Regional Strategic Profile for Latin America and the Caribbean (RSP) 2007–2013

ARCAL

IAEA
International Atomic Energy Agency

PUBLICATIONS RELATED TO THE RSP

To facilitate review of the material generated by the RSP preparation process, it has been published in separate parts covering the following aspects:

Regional Strategic Profile for Latin America and the Caribbean (RSP) 2007–2013

Background, Methodology and Process for the Preparation of the RSP for Latin America and the Caribbean
Food Safety in Latin America and the Caribbean in the Light of the RSP
Human Health in Latin America and the Caribbean in the Light of the RSP
Environment in Latin America and the Caribbean in the Light of the RSP
Energy and Industry in Latin America and the Caribbean in the Light of the RSP
Radiation Safety in Latin America and the Caribbean in the Light of the RSP

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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

ARCAL-IAEA Strategic Alliance

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ANNEXES

REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

ARCAL-IAEA Strategic Alliance

I. BACKGROUND

As part of the ARCAL-IAEA Strategic Alliance established at the VI meeting of the Board of ARCAL Representatives (BAR) held in September 2005 and in line with the objectives of its Action Plan, the decision was taken to prepare a *Regional Strategic Profile for Latin America and the Caribbean (RSP)*. This was approved at an extraordinary meeting of the Board of ARCAL Representatives (BAR) held on 14 June 2007.

The document establishes, based on the technical cooperation implemented by ARCAL in its four phases and the situation of the member countries, a descriptive analytical profile of the region's most pressing needs and problems and the priority with which they can be addressed using available nuclear technology. They can be addressed with the support of the IAEA or other international sources of cooperation.

Thus, the RSP will serve as a basis for the preparation of regional programmes to be carried out using nuclear technology, but it will serve fundamentally as an aid in the process of project submission and selection under ARCAL, in accordance with its specific procedures.

ARCAL representatives at all levels (BAR, ARCAL Technical Co-ordination Board (ATCB) and BAR Working Group) participated in the various parts of the preparation and approval process. The Department of Technical Cooperation and technical departments took part on behalf of the IAEA, making valuable contributions in their respective areas in line with the one house approach that guides their activities. Support was also provided by national experts from the region and from Spain, a partner country of ARCAL, and France.

In preparing the RSP, account was taken of such documents as the 2004 Regional Cooperation Plan (RCP) and the guidelines from the report of the Standing Advisory Group on Technical Assistance and Cooperation (SAGTAC) on regional programming of the IAEA technical cooperation programme presented in February 2007.

To address the task of preparing the RSP, five sectoral groups were established comprising experts from the region. The sectors identified were:

- Food safety;
- Human health;
- Environment;
- Energy and industry;
- Radiation safety.

In January 2007, a first meeting took place at the IAEA with the aim of preparing and approving the terms of reference for the RSP process and a questionnaire to obtain the information needed to implement the subsequent work, and the composition of the sectoral working groups.

Before the preparatory workshop which took place in Santa Cruz de la Sierra, Bolivia, in March 2007, there was an ongoing exchange of information among the designated experts for each sector and with the IAEA, through the Technical Officers and the Programme Management Officers, allowing diagnoses to be prepared for each of the five areas which were developed further at the meeting in question.

From 16 to 20 April 2007, a prioritization workshop took place in Madrid, Spain, where the needs and/or problems identified were prioritized.

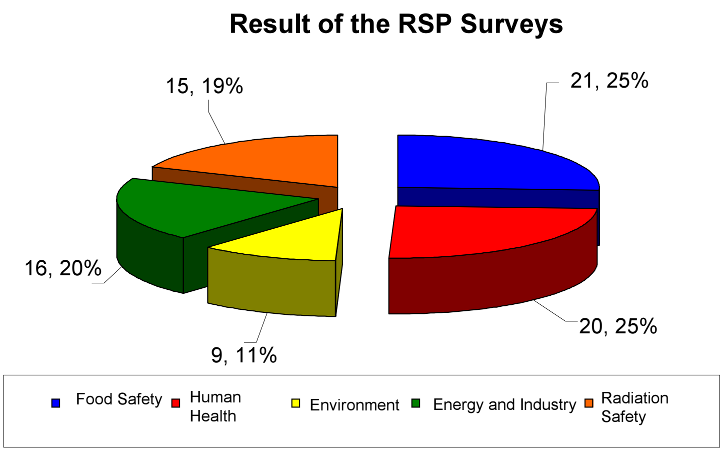
Finally, from 23 to 27 April 2007, the conclusions meeting took place at IAEA Headquarters, where the final reports of the working groups were harmonized, producing a document which was presented at the VIII meeting of the ATCB, which took place in May 2007 on Isla Margarita, Venezuela. The ATCB was responsible for technical approval of the RSP prior to its final consideration by the BAR.

Other important details relating to the background and preparation process for the RSP for Latin America and the Caribbean are available in the relevant part of the RSP publication.

II. WORK METHODOLOGY

First of all, terms of reference were established for the preparation of the RSP and a survey was designed and sent to ARCAL participating countries to assist in the initial identification of regional needs in each sector.

A total of 84 responses were received, which were distributed among the five sectors as shown in the following diagram.



Next, national experts carried out a SWOT (strengths, weaknesses, opportunities and threats) analysis, allowing the region's most pressing problems/needs to be identified.

The experts, for reasons of prioritization, assigned specific attributes to these related to their seriousness, time, extent, relevance and level of difficulty. The resulting values allowed for a quantitative comparison among them in their corresponding sectors, also taking into account the different levels of development of each country in the sectors in question.

Within the framework of the RSP, an intersectoral prioritization exercise was also carried out the results of which are shown in Annex 6. These results are, however, only indicative, as ARCAL and the IAEA have their own mechanisms for this purpose which will be followed for prioritization of the technical cooperation programme for the respective cycles.

In addition, representatives of the United Nations Environment Programme (UNEP), the Pan American Health Organization (PAHO) and the Food and Agriculture Organization of the United Nations (FAO) presented both the priorities and the guidelines for technical cooperation with those implementing their programmes in Latin America and the Caribbean.

Further information on methodology can be found in the separate part of the RSP publication related to this topic. The SWOT analysis and the detailed results for the prioritization of each of the sectors are included in the corresponding separate part of the RSP publication.

III. GENERAL ANALYSIS OF THE REGIONAL SITUATION

Below is a summary of the evaluations of the situation in the region for each of the sectors based on the reports prepared by each group. There are separate parts of the RSP publications for each of the five sectors which examine in greater depth the information collected during the RSP preparation process.

1. Food Safety

The main subsectors analysed in this area were: mutation induction and genetic improvement of plants; integrated management of soils, water, plants and fertilizers; integrated pest management; animal production and health; nutrition and environmental protection.

The world population is estimated to be 6400 million, of whom approximately 10% live in Latin America and the Caribbean. Owing to the increasing rural exodus to urban areas, only 22% of these on average live in rural areas, whereas the proportion is over 43% in the poorest countries.

Latin America and the Caribbean account for 15% of the world's surface area and have 100 million hectares of arable land, which is 7% of the world's surface area. It is recognized that Latin America and the Caribbean have great potential for food production and they are therefore considered a bulwark of world food safety. As regards their contribution to world food production, Latin America and the Caribbean account for 21% of world fruit production, 7.68% of cereal production, 7.73% of root and tuber production and 11.97% of grain legume production. Latin American livestock herds are estimated at 500 million head, i.e. approximately one head per inhabitant. These figures convincingly demonstrate that agriculture continues to be a strategic sector for regional development.

In recent decades, the contribution of the agricultural sector to regional GDP has exceeded 8% and in some countries has been greater than 20%. However, from the point of view of economic accounting, the real contribution of the agricultural sector to GDP is viewed more broadly since, in addition to its share in terms of the primary products it generates, the contribution from its intersectoral links must also be taken into account, in particular its links with the container and packaging manufacturing industry, food processing, textiles, and transport and trade services. It is estimated that, in the region, for every dollar generated in the agricultural sector, an average of three to six dollars are added to the country's economy, the figure being higher in the relatively more developed countries (Argentina, Brazil, Chile, Mexico and Uruguay). These figures reflect the fact that the agricultural sector is an important driving force for regional progress.

However, positioning agricultural activity as a net provider of food and as a strategic sector for regional development has brought with it negative consequences in return. Among these may be highlighted: a progressive degradation of arable soils owing to intensive use and poor fertilization and irrigation practices; the continual reduction in the area of natural woodland in order to increase the area available for production of industrial crops for export; and, in general, a deterioration in the environment reflected in loss of biodiversity owing to the substitution of native species crops with crops of high commercial value, as well as pollution by agrochemicals used in pest control and in post-harvest treatment of agricultural products.

Furthermore, in rural areas the scourges of hunger and undernutrition are present, eroding and concealing the intrinsic value of agricultural and stockbreeding activities. Latin America and the Caribbean mirror the global distribution in terms of the poor and malnourished: 80% in rural areas and 20% in urban areas. The highest indicators of poverty and undernutrition in the region are found in the rural areas of the Andean subregion, Mesoamerica, the Caribbean and the tropical areas of South America.

In short, though the sector in the region exhibits generally positive results, it also faces a series of crucial challenges which must be overcome in the coming years to opt for sustained food development compatible with higher levels of growth and social welfare, combined with conservation and use of biological diversity without harming natural resources. For this development to occur, the condition sine qua non is that regional agricultural activity must increase significantly.

Numerous specialists in economic development have identified technological change as the variable which contributes most to economic growth. In Latin America and the Caribbean, for example, it is calculated that approximately 40% of the improvements achieved in agricultural production are attributable to technological change. In this connection, the use of nuclear techniques for genetic improvement of plants and animals, improvement of soil management and of the efficient use of fertilization and irrigation, suppression and eradication of agricultural pests, and the early diagnosis of animal diseases, stands out.

However, technological change in the region is insufficient to respond successfully to global trade liberalization and to exploit the opportunities this offers, assuming as a paradigm sustainable agricultural development founded on increasing production and export of agricultural products without concomitant effects for human health or damage to the environment.

There is a lack of technological change in which nuclear technology could play a role in the fields of: genetic improvement of agricultural and livestock species, both traditional and non-traditional; development of good practices in the use and management of soil and water resources; prevention, suppression or eradication of transboundary agricultural and livestock pests; management of health and genetic limitations in the rearing of livestock species and captive aquatic organisms; post-harvest treatments as an alternative to the use of chemicals; prevention of residues posing a risk to human health in food; and strengthening of networks and capacity for supporting agricultural analysis services.

2. Human Health

In this area, the following were considered subsectors within the framework of the RSP: nuclear medicine; radiotherapy; medical physics; radiopharmacy; nutrition; radiation protection of patients; and nuclear molecular biology — infectious diseases.

It may be observed that the population of Latin America is going through a process of demographic and epidemiological transition, exhibiting considerable variation in its health situation. This has resulted in a complex situation in which health problems related, on the one hand, to underdevelopment, such as enteric, communicable and deficiency-related diseases, and, on the other hand, to urban lifestyles and economic development, such as chronic and degenerative diseases, cancer, accidents and mental health problems, coexist.

2.1 Nuclear medicine and radiopharmacy

Radioisotope techniques allow for cost-effective management of pathologies by allowing early diagnosis and timely and appropriate therapy. In recent decades, they have grown in complexity. Efficient and safe implementation of diagnostic and treatment procedures employing open radiation sources requires that the multidisciplinary staff involved are adequately trained, with ongoing learning and training, as new equipment and radiopharmaceuticals are introduced.

In recent decades, there has been significant development of this specialty in the Latin America and Caribbean region. However, development and growth have been uneven among the countries in the region, which has had a negative impact on equitable access to this technology for lower-income sectors and people living far from major cities and/or capitals.

In terms of training, the situation in the region is uneven, as some countries have training programmes in the radiopharmaceutical field with university-level courses held annually and master's degrees and doctorates taken in this discipline. In the remaining countries, training of professionals working in radiopharmacy is conducted abroad, through fellowships, courses and workshops.

It is highly important to organize training leading to a qualification in radiopharmacy which should be recognized at regional level. This could be achieved through the development of harmonized study programmes for a licentiate degree course in radiopharmacy and horizontal coordination among university centres together with work experience at production, development and research centres.

2.2 Radiotherapy

Radiotherapy is the non-surgical therapy which produces the most cancer cures (surgery 49%, radiotherapy 40% and chemotherapy 11%). It is used for curative purposes in 60% of cases and is even more effective in combination with surgery and/or chemotherapy and, more recently, with biological therapies. It is an effective option for alleviation and control of symptoms in advanced cancer. In many cases it replaces supraradical surgery, achieving higher rates of anatomical and functional preservation of organs and improving the quality of life of the cancer patient.

Most radiotherapists have been trained within the region: 12 out of 18 countries have 3- to 4-year postgraduate programmes. For the most part, technicians are not trained at universities.

Bearing in mind that, in the region, there has been a rapid increase not only in the quantity of centres and equipment but also in their complexity, the deficit in the number of professionals has been aggravated by the additional need for training related to new demand and greater complexity. At present there are 35 institutions in the region offering training, of which 50% are in Argentina, Brazil and Cuba.

