific Region, and NUTEC Plastics has been highlighted at relevant regional events such as the ASEAN regional symposium entitled 'Bridging Science to Policy: Science-Based Solution to Marine Plastic Pollution in ASEAN'. Under the regional project RAS1024, 'Reutilizing and Recycling Polymeric Waste through Radiation Modification to Produce Industrial Goods', capacity building for techno-economic feasibility studies for recycling plants was completed, thereby contributing



IAEA Director General Rafael Mariano Grossi delivers opening remarks at the Roundtable for the Asia and the Pacific Region, Atoms Contributing to the Search for Solutions to Plastic Pollution, held in May 2021. (Photo: Dean Calma/IAEA)

to the objective of NUTEC Plastics. Indonesia, Malaysia, Philippines and Thailand have drafted proposals for technological and financial support to conduct pilot activities in recycling using irradiation. Steps have also been taken to build the capacity for marine plastics monitoring in participating laboratories. In addition, projects were developed under the 2022–2023 TC programme cycle, focusing on marine environmental monitoring of plastic pollution and the protection of marine, terrestrial, and coastal environments through holistic environmental monitoring programmes.

The roundtable for North, Central, South America and the Caribbean took place in August, and brought together over 400 participants from 36 countries. Senior officials from Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba and Mexico presented ongoing national policies and initiatives to address plastic pollution from its sources to the sea. The United States of America announced it would provide US \$1 million to the Agency's NUTEC Plastics to support the establishment of pilot plants for plastic recycling in the region.

National partnerships for NUTEC Plastics

The IAEA has established a strong alliance with the Oceanographic Institute of the Navy (INOCAR) and the Polytechnic University (ESPOL) in Guayaquil, increasing national capacities to monitor microplastics in the northern oceanic zone of Ecuador, including the Galapagos Islands, under the umbrella of technical cooperation project ECU0009, 'Strengthening Human Resources for the Safe Control and Use of Nuclear Techniques'. To support the creation of a specialized laboratory, the IAEA has provided equipment and supplies, and trained personnel in sampling techniques, microscopic analysis, and application of nuclear techniques for chemical characterization. With this assistance, in line with the goals of NUTEC Plastics, Ecuador will be able to assess plastic contamination levels, build capacity to classify polymers to determine their source of origin, and study environmental impact on the vulnerable biodiversity of the Galapagos Islands and take accurate control measures. The laboratory will also be used for training purposes to strengthen capacity in other Member States of the Latin America and Caribbean region.

In September, Ministers from several countries in Africa, as well as representatives of international organizations, convened virtually to participate in the NUTEC Plastics roundtable for the region. A NUTEC Plastics action plan has been prepared to coordinate activities. Consultations with Member States on feasibility studies for plastic waste monitoring are ongoing.

Finally, in October, a NUTEC Plastics roundtable took place for Europe and Central Asia. Over 300 participants from 56 countries met online to share their policies and experiences in addressing the global challenge of plastic pollution and to learn about and discuss the place of nuclear technology. Several countries are already participating in projects related to marine monitoring, with eighteen working together to enhance coastal management in the Aral Sea, the Black Sea, the Caspian Sea and the Mediterranean Sea. Five Member States (Croatia, Hungary, Poland, Romania and Turkey) are conducting technical and economic feasibility studies on the establishment of pilot-scale plants to recycle plastic waste using radiation technology. A survey on the status of plastic waste recycling and monitoring using nuclear applications has been conducted and an action plan prepared.

WATER RESOURCE MANAGEMENT



Sampling campaign being undertaken at a thermal spring area in the Eastern Highlands, Zimbabwe (Photo: Michael Schubert)

The Agency has provided assistance to the Zimbabwe National Water Authority (ZINWA) under the Ministry of Water Resources and Infrastructural Development (MoWRID) as well as the University of Zimbabwe to include isotope hydrology in characterising groundwater resources in the Save Catchment, Nyamandlovu Aquifer, and the urban area of Harare. Zimbabwe has resuscitated the Global Network of Isotopes in Precipitation (GNIP) stations in Harare, Bulawayo and Mutare with the support of the Agency. Under ZIM7002, ‘Characterizing Surface Water and Groundwater Interaction’, local personnel were trained in the basic principles of isotope hydrology. The training course put special emphasis on the use of stable and radioactive tracers as tools to investigate surface water-groundwater interactions; groundwater dating techniques; and the vulnerability of aquifers to contamination.



The isotope hydrology project team during a field sampling campaign (Photo: Frederic Huneau)

The first isotopic maps of the Central African Republic for water resource management have been developed under CAF7004, ‘Strengthening National Capacities for Assessing the Quality of Water Resources by Using Isotopic Techniques’, and shared with national stakeholders. The Atlas of Isotope Hydrology compiles all results of IAEA activities in isotope hydrology in the country over the last decade. Isotopic data were used to produce thematic maps which provide insight into the quality, availability and origin of water resources – key information for future decision-making on the sustainable use of water resources. The Atlas was presented to the Ministry of Water Resources for consideration in the ongoing draft of a new water law.



Water table depth measurement and groundwater isotopic sampling in the municipality of Mupalaca, Lempira Department, Honduras. (Photo: Ricardo Murrillo/Costa Rica)

Twenty-seven countries in Europe and Central Asia are cooperating to enhance evidence-based decision making in integrated water management by improving the monitoring and characterization of groundwater resources using isotope techniques. Pressing regional and transboundary issues, such as the impact of climate change on karst aquifers and groundwater–surface water interactions in the Western Balkans, nitrate contamination of aquatic systems in Eastern Europe and Caucasus, the vulnerability of stratified transboundary aquifers to over-abstraction and pollution, contamination of selected coastal aquifers in Europe, and water balance and quality control in Central Asia, are being studied within the framework of seven case studies. Through RER7013, ‘Evaluating Groundwater Resources and Groundwater-Surface-Water Interactions in the Context of Adapting to Climate Change’, the Agency provided participating countries with equipment to enable sampling campaigns that started in the summer of 2021. Scientific visits, fellowships and virtual training courses were used to build knowledge in the use of isotope hydrology techniques.

The Agency is helping countries in the Central American Dry Corridor under regional project RLA7024, ‘Integrating Isotope Hydrology in National Comprehensive Water Resources Assessments’, to better understand linkages between rain, surface runoff and groundwater recharge, with the goal of supporting improved water management plans. Reliable and up-to-date hydrological information is required to implement public water policies and measures. Critical recharge zones and their connectivity with surface water systems have been identified in all participating countries, and sampling campaigns for rainfall, surface water and groundwater have been carried out in Costa Rica, El Salvador, Honduras, Nicaragua and Panama. Isotopic analyses have allowed the establishment of isotopic databases and development of rainfall models. In July 2021, Costa Rica hosted a virtual workshop on the interpretation of stable water isotopes in the evaluation of

groundwater resources in the dry corridor of Central America under scenarios of variability and climate change. This allowed specialists and water authorities to interpret the results and data and to produce relevant maps and modelling, with the objective of facilitating decision making in their respective countries. Related scientific publications and a side event organized during COP26 (with the launch of a video on the Dry Corridor Initiative) contributed to promote the power of isotopes in evaluating the impact of climate change on water resources. In 2021, the network of laboratories in Latin America and the Caribbean performing isotope analysis was expanded by the delivery of laser spectrometry equipment for Bolivia, El Salvador, Honduras and Paraguay, which will be installed in early 2022.

Under national project HAI7001, 'Strengthening National Capacities for the Use of Isotope Hydrology for Integrated and Sustainable Water Management of the Cul-de-Sac Aquifer', a situational analysis of water resources in Haiti was carried out in 2021 in collaboration with the Ministry of Environment and related national stakeholders to collect baseline information on water resources, data availability, institutional responsibilities and plans for the management and use of surface and groundwater. The report outlined a preliminary action plan for isotope hydrology implementation in Haiti that was presented and discussed with national stakeholders during a virtual workshop in June 2021.

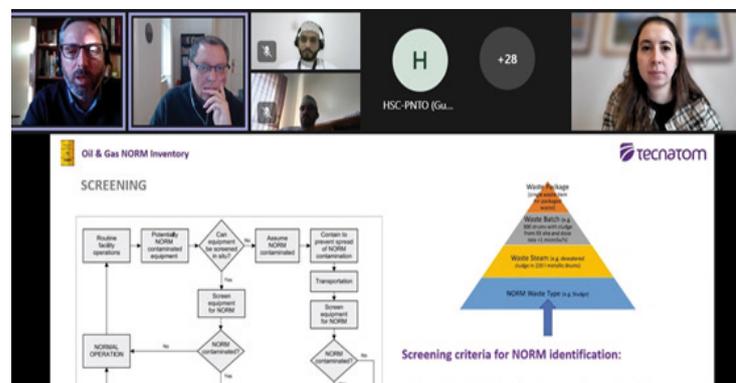
MARINE, TERRESTRIAL AND COASTAL ENVIRONMENTS

The TC programme has strengthened national capacities in Bahrain to monitor the terrestrial, marine, and coastal environment under TC project BAH7001, 'Enhancing Analytical Capabilities for Improved Environmental Monitoring'. The project goal is to protect people and the environment and to preserve natural resources and ecosystems. In 2021, several items of equipment were procured, including an X-ray fluorescence spectrometer to measure trace elements and in-organic pollutants in environmental samples and a liquid scintillation counter to analyse radionuclides activities in environmental samples. National staff were also provided with online training, and as a result, Bahrain's capacity to perform environmental analyses has been enhanced.

The chemical characteristics of groundwater in Syria have been determined under SYR7005, 'Assessing Groundwater Quality Using Nuclear and Isotopic Techniques'. The findings give a preliminary indication that the main sources of nitrate pollution in the Ghouta of Damascus are manure, septic waste and soil organics, which contain nitrogenous compounds due to anthropogenic activities, and lead to the increase of nitrate pollution.

A month-long virtual training course on 'Measurement Techniques for Natural and Artificial Radionuclides and Radiochemical Methods for their Determination in Marine Environment' was held in 2021 under TC projects MAL7007, 'Enhancing Radiochemical Analytical Capabilities for Sustainable Coastal and Terrestrial Environmental Monitoring' and MYA7008, 'Upgrading the Marine Environmental Radiation Monitoring Infrastructure'. The training covered a wide range of topics in environmental radiation monitoring and related measurement techniques, such as gamma-ray spectrometry, Alpha-particle spectrometry, gas proportional counting and liquid scintillation counting. The training course was attended by more than 35 participants from Malaysia and Myanmar, with nine experts in environmental monitoring providing lectures.

Oman's capacity to assess and monitor coastal and marine pollution has been assessed with the support of project OMA7004, 'Assessing and Monitoring Radioactive and Non-Radioactive Pollutants in the Marine Environment and Coastal Zones', and a roadmap for necessary training has been developed. In 2021, local personnel attended a



A virtual National Workshop on Inventory and on Strategies for the Management of NORM held in December brought together more than 40 participants from the Ministry of Energy and Minerals and oil and gas companies in Oman. (Photo: Linda Eid/IAEA)

course on oil spills, and benefitted from a virtual expert mission which provided detailed requirements for the development of necessary infrastructure.

A virtual regional training course for ARASIA State Parties was held in 2021 to provide training on the laboratory management software TRIMS, a laboratory management system designed for the standardized analysis of tritium in isotope hydrology. The training was supported through regional project RAS7034, 'Managing and Protecting Urban Coastal Aquifers in States Parties (ARASIA)'.

Through project RER7014, 'Improving Environmental Monitoring and Assessment for Radiation Protection in the Region', understanding of specific aspects of QA/QC and integrated quality management practices in environmental radioactivity monitoring programmes were improved in laboratories in Europe and Central Asia in 2021. In addition, national capabilities to determine anthropogenic and natural radionuclides were also improved. Through the consolidation of country baseline reports it is now possible to better understand the environmental monitoring situation in the participating Member States, including the legal and regulatory aspects of monitoring for protection of the public and the environment. This information has contributed to the development of a regional action plan to support the improvement of national capabilities, including enhancement of analytical technical capacities.

Regional project RLA7025, 'Strengthening Capacities in Marine and Coastal Environments



Collection of 230-year-old coral core for historical reconstruction of pH and Temperature proxies using delta-11Boro and 18Oxygen techniques respectively. (Photo: Luis Angal Aragon Lopez/CEAC-CUBA)

Using Nuclear and Isotopic Techniques,' aims to strengthen the capacity of countries that are part of the REMARCO network to achieve targets related to SDG 14, specifically coastal eutrophication, floating plastic debris density and ocean acidification. A Regional Observatory on Ocean Acidification comprising Colombia, Cuba, Mexico was established in 2018 for the regular monitoring of ocean acidification. As a result, Cuba and Mexico reported data in 2021 on the SDG 14.3.1 Data Portal hosted by IOC-UNESCO – the custodian agency for the indicators for SDG target 14.3 on ocean acidification.

In 2021, REMARCO network specialists prepared a manual of harmonized protocols with the goal of standardizing methodologies and data interpretation for ocean acidification measurements. To support the development of the manual, an e-learning course on the measurement of carbonate systems as an indicator of mean marine acidity was developed under RLA7025. The training course provided information and tools for sampling and chemical analysis of pH, total alkalinity and

dissolved inorganic carbon of coastal waters to 65 specialists from 17 Latin American and Caribbean Member States, following the standardized protocol developed by REMARCO. Participants in the course included several SDG 14 national focal points, who were trained on how to prepare and validate content for SDG 14.3.1 data reporting. The training course was led by INVEMAR (Colombia) and is hosted on the IOC/UNESCO Global Ocean Teacher Academy platform. It is accessible as an e-learning course for all specialists in the region.

Efforts to build capacity in the Caribbean region in the area of marine environment monitoring continued with the procurement of equipment for laboratories in Antigua and Barbuda, Belize, Jamaica and Trinidad and Tobago under RLA0063, 'Using Nuclear Techniques for Climate Change Adaptation and Mitigation'. The equipment will support analysis related to ocean acidification and microplastics.

Industrial Applications

REGIONAL HIGHLIGHTS

The TC programme in Africa assists Member States with capacity-building, research and development in nuclear science through national and regional projects, and supports them in using nuclear technology, including research reactors, in a variety of practical industrial applications.

In the Asia and Pacific region in 2021, the component of the TC programme related to industrial applications and radiation technology focused on areas such as establishing commercial facilities, building capacity in non-destructive testing, and supporting the operation of research reactors.