2.3 Medical physics and radiation protection of the patient

The quality of radiotherapy treatment is closely linked to clinical factors (diagnosis, tumour localization, selected treatment strategy, ongoing verification and monitoring of the patient) and physical factors (uncertainty in dose calculation, dose optimization and verification, adequacy of dosimetric, calculation and treatment delivery equipment, inter alia). The level of knowledge and experience of each member of the team will significantly affect treatment quality and patient protection.

This type of treatment requires a highly complex technological infrastructure which usually includes dosimetry systems for characterization and calibration of the radiation beams, simulation systems (conventional, computerized tomography or virtual), computerized planning systems, treatment units (megavoltage and brachytherapy), verification systems and internal networks for managing and transmitting technical and administrative information.

Given that the number of qualified medical physicists is insufficient or zero in many centres in the region, the BSS requirements relating to calibration, dosimetry and quality assurance in radiotherapy are not being met, to the detriment of radiation protection of the patient.

The incidence of severe exposure of patients globally, and particularly in the region, indicates that it is due to a lack of properly structured and functional quality assurance programmes. In all cases, the initiating events were related to a physical aspect of the process, demonstrating the urgent need for sufficiently thorough training and clinical education for the region's medical physicists, as well as for rigorous work guided by codes of practice and technical guidelines.

Accelerated technological development in the design and manufacture of imaging systems in the last ten years has led to the gradual integration in our region of more complex technologies in all types of imaging. One of the challenges this trend poses for the region is the general lack of management and planning processes for the incorporation of technology. This usually results in underuse of imaging systems and — in cases such as digital radiography, multislice helical tomography and fluoroscopy-guided intervention systems — in increased risk of unnecessarily high exposure of patients, among whom children are a group of particular concern.

The availability of digital imaging systems (particularly in radiography and digital mammography) also offers the possibility of using teleradiology as a means of remote participation by radiologists in order to minimize the problem of access in regions remote from urban centres. This possibility has already been envisaged by the Pan American Health Organization (PAHO). However, in addition to the installation and maintenance difficulties in these regions, the lack of medical physics professionals capable of providing advice and supervision for this type of facility is another factor which makes the implementation of such solutions difficult.

2.4 Nutrition

A well-fed population is more healthy, has lower fertility and mortality rates, enhanced mental development and cognitive capacity, better education, and is consequently a more productive population, which has an impact on the country's development. However, in Latin America and the Caribbean economic and developmental imbalances have given rise to two realities in the health sphere in the region: malnutrition owing to excess and malnutrition owing to deficit. The fight against undernutrition has progressed much more slowly than anticipated. Although the goal of the 1996 World Food Summit was to reduce by half the number of people suffering from food insecurity by 2015, the undernutrition rate went down by only 4 million per year during the 1990s.

Data on causes of death are an approximate indicator of the type of malnutrition present in the population. As obesity increases, so do deaths due to cardiovascular diseases and cancer. Conversely, where infections are the predominant cause of death, undernutrition tends to be high and obesity low. The pattern of mortality in Latin America has been influenced by demographic and epidemiological transition. As the infant mortality and fertility rate falls, the population ages and the level of chronic non-communicable diseases increases. Currently, chronic non-communicable diseases account for almost two thirds of all deaths.

2.5 Nuclear molecular biology — infectious diseases

Emerging infectious diseases are a cause for concern at global level. The agents causing infections in humans have increased in incidence or are expected to do so in the near future. The emergence of infectious agents can be due to the appearance and dissemination of a new agent, the recognition of an infectious disease which had so far passed unnoticed, or the discovery that a known disease has an infectious agent as its aetiology. The term emerging can also be used to describe the reappearance (or re-emergence) of a known infection which increases in incidence from very low levels achieved in the past.

Infectious diseases are a significant health problem in Latin America and the Caribbean. Many infectious agents are emerging or re-emerging every year, increasing the region's economic problems and infecting a population already suffering from other social factors. Many efforts are being made at the initiative of the international community to control this problem, but ecological, social and economic factors are having an impact on the persistence of such diseases as malaria, leishmaniasis, AIDS, dengue, Chagas' disease, hantavirosis, hepatitis A and many others. A further coordinated effort should be made to improve the state of public health in Latin America.

Natural reservoirs and asymptomatic patients are a significant factor in the spread of vectors or infectious agents. In the case of the parasite which causes malaria, asymptomatic infected patients are capable of infecting new mosquitoes, promoting the spread of the disease. In the specific case of the malaria parasite, asymptomatic infected patients in contact with the mosquito vector are significant factors in the persistence of the disease in the region. Molecular techniques improve detection of such cases, allowing for their timely treatment and reducing the chances of infection of new mosquitoes feeding on the blood of these patients.

It is also necessary to be prepared from an influenza strategic point of view for the emergence of infectious diseases which could affect the region. In the case of such infectious diseases as SARS (severe acute respiratory syndrome) and avian influenza, there is a need to join forces with other international organizations in order to prepare the region for a possible future outbreak. Setting up reference laboratories for these globally significant diseases is appropriate in the context of regional public health.

Progress in molecular biology and the extensive availability of methods employing nucleic acids have permitted the development of fast and reliable diagnostic methods, as well as genotyping techniques for infectious agents. Application of these molecular techniques in the study and diagnosis of infectious diseases has increased in the past decade and techniques have even been developed for nucleic acid amplification with isothermal incubation for field work.

Despite the existence of geographic boundaries, infectious agents and their vectors do not respect such legal borders. Globalization, frequent air transport, migration processes and invasion of recently deforested areas have contributed to the spread of many pathogens in the region. It would be artificial to view health problems as exclusively national and not take into account a regional context. Thus, a regional plan should be implemented to control these diseases.

As a result, asymptomatic infection, which has been recently discovered thanks to the high sensitivity of molecular methods, could be a significant challenge to be taken into consideration in disease control. Asymptomatic patients who are under the supervision of national control programmes frequently cross borders, promoting change of the genotypes circulating in a given period of time.

3. Environment

The subsectors defined in the environment analysis were: atmosphere, water resources, terrestrial environment and marine environment.

The Latin America and Caribbean region covers 15% of the planet's surface, has a great topographic and climatic diversity, reflected in a great variety of ecosystems, and comprises four subregions:

1 The Andean region, with an area of 4.7 million km^2, comprising 25% of the region, with 230 million hectares of forest, which is 35% of the region's total;

2 The Caribbean, comprising islands of a wide variety of sizes and with a broad diversity of marine coastal habitats (coral reefs, seaweed meadows, mangrove swamps, marshes and rocky coasts);

3 Central America, with a broad biodiversity, extensive chains of mountains and mangrove swamps, and 8000 km of coast;

4 The Southern Cone, with the lowest population density in the region and the highest rate of urbanization.

The Latin America and Caribbean region's greatest environmental problems are as follows.

3.1 Use, availability and pollution of water resources

The region has the largest pluvial system in the world, the Amazon, which is 7.5 million km^2 in extent and which, together with other pluvial systems such as the Paraná-Plata and the Orinoco, carries more than 30% of the planet's fresh water to the Atlantic Ocean. More than 70% of the region's hydrographic basins are shared by two or more countries. 60% of the territory of South America is made up of transboundary basins.

Moreover, the region has a significant volume of groundwater resources which are used intensively by some countries. The Guaraní aquifer deserves to be highlighted, as one of the largest bodies of groundwater in the world, 1200 km^2 in extent, with an average thickness of 300 metres, and located in Argentina, Brazil, Paraguay and Uruguay.

Furthermore, 7% of the urban population and 39% of the rural population do not have access to potable water and 60% of urban and rural homes lack a regular water supply and are heavily dependent on groundwater. 13% of the urban population and 52% of the rural population do not have access to sanitation services and only 5% of sewage from cities receives any kind of treatment, so waste water is a source of pollution for water sources and soils.

Management of potable water — particularly in coastal aquifers — and waste water is a problem for many cities. The intensive and uncontrolled extraction of groundwater seriously affects the delicate saltwater/freshwater balance, causing changes in flow patterns, a drop in water tables, saltwater intrusion and leaching of pollutants.

Although the demand for water is intensive in the food, chemical and textile industries, water consumption in agriculture accounts for more than 70% of the total extracted, so agricultural production exerts an extraordinary pressure on water resources. Uncontrolled agricultural use is a problem, since it leads to pollution of surface water and groundwater by pesticide residues from run-off and leaching of these residues from soils. These come from aerial applications and/or evaporation of these products and their transport by wind, and from unauthorized uses such as illegal fishing or washing of equipment used for applications in rivers and streams.

Water resources in Latin America and the Caribbean are also used intensively as an energy source in hydroelectric and geothermal power generation. Large dams and their reservoirs are subject to both climate variation and climate change, which may affect the reservoirs' regulation and storage capacity and, consequently, reduce the volume which may be used for electricity generation, drinking water supplies and flood control, causing frequent rationing of these basic public services. This justifies characterization of the interrelation of surface water and groundwater, in order to evaluate these effects in a systematic way and ensure better levels of structural and functional safety in hydraulic structures where required. In addition to this we would add the outdated juridical and institutional frameworks which regulate the management of water resources in countries.

3.2 Pollution of other environmental compartments and foodstuffs

Countries in the region are faced with a series of problems related to pesticide residues in food for local consumption and export, though the latter tends to be given greater importance since, in these cases, the hold-up of products in importing countries' ports of entry causes losses of exports and/or markets.

As regards metals, the majority of mining sites are in Andean countries, where there are high concentrations of metals in soils and associated problems of pollution affecting the environment and public health. By contrast, in certain industrial areas soils are polluted by heavy metals as a result of atmospheric deposition, or by waste rich in metals, fertilizers, pesticides, etc.

The increase in energy consumption by industry and for domestic uses is the main cause of atmospheric pollution in urban areas. However, it is not only urban centres which suffer from environmental problems; rural areas are also exposed to anthropogenic and natural emissions, both of local origin and transported over a large distance. Contributions from other sources must also be taken into account, such as agricultural activities, soil erosion, resuspension of urban dust, and natural sources such as marine aerosol and volcanic eruptions, inter alia.

The populations of Latin America are exposed to growing levels of air pollution which often exceed those experienced by the industrialized countries in the first half of the 20th century. In the region, air pollution is the cause each year of 2.3 million cases of chronic respiratory disease in children and 100 000 cases of chronic bronchitis in adults.

In general, the whole region has poor-quality management of solid and liquid waste, both urban and industrial. The amount of rubbish generated per person in the region has doubled. Municipal solid waste is made up of organic and recyclable materials, domestic hazardous materials, medical and industrial waste and construction debris. The effects on public health are clear, in the incidence of certain diseases, pollution of soils, water, air, flora and fauna, and disasters such as floods.

3.3 Overexploitation of living resources, including the soil, and modification of habitat and communities

The Latin America and Caribbean region has the largest reserves of cultivable land on the planet; however, the 2000 UNEP report indicates that the region has 16% of all the planet's degraded soils. The causes are indiscriminate logging, overgrazing, expansion of agricultural areas and fires. Deforestation is one of the factors which contributes most to soil erosion and is one the region's greatest challenges.

Deforestation has caused an increase in the sediment load in rivers, lakes and reservoirs, which is becoming an ever more frequent problem, manifesting itself in the accelerating rate at which sediment accumulates, in a much shorter time than the operating lifetime of the structures which regulate flow for supply, electricity generation and flood control. Biodiversity is also affected.

There is growing concern regarding the negative environmental effects of mariculture, owing principally to habitat loss, eutrophication related to the discharge of effluents, other changes in the quality of estuarine waters and the introduction of exotic species.

Harmful algal blooms have a wide range of negative economic impacts which include: the cost of implementing routine monitoring programmes for shellfish and other affected resources; the short-term or permanent cutting off of stocks of harvestable fish and shellfish; reduction in sales of seafood; death of wild and farmed fish, shellfish, underwater vegetation and coral reefs; the impact on tourism and related businesses; and medical treatment for the exposed population.

The determination and quantification of microalgal toxins is a problem in the Latin America and Caribbean region. In the majority of countries in the region there are no experts or analytical instruments for detection of toxins.

3.4 Global changes most relevant at the regional level

The Latin America and Caribbean region is remarkably heterogeneous as regards climate, ecosystems, distribution of human population and cultural traditions. Changes in land use are the main cause of the trend in ecosystem changes. Complex climatic patterns, which are the result in part of interactions of atmospheric flow with topography, and changes in land use make it difficult to identify common patterns of vulnerability to climate change in the region. Water resources, ecosystems, agriculture, rising sea levels and human health may be viewed as the most important sectors which could be affected by climate change.

Latin America contains a large percentage of the world's biodiversity and climate change could accelerate the losses in biodiversity which are already taking place.

The economies of countries in the region could be severely affected by variability of the natural climate. Despite the magnitude of these problems, the region does not have the infrastructure and adequate technical capacity for the research needed to understand these phenomena.

4. Energy and Industry

Nuclear power, experimental reactors and industrial applications were the subdivisions which were analysed in this sector.

4.1 Nuclear power

Primary energy consumption has doubled in Latin America and the Caribbean over 25 years, between 1980 and 2005, reaching a little over 30 EJ. Electricity generation has grown over the same period at a similar rate, reaching 1184 TW·h in 2005, which is 6.5% of global production. The region's electricity is produced mainly by hydroelectric plants (58.37%). Burning of fossil fuels comes in second, contributing 38.31%. Nuclear power is in third position with 2.42%, and renewables make up scarcely 0.9%.