In the Member States of Europe and Central Asia, activities focused on strengthening capacity for the safe and efficient use of radiation technology for applications such as recycling of polymer waste, control and detection of pollution, characterization and preservation of cultural heritage artefacts, inspection and certifying the integrity of civil structures, and research into nanomaterials for biomedical and industrial applications. The programme also supported harmonization of quality assurance and control procedures in line with European Union and international standards, contributing to enhanced resource efficiency and paving the way for a circular economy at the regional level.

The promotion of regional industrial competitiveness, with a focus on sustainability, is critical for the development of the Latin America and the Caribbean region. In 2021, the Agency supported the development of capacity building in non-destructive testing (NDT) techniques that are used to confirm that civil and industrial buildings can withstand damage caused by natural disasters.



RADIOISOTOPES AND RADIATION TECHNOLOGY FOR INDUSTRIAL APPLICATIONS

Capacity building activities and procurement in 2021 under TC project THA1015, 'Establishing a Cyclotron Facility for Radioisotope Production and Industrial Research', supported efforts to commission Thailand's new 30 MeV cyclotron facility in 2022. The facility will be able to produce both single photon emission computed tomography (SPECT) and positron emission tomography (PET) radionuclides. The multidisciplinary facility will serve several functions, including the production of radiopharmaceuticals to assist in the diagnosis and treatment of diseases including cancer for all ASEAN countries.

Regional project RLA1014, 'Advancing Non-Destructive Testing Technologies for the Inspection of Civil and Industrial Structures (ARCAL CLIX)', aims to improve regional capacities in Latin America and the Caribbean for the inspection of civil and industrial infrastructure using non-destructive testing (NDT) techniques. The four-year project has supported the implementation of NDT training and qualification certification systems in accordance with ISO 9712 and ISO 17024. In 2021 the project took important steps in the establishment of four subregional centres in Argentina, Chile, Mexico and Peru. These facilities will serve as reference centres for the region in the event of emergencies, providing technical assistance and lending NDT equipment for the diagnosis of structures at risk. This will increase the speed and efficiency of emergency response in the region, which will be guided by a joint emergency protocol under



Ongoing construction work at the Cyclotron Complex Building. (Photo: Dr Kanokporn Boonsirichai, Thailand Institute of Nuclear Technology TINT)

development with the support of experts from the Italian Association of Non-Destructive Testing (AIPnD).

RESEARCH REACTORS

Expert assistance provided by the Agency through project PHI0016, 'Building Capacity for the Safe Operation and Utilization of the Research Reactor's Subcritical Assembly for Training, Education, and Research', is supporting preparatory work for the commissioning of a research reactor in the Philippines, planned for the first quarter of 2022. The project also provided support for the procurement of equipment, including an underwater camera and a portable neutron survey meter. A virtual tour to the Nuclear Reactor Laboratory (NRL) at the Massachusetts Institute of Technology (MIT) was organized for national researchers in September 2021.

Several training activities were conducted under TC project SAU1006, 'Enhancing the Safety and Utilization of the Low Power Research Reactor' in 2021 to support the development of a low power research reactor in the country. Two Saudi nationals attended the Eastern European Research Reactor Initiative (EERRI) Group Fellowship Training Course, an extensive learning opportunity that included theoretical classes, facilities familiarization, and hands-on experimental activities related to research reactors. A virtual expert mission was conducted in 2021 on the review of the commissioning programme of the Low Power Research Reactor. The mission provided recommendations and suggestions based on the IAEA Safety Standards to ensure safety during the commissioning phase of the reactor.

Under RAF1007, 'Strengthening the Capacities of Research Reactors for Safety and Utilization (AFRA)', a second proficiency test exercise for African Member States' laboratories using Neutron Activation Analysis and nuclear-related analytical techniques was initiated in 2020 and completed in 2021. Five out of six operational research reactors participated. Where appropriate, areas for improvement were proposed, including enhanced quality assurance and control procedures that will contribute to sustained high performance. A virtual regional meeting on Regulatory Review and Assessment and Inspection of Research Reactors was organized to assist participating countries to enhance their capacities for the continued safe utilisation of their research reactors.

Under UZB1006 'Strengthening Radiation and Nuclear Safety and Improving Use of the WWR-SM Research Reactor at the Institute of Nuclear Physics of the Academy of Sciences', the Agency procured components and services for the modernization of the primary cooling system of the 10MW research reactor and conducted an expert mission to assist Uzbekistan with a visual inspection of the reactor tank and internal structures, using Agency equipment.

"Several training activities were conducted under TC project SAU1006, 'Enhancing the Safety and Utilization of the Low Power Research Reactor' in 2021 to support the development of a low power research reactor in the country."

Energy Planning and Nuclear Power

REGIONAL HIGHLIGHTS

The Agency participated in meetings on the theme of energy organized by the Office of the Special Adviser for Africa (OSAA), in collaboration with several other UN entities that include UNECA, DESA, UNIDO, UNDP, IAEA and UNCTAD, in 2021. They brought together the UN system as well as global development agencies, leaders from business, foundations, international civil society and youth organizations, to mobilize commitments and actions to transform the way Africa could leverage the benefits of transitioning to clean, renewable and affordable energy, as well its financing, with the aim of tackling climate change and the energy access crisis. Several Member States in Africa completed national projects on energy planning during 2021. The IAEA's energy planning tools were transferred to national teams, and national experts were trained and subsequently used their new analytical capacity to support the development of national energy plans, strategies and policies.

Many countries in the Asia and the Pacific region received Agency assistance for energy planning and nuclear power in 2021.

Countries in Europe operate the largest fleet of nuclear power plants (NPPs) in the world that supply clean and reliable electricity to millions of businesses and households. National, regional and interregional TC projects supported Member States by providing training and assistance for countries to embark on new nuclear power programmes, ensure continuity of excellence in performance of NPPs, and gain knowledge of future nuclear power technologies as part of a clean and carbon-low electricity generation effort. Within a regional project on energy planning, 27 countries were supported to understand and independently apply IAEA models that assess energy technologies to take knowledgeable decisions on how to shape their optimal future low-carbon energy mix in line with the Paris Agreement. Several national, regional and interregional projects are also supporting Member States in the safe, effective and efficient management of their radioactive waste. This includes predisposal planning and integrated waste management, storage and final disposal of waste, and the decommissioning of facilities and sites.

The Latin American and Caribbean region continues to face growing energy demands. The comprehensive analysis of energy supply and demand scenarios has been identified as a priority.



"Within a regional project on energy planning, 27 countries were supported to understand and independently apply IAEA models that assess energy technologies to take knowledgeable decisions on how to shape their optimal future low-carbon energy mix in line with the Paris Agreement."

ENERGY PLANNING

The Agency was selected as a modelling partner (along with the International Renewable Energy Agency) to support the development of a Continental Master Plan (CMP) for Africa. CMP activity started in March 2021, financed by the EU Technical Assistance Facility. The Agency is providing energy system assessment tools and is conducting and supporting training activities.

With the assistance of the International Renewable Energy Agency, Eswatini published an Energy Master Plan in 2018, based on the IAEA modelling tool MESSAGE. To refine, update and extend this Master Plan to 2050, the Agency is supporting a multi-institutional project team in Eswatini in developing an Integrated Resource Plan (IRP). In 2021, virtual expert missions and a fellowship were organised, applying the IAEA's Model for Analysis of Energy Demand) for improving the reliability of the demand assessment and the IAEA's Model for Energy Supply Strategy Alternatives and their General Environmental Impact for considering additional energy supply technologies.