As regards CO_2 emissions relative to total energy consumption, though the volume of emissions increased by 25% between 1994 and 2004, from 1140 to 1427 million tonnes of CO_2 (Mt), these figures could still be considered reasonable, since in Europe they are 3.26 times higher, reaching 4635 Mt CO_2 in 2004.

Whether in terms of per capita income or in terms of human welfare, energy and, in particular, electricity constitute a platform without which progress is significantly more difficult for a society. The correlation between per capita income and per capita electricity consumption in the region indicates, if compared with a typical European Union country (e.g. Spain), that there is still much to be done to meet the welfare needs of our societies. The average levels for the region in 2003 were US $3300 and 1500 kW·h per year respectively, whereas the corresponding income and consumption values in Spain were US $18 000 and 6000 kW·h, i.e. four times higher than those for the region.

It is forecast that the region's population will rise to around 720 million by 2030, which poses an enormous challenge for the establishment of the necessary conditions to meet the welfare requirements of such a population size.

The corresponding consumption of total primary energy would rise by 2030 to an average level of 62.1 EJ. Accordingly, electricity consumption would rise to an average level of 2621 TW·h, which would be more than double the current level. Similarly, as regards CO_2 emissions, the scenarios predict an average figure of 2680 Mt CO_2. The IAEA estimates that installed capacity will rise from the current level of 276 GWe to 485 GWe by 2030 in a low-growth scenario, and to 802 GWe in a high-growth scenario. This means expanding current capacity by between 75% and 190% over 25 years.

4.2. Experimental reactors

Seven countries in the Latin America and Caribbean region have experimental nuclear reactors of various types and power levels. The purpose of these reactors is to provide neutron sources for research, experimentation, training of human resources and radioisotope production.

For more than 60 years, experimental reactors have been centres of innovation and productivity for nuclear science and technology. The reactors have assisted multidisciplinary research covering new developments in the production of radioisotopes for medical and industrial uses, research involving neutron beams, human medicine, development of materials, testing and qualification of components, computer code validations, etc.

Human resources development, which includes activities such as outreach, education and training, can be conducted at any of the region's reactors.

In the field of operation, maintenance and radiation protection of experimental power reactors, regional mutual cooperation could be achieved in order to improve standard practices and provide mutual assistance in these tasks.

4.3 Applications in industry

All countries in the region have some kind of nuclear application in industry, which can range from level meters to irradiators or accelerators for the sterilization of disposable medical products.

The most important applications are as follows:

- Non-destructive testing;
- Gamma, electron, X-ray or heavy ion radiation processing;
- Nucleonic control gauges;
- Radioactive tracers;
- Other applications.

5. Radiation Safety

Work in this sector within the framework of the RSP included analysis of regulatory infrastructure, occupational radiation protection, regulatory aspects of exposure in medical practices, radiation protection of the public, radiological emergency preparedness and response, and education and training.

Acceptance in society of the risks associated with radiation is dependent on the net benefit from its multiple applications. Radiation safety aims to protect individuals, society and the environment from the harmful effects of ionizing radiation and ensure adequate protection of current and future generations from any activity which involves exposure to ionizing radiation.

Radiation safety principles stipulate that States should have a national system for effective control of all radiation sources, foreseeing the establishment of a regulatory authority with clear responsibilities, authority and resources which allow it to fulfil its mandate of regulation, control and sanction, and with clear authority to meet international commitments laid down in international agreements, protocols or conventions. States should also have the necessary arrangements in place so that, if needed, a capacity for intervention and mitigation in the event of accidents exists.

Efforts should be directed at ensuring that States establish a safety culture for radiation sources, starting with the commitment of governments to manage the regulatory authority, and the commitment of users of ionizing radiation to radiation safety by considering in their proposals protection of occupationally exposed staff, the environment and the patient through adequate use of the criteria for justifying a practice, optimization of protection and the application of dose limitation criteria, with the goal of minimizing individual and collective risk.

5.1 Regulatory infrastructure

There is a need to improve or modernize regulatory frameworks in those countries where they already exist, and promptly to establish them in those countries where they still do not exist, in order to ensure protection of individuals and the environment. This will only be achieved if regulatory authorities have legal existence and the resources and infrastructure they need to fulfil their designated responsibilities in the regulatory framework.

5.2 Occupational radiation protection

To establish an effective and sustainable occupational protection programme in line with international safety requirements and guidelines, it is necessary to have an infrastructure which ensures control over exposure of every occupationally exposed worker.

5.3 Radiation protection in medical practice

It is important to keep the dose to the patient to a minimum while maintaining image quality and avoiding accidental exposure in therapeutic procedures. Radiation protection of the family members of a patient to whom radionuclides have been administered for therapy, and of anyone else who might be in close contact with the patient, should also be ensured.

5.4 Radiation protection of the public

In this area, the fact that the majority of countries do not have defined national policies or strategies for radioactive waste management has been identified as a relevant issue. Even though the establishment of national policies and strategies is a recurrent theme in all international forums and in regional projects, this issue has not managed to get off the ground. This is probably due to a lack of clarity on the part of the relevant competent authorities regarding the significance, scope and profound importance of these concepts.

5.5 Radiological emergency preparedness and response

The need for countries to implement in concrete terms radiological emergency response capacities, including coordination of regional support, is clear from the number of incidents involving orphan sources and accidents at facilities in recent years, and the threat of malevolent acts of a terrorist nature employing radioactive substances as a means of harming individuals and damaging property with the grave social consequences that would have.

5.6 Education and training

There is a need to increase the capacity of Member States to establish or improve education and training programmes on safety of radiation sources and transport and safety of radioactive waste, to ensure they are adequate, harmonized and sustainable, through various training mechanisms aimed at qualified experts, operators, administrators, regulators and trainers.

IV. NEEDS/PROBLEMS IDENTIFIED AND PRIORITIZED BY SECTOR

The SWOT analyses allowed problems/needs to be identified, and use of the chosen prioritization methodology allowed the levels of the specific attributes corresponding to their seriousness, time, extent, relevance as regards the use of nuclear technology to address them, and level of difficulty, to be defined.

Included as an annex are tables containing criteria applied by the members of the sectoral groups for the problems/needs relating to the aforementioned attributes (Annex 1 to Annex 5).

The SWOT analysis of the respective sectors, the justification of the needs/problems identified here, and more information of a general nature and about their levels of prioritization may be found in the relevant separate part of the RSP publication for each of the five sectors of the RSP.

The identified problems/needs are presented in the following paragraphs. The number in brackets was assigned to each problem/need according to the priority attributed by the members of the sectorial Groups within each sector. These numbers can also be used as orientation for reading the tables which feature in the annex, as well as for other information or graphs contained in the respective separate part of the RSP publication.

***Food safety** (Sector A)*

- Inadequate sustainability in the application of nuclear techniques in agriculture *(A1)*.
- Restricted access to markets owing to the presence of chemical residues that pose a risk to human health in foodstuffs of animal and plant origin *(A2)*.
- Deficient agricultural soil management practices and inadequate use of fertilizers, water and biological nitrogen fixation *(A3)*.
- Presence of areas with a high prevalence of fruit flies *(A4)*.
- Loss of agricultural areas through soil degradation caused by extensive agricultural activity *(A5)*.
- Incidence of exotic transboundary diseases in animals *(A6)*.
- Low productivity, and susceptibility to biotic and abiotic stress, of traditional basic food crops *(A7)*.
- Presence of areas infested with New World screwworm *(A8)*.
- Vulnerability of livestock species at risk of extinction *(A9)*.
- Low productivity of native plants with nutritional and/or medicinal potential in areas of biodiversity *(A10)*.
- Limited development of aquaculture owing to health and genetic factors *(A11)*.
- Presence of areas with a high prevalence of codling moths *(A12)*.

***Human health** (Sector S)*

- Regional deficit in trained human resources in terms of both quality and quantity (medical physicists, technicians, oncological radiotherapists, nuclear medicine specialists, molecular biologists, radiopharmacists and specialists in nuclear applications in nutrition) *(S1)*.
- Lack of protocols (mainly clinical) and procedural manuals that have been evaluated, adapted and adopted by the region, for the application of nuclear techniques in human health *(S2)*.
- The processes for the technological management of the infrastructure for application of nuclear techniques in human health in the region, including planning, incorporation and sustained operation of new technologies, are generally not implemented in accordance with international requirements *(S3)*.
- Lack or non-adoption of quality management systems in many centres in the region *(S4)*.
- Insufficient awareness among national and international decision-makers and in the scientific community about the usefulness and safety of nuclear techniques in preventing and resolving public nutrition problems *(S5)*.
- Lack of institutionalization of the position and functions of the medical physicist in radiotherapy and imaging services (nuclear medicine and radiology), and to a lesser degree of other professionals associated with medical practices, by health ministries in many countries in the region *(S6)*.
- Limited application of molecular isotopic techniques in the region for the diagnosis of emerging infectious and contagious diseases such as SARS (severe acute respiratory syndrome) and avian influenza, and re-emerging ones such as dengue, malaria and tuberculosis, and lack of a regional laboratory network *(S7)*.
- Unequal access in the region to radionuclides, radiopharmaceuticals, reagent kits and stable isotopes for diagnostic and therapeutic procedures in nuclear medicine, nutrition and medicine *(S8)*.
- Insufficient human resources in the region trained in predictive, preventive and corrective maintenance of laboratory, diagnostic and treatment equipment employing nuclear technology that is many years old *(S9)*.
- Regional databases on infrastructure in nuclear medicine, radiopharmacy, molecular biology, radiotherapy and radiology, which can assist with planning and investment, are not up to date or do not exist *(S10)*.

***Environment* (Sector M)**

- Lack and/or inadequacy of systems for early warning, diagnosis and evaluation of the environmental impact of pollution with pesticides, persistent organic compounds, heavy metals and other pollutants of anthropogenic and natural origin in foodstuffs and environmental matrices at basin level *(M1)*.
- Inadequate systems for management, protection and knowledge of the availability and quality of water resources *(M2)*.
- Lack of regional systems for early prediction and evaluation of the toxicity of harmful algal blooms, via radiotoxicological tests and bioassays *(M3)*.
- Limited knowledge of the processes that occur in the coastal area (loss of habitats, transfer of pollutants, sedimentation, nutrient cycles, climate changes and effects of the El Niño phenomenon), to establish regional management programmes that reduce its degradation *(M4)*.
- Inadequate diagnosis and evaluation of the impact on human health of atmospheric pollution with trace elements in urban and rural areas and in enclosed spaces *(M5)*.
- Inadequate assessment of the hydrological and hydrogeological risk in hydraulic structures and lack of systematic monitoring of sedimentation in the region's artificial and natural water bodies *(M6)*.

***Energy and industry* (Sector E)**

Nuclear power

- Need to improve the provision to the public of objective and extensive information on nuclear energy *(E1)*.
- Need to expand and strengthen training of qualified personnel to manage nuclear power projects and nuclear power plants *(E7)*.
- Shortage of long-term energy and electricity supply and demand scenarios and analyses to decide on possible inclusion of nuclear power in order to diversify efficient and sustainable energy sources and provide power to areas with no supply *(E10)*.
- Expediency of countries having nuclear fuel cycle policies covering everything from mining of energy resources to disposal of radioactive waste *(E12)*.
- Lack of statistical databases and procedures and adequate indicators for use in energy assessment and planning studies *(E13)*.
- Need to strengthen exchange and transfer of experience and knowledge in the nuclear power sector *(E14)*.
- Insufficient energy integration in the region *(E16)*.

Experimental reactors

- Need to exchange experience in order to enhance reactor safety, operation and maintenance *(E2)*.
- Need to train highly qualified personnel in the management and operation of experimental and production reactors and to replace professional staff who are retiring *(E5)*.
- Need to upgrade the region's reactors to improve their safety and extend their operating lifetime *(E8)*.
- Insufficient use of experimental and production reactors *(E9)*

Applications in industry

- Need to disseminate the benefits of applications to end users, making use of existing capabilities and experience in the region *(E3)*.
- Need to strengthen the training of personnel who assist in the development of the required applications *(E6)*.
- Insufficient use of nuclear applications in industry which affects its competitiveness *(E4)*.

- Restrictions on trade and transport of radioactive material among countries in the region *(E11)*.
- Limited indigenous technology development for transfer to industry *(E15)*.

Radiation safety ***(Sector R)***

- Lack of regulatory control standards in potentially high-risk practices (linear accelerators, interventional radiology) *(R1)*.
- Lack of standardized training requirements for occupationally exposed workers in various practices *(R2)*.
- Deficiencies in control over materials to be recycled to ensure the absence of radioactive material *(R3)*.
- Limited coverage of the demand for postgraduate training in radiation protection *(R4)*.
- Difficulties with the application of the concepts of exemption, exclusion, declassification or clearance *(R5)*.
- Insufficient individual internal monitoring coverage *(R6)*.
- Insufficient knowledge of the radiological impact of NORM (naturally occurring radioactive material) industries *(R7)*.
- Lack of effective regional coordination to provide assistance in emergencies *(R8)*.

V. IMPORTANCE OF THE REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013 FOR THE IAEA TECHNICAL COOPERATION PROGRAMME

The RSP is the main instrument for the preparation and definition of the portfolio of IAEA regional projects to be carried out within the framework of the Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL). Its use is envisaged for the 2009–2011 and 2012–2013 cycles of the technical cooperation programme. In addition, the extensive list of needs/problems which can be addressed using nuclear techniques gives the Agency a guideline for future action in the region.