A three-day virtual workshop on Project Financing Structures and Tariff Setting was conducted for Saudi Arabia, covering topics such as structuring and developing nuclear

newbuild projects, financial models, country cases, and applicability to the Saudi Arabian nuclear programme.

In 2021, energy planners from 15 Latin America and Caribbean countries gathered virtually to evaluate national needs for the next 30 years using the IAEA's Model for Analysis of Energy Demand, and to jointly analyse the implications of growing electricity demand at a regional level. Participants at the meeting included representatives from the Latin American Energy Organization (OLADE), the Economic Commission for Latin America and the Caribbean (CEPAL) and the International Energy Agency (IEA). In addition to the virtual workshop, online training courses on energy supply analysis using the IAEA's Model for Energy Supply Strategy Alternatives and their General Environmental Impact were organized with over 30 participants from Colombia, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panamá and Venezuela. The national teams presented their national energy demand case studies at a workshop in November. The Agency's efforts to build capacity in energy planning in Latin America and the Caribbean were highlighted and promoted during a side event organized by Climate Compatible Growth on the margins of COP26.

INTRODUCTION OF NUCLEAR POWER

Twenty-four training courses were implemented within the framework of the Interregional Training Programme to increase awareness and understanding of the Milestones Approach. Training was provided to over 480 participants from 39 Member States. The Agency conducted two face-to-face and three virtual expert missions to Egypt, Ghana and Poland to advise key organizations on the development of leadership, management systems and improved nuclear organizational culture in line with the Agency's safety standards. Additionally, three virtual national workshops for Kenya, Poland and Sri Lanka, as well as four virtual Expert Missions for Ghana, Morocco and Saudi Arabia and two workshops on Strategic Environmental Impact Assessment were held.

A virtual expert mission to Indonesia in 2021, under INS2017, 'Improving National Capacity to Develop Reactor Design and Safety Analysis, Fuel Manufacturing, Testing, Infrastructure and Construction Strategy of Daya Experimental Reactor', supported the review of a pre-feasibility study on Economics, Financing, and Macroeconomic Impact Assessment of NPP deployment in West Kalimantan. The expert mission provided suggestions on further improvements of the pre-feasibility study in the areas of economics and financing to the Indonesian counterparts.

A national workshop on economics and finance for new build NPPs, supported by TC Project UZB2002, 'Building Human Resources Capacity and Developing National Nuclear Infrastructure for a First Nuclear Power Plant', was held in Uzbekistan in September. The workshop, which brought together over 30 participants from UzAtom and other institutions in Uzbekistan, focussed on the economics of nuclear power, cost estimation methodologies for nuclear new builds, and on challenges and solutions for financing.

A virtual inception workshop for Israel on Design Provisions of Small Modular Reactors was supported by project ISR9014, 'Establishing Criteria and Guidelines for the Site Selection of Nuclear Power Plants – Phase II'. The workshop built national capacity for the potential deployment of a small modular reactor in preparing for a national nuclear energy programme. Technical discussions focused on seismotectonic safety criteria and dialogue was conducted with SMR technology developers on how their design and technology would cope with external safety events, underground construction, and flexibility of operation.

A virtual workshop on Design and Technology Fundamentals of Advanced Nuclear Power Reactors for Near Term Deployment was held for Singapore in 2021, supported by TC project SIN0003, 'Building Capacity in Nuclear Power Technology and Safety'. The workshop, which brought together 120 participants from various institutions in Singapore, including the Energy Market Authority, the National University of Singapore and the National Environment Agency, examined developments in advanced reactor technology,

"Twenty-four training courses were implemented within the framework of the Interregional Training Programme to increase awareness and understanding of the Milestones Approach. Training was provided to over 480 participants from 39 Member States."

including small modular reactors (SMRs) and micro reactors. This workshop continued efforts to build the required core technical capacity for the continued assessment of Singapore's options for an optimized nuclear energy strategy, in a manner that creates public awareness and interest.

A virtual training course on Advancements and Innovations in Water Cooled Reactor Technologies with Hands-On Learning Tools was held in 2021 for the Asia and the Pacific region, supported by TC RAS2018, 'Supporting Decision Making for Nuclear Power Planning and Development - Phase III'. Participants travelled virtually with the hosts and experts to four countries: moving the first day from Vienna (Austria) to Sharjah (UAE), the following day to Islamabad (Pakistan), and the last day to Raleigh (USA) and back to Vienna (Austria). Each day started with a virtual video tour of the city and institution hosting that day's course activities. At the end of every day the participants had the opportunity to practice the concepts, working together in virtual teams



NUCLEAR POWER REACTORS

In 2021, the Agency continued its assistance to Member States in Europe to strengthen nuclear power plant lifetime management for long term operation. Virtual and in-person capacity building events were conducted under regional project RER2015, 'Strengthening Nuclear Power Plant Lifetime Management for Long Term Operation'. A hybrid regional workshop on Challenges with Maintaining the Reliable, Long-term Operation of Instrumentation and Control (I&C) Systems at Nuclear Power Plants took place in Ljubljana, Slovenia. The workshop focused on knowledge and best practice sharing on the long-term operation of I&C systems, and case studies, practical experiences and lessons learned from real applications. Participants presented their national operational experience, long term operation status, ageing management and license renewal activities. In addition, a technical tour to the Slovenian Research Reactor and the Nuclear Training Centre was arranged. This event greatly contributed to capacity building on the safe and reliable long-term operation of NPP I&C systems.

In July 2012, Belarus signed a construction contract with the Russian Federation for two 1194 MWe units, as well as fuel supply, spent fuel take-back, training and other services. Unit 1 was fully commissioned in June 2021. To develop the workforce for the new nuclear power plant, a national training system to supply qualified specialists for the nuclear power sector was created within the State Programme of Education and Training for the Belarus Nuclear Power Programme, and the Agency supported further personnel training

for the Belarusian Nuclear Power Plant (BelNPP) in Ostrovetz through group fellowships and group scientific visits dedicated to proper management, operation and maintenance of the plant. In 2021, in-person training courses were organized on the practical application of the probabilistic safety assessment model for the BelNPP, durability and reliability of technological equipment, and non-destructive testing. In addition, both a virtual expert mission on management of the design configuration of the NPP and a group scientific visit to the Crisis Centre in Russian Federation to observe the development and implementation of an emergency response system as well as EPR system structure and procedures took place in 2021, supported under BYE2008, 'Enhancing the Operational Safety of the Nuclear Power Plant during Commissioning and Operation' as well as an OSART follow-up mission to the BelNPP. An IAEA Preoperational OSART follow-up mission was conducted in October.

The Agency is supporting the operational safety and lifetime extension of the Armenian Nuclear Power Plant Unit (ANPP) 2 in accordance with the IAEA Safety Standards. In 2021, a SALTO (Safety Aspects of Long-Term Operation) follow-up mission was conducted under ARM2004, 'Enhancing Operational Safety for Lifetime Extension of the Nuclear Power Plant Unit 2 in Accordance with International Standards', to assess the ANPP's preparedness for safe Long Term Operation (LTO) following the recommendations raised in the SALTO in 2018. The ANPP has made progress in developing a proactive approach to prepare for LTO; improving and updating its Safety Analysis Report to support LTO; and improving the methodology for defining the scope of components designated for ageing management. Furthermore, the project supported the acquisition of a thyroid uptake probe system and four contamination monitors for radiation protection, including on-site installation and necessary training for the operating staff.