Observation.- As regards security of nuclear installations, the Division of Nuclear Installation Safety (NSNI), which is responsible for this issue at the IAEA, has noted the need for programmes in this area in the future. This concern is based on the fact that there are already, at present, nuclear power plants and nuclear research reactors in various countries in the region.

ANNEX 1. ATTRIBUTES OF NEEDS IN FOOD SAFETY

FOOD SAFETY					
NEED	**SERIOUSNESS**	**TIME**	**EXTENT**	**RELEVANCE**	**DIFFICULTY**
A1) Inadequate sustainability in the application of nuclear techniques in agriculture.	Regional agricultural development is being affected by the significant reduction in trained personnel and the closing down of laboratories employing nuclear techniques.	Without appropriate attention, this problem will worsen in the near future.	The majority of countries in the region note the existence of this problem.	The application of nuclear techniques is indispensable for the development of agricultural technologies for food production.	Implementation requires the coordination of a large number of academic, technical and financial institutions, both national and international.
A2) Restricted access to markets owing to the presence of chemical residues that pose a risk to human health in foodstuffs of animal and plant origin.	Limited application of quality and safety standards for the region's agricultural and seafood products. Risk to human health and the environment caused by the use of pesticides.	The increasing importance attributed by society to the quality and safety of foodstuffs requires the urgent establishment of standards and systems to monitor the presence of chemical residues in food.	Throughout the region.	Processes involving nuclear techniques used for post-harvest treatment and monitoring of pesticide residues in agricultural products have been developed and are in universal use.	Limited infrastructure and harmonization of regulations for the use of ionizing radiation in food. There is a lack of awareness in certain sectors of society of the seriousness of consuming food products contaminated with pesticides.
A3) Deficient agricultural soil management practices and inadequate use of fertilizers, water and biological nitrogen fixation.	The region is dominated by agricultural soils that are extremely poor in nutrients.	There is an urgent need for the development of rational soil management and fertilizer use systems to compensate for the insufficient availability of food.	The great majority of the region's agricultural soils require sustainable agricultural technologies.	Isotopic tracer techniques are essential for evaluating the efficiency of management systems from the point of view of sustainability. They allow the fate of different agricultural inputs to be determined in production systems, rationalizing the use of organic and manure fertilizers.	Proven isotopic tracer methodologies exist and are in widespread use in the region.
A4) Presence of areas with a high prevalence of fruit flies.	Causes losses of up to 40% in the production of fruit and vegetables. Restricts the export of over 100 species of fruit and vegetables.	For the urgently needed improvement of socio-economic conditions in countries, foreign exchange income is needed which can be obtained by increasing exports through control of fruit flies.	The problem is present in all countries except Chile and is of a transboundary nature	Nuclear technology is the only tool capable of eliminating this problem without affecting the environment	Its implementation requires specialized training and coordination of a large number of technical and financial institutions.

NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
A5) Loss of agricultural areas through soil degradation caused by extensive agricultural activity.	Food safety and preservation of the regional environment are at risk because of increasing loss of agricultural soils owing to erosion and the reduction of their production capacity.	Increasing deforestation and soil degradation require urgent attention.	The degradation of agricultural soils is an issue of regional scope, being particularly critical in Andean and tropical zones.	Isotopic tracer techniques are essential for evaluating the extent and level of degradation, as well as for monitoring recovery processes.	Proven isotopic tracer methodologies exist and are in widespread use in the region. However, preliminary work is required on characterization and applicability of techniques.
A6) Incidence of exotic transboundary diseases in animals.	Diseases such as avian influenza, bovine spongiform encephalopathy and foot-and-mouth disease are emerging and are transboundary in nature. They pose a high potential risk of causing major damage to human and animal health, and of destroying production chains.	Prevention of this kind of threat requires immediate initiatives to harmonize diagnostic methods and promote regional integration in order to coordinate rapid and effective response.	Present throughout the region and transboundary in nature.	The nuclear component of the processes used to address this need forms part of an extensive chain of other complex biotechnological processes.	Requires optimization of techniques and integration among the competent authorities of countries in the region with a view to coordinated action in epidemic situations.
A7) Low productivity, and susceptibility to biotic and abiotic stress, of traditional basic food crops.	The deficit in the production of basic foodstuffs in the region has repercussions for poverty and undernutrition levels, particularly in rural agricultural areas. 80% of poor and undernourished people live in rural areas.	Urgent need to reduce the region’s vulnerability as regards its dependence on basic food products.	Rural areas throughout the region.	Induction of mutations is an internationally established and accepted method of genetic improvement of plants.	Methodology established for 162 species of plants in 62 countries giving rise to 2300 varieties.
A8) Presence of areas infested with New World screwworm.	The region has livestock herds of almost 450 million head which are subject to potential infestation with a resulting reduction in productivity.	It is important to ascertain, in the near future, the distribution and scale of infestation in order to plan suppression or eradication methods.	The problem exists in all countries in the region except the subregion of Mesoamerica. It is transboundary in nature.	Nuclear technology is the only tool capable of eliminating this problem without affecting the environment	Its implementation requires preliminary studies of how widespread and serious the infestation is in the field. Its implementation requires highly specialized training and the coordination of a large number of technical and financial institutions.

NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
A9) Vulnerability of livestock species at risk of extinction.	There is a limited infrastructure in the region for scientific research and technological development capable of ensuring conservation and exploitation of the genetic resources of livestock at risk of extinction.	Action to preserve these livestock species should be taken in the near future to avoid the risk of extinction of the germplasm of animals of great interest for humanity.	Throughout the region.	Little is known about the characteristics of these breeds of animal at molecular biochemical level and the use of nuclear techniques is a fundamental component for development of this field.	Lack of recognition of the vulnerability of livestock species at risk of extinction. There are not enough groups using nuclear techniques to conserve livestock species at risk of extinction.
A10) Low productivity of native plants with nutritional and/or medicinal potential in areas of biodiversity.	Degradation of genetic diversity owing to extractive exploitation of native species. Replacement of native plants with genetically uniform commercial crops.	Increasing cultural and genetic erosion leads to the loss of native species of importance for food and pharmaceuticals.	Five of the world's ten megacentres of biodiversity are located in the region.	As native plants generally do not possess desirable characteristics as regards productivity, induction of mutations is the appropriate genetic improvement method to change features which limit the use of native species, preserving their nutritional and/or medicinal value.	Preliminary work on characterization of native species is required.
A11) Limited development of aquaculture owing to health and genetic factors.	Genetic deterioration and the severity of epidemics caused by infectious diseases are magnified by the exponential growth of aquaculture.	The disorganized growth of parts of the aquaculture sector calls for urgent attention to avoid the collapse of aquaculture owing to the occurrence of epidemics of infectious diseases and the deterioration of genetic resources.	Throughout the region.	Little is known about the molecular characteristics of the various aquatic organisms reared in the region and their main pathogens and the use of nuclear techniques is a fundamental component for development of this field.	Requires integration and training of the existing competencies in countries in the region for the application of nuclear technologies. The region does not have a sufficient number of laboratories devoted to this topic.
A12) Presence of areas with a high prevalence of codling moths.	They cause significant losses in the production of apples, pears, quinces and nuts. Current control methods cause environmental pollution owing to extensive pesticide use.	Although this pest does not restrict exports of the affected agricultural products, the excessive use of pesticides calls for the use of non-polluting techniques.	The problem is subregional since it is present in the countries of the Southern Cone.	Nuclear technology is the only tool capable of eliminating this problem without affecting the environment	Its implementation requires highly specialized training and the coordination of a large number of technical and financial institutions.

ANNEX 2. ATTRIBUTES OF NEEDS IN HUMAN HEALTH

HUMAN HEALTH					
NEED	**SERIOUSNESS**	**TIME**	**EXTENT**	**RELEVANCE**	**DIFFICULTY**
S1) Regional deficit in trained human resources in terms of both quantity and quality (medical physicists, technicians, oncological radiotherapists, nuclear medicine specialists, molecular biologists, radiopharmacists and specialists in nuclear applications in nutrition).	The lack of availability and quality of education and training for human resources in all areas of application of nuclear techniques for managing human health has a 100% negative impact on the safety and quality of practices.	Although in the past ten years the number of centres for education and training of specialists in various fields in the region has increased and their graduates are addressing the problem to an extent, this is not enough.	The current coverage of existing education and training programmes in the region is very heterogeneous. Even in more developed countries they do not meet the need, as these are increasing their available technology.	Adequate education and training of human resources requires the existence of reference centres suitably equipped with nuclear technology. Centres with cutting-edge nuclear technology already exist in the region and could have a great impact on solving the problem, but support is required to improve the less developed centres.	Difficulty is low owing to the existence of programmes approved by the competent authorities and the presence in the region of training centres for some specialties, but with limited capacity to receive fellows to provide education and training of the required quality.
S2) Lack of protocols (mainly clinical) and procedural manuals that have been evaluated, adapted and adopted by the region, for the application of nuclear techniques in human health.	The lack of protocols and procedural manuals in human health results in practices and products with an unsatisfactory diagnostic and therapeutic impact, which impairs the cost-benefit ratio and radiation protection of the patient.	The lack or shortage of protocols, combined with the incorporation of new technologies makes the resolution of this issue a matter of even greater urgency.	Independent of the level of development of the sector in the region, this problem is present in all countries and is tending to become chronic.	The application of nuclear techniques in health in line with protocols and procedures improves the quality and homogeneity of public care; their absence leads to a negative impact on morbidity and mortality for the pathologies prevalent in the region.	Difficulty is low owing to the fact that development and/or adaptation of protocols and procedural manuals is easy to achieve; however, for them to be adopted and implemented at regional level requires the collaboration of organizations.
S3) The processes for the technological management of the infrastructure for application of nuclear techniques in human health in the region, including planning, incorporation and sustained operation of new technologies, are generally not implemented in accordance with international requirements.	It is essential to incorporate processes for the technological management of the infrastructure used in human health.	It is necessary in the short to medium term to incorporate these processes in order to improve and ensure optimal use of existing technological resources and those to be installed.	Incorporation and application of technological management is needed in all countries in the region.	Their incorporation allows optimization of investment, ensures adequate and ongoing operability of installations and more homogeneous coverage of public needs.	Difficulty is moderately high since, while it is true that the development of guides, manuals and other reference documents for directors of centres and high-ranking officials in the health sector is reasonably simple to achieve through expert group meetings, their effective use by decision-makers is a rather complex matter.

NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
S4) Lack or non-adoption of quality management systems in many centres in the region.	Significant advances have been made in the region in the dissemination and establishment of infrastructure and implementation of quality assurance systems. However, implementation has been limited, owing in part to the investment required and the need for specialized professionals.		The problem is heterogeneous in the region and among countries. However, global impetus is needed in this area, particularly as regards the legal requirements for the existence and effective implementation of quality assurance systems.	The safe use of nuclear technology requires planning, management, control and safety. Quality management systems, although they are demanding in terms of financial and human resources, are indispensable.The lack of protocols and procedural manuals has a negative impact on morbidity and mortality in the pathologies in which nuclear techniques are indispensable.	Difficulty is high, since the development and implementation of training programmes in quality management systems are relatively easy to carry out, but their adoption and application by users (both public and private regional centres) can be rather difficult.
S5) Insufficient awareness among national and international decision-makers and in the scientific community about the usefulness and safety of nuclear techniques in preventing and resolving public nutrition problems.	Lack of knowledge among decision-makers about the benefit and safety of these techniques has a direct impact on increasing risk factors which directly impact on the diseases prevalent in the region.	The problem needs to be solved in the short term since its persistence has a direct impact on prolonging the nutritional disorder or low efficiency in nutritional interventions.	Though this problem affects the majority of countries in the region, Mexico and Chile have partially solved it thanks to IAEA support.	The problem is highly relevant, because isotopic techniques have the advantage of detecting small changes earlier and more accurately, reducing the cost of a nutritional intervention.	Average difficulty. The tools for public communication and building opinion are relatively well known and health sector professionals have, in general, a high degree of influence in countries in the region.
S6) Lack of institutionalization of the position and functions of the medical physicist in radiotherapy and imaging services (nuclear medicine and radiology), and to a lesser degree of other professionals associated with medical practices, by health ministries in many countries in the region.	The lack of this type of professional leads to the provision of services without appropriate guarantees of patient safety.	The problem needs to be resolved in the short term because of the growing demand for medical physicists in health services.	This problem affects many countries since, while some of them have relevant legislation, it is not always applied.	Medical physicists and other professionals involved in medical practices are the persons responsible for ensuring the safe use of sources and equipment which generates ionizing radiation.	Difficulty is moderately high owing to the lack of awareness of national authorities and hospital and service management of the importance of the functions of medical physicists and other professionals involved in medical practices.
S7) Limited application of molecular isotopic techniques in the region for the diagnosis of emerging infectious and contagious diseases such as SARS and avian influenza, and re-emerging ones such as dengue, malaria and tuberculosis, and lack of a regional laboratory network.	Infectious and contagious diseases are a cause of death in part of Latin America and, along with new pathologies (SARS and avian influenza), pose a high risk of widespread epidemics.	The problem needs to be resolved in the very short term because of the potential risk of pandemics.	This problem affects the entire region.	The problem is highly relevant because isotopic techniques have the advantage of early detection and allow the various strains of viruses and bacteria to be characterized.	Difficulty is moderately high owing to the need for equipment and supply of inputs and materials to the regional laboratory networks of WHO/PAHO and FAO.

NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
S8) Unequal access in the region to radionuclides, radiopharma-ceuticals, reagent kits and stable isotopes for diagnostic and therapeutic procedures in nuclear medicine, nutrition and medicine.	The lack of availability of radionuclides, radiopharma-ceuticals and reagent kits impedes public access to diagnostic and therapeutic methods.	There is a growing demand for new radio-pharmaceuticals and radionuclides for use in diagnostic and therapeutic procedures.	While some countries in the region have a high level of development in radiopharmacy, others do not have the infrastructure needed for it. Few countries in the region have centralized radiopharmacy laboratories.	The use of radionuclides is an indispensable tool for the preparation and application of radiopharmaceuticals for diagnosis and therapy. The stable isotopes used in the evaluation of nutritional parameters in the population are of enormous importance for evaluating metabolic processes, intake of nutrients, etc.	Average to high difficulty. While training of staff is a relatively simple task, import of basic inputs by countries which have less access to them is difficult owing to logistical and customs problems, though, for the most part, they can be obtained in the region's more developed countries.
S9) Insufficient human resources in the region trained in predictive, preventive and corrective maintenance of laboratory, diagnostic and treatment equipment employing nuclear technology that is many years old.	A significant proportion of the technological infrastructure is not operational or is subject to long operational outages, which directly affects services and laboratories.	The problem needs to be solved immediately and permanently to ensure adequate care for the public.	Affects all countries in the region.	These are highly qualified personnel and the lack of them has a direct impact on operation of a major part of the nuclear instrumentation in human health in the region.	Difficulty is moderately high owing to the fact that training and active retention of personnel in these areas is not such an easy task as it might seem at first sight.
S10) Regional databases on infrastructure in nuclear medicine, radiopharmacy, molecular biology, radiotherapy and radiology, which can assist with planning and investment, are not up to date or do not exist.	Existing databases are not up to date and do not have mechanisms for ongoing submission of information by centres and countries. As a result, they are not useful for evaluating the current state of technology, human resources and the quality of laboratory services in the region.	The definition of secure mechanisms for updating databases requires solutions and agreements in the near future. These databases must be functional and useful when quality systems have improved in the region.	There are databases in countries in the region, but there is no updating of international databases.	The use of up-to-date data on the region's infrastructure facilitates coherent planning and strategic and timely management of the region's resources.	Difficulty is average owing to the fact that some databases have already been established and there is the necessary expertise to develop those which are required, but there is a problem with ensuring that the region's institutions give the required priority to the goal of keeping information up to date.

ANNEX 3. ATTRIBUTES OF NEEDS IN ENVIRONMENT

ENVIRONMENT					
NEED	**SERIOUSNESS**	**TIME**	**EXTENT**	**RELEVANCE**	**DIFFICULTY**
M1) Lack and/or inadequacy of systems for early warning, diagnosis and evaluation of the environmental impact of pollution with pesticides, persistent organic compounds, heavy metals and other pollutants of anthropogenic and natural origin in foodstuffs and environmental matrices at basin level.	A significant proportion of the region's soils are polluted with heavy metals and various polluting compounds are present in water, soils, flora and fauna. There is not enough information and/or analytical capacity.	The problem has existed for some time and is becoming rapidly worse.	All countries in the region.	Capacities and expertise exist in the majority of countries in the region.	Average owing to the fact that the region lacks sufficient access to advanced technology and/or human resources to quantify these pollutants.
M2) Inadequate systems for management, protection and knowledge of the availability and quality of water resources.	A third of the world's renewable water resources are to be found in Latin America and the Caribbean. Overexploitation of limited water resources causes irreversible damage such as: falling water tables, saltwater intrusion and leaching of pollutants.	Urgency is high because the problem becomes irreversible and it therefore must be prevented before it arises.	Affects the whole region.	Mass and laser spectrometry provide unique information.	Average owing to the fact that programmes to manage and conserve groundwater resources are limited.
M3) Lack of regional systems for early prediction and evaluation of the toxicity of harmful algal blooms, via radiotoxicological tests and bioassays.	Aquaculture accounts for 2.2% of the region's GDP and there are losses of US $300 million per year owing to the effect on the human population and loss of marine resources caused by red tide in the region.	Action must be taken urgently since, once the problem has arisen, its negative impact is immediate.	The majority of the region's countries.	^{3}H-STX with LSC facilitates early prediction.	High for the implementation of nuclear technology, because of the poor availability of suppliers of the required reagents. Insufficient personnel, technology and infrastructure to quantify the toxicity of blooms and manage them adequately.
M4) Limited knowledge of the processes that occur in the coastal area (loss of habitats, transfer of pollutants, sedimentation, nutrient cycles, climate changes and effects of the El Niño phenomenon), to establish regional management programmes that reduce its degradation.	Significant deterioration of the coastal area of Latin America.	Degradation of the coastal area is rapidly increasing and urgent action is therefore essential.	With the exception of Paraguay and Bolivia, all countries in the region have coastal areas affected by this phenomenon.	Isotopic and nuclear techniques have a key role in the reconstruction of ecological databases.	High, owing to insufficient technological capacity and trained personnel in the region.

NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
M5) Inadequate diagnosis and evaluation of the impact on human health of atmospheric pollution with trace elements in urban and rural areas and in enclosed spaces.	75% of the region's population lives in cities with serious atmospheric pollution problems. Rural areas are also exposed to anthropogenic and natural emissions.	The deterioration in air quality and its impact on health are becoming more severe.	All countries have rural and urban areas affected by air pollution.	Nuclear analytical techniques are the only tools for chemical characterization of atmospheric aerosol.	Average, since many countries in the region have the experience, installations and human resources to apply nuclear analytical techniques to atmospheric pollution.
M6) Inadequate assessment of the hydrological and hydrogeological risk in hydraulic structures and lack of systematic monitoring of sedimentation in the region's artificial and natural water bodies.	Large hydraulic structures have a great impact on the environment.	Continues to grow.	All countries in the region.	Isotopic techniques supply unique information.	Low, since the application of nuclear techniques is usually immediate.

ANNEX 4. ATTRIBUTES OF NEEDS IN ENERGY AND INDUSTRY

Please note that the sectoral group for energy and industry has divided this table into subsectors: nuclear power, experimental reactors and applications in industry.

NUCLEAR POWER					
NEED	**SERIOUSNESS**	**TIME**	**EXTENT**	**RELEVANCE**	**DIFFICULTY**
E1) Need to improve the provision to the public of objective and extensive information on nuclear energy.	High social and political importance.	Urgently required before starting a nuclear programme.	All countries potentially involved should address this matter.	High for the development of nuclear power programmes.	Average. Achieving it requires political will.
E7) Need to expand and strengthen training of qualified personnel to manage nuclear power projects and nuclear power plants.	Essential for the viability of nuclear power.	In accordance with the rate of introduction of nuclear power.	Required in countries which are introducing nuclear power.	High for safe and efficient operation.	Average. It could be implemented through agreements with international organizations.
E10) Shortage of long-term energy and electricity supply and demand scenarios and analyses to decide on possible inclusion of nuclear power in order to diversify efficient and sustainable energy sources and provide power to areas with no supply.	Development of these scenarios is important as a starting point for planning with a high degree of certainty.	Urgent for definition of scenarios and programmes.	The majority of countries in the region.	Important for optimal combination of energy sources including nuclear power.	Average. Could be achieved with available energy models.
E12) Expediency of countries having nuclear fuel cycle policies covering everything from mining of energy resources to disposal of radioactive waste.	This is of environmental importance and is indispensable for the use of nuclear power.	Steps should be taken to achieve gradual but steady progress on this matter.	All countries should be involved.	Essential for the nuclear option.	High, there is public resistance. Essential for the nuclear option.
E13) Lack of statistical databases and procedures and adequate indicators for use in energy assessment and planning studies.	The integrity and quality of the data used in planning studies has a great impact on their results.	Databases and reliable indicators for use in analyses of scenarios used in planning are urgently required.	The majority of countries in the region.	Important for the nuclear option.	Average. Could be implemented based on processes already in use.
E14) Need to strengthen exchange and transfer of experience and knowledge in the nuclear power sector.	This has a major impact. The nuclear option improves safety and reduces costs.	This activity could be developed gradually during the introduction of nuclear power.	Affects countries in line with their involvement in nuclear power programmes.	Is closely linked to the operation of nuclear power plants.	Average. Could be implemented through agreements with countries with experience.
E16) Insufficient energy integration in the region.	It is desirable to have a certain degree of energy integration in order to optimize systems and improve the economic aspect.	This is a step which could be taken gradually, as has in fact been happening.	Many countries would benefit from integration.	Highly relevant to the nuclear option.	Requires joint political decisions.

EXPERIMENTAL REACTORS					
NEED	**SERIOUSNESS**	**TIME**	**EXTENT**	**RELEVANCE**	**DIFFICULTY**
E2) Need to exchange experience in order to enhance reactor safety, operation and maintenance.	Important for the efficient use of infrastructure and cost reduction.	Safety is always urgent.	Countries with experimental reactors.	Would have great impact on the management and use of experimental reactors.	Low. Could be achieved through agreements with countries in the region which have reactors.
E5) Need to train highly qualified personnel in the management and operation of experimental and production reactors and to replace professional staff who are retiring.	Qualified personnel are an inescapable condition for the successful operation of experimental reactors.	Steps should be taken in a very firm but consistent manner to plan for replacement of personnel.	Countries which operate experimental reactors and those with programmes at the planning stage should be involved.	Of great impact for nuclear technology.	Average. Could be achieved through agreements with countries in the region.
E8) Need to upgrade the region's reactors to improve their safety and extend their operating lifetime.	This is a subject which should be analysed from a cost-benefit point of view, above all with respect to the financial aspects involved.	Draw up a schedule of activities.	Only countries with experimental reactors that have reached or are about to reach the end of their design operating life.	Of great impact for nuclear technology.	Average. Requires the availability of the necessary financial resources.
E9) Insufficient use of experimental and production reactors.	Experimental reactors provide a good foundation for extensive nuclear programmes.	Consistent promotion of the use of experimental reactors is considered to be urgent.	All countries which possess experimental reactors.	Important for health, science and technological applications.	Average difficulty.

APPLICATIONS IN INDUSTRY					
NEED	**SERIOUSNESS**	**TIME**	**EXTENT**	**RELEVANCE**	**DIFFICULTY**
E3) Need to disseminate the benefits of applications to end users, making use of existing capabilities and experience in the region.	This is imperative in order to ensure acceptance of their introduction.	Immediate.	All countries.	In order to spread the benefits, the relevant illustrative aspects of nuclear technology should be stressed.	Low. The majority of countries have the infrastructure.
E4) Insufficient use of nuclear applications in industry which affects its competitiveness.	The incorporation of nuclear applications with proven viability and advantages is very important.	The more quickly this technology is adopted, the better the opportunities for successful incorporation.	All countries.	Of enormous importance for technical and economic competitiveness.	High. Requires demonstration of value in cost/benefit terms.
E6) Need to strengthen the training of personnel who assist in the development of the required applications.	Qualified personnel are an indispensable requirement to guarantee the benefits of techniques.	Human resource training programmes should be developed.	Should be developed in all countries.	Important in order to be competitive in the market.	Average. Requires the support of international agencies.

NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
E11) Restrictions on trade and transport of radioactive material among countries in the region.	Not doing this limits the expansion and spread of nuclear technologies.	Should be done in the short term.	All countries.	Very important for the timely availability of radioisotopes.	High, owing to the need for legislative harmonization.
E15) Limited indigenous technology development for transfer to industry.	Technology assimilation may bring significant financial benefits.	Technology assimilation can begin as soon as required.	Technology assimilation is within the scope of virtually all countries where nuclear applications are used.	Entirely linked to nuclear technology.	High. Important for competitiveness in the market.