Improving operational safety in nuclear power plants is a major concern, as well as an essential goal, for Latin American countries operating NPPs for commercial purposes (Argentina, Brazil and Mexico). TC project RLA9089, 'Supporting Nuclear Power Plant Ageing Management, Preparation for Safe Long-Term Operation and Safety Culture Practices,' aims to improve operational safety of NPPs by fostering and promoting the direct development of human resources managing and working at NPPs, as well as fostering and facilitating the interchange of international experience, best practices, and expert and peer assessment and feedback.

Argentina has two operating units in Buenos Aires (Atucha 1 and 2) and a third NPP located in the Cordoba province (Embalse). Embalse and Atucha 1 are in long-term operation. In 2021, Argentina received a SALTO follow-up mission to Atucha 1 (23-26 November). The mission reviewed progress in resolution of each issue from the Pre-SALTO mission conducted in 2018. Atucha 1 has made progress in the areas of scope setting and ageing management review for electrical and instrumentation and control components.

Brazil has two operating units at Angra site. Angra I is in preparation for long-term operation. Brazil has already started to prepare the ageing management programme of unit 2. During 2021, Angra NPP hosted two virtual workshops focusing on Periodic Safety Review and on data management for ageing management and long-term operation. Utilities and technical support organizations from Brazil participated actively.

In Mexico, Laguna Verde Nuclear Power Plant (LVNPP) submitted a license renewal application to the regulatory authority in 2015 to reach a total operation of 60 years. Licence renewal was granted in 2021. During 2021, Mexico hosted a virtual support mission on ageing management of cables. Mexico also hosted two virtual workshops in safety culture and knowledge management in June and September 2021. The main purpose of the workshops was to train the Safety Culture Self-Assessment Team and to provide support in completing analysis and conclusions of safety culture self-assessment.

In 2021, the Regulatory authorities of Argentina, Brazil and Mexico participated in a virtual workshop on regulatory oversight and review of development, implementation and enhancement of Aging Management programme and Equipment Qualification programme.

Radiation Protection and Nuclear Safety

REGIONAL HIGHLIGHTS

Use of radiation sources has become widespread in Africa. To fully maximize the contribution of nuclear science and technology as a catalyst for development, radiation safety infrastructure in Member States should be improved to ensure the safe and secure use of such sources. In 2021, Djibouti and Togo adopted the decree establishing their National Regulatory Authorities. Efforts were also placed on strengthening radioactive waste management in Africa in 2021.

Projects in the Asia and the Pacific region under the thematic area of nuclear, radiological, and waste safety focused on radiation safety infrastructure, emergency preparedness and response and radiation protection training in 2021.

The Agency continued to support Member States in Europe and Central Asia with the safe, effective and efficient management of their radioactive waste in 2021. This includes predisposal planning and integrated waste management, storage and final disposal of waste, and the decommissioning of facilities and sites. There is an ongoing need to improve technologies and human resource competencies to enhance and strengthen Member States' waste management expertise.

Nuclear safety and radiation protection remain priorities for the Latin America and Caribbean region. In 2021, a new coaching programme in regulatory infrastructure was initiated under regional project RLA9087, 'Building Capacity and Sustaining the National Regulatory Bodies'. The coaching programme offers tailor-made assistance for Member States in the Caribbean, informed by a Strategic Planning Tool developed with Latin America countries. Presently, Antigua and Barbuda, Belize, Jamaica and Guyana are leveraging support under the programme to accelerate the development of their regulatory infrastructure with the elaboration of a detailed roadmap for each country. Looking ahead, the coaching programme will deliver capacity building support to the remaining Member States in the region, and its scope will be expanded to include individual coaching on the safety of disused radioactive sources.



GOVERNMENTAL REGULATORY INFRASTRUCTURE FOR RADIATION SAFETY

Under TC project SAU9011, 'Supporting the Implementation of the Regulatory Body and the Development of Nuclear Regulations', a virtual training course provided first responders in Saudi Arabia with knowledge of the basic principles and best practices which underpin an effective response to a radiological or nuclear emergency. The course was attended by 50 nuclear regulators, national guards, customs and port authority agents, and other officials. Courses were also held on first response to radiological emergencies, and on developing national radiation emergency plans.

The Department of Nuclear Science and Technology (DNST) of the Ministry of Mines and Energy of Cambodia received a Regulatory Authority Information System (RAIS) procured by the Agency to support the establishment of Cambodia's National Inventory of Radiation Sources under TC project KAM9004, 'Establishing a Regulatory Infrastructure for the Control of Radiation Sources'. Subsequently, some 20 DNST staffs received Agency-supported virtual training on RAIS 3.4. DNST is currently importing existing data on radiation sources in Cambodia into the new RAIS system. The Ministry of Mines and Energy promulgated Declaration (PRAKAS)



A technical officer in the Department of Nuclear Science and Technology (DNST) of the Ministry of Mines and Energy of Cambodia. (Photo: DNST)

No.0126 dated 1 April 2021 on the Management of Import and Use of Radiation Substances and Sources which outlines the procedures, terms and conditions to apply when importing and using radiation substances and sources in Cambodia.

"The project also assisted 25 specialists from regulatory authorities to establish or strengthen integrated regulatory bodies' management systems, with special attention on human resource planning."

The regional project RER9148, 'Strengthening the Regulatory Infrastructure for Radiation Safety', is assisting countries in Europe and Central Asia to establish missing regulatory framework elements and is facilitating the exchange of experience to accelerate the process of sustaining regulatory infrastructure, supporting harmonization, networking, knowledge exchange, and a common understanding of the issues and challenges. Under the project, specialists have been trained to self-assess the status of their national regulatory infrastructure for safety against the relevant IAEA Safety Standards using the Self-Assessment of Regulatory Infrastructure for Safety (SARIS) and on how to develop an action plan for establishing or improving their legal, governmental and regulatory framework. The project also assisted 25 specialists from regulatory authorities to establish or strengthen integrated regulatory bodies' management systems, with special attention on human resource planning. In addition, regulatory bodies from 15 Member States were provided with identifier devices for gamma and neutron radiation measurement to increase their inspection capabilities. A final training event focused on increasing knowledge on methodologies for safety culture self-assessment to sustain a strong culture for radiation safety in Member State regulatory authorities.

Project RLA9086, 'Strengthening Radiation Safety Infrastructure,' aims to enhance radiation safety infrastructure in Member States in Latin America and the Caribbean, including improved safe management of radioactive waste and protection of the public and environment. In 2021, project funds were used to procure equipment to carry out environmental monitoring programmes related to normal operation and existing exposure situations for Member States. Specific hands-on training on the use of such equipment is planned for 2022.

In Costa Rica, the revision of the draft regulation for radiation protection was successfully carried out in 2021 with Agency assistance through the national project COS9012, 'Strengthening National Infrastructure for Radiation Safety'. The country will include the revised regulation into the national legal framework and will continue working with the Agency to improve the specific regulation instrument on physical security in the next project cycle.

RADIATION PROTECTION OF WORKERS, PATIENTS AND THE PUBLIC

In 2021, Agency support was provided to Poland through POL9025, 'Promoting a Safety Culture and Enhancing the Quality Assurance and Quality Control Capability of Nuclear Medicine Departments'. Training courses were organized to increase awareness and to promote good practices in relation to quality assurance and quality control (QA/QC) and patient safety. Equipment was procured to support the establishment of two QA/QC reference nuclear medicine departments which serve as national training centres. As a result, the QA/QC capabilities of nuclear medicine departments in Poland have been strengthened, and radiation protection and safety culture in the country has been enhanced.

Capacity building and strengthening radiation safety culture in medicine are priority areas for Agency collaboration with Latvia. In 2021, two virtual training courses were organized by the Agency and the Radiation Safety Centre of State Environmental Service under LAT9015, 'Strengthening Radiation Safety Culture in Medicine and Improving the Knowledge of Regulatory Personnel', with the goal of further strengthening human resource development. The first course increased the knowledge and competence of medical staff on practical aspects of medical exposure in the field of X-ray imaging while the second course provided necessary theoretical knowledge of safety standards and good practices for improved radiation protection of patients and staff in nuclear medicine. In total, more than 90 Latvian professionals were trained.

EMERGENCY PREPAREDNESS AND RESPONSE

When a radiological incident occurs, ambulances, police officers and fire fighters are often the first to reach the scene. Time is a critical factor in a radiological emergency and the actions taken by first responders in the minutes and hours following an incident can be of paramount importance in ensuring lives are saved and consequences are mitigated. By managing the medical response, allocating evacuation routes or protecting potential evidence, first responders have a unique role to play in protecting the public.

Bahrain received support through project BAH9010, 'Ensuring the Sustainability of National Capabilities in Preparedness and Response to Radiation Emergencies', to ensure the sustainability of national capabilities for preparedness and response to radiation emergencies. A range of national training courses were held in 2021 on topics related to emergency preparedness and response, many in Arabic. Over 220 national staff took part in the training courses.

Under QAT9014, 'Strengthening National Emergency Preparedness and Response Capabilities – Phase III', a virtual national training course for customs officers on preparedness and response to nuclear or radiological emergencies provided training on basic emergency preparedness and response (EPR) concepts, with an emphasis on first response in case of radiological or nuclear emergency. The course was attended by 55 participants from Qatar.

In Cyprus, the Agency trained first responders for radiological emergencies under CYP9007, 'Strengthening the Regulatory Infrastructure and Capabilities to Ensure Radiation Safety in Accordance with IAEA Safety Standards', on skills and knowledge to protect themselves effectively while responding to a crisis. Participants learned how best to assign duties and allocate resources under moments of extreme pressure and how to protect themselves and those at the scene affected by radiation. The training also included a series of tabletop scenarios for medical personnel and response officials, simulating emergency scenarios that required quick and close coordination to address. The training course was attended by 34 medical first responders over the course of three weeks to accommodate their rotating ambulance shift schedules.

Three regional training events were organized for Member States participating in RER9151, 'Updating and Harmonizing Emergency Preparedness and Response Plans'. The training events addressed development of a protection strategy for a nuclear and radiological emergency, the role of first responders, and combined emergencies.

In an effort to improve capabilities in Latin America and the Caribbean to respond to radiological emergencies, 21 participants from eight Caribbean Member States participated in a training course for first responders organized under RLA9087, 'Building Capacity and Sustaining the National Regulatory Bodies'. In addition, expert missions on hazard assessments for Building National Radiological Emergency Plans were conducted in Antigua and Barbuda and Jamaica, providing a basis to develop effective emergency arrangements commensurate with the radiological risk profile for these countries.

Two training activities were carried out in December under RLA9086, 'Strengthening Radiation Safety Infrastructure'. A regional training course for first responders brought together 31 participants from 13 countries in Latin America, and a webinar on Arrangements for the Termination of a Nuclear or Radiological Emergency Irrespective of Its Cause was delivered.

Bolivia received support under BOL9009, 'Strengthening National Capabilities for the Implementation of the Center for Research and Development of Nuclear Technology and the Centers for Nuclear Medicine and Radiotherapy', to build EPR capacities to meet the requirements of new infrastructure under construction in the country, including a multi-purpose irradiation plant, cyclotron and radiopharmaceutical facilities and a research reactor. A national training course on Preparedness and Response for a Nuclear or Radiological Emergency Involving the Transport of Radioactive Material was attended by 76 participants in October.

"Time is a critical factor in a radiological emergency and the actions taken by first responders in the minutes and hours following an incident can be of paramount importance in ensuring lives are saved and consequences are mitigated."

"In an effort to improve capabilities in Latin America and the Caribbean to respond to radiological emergencies, 21 participants from eight Caribbean Member States participated in a training course for first responders organized under RLA9087, 'Building Capacity and Sustaining the National Regulatory Bodies'."

In Ecuador, project ECU9017, ‘Strengthening the National Infrastructure for Radiation Safety’, supported a national training course in November on basic medical response during a radiological emergency. The course was attended by 24 participants from Hospital de Especialidades Carlos Andrade Marín, Quito, as part of its preparedness to act as the Reference Hospital to deal with radiological emergencies in the country. The activity is part of the implementation of a roadmap established in 2020 to build EPR medical capabilities, arising from the recommendations of two expert missions conducted in 2020 under the same project.

RADIOACTIVE WASTE MANAGEMENT, DECOMMISSIONING AND ENVIRONMENTAL REMEDIATION

Under the framework of regional project RAF9062, ‘Strengthening Radioactive Waste Management (AFRA)’, notable progress continues to be made in the development of waste infrastructure in Africa. In 2021, Mauritius completed the construction of its first centralized disused sealed radioactive sources (DSRS) facility. The facility has been constructed for the long-term storage of DSRS, for a period not exceeding 50 years, and will become operational in 2022. Agency assistance will continue for the provision of the operational training, equipment and tools required for the facility.

Under TC project OMA9006, ‘Implementing Safe Management of Radioactive Waste and Naturally Occurring Radioactive Materials from the Oil and Gas Industries’, the Agency provided expert support for a virtual mission on establishing an inventory of naturally occurring radioactive materials (NORM) from the oil and gas industry in Oman. Following the mission, a virtual national workshop was held on Inventory and Strategies for the Management of NORM. The workshop brought together different national stakeholders, including national authorities and waste producers, to establish a common understanding on the importance of having an integrated approach in place that allows the cost-effective development of a NORM national inventory. The workshop covered topics such as the expected role of inventory in the overall NORM waste management strategy, main challenges, technical solutions and good practices for inventory development.



The proposed site for the underground research laboratory lies in the Beishan area of China’s Gansu Province, which is bound from the north by the Gobi Desert. (Photo: G. Nieder-Westermann/IAEA)

Through TC project CPR9054, ‘Evaluating Underground Research Laboratory Site Characteristics at Depth for High-Level Radioactive Waste Disposal’, a six-week virtual expert mission to assist China in the construction of its first underground research laboratory for high level waste disposal took place in 2021, to provide input, guidance, and recommendations to support plans for the laboratory. In 2021, with the support of RER9150, ‘Improving Capabilities to Efficiently Implement Large Ongoing Decommissioning Projects and Waste Management with Minimization of Risks Based on Initiatives and Potential Synergies’, stakeholders from thirteen Member States in Europe gained knowledge and best practices on decommissioning procedures to achieve safer and effective waste management operations. The project also supported discussions among specialists to identify reliable and effective high temperature treatment methods for solid radioactive waste, including incineration, plasma treatment and re-melting, and the examination of key factors influencing the selection of

thermal technologies. Member States also improved their knowledge of the implementation of release of materials from regulatory control, including conditional clearance, and of the process for conditioning waste containing alpha and transuranium radionuclides. As a result, regional capacity to efficiently implement large decommissioning projects and waste

management with minimization of risks based on initiatives and potential synergies was significantly enhanced.