ANNEX 5. ATTRIBUTES OF NEEDS IN RADIATION SAFETY

RADIATION SAFETY					
NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
R1) Lack of regulatory control standards in potentially high-risk medical practices (linear accelerators, interventional radiology).	Severely affects patient protection.	It is to be recommended that these criteria be implemented as soon as possible.	This applies to the majority of countries in the region.	Implementation will increase protection of patients and of interventional radiologists.	Establishment and application of procedures.
R2) Lack of standardized training requirements for occupationally exposed workers in various practices.	Affects the level of safety for the workers themselves and installations.	It is to be recommended that these criteria be implemented as soon as possible.	This applies to the majority of countries in the region.	Crucial for occupational protection.	Designing the appropriate requirements.
R3) Deficiencies in control over materials to be recycled to ensure the absence of radioactive material.	Possibility of radiological emergencies occurring.	It is to be recommended that these criteria be implemented as soon as possible.	This applies to the majority of countries in the region.	Implementation will increase protection of the public and of workers.	Implementation of methodologies for the detection of orphan sources is complex.
R4) Limited coverage of the demand for postgraduate training in radiation protection.	Compromises the sustainability of radiation protection infrastructure.	Should be addressed as soon as possible to ensure the availability of trained personnel in the immediate future.	This problem affects the whole region.	Considerable, with the aim of having a pool of professionals trained in their functions.	There are difficulties in expanding existing quotas and there is little probability that another regional training centre will be established.
R5) Difficulties with the application of the concepts of exemption, exclusion, declassification or clearance.	The failure to apply these concepts makes regulatory oversight difficult.	It is to be recommended that these criteria be implemented as soon as possible.	This applies to the majority of countries in the region.	The application of these concepts is of substantial importance for regulation of practices.	Directly related to risk awareness.
R6) Insufficient individual internal monitoring coverage	There is a lack of knowledge of the internal doses received by a significant number of exposed workers.	Should be addressed in the relatively short term because of its seriousness.	This is a problem which affects almost all countries in the region.	It is relevant from a radiological point of view because of the large number of occupationally exposed workers.	Considerable difficulty in implementing monitoring methodology.
R7) Insufficient knowledge of the radiological impact of NORM (naturally occurring radioactive material) industries.	The level of radiological impact is of concern because of existing exposure which would require intervention.	Should be addressed in the relatively short term because of its seriousness.	This is a problem which affects almost all countries in the region.	It is relevant from a radiological point of view because of the large number of people exposed.	Implementation of the protection measures is fairly complex.
R8) Lack of effective regional coordination to provide assistance in emergencies.	Not a pressing matter owing to installed infrastructure.	Not an imminent need.	It is thought it would be good for the majority of countries to benefit from this coordination.	The coordination will improve the level of public protection.	Only requires coordination to take advantage of installed capacity.

ANNEX 6. INTERSECTORAL PRIORITIZATION WITHIN THE FRAMEWORK OF THE RSP

Within the framework of the RSP, an intersectoral prioritization exercise was also carried out the results of which are given here, according to its Final Grade of Priority. However, these results are only indicative since ARCAL and the IAEA have their own mechanisms for this purpose which will be followed for the prioritization of the technical cooperation programme for the respective cycles.

	Need/problem	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	Final grade
E2	Need to exchange experience in order to increase reactor safety, operation and maintenance.	4.43	4.43	4.00	4.14	17.00	1.71	2.42	41.08
S1	Regional deficit in trained human resources in terms of both quantity and quality (medical physicists, technicians, oncological radiotherapists, nuclear medicine specialists, molecular biologists, radiopharmacists and specialists in nuclear applications in nutrition).	5.00	4.60	4.00	4.80	**18.40**	2.20	**2.18**	**40.15**
S2	Lack of protocols (mainly clinical) and procedural manuals that have been evaluated, adapted and adopted by the region, for the application of nuclear techniques in human health.	4.60	4.20	4.40	4.60	**17.80**	2.20	**2.09**	**37.22**
E3	Need to disseminate the benefits of applications to end users, making use of existing capabilities and experience in the region.	4.57	4.29	4.14	3.71	16.71	1.71	2.17	36.21
E5	Need to train highly qualified personnel in the management and operation of experimental and production reactors and to replace professional staff who are retiring.	3.87	4.00	3.71	4.71	16.30	2.29	2.06	33.62
A4	Presence of areas with a high prevalence of fruit flies.	3.50	2.80	3.20	4.60	**14.10**	2.00	**2.30**	**32.43**
A3	Deficient agricultural soil management practices and inadequate use of fertilizers, water and biological nitrogen fixation.	3.80	3.60	3.80	3.40	**14.60**	1.60	**2.13**	**31.03**
A7	Low productivity, and susceptibility to biotic and abiotic stress, of traditional basic food crops.	3.00	3.00	3.60	3.60	**13.20**	1.60	**2.25**	**29.70**
E6	Need to strengthen the training of personnel who assist in the development of the required applications.	4.29	4.00	3.71	4.29	16.29	2.43	1.76	28.74

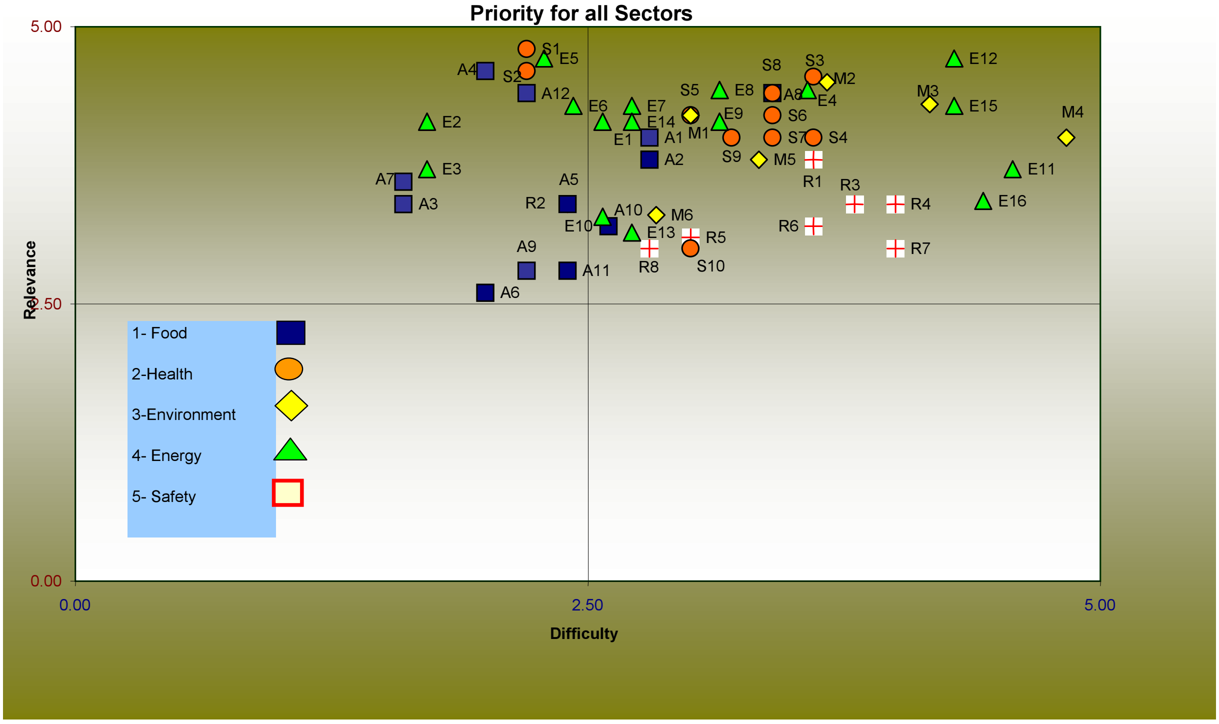
	Need/problem	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	Final grade
E1	Need to improve the provision to the public of objective and extensive information on nuclear energy.	5.00	4.14	4.43	4.14	17.71	2.57	1.61	28.54
E7	Need to expand and strengthen training of qualified personnel to manage nuclear power projects and nuclear power plants.	4.86	3.43	3.57	4.29	16.14	2.71	1.58	25.49
M1	Lack and/or inadequacy of systems for early warning, diagnosis and evaluation of the environmental impact of pollution with pesticides, persistent organic compounds, heavy metals and other pollutants of anthropogenic and natural origin in foodstuffs and environmental matrices at basin level.	5.00	4.20	4.80	4.20	**18.20**	3.00	**1.40**	**25.48**
S5	Insufficient awareness among national and international decision-makers and in the scientific community about the usefulness and safety of nuclear techniques in preventing and resolving public nutrition problems.	4.40	4.15	4.15	4.20	**16.90**	3.00	**1.40**	**23.66**
E14	Need to strengthen exchange and transfer of experience and knowledge in the nuclear power sector.	4.14	3.27	3.57	4.14	15.13	2.71	1.53	23.09
A1	Inadequate sustainability in the application of nuclear techniques in agriculture.	3.60	4.00	4.20	4.00	**15.80**	2.80	**1.43**	**22.57**
E8	Need to upgrade the region's reactors to improve their safety and extend their operating lifetime.	4.00	4.00	3.57	4.43	16.00	3.14	1.41	22.55
A12	Presence of areas with a high prevalence of codling moths.	2.40	2.20	2.20	4.40	**11.20**	2.20	**2.00**	**22.40**
S3	The processes for the technological management of the infrastructure for application of nuclear techniques in human health in the region, including planning, incorporation and sustained operation of new technologies, are generally not implemented in accordance with international requirements.	4.60	4.00	4.55	4.55	**17.70**	3.60	**1.26**	**22.37**
M2	Inadequate systems for management, protection and knowledge of the availability and quality of water resources.	4.50	4.50	4.60	4.50	**18.10**	3.67	**1.23**	**22.21**

	Need/problem	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	Final grade
A2	Restricted access to markets owing to the presence of chemical residues that pose a risk to human health in foodstuffs of animal and plant origin.	3.80	3.80	4.00	3.80	**15.40**	2.80	**1.36**	**20.90**
S6	Lack of institutionalization of the position and functions of the medical physicist in radiotherapy and imaging services (nuclear medicine and radiology), and to a lesser degree of other professionals associated with medical practices, by health ministries in many countries in the region.	4.70	4.20	3.70	4.20	**16.80**	3.40	**1.24**	**20.75**
E9	Insufficient use of experimental and production reactors.	4.14	3.86	3.57	4.14	15.71	3.14	1.32	20.71
E4	Insufficient use of nuclear applications in industry which affects its competitiveness.	4.29	4.14	3.71	4.43	16.57	3.57	1.24	20.55
S8	Unequal access in the region to radionuclides, radiopharmaceuticals, reagent kits and stable isotopes for diagnostic and therapeutic procedures in nuclear medicine, nutrition and medicine.	3.75	3.75	3.80	4.40	**15.70**	3.40	**1.29**	**20.32**
R2	Lack of standardized training requirements for occupationally exposed workers in various practices.	3.20	3.30	4.20	3.40	14.10	2.40	1.42	**19.98**
E10	Shortage of long-term energy and electricity supply and demand scenarios and analyses to decide on possible inclusion of nuclear power in order to diversify efficient and sustainable energy sources and provide power to areas with no supply.	4.29	4.43	3.57	3.29	15.57	2.57	1.28	19.90
A5	Loss of agricultural areas through soil degradation caused by extensive agricultural activity.	4.00	3.60	3.00	3.40	**14.00**	2.40	**1.42**	**19.83**
S9	Insufficient human resources in the region trained in predictive, preventive and corrective maintenance of laboratory, diagnostic and treatment equipment employing nuclear technology that is many years old.	4.00	4.00	3.60	4.00	**15.60**	3.20	**1.25**	**19.50**
S4	Lack or non-adoption of quality management systems in many centres in the region.	4.80	4.00	4.20	4.00	**17.00**	3.60	**1.11**	**18.89**

	Need/problem	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	Final grade
S7	Limited application of molecular isotopic techniques in the region for the diagnosis of emerging infectious and contagious diseases such as SARS (severe acute respiratory syndrome) and avian influenza, and re-emerging ones such as dengue, malaria and tuberculosis, and lack of a regional laboratory network.	3.60	4.20	4.00	4.00	**15.80**	3.40	**1.18**	**18.59**
M5	Inadequate diagnosis and evaluation of the impact on human health of atmospheric pollution with trace elements in urban and rural areas and in enclosed spaces.	4.20	3.80	4.30	3.80	**16.10**	3.33	**1.14**	**18.35**
M3	Lack of regional systems for early prediction and evaluation of the toxicity of harmful algal blooms, via radiotoxicological tests and bioassays.	4.50	4.30	4.20	4.30	**17.30**	4.17	**1.03**	**17.85**
E13	Lack of statistical databases and procedures and adequate indicators for use in energy assessment and planning studies.	4.14	3.86	4.00	3.14	15.14	2.71	1.16	17.53
A6	Incidence of exotic transboundary diseases in animals.	3.60	3.60	3.60	2.60	**13.40**	2.00	**1.30**	**17.42**
A8	Presence of areas infested with New World screwworm.	2.72	2.80	3.20	4.40	**13.12**	3.40	**1.29**	**16.98**
E12	Expediency of countries having nuclear fuel cycle policies covering everything from mining of energy resources to disposal of radioactive waste.	3.57	3.43	3.71	4.71	15.43	4.29	1.10	16.97
M6	Inadequate assessment of the hydrological and hydrogeological risk in hydraulic structures and lack of systematic monitoring of sedimentation in the region's artificial and natural water bodies.	4.20	3.30	3.70	3.30	**14.50**	2.83	**1.16**	**16.89**
A9	Vulnerability of livestock species at risk of extinction.	3.64	3.40	3.20	2.80	**13.04**	2.20	**1.27**	**16.60**
A10	Low productivity of native plants with nutritional and/or medicinal potential in areas of biodiversity.	3.30	3.40	3.00	3.20	**12.90**	2.60	**1.23**	**15.88**
S10	Regional databases on infrastructure in nuclear medicine, radiopharmacy, molecular biology, radiotherapy and radiology, which can assist with planning and investment, are not up to date or do not exist.	4.00	3.80	4.40	3.00	**15.20**	3.00	**1.00**	**15.20**

	Need/problem	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	Final grade
R1	Lack of regulatory control standards in potentially high-risk practices (linear accelerators, interventional radiology).	3.60	3.20	3.80	3.80	14.40	3.60	1.06	**15.20**
E15	Limited indigenous technology development for transfer to industry.	3.57	3.14	3.43	4.29	14.43	4.29	1.00	14.43
A11	Limited development of aquaculture owing to health and genetic factors.	3.20	2.80	3.20	2.80	**12.00**	2.40	**1.17**	**14.00**
M4	Limited knowledge of the processes that occur in the coastal area (loss of habitats, transfer of pollutants, sedimentation, nutrient cycles, climate change and effects of the El Niño phenomenon), to establish regional management programmes that reduce its degradation.	4.20	4.00	4.70	4.00	**16.90**	4.83	**0.83**	**13.99**
R5	Difficulties with the application of the concepts of exemption, exclusion, declassification or clearance.	3.00	3.00	3.80	3.10	12.90	3.00	1.03	**13.33**
E11	Restrictions on trade and transport of radioactive material among countries in the region.	3.86	3.86	4.14	3.71	15.57	4.57	0.81	12.65
R3	Deficiencies in control over materials to be recycled to ensure the absence of radioactive material.	3.20	3.20	4.20	3.40	14.00	3.80	0.89	**12.53**
R8	Lack of effective regional coordination to provide assistance in emergencies.	2.40	2.40	3.80	3.00	11.60	2.80	1.07	**12.43**
R4	Limited coverage of the demand for postgraduate training in radiation protection.	2.80	3.00	4.40	3.40	13.60	4.00	0.85	**11.56**
R6	Insufficient individual internal monitoring coverage.	3.00	2.80	3.80	3.20	12.80	3.60	0.89	**11.38**
E16	Insufficient energy integration in the region.	3.71	3.00	4.14	3.43	14.29	4.43	0.77	11.06

Afterwards the graph Difficulty X Relevance was created, where the results that appear in the previous Table can be appreciated, distributed according to the position that they occupy in the respective above quadrants I and II.