Three radioactive waste management specialists from the Waste Management Department of the Agency of Nuclear and Radiation Safety of Georgia received on-site practical training on the handling of Disused Sealed Radioactive Sources (DSRS) at the Centralized Radioactive Waste Storage Facility, Andronikashvili Institute of Physics, Tbilisi, Georgia. The training, under GEO9015, 'Enhancing Radioactive Waste Safety by Establishing Proper Processing and Safe Storage', took place using mobile infrastructure and a toolkit specifically designed for the conditioning and reconditioning of DSRS in Georgia. Several reconditioning sessions provided the specialists with the theoretical and practical knowledge required to conduct the DSRS reconditioning process from start to the end. The project has made it possible to ensure the safe storage of many DSRS and enhanced radioactive waste safety in the country.

The 1 MW Portuguese Research Reactor is the only nuclear installation in Portugal. The current national programme for management of spent fuel and radioactive waste only considers surface storage of radioactive waste and contains a preliminary estimate of the amounts and types of waste which could be generated by the decommissioning of the Portuguese Research Reactor (RPI). While the spent fuel has already been sent to the United States of America, the facility requires a decommissioning plan, for which Portugal has requested Agency support. Training was delivered under POR9011, 'Preparing a Decommissioning Plan for the Research Reactor', addressing radiological characterization prior to the decommissioning of a nuclear facility and including the different aspects of radiological characterization applied throughout the decommissioning project, identification of the nature and extent of decommissioning actions and decontamination as well as supporting planning of decommissioning and estimation of decommissioning costs. The training has built the capacity of the reactor team to draft the decommissioning plan for the research reactor. In addition, necessary instruments and tools to perform radiological characterization were provided.

In 2021, further progress was made in Latin America and the Caribbean regarding the safe management of waste containing natural occurring radioactive materials (NORM) from non-nuclear industries. Virtual sessions were held to assist countries with such industries in the region (for example, oil and gas industries, and mineral extraction and production). High level expert advisory missions to review and follow up on the implementation of national safety strategies continued to be provided virtually in 2021, aiming to support Member States with the prioritization of needs to close existing gaps in their safety infrastructures. Likewise, in 2021 within the framework of the project RLA9086, 'Strengthening Radiation Safety Infrastructure', an enforcement policy document for nuclear and radiological regulators was prepared, and the material for a training course developed. Work was also devoted to developing a guide to estimate the regulatory body staff necessary to implement regulatory processes and activities.

National project BRA0024, 'Developing Human Resources in Nuclear Technology,' supported the development of a roadmap for a holistic approach to natural radioactive materials (NORM) management in Brazil. A successful workshop on the topic was organized in May 2021, with the goal of establishing an understanding of the importance of a comprehensive and integrated approach for the safe and economical management of NORM. The workshop was based on the structure of the ENVIRONET (Network on Environmental Management and Remediation) NORM project. Participants from the national regulatory body and industry worked together to tackle NORM related issues. The road map produced by the workshop participants was delivered to the National Nuclear Energy Commission (CNEN) and provides the basis for implementing a holistic approach to NORM management in Brazil.

Regional project RLA9088, 'Strengthening Regional Capabilities of End Users and Technical Support Organizations on Radiation Protection as well as Emergency Preparedness and Response in Line with IAEA Requirements,' assists Latin American countries to

"High level expert advisory missions to review and follow up on the implementation of national safety strategies continued to be provided virtually in 2021, aiming to support Member States with the prioritization of needs to close existing gaps in their safety infrastructures."

advance the implementation of the IAEA General Safety Requirements, particularly the necessary safety elements of radiation protection and those related to Thematic Safety Area (TSA) 2 (Radiation Protection of Workers), TSA 3 (Radiation Protection of Patients), TSA 5 (EPR with focus on medical response, including Dosimetry for Accidents), and human health (regarding calibration of detectors and quality control of radiodiagnosis and radiotherapy devices). Despite the pandemic conditions, many activities were carried out virtually in 2021. As a result, relevant content and materials on radiation protection and advanced medical response for radiological emergencies have been adjusted for e-learning and virtual delivery of training courses, increasing access to this thematic area for more stakeholders. Two webinars were conducted, one on biodosimetry as a technique for Dose Evaluation in the response to a nuclear or radiological emergency and another on response to radiological emergencies. In addition, equipment was provided to Member States to enhance their capacity to measure dose rate and radiation contamination. The Agency also provided equipment related to irradiation services in support of participation in the European Radiation Dosimetry Group (EURADOS), which allows the intercomparison of dosimeters, which is essential for maintaining quality systems in secondary standard dosimetry laboratories.

Uruguay's national capacities to determine the presence of radioactive pollutants in environmental samples in real-time, particularly in air samples, were strengthened by the installation of three new real time analytical stations in Colonia, Cerro Lago and Tacuarembó. Together with the existing centralized operation centre in Montevideo, the stations form a nationwide network for the establishment of an early radiological warning system. The network became fully operational in 2021 and to ensure sustainability, the Agency supported the provision of a remote capacity-building programme to train and support national professionals in areas such as environmental radiological surveillance, data interpretation, gamma spectrometry, calibration and field measurement, under national project URU9012, 'Strengthening National Infrastructure for Radiation Safety and Security'.

A three-day virtual expert mission on 'Waste Management and Decommissioning Funds', covering topics such as funding arrangements, costing approaches, fees and guarantees, funds management and governance, and reporting standards, was conducted for Turkey in 2021, with the support of TUR2020, 'Strengthening the National Nuclear Infrastructure and Radioactive Waste Management System'.

Nuclear Knowledge Development and Management

REGIONAL HIGHLIGHTS

Human resource development is a priority in the African region. In 2021, efforts continued to provide training to skilled mid-level personnel such as engineers and technicians through short- and long-term academic training to build capacities and ensure the availability of skilled staff in African Member States.

For Member States from Europe and Central Asia, human resource development remains a priority to maximize the peaceful use of nuclear science and technology. Efforts continued to support the education and training of professionals in nuclear science and technology at various stages in their careers. The application of nuclear science and technology in Europe and Central Asia is wide and diverse and there are significant differences in nuclear infrastructure. Nuclear power continues to play an important role in ten Member States operating NPPs and five considered as NPP newcomers. At the same time non NPP Member States also make various uses of nuclear applications.

Efforts to promote the education and training of young professionals in the field of nuclear science and technology continued in the Latin America and Caribbean region, delivered notably through NUCLEANDO, a new educational programme developed by the Latin American Network for Education in Nuclear Technology (LANENT) with Agency support. NUCLEANDO provides a suite of scholastic tools and resources to help teachers in the regional incorporate nuclear science concepts in their curricula.



CAPACITY BUILDING, HUMAN RESOURCE DEVELOPMENT AND KNOWLEDGE MANAGEMENT

A core curriculum for radiation, clinical oncology and radiotherapy training schemes in Africa was finalized in 2021. This aims to provide the basic minimum requirements for AFRA Regional Designated Centres (RDCs) and any training programmes to be developed in radiation and clinical oncology on the continent.

In the framework of RAF1008, 'Supporting Radiation Technologies in Industrial Applications and Preventive Maintenance of Nuclear and Medical Equipment (AFRA)', a one-month group fellowship training on nuclear instrumentation was hosted by the Nuclear Research Centre of Birine, Algeria. Eleven candidates received training in the principles of nuclear electronics, and on the operation and repair of medical and nuclear instruments.

Through TC project INS0020, 'Supporting Comprehensive Capacity Building of National Nuclear Institutions to Support the Nuclear Industry and Stakeholder Utilization of Nuclear Technology', more than 280 participants with knowledge management responsibilities from three different national organizations and 23 divisional centres under the National Nuclear Energy Agency of Indonesia (BATAN) attended a series of three virtual national knowledge management workshops. The workshops provided participants with knowledge and tools on how to align the knowledge management strategy with the organization's business goals, how to ensure the growth of an organizational culture for knowledge-sharing, including practical approaches for tacit knowledge capture, and how to continuously implement a proactive knowledge retention and transfer plan to ensure critical knowledge is identified, shared and retained.

Project INS0020 is also providing the Polytechnic Institute of Nuclear Technology (PoINT) with support to develop an industry-based curriculum, taking into consideration a goal in Indonesia's National Medium-Term Development Plan to accelerate and strengthen the link between education and employment by enhancing cooperation between vocational

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colleges, universities and industry. To help improve the Institute's nuclear curriculum, Agency experts provided advice on the establishment of educational standards, strengthening existing laboratory resources and increasing the relevance of course syllabi to practical applications. The support provided under this project helped develop PoINT into a global vocational higher education establishment in nuclear science and technology, as it provided the opportunity for PoINT to review and strengthen its curriculum according to international standards. Following months of work, a draft curriculum for the nuclear teaching industry, as well as a new student internship programme and quality assurance regulations has been drafted by PoINT experts, for review and finalization in the coming months.

"The Agency arranged training for Czech specialists to ensure the safe, sustainable and reliable operation of institutions and services in the nuclear field."

Due to the approaching retirement age of experienced staff and an increasing demand for nuclear personnel, nuclear knowledge development is a priority in the Czech Republic. Through a national project, CZR0010, 'Strengthening Human Resources Capacity, Nuclear Knowledge, Skills Preservation, and Expertise in Relevant Fields of the Peaceful Use of Nuclear Energy', the Agency arranged training for Czech specialists to ensure the safe, sustainable and reliable operation of institutions and services in the nuclear field. In 2021, for example, France's Grand Accélérateur National d'Ions Lourds (GANIL) hosted a fellow, enabling the young professional to build capacities in the field of measurements on the collimated fast neutron beams produced at the new Neutrons for Science facility.

Leadership for safety in nuclear and radiological environments is key to preventing accidents and mitigating their consequences, should they occur. Safety leadership is particularly important in nuclear and radiological work environments. The International School of Nuclear and Radiological Leadership for Safety was held in Athens, Greece, at the end of November, to train mid-level professionals in safety leadership. The School, supported by regional project RER0043, 'Enhancing Capacity Building Activities in the European Nuclear and Radiation Safety Organizations for the Safe Operation of Facilities', provided participants with know-how to enhance their leadership skills in nuclear and radiological safety throughout their careers.

Regional project RLA0065, 'Enhancing Nuclear Education, Training, Outreach and Knowledge Management', aims to improve and expand education and training in nuclear science, engineering and technology, and supports the educational programme NUCLEANDO. In 2021, NUCLEANDO was selected as a good practice by the Department of Economic and Social Affairs of the United Nations for its contribution to the attainment of the SDGs. In total, 352 teachers have been trained in nuclear sciences under the NUCLEANDO programme. In 2021, a new Train the Trainers (ToT) model was created in Nicaragua to expand NUCLEANDO in a virtual format countrywide, which can be replicated in other countries in the coming years. The Agency also continued to engage in virtual knowledge management visits to assist Member States in maintaining and preserving knowledge in national nuclear institutions.

Regional project RLA0069, 'Promoting Strategic Management and Innovation at National Nuclear Institutions through Cooperation and Partnership Building - Phase II (ARCAL CLXXII),' continues to support national nuclear institutions (NNIs) in Latin America and the Caribbean to become technically and financially self-reliant. A series of workshops and training courses took place in 2021 to provide young leaders and higher management with the tools necessary to develop strategic and business plans, as well as sound communication strategies for their institutions. A training course on Computer Models for Feasibility Analysis and Reporting (COMFAR) was organized in September in partnership with the United Nations Industrial Development Organization (UNIDO). COMFAR is a software that facilitates the fast computation of financial statements needed for financial and economic appraisal of investment projects, and can be used for small- to large-scale projects, expansion, rehabilitation and modernization of existing enterprises and joint ventures. The training course aimed to improve the feasibility analysis skills of project counterparts and was attended by 18 participants from Argentina, Brazil, Chile, Costa Rica, Cuba, El Salvador, Mexico, Panama, Peru, Uruguay and Venezuela. The course participants

received software licenses for their institutions. The training courses focused on UNIDO's methodology for the identification of investment opportunities and the formulation and appraisal of investment projects based on COMFAR. Feasibility studies done with the help of tools such as COMFAR are very important in order to determine whether services and investment projects planned by NNIs are sustainable and profitable from a financial and economic standpoint.

Annex 2. TC Programme Fields of Activity²²

Nuclear Knowledge Development and Management
Capacity establishment, programme knowledge management and facilitation of cooperation among Member States (01)
Building national nuclear legal infrastructures (03)
Industrial Applications/Radiation Technology
Reference products for science and trade (02)
Research reactors (08)
Radioisotopes and radiation technology for industrial, health-care and environmental applications (18)
Accelerator technology (32)
Nuclear instrumentation (33)
Energy
Energy planning (04)
Introduction of nuclear power (05)
Nuclear power reactors (06)
Nuclear fuel cycle (07)
Food and Agriculture
Crop production (20)
Agricultural water and soil management (21)
Livestock production (22)
Insect pest control (23)
Food safety (24)
Health and Nutrition
Comprehensive cancer control (25)
Radiation oncology in cancer management (26)
Nuclear medicine and diagnostic imaging (27)
Radioisotopes and radiopharmaceuticals production for medical applications (28)
Dosimetry and medical physics (29)
Nutrition for improved health (30)
Water and the Environment
Water resources management (15)
Marine, terrestrial and coastal environments (17)
Safety and Security
Governmental and regulatory infrastructure for radiation safety (09)
Safety of nuclear installations, including siting and hazard characterization (10)
Governmental and regulatory infrastructure for nuclear installations safety (11)
Radiation protection of workers and the public (12)
Transport safety (13)
Nuclear security (14)
Emergency preparedness and response (16)
Radioactive waste management, decommissioning and remediation of contaminated sites (19)
Radiation protection in medical uses of ionizing radiation (31)

²² Updated in 2020 for the IAEA TC programme 2022–2023. The field of activity number is shown in parentheses.



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