At the VIII meeting of the ATCB, held on Isla Margarita, a ***proposal for normalization of prioritiest*** was presented, which yielded the results which follow. ARCAL took note of this point of view and included it as an annex to the RSP.

The proposal is based on the observation that, in the quadrants graph, only quadrants I and II contain needs/problems, because of the high level of relevance assigned to them (all above 2.5). Similarly, on the difficulty axis, the lowest value is 1.6 and the highest almost 5.0. Therefore, this first value of 1.6 can be used as the origin on this axis, adjusting the quadrants proportionally.

Applying this procedure, quadrant I corresponds to the difficulty range from 1.6 to 3.3 and quadrant II 3.3 to 5.0. This procedure normalizes the difficulty axis from the lowest value obtained in the prioritization process.

With the new range, quadrant I includes other needs/problems that were previously in quadrant II. For the final selection of needs/problems, in the new quadrant I a selection was made starting with those with the highest level of relevance until a set of needs/problems which was sufficiently representative of all sectors present was arrived at. A total of 30 needs/problems was obtained which are shown in the following table.

	Need/problem	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	Final grade
E2	Need to exchange experience in order to enhance reactor safety, operation and maintenance.	4.43	4.43	4.00	4.14	17.00	1.71	2.42	41.08
S1	Regional deficit in trained human resources in terms of both quantity and quality (medical physicists, technicians, oncological radiotherapists, nuclear medicine specialists, molecular biologists, radiopharmacists and specialists in nuclear applications in nutrition).	5.00	4.60	4.00	4.80	**18.40**	2.20	**2.18**	**40.15**
S2	Lack of protocols (mainly clinical) and procedural manuals that have been evaluated, adapted and adopted by the region, for the application of nuclear techniques in human health.	4.60	4.20	4.40	4.60	**17.80**	2.20	**2.09**	**37.22**
E3	Need to disseminate the benefits of applications to end users, making use of existing capabilities and experience in the region.	4.57	4.29	4.14	3.71	16.71	1.71	2.17	36.21
E5	Need to train highly qualified personnel in the management and operation of experimental and production reactors and to replace professional staff who are retiring.	3.87	4.00	3.71	4.71	16.30	2.29	2.06	33.62
A4	Presence of areas with a high prevalence of fruit flies.	3.50	2.80	3.20	4.60	**14.10**	2.00	**2.30**	**32.43**
A3	Deficient agricultural soil management practices and inadequate use of fertilizers, water and biological nitrogen fixation.	3.80	3.60	3.80	3.40	**14.60**	1.60	**2.13**	**31.03**
A7	Low productivity, and susceptibility to biotic and abiotic stress, of traditional basic food crops.	3.00	3.00	3.60	3.60	**13.20**	1.60	**2.25**	**29.70**
E6	Need to strengthen the training of personnel who assist in the development of the required applications.	4.29	4.00	3.71	4.29	16.29	2.43	1.76	28.74
E1	Need to improve the provision to the public of objective and extensive information on nuclear energy.	5.00	4.14	4.43	4.14	17.71	2.57	1.61	28.54
E7	Need to expand and strengthen training of qualified personnel to manage nuclear power projects and nuclear power plants.	4.86	3.43	3.57	4.29	16.14	2.71	1.58	25.49
M1	Lack and/or inadequacy of systems for early warning, diagnosis and evaluation of the environmental impact of pollution with pesticides, persistent organic compounds, heavy metals and other pollutants of anthropogenic and natural origin in foodstuffs and environmental matrices at basin level.	5.00	4.20	4.80	4.20	**18.20**	3.00	**1.40**	**25.48**
S5	Insufficient awareness among national and international decision-makers and in the scientific community about the usefulness and safety of nuclear techniques in preventing and resolving public nutrition problems.	4.40	4.15	4.15	4.20	**16.90**	3.00	**1.40**	**23.66**

	Need/problem	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	Final grade
E14	Need to strengthen exchange and transfer of experience and knowledge in the nuclear power sector.	4.14	3.27	3.57	4.14	15.13	2.71	1.53	23.09
A1	Inadequate sustainability in the application of nuclear techniques in agriculture.	3.60	4.00	4.20	4.00	**15.80**	2.80	**1.43**	**22.57**
E8	Need to upgrade the region's reactors to improve their safety and extend their operating lifetime.	4.00	4.00	3.57	4.43	16.00	3.14	1.41	22.55
A12	Presence of areas with a high prevalence of codling moths.	2.40	2.20	2.20	4.40	**11.20**	2.20	**2.00**	**22.40**
A2	Restricted access to markets owing to the presence of chemical residues that pose a risk to human health in foodstuffs of animal and plant origin.	3.80	3.80	4.00	3.80	**15.40**	2.80	**1.36**	**20.90**
E9	Insufficient use of experimental and production reactors.	4.14	3.86	3.57	4.14	15.71	3.14	1.32	20.71
R2	Lack of standardized training requirements for occupationally exposed workers in various practices.	3.20	3.30	4.20	3.40	14.10	2.40	1.42	**20.0**
E10	Shortage of long-term energy and electricity supply and demand scenarios and analyses to decide on possible inclusion of nuclear power in order to diversify efficient and sustainable energy sources and provide power to areas with no supply.	4.29	4.43	3.57	3.29	15.57	2.57	1.28	19.90
A5	Loss of agricultural areas through soil degradation caused by extensive agricultural activity.	4.00	3.60	3.00	3.40	**14.00**	2.40	**1.42**	**19.83**
S9	Insufficient human resources in the region trained in predictive, preventive and corrective maintenance of laboratory, diagnostic and treatment equipment employing nuclear technology that is many years old.	4.00	4.00	3.60	4.00	**15.60**	3.20	**1.25**	**19.50**
M5	Inadequate diagnosis and evaluation of the impact on human health of atmospheric pollution with trace elements in urban and rural areas and in enclosed spaces.	4.20	3.80	4.30	3.80	**16.10**	3.33	**1.14**	**18.35**
E13	Lack of statistical databases and procedures and adequate indicators for use in energy assessment and planning studies.	4.14	3.86	4.00	3.14	**15.14**	2.71	1.16	17.53
M6	Inadequate assessment of the hydrological and hydrogeological risk in hydraulic structures and lack of systematic monitoring of sedimentation in the region's artificial and natural water bodies.	4.20	3.30	3.70	3.30	**14.50**	2.83	**1.16**	**16.89**
A10	Low productivity of native plants with nutritional and/or medicinal potential in areas of biodiversity.	3.30	3.40	3.00	3.20	**12.90**	2.60	**1.23**	**15.88**
S10	Regional databases on infrastructure in nuclear medicine, radiopharmacy, molecular biology, radiotherapy and radiology, which can assist with planning and investment, are not up to date or do not exist.	4.00	3.80	4.40	3.00	**15.20**	3.00	**1.00**	**15.20**

	Need/problem	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	Final grade
R5	Difficulties with the application of the concepts of exemption, exclusion, declassification or clearance.	3.00	3.00	3.80	3.10	**12.90**	3.00	1.03	**13.3**
R8	Lack of effective regional coordination to provide assistance in emergencies.	2.40	2.40	3.80	3.00	**11.60**	2.80	1.07	**12.4**

ANNEX 7. PARTICIPANTS IN THE RSP PROCESS

Advisory Committee and ATCB Directive Group

1. Jorge Vallejo (**Chairman of the ATCB**) General Coordinator — Colombia
2. Juan Antonio Casas Zamora — Director of the Division for Latin America at the IAEA
3. Ángel Díaz (**Vice-Chairman of the ATCB**) — Venezuela
4. Alberto Miranda (**Secretary of the ATCB**) — Bolivia
5. Hadj Slimane Cherif — Director of the Office of Programme Development and Performance Assessment at the IAEA
6. Jane Gerardo-Abaya — Programme Management Officer supporting DIR-TCLA
7. Francisco Rondinelli — strategic planning expert
8. Angelina Díaz — expert with ARCAL experience
9. Sergio Olmos – expert with experience in the BAR and BAR Working Group

Group 1. Food safety (mutation induction and genetic improvement of plants; integrated management of soils, water, plants and fertilizers; integrated pest management; animal production and health; nutrition and environmental protection)

1. Silvia Fascioli (**member of the ATCB**) — Uruguay
2. Luz Gómez Pando (**mutation induction and genetic improvement of plants**) — Peru
3. Jesús Reyes (**pest control**) — Mexico
4. Segundo Urquiaga (**integrated management of soils, water, plants and fertilizers**) — Brazil
5. José Fernando García (**animal sciences**) — Brazil
6. Cecilia Urbina (Programme Management Officer)

Focal points from IAEA technical departments

1. Jorge Hendrichs (NAFA)
2. Walther Enkerlin (NAFA)
3. Pierre Lagoda (NAFA)
4. Tatiana Rubio Cabello (NAFA)
5. Ian Ferris (NAFA)

Group 2. Human health (nuclear medicine, radiotherapy, medical physics, radiopharmacy, nutrition, radiation protection of patients, nuclear molecular biology — infectious diseases)

1. Angel Díaz (**member of the ATCB**) — Venezuela
2. Pilar Orellana (**nuclear medicine**) — Chile
3. Rolando Camacho (**radiotherapy**) — Cuba
4. Esperanza Castellanos (**medical physics**) — Colombia
5. Henia Balter (**radiopharmacy**) — Uruguay
6. José Luis San Miguel Simbrón (**nutrition**) — Bolivia
7. Mari Carmen Franco (**radiation protection of patients**) — Mexico
8. Henia Balter (**nuclear medicine and radiopharmacy**) — Uruguay
9. *Hugo Marsiglia* (**radiotherapy**) — *France*
10. Octavio Fernandes (**nuclear molecular biology — infectious diseases**) — Brazil
11. José Antonio Lozada (Programme Management Officer)

Focal points from IAEA technical departments

1. Pedro Andreo (NAHU)
2. Eduardo Zubizarreta (NAHU)

Group 3. Environment (atmosphere, water resources, terrestrial environment, marine environment)

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2. Carlos Alonso (**marine environment**) **—** Cuba
3. Samuel Hernández (**water resources**) — Venezuela
4. Rita Pla (**atmosphere**) — Argentina
5. Elizabeth Carazo (**terrestrial environment**) — Costa Rica
6. Jane Gerardo-Abaya (Programme Management Officer)

Focal points from IAEA technical departments

1. Luis Araguás (NAPC)
2. Joan Albert Sánchez Cabeza (NAML)
3. Gabriele Voigt (NAAL/SEIB)

Group 4. Energy and industry (nuclear power, experimental reactors and applications in industry)

1. Raúl Ortiz Magaña (**member of the ATCB**) — Mexico
2. Gonzalo Torres Oviedo (**energy planning**) — Chile
3. Betonus Pierre (**energy planning**) — Haiti
4. Gustavo Molina (**industrial applications**) — Mexico
5. Ana Fittipaldi (**nuclear energy**) — Argentina
6. *Félix Barrio — Spain*
7. Javier Guarnizo/Alain Cardoso (Programme Management Officer)

Focal points from IAEA technical departments

1. Iván Vera (NE) *
2. Ismael Concha (NE)
3. Taghrid Atieh (NE/INIS)

Group 5. Radiation safety (regulatory infrastructure, occupational radiation protection, regulatory aspects of exposure in medical practices, radiation protection of the public, radiological emergency preparedness and response, and education and training)

1. Maria Cristina Lourenço (**member of the ATCB**) — Brazil
2. Alejandro Náder — Uruguay
3. Gustavo Massera — Argentina
4. Paulo Ferruz — Chile
5. Tsu Chia Chao (Programme Management Officer — IAEA)

Focal points from IAEA technical departments

1. Ronald Pacheco (NSRW) *
2. Christer Viktorsson (NSNI)
3. María Josefa Moracho Ramírez (NSNI)

* Also participated in the working groups of the RSP preparation and prioritization workshops.

International organizations represented at the workshop in Santa Cruz de la Sierra, Bolivia

Food safety
Food and Agriculture Organization of the United Nations (FAO)
Gonzalo Flores Céspedes, Assistant to the FAO Representative in Bolivia

Human health
Pan American Health Organization (PAHO)
Pablo Jiménez, Regional Advisor for Radiological Health

Environment
United Nations Environment Programme (UNEP)
Antonio Villasol Núñez, Director General of the Centre for Engineering and Environmental Management of Bays and Coasts

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Co-operation Agreement for the Promotion of Nuclear Science
and Technology in Latin America and the Caribbean

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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

Background, Methodology and Process for the Preparation of the RSP for Latin America and the Caribbean

ARCAL

IAEA

International Atomic Energy Agency

PUBLICATIONS RELATED TO THE RSP

To facilitate review of the material generated by the RSP preparation process, it has been published in separate parts covering the following aspects:

Regional Strategic Profile for Latin America and the Caribbean (RSP) 2007–2013

Background, Methodology and Process for the Preparation of the RSP for Latin America and the Caribbean

Food Safety in Latin America and the Caribbean in the Light of the RSP

Human Health in Latin America and the Caribbean in the Light of the RSP

Environment in Latin America and the Caribbean in the Light of the RSP

Energy and Industry in Latin America and the Caribbean in the Light of the RSP

Radiation Safety in Latin America and the Caribbean in the Light of the RSP

IAEA
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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

ARCAL-IAEA Strategic Alliance

BACKGROUND, METHODOLOGY AND PROCESS FOR PREPARATION OF THE RSP FOR LATIN AMERICA AND THE CARIBBEAN

CONTENTS

REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013
ARCAL-IAEA Strategic Alliance

BACKGROUND, METHODOLOGY AND PROCESS FOR PREPARATION OF THE RSP FOR LATIN AMERICA AND THE CARIBBEAN

I. BACKGROUND TO THE RSP

The preparation of the Regional Strategic Profile for Latin America and the Caribbean (RSP) is the basis for developing cooperation activities among countries within the framework of ARCAL and a basic instrument for improving mutual collaboration among its members, i.e. the countries of Latin America and the Caribbean, with the IAEA and with other current partners, such as Spain, or potential partners. One of the essential elements taken into consideration in the RSP is the technical cooperation strategy of the International Atomic Energy Agency, ARCAL's main collaborator and strategic partner.

In this context, effective and efficient collaboration in the field of technical cooperation should meet regional needs and address problems requiring active cooperation among countries, this being one of the premises of ARCAL.

The Regional Strategic Profile therefore aims to consolidate the strategic alliance between ARCAL and the IAEA through an ongoing consultation process which involves optimizing cooperation activities within the framework both of the Agreement and the Agency, giving continuity to the guidelines laid down in the various documents approved by the Board of ARCAL Representatives (BAR) and also by the advisory and governing bodies of the IAEA, with a view to drawing up proposals that might lead to harmonious work to the benefit of the countries that participate in ARCAL.

In preparing the RSP, account was taken of such documents as the 2004 Regional Cooperation Plan (RCP), which was approved by the BAR and not only establishes the mission, vision, objectives and goals for ARCAL but also lays down the framework for cooperation with the IAEA and among countries, and identifies sectors where nuclear technology could provide solutions for the region.

Both the IAEA and ARCAL have gradually recognized the need to strengthen the framework in which they carry out their activities. They therefore decided to establish a strategic alliance, which was realized at the VI meeting of the BAR held in September 2005. In March 2006, an action plan was conceived whose implementation steps were approved in September 2006 during the VII meeting of the BAR.

Two specific objectives are established as the pillars of this action plan: optimization of management of ARCAL and strengthening of the institutional structure of the Agreement. The RSP is the mechanism through which the first of these objectives is to be achieved.

From the point of view of the IAEA, account was taken of the guidelines from the report of the Standing Advisory Group on Technical Assistance and Cooperation (SAGTAC) on the regional programming of the IAEA's technical cooperation programme, presented in February 2007, which states that the preparation of the Regional Strategic Profile is a prerequisite for defining strategy and the regional programme of IAEA technical cooperation with Member States and the relevant regional agreements. Therefore it was envisaged that this Regional Strategic Profile be prepared jointly with the IAEA, the relevant regional agreement and Member States, so that it can serve as a basis for the preparation and negotiation of the relevant regional cooperation programmes.

Thus, the RSP will not only serve as a basis for the preparation of regional programmes to be undertaken using nuclear technology, but will also act as an aid in the process of project submission and selection under ARCAL, in accordance with its specific procedures.

The first outline of the RSP initiative was presented by the then General Coordinator of the process, Ms Angelina Díaz, National Coordinator for Cuba, on 19 October 2006 at an ARCAL meeting (BAR, ATCB and BAR Working Group), during the Technical Cooperation Coordination Meeting for the Latin America and Caribbean Region held in Vienna.

It should be noted that, for the preparation of the RSP, the BAR, in consultation with the ARCAL Technical Coordination Board (ATCB), approved the following guide on 22 December 2006: Preparation of the Regional Strategic Profile for the ARCAL-IAEA Strategic Alliance, 2007–2013. This document laid down the guidelines for preparation of the RSP, this process having been closely supported by the BAR Working Group and other ARCAL bodies, together with various areas of the Agency in line with the one house approach. The support given by the technical departments of the IAEA deserves note. They made valuable contributions in their respective areas, having been kept constantly informed of the process, including through ongoing electronic contacts from the various workshop venues.

Spain, an associate country of ARCAL, through the Research Centre for Energy, Environment and Technology (CIEMAT), and France provided financial and expert assistance with the preparation of the RSP.

II. RSP PREPARATION PROCESS

1. Objective and priority sectors

The Profile establishes, based on cooperation within ARCAL, a descriptive analytical profile of the most pressing priorities and needs in the region which may be addressed with the help of the available nuclear technology featuring in areas of cooperation with the IAEA, and other regional priorities for which cooperation could be sought from other international organizations and governments of Agency Member States.

In developing the RSP, the work was divided into sectors, taking into account the priorities and needs of the Latin American and Caribbean region, including a study of trends and possible scenarios. The selected sectors were as follows:

1. Food safety (agriculture, food, veterinary science);
2. Human health (nuclear medicine, radiotherapy, medical physics, radiopharmacy, nutrition, radiation protection of patients, nuclear molecular biology — infectious diseases);
3. Environment (atmosphere, water resources, terrestrial environment, marine environment);
4. Energy and industry (nuclear power, experimental reactors and applications in industry);
5. Radiation safety (regulatory infrastructure, occupational radiation protection, regulatory aspects of exposure in medical practices, radiation protection of the public, radiological emergency preparedness and response, and education and training).

2. Implementation of work

In preparing the RSP, the following were held: a preparatory meeting, two sectoral group workshops and a final meeting for conclusions. The sectoral group workshops were held in Santa Cruz de la Sierra (Bolivia) and Madrid (Spain). At these workshops, all the groups were working simultaneously in the same place, in plenaries and independently. The Advisory Committee was in constant contact with the various groups throughout the process, both during the work meetings and between meetings.

The preparatory meeting took place in Vienna from 22 to 24 January. It was attended by the ATCB members from each sectoral group, the focal points from the technical departments at the IAEA, the Advisory Committee, Mr H.S. Cherif — Director of the Office of Programme Development and Performance Assessment at the IAEA, Mr Francisco Rondinelli — strategic planning expert, and the TCLA Programme Management Officers for each sector. The programme for this and other meetings appear as annexes.

The objectives of the meeting were: to prepare and approve the terms of reference for the RSP and to design the questionnaire for the survey to help determine regional needs and priorities.

This meeting concentrated on ensuring that all participants were equally well acquainted with the planning techniques and on agreeing on a methodology for the work on the RSP. It also enabled the regional experts who would belong to each sectoral group to be selected. This was done on the basis of proposals received from ARCAL countries between October and December 2006, and in consultation with the technical departments of the Agency. The Advisory Committee was responsible for coordinating and holding this meeting.

As one of the mechanisms for collecting additional information for the process, a questionnaire was designed with a view to identifying, from a regional perspective, common problems and needs in the region, transboundary aspects and essential needs for other types of cooperation in the region in the five previously identified sectors. The questionnaire was sent through the ARCAL Chairman to the National Coordinators of all countries for internal distribution, and by the IAEA to international organizations working in the relevant sectors in the region. High-level officials with strategic vision and ample knowledge of each sector were invited to respond to it.

Progress in the work was reported to the BAR Working Group at a meeting with the participants. In addition, at this meeting the decision was ratified to nominate Mr Jorge Vallejo, National Coordinator for Colombia and Chairman of the ATCB, as General Coordinator of the RSP preparation process, replacing Ms Díaz who could not continue with this task.

The preparatory workshop was held in Santa Cruz de la Sierra (Bolivia) between 12 and 16 March. It was attended by the members of the sectoral groups and the Advisory Committee, Mr Cherif and Mr Rondinelli, and representatives of the United Nations Environment Programme (UNEP), the Pan American Health Organization (PAHO) and the Food and Agriculture Organization of the United Nations (FAO).

At this workshop, an advanced stage was reached in the preparation of the RSP by analysing the survey results, preparing the various sectoral contributions to the draft RSP and identifying needs and problems by subsector. The methodology that would be used for prioritization was explained. In addition, the schedule of activities to be followed up to the prioritization workshop in Madrid, Spain, (16–20 April 2007) was agreed, along with the programme for that workshop.

The representatives of FAO, PAHO, UNEP and the IAEA gave presentations at the start of the work of the respective sectoral groups on food safety, human health, environment and radiation safety, setting out the priorities and the guidelines for technical cooperation with those implementing programmes in the region, and also getting involved in the dynamics of the work of each sectoral group.

At this meeting, the next stage of priority identification was planned, based on the information accumulated and provided by the IAEA on the current status and development trends in the various sectors where nuclear techniques can help resolve regional problems. The meeting's outcome document remained under consideration in the sectoral groups.

On returning to Vienna, the Director for Latin America reported to the BAR Working Group at a meeting on the progress of the work.

The prioritization workshop was held in Madrid, Spain, from 16 to 20 April, at the Research Centre for Energy, Environment and Technology (CIEMAT). It should be noted here that, in January 2007, the association between ARCAL and Spain was concluded. Spain designated CIEMAT as its executive body for this purpose, and CIEMAT offered to host the workshop. The same participants were present as at the Santa Cruz de la Sierra workshop, with a few exceptions in the human health area, and there were no representatives from international organizations.

The objectives achieved were a clear understanding of priorities within the framework of the RSP, the finalization of the document on sectoral contributions to the RSP and the prioritization of regional needs and problems.

The conclusions meeting was held in Vienna in the week of 23–27 April. The participants were the Advisory Committee, the members of the ATCB from the sectoral groups, Mr Cherif and Mr Rondinelli.

The objective of this meeting was to finalize the results of the various working groups and consolidate all the work in a single document called the Regional Strategic Profile for Latin America and the Caribbean (RSP) 2007–2013, to be submitted for technical approval by the ATCB at its VIII meeting to be held on Isla Margarita, Venezuela, from 21 to 25 May 2007.

At the conclusions meeting, the RSP was also given to the technical departments of the IAEA, the BAR Working Group, and the Deputy Director General for Technical Cooperation, Ms Ana María Cetto, for their consideration.

3. Document approval process

The RSP was given technical approval by the ARCAL National Coordinators during the VIII meeting of the ATCB held from 21 to 25 May 2007 on Isla Margarita, Venezuela. The RSP was subsequently submitted as a proposal to the Board of ARCAL Representatives (BAR). The latter, in turn, entrusted its final revision to the BAR Working Group.

The RSP was finally adopted by ARCAL on 14 June 2007 at an extraordinary BAR meeting called for that purpose, the IAEA having been requested to publish it.

III. METHODOLOGY FOR PREPARATION OF THE RSP

1. Working method

First of all, terms of reference were established for the preparation of the RSP and a survey was designed and sent to ARCAL participating countries to assist in the initial identification of regional needs in each sector. Both documents appear as annexes to this publication.

Next, national experts carried out a SWOT (strengths, weaknesses, opportunities and threats) analysis, allowing the region's most pressing problems/needs to be identified. The SWOT analysis and the detailed results of the prioritization for each sector are covered in the corresponding separate part of the RSP publication.

The experts, for reasons of prioritization, assigned specific attributes to these related to their seriousness, time, extent, relevance and level of difficulty. The resulting values allowed for quantitative comparison among them in their corresponding sectors, also taking into account the different levels of development of each country in the sectors in question. The prioritization methodology will be considered in detail later.

In addition, representatives of the United Nations Environment Programme (UNEP), the Pan American Health Organization (PAHO) and the Food and Agriculture Organization of the United

Nations (FAO) presented both the priorities and the guidelines for technical cooperation with those implementing their programmes in Latin America and the Caribbean at the start of the workshop in Santa Cruz de la Sierra.

2. Prioritization methodology

2.1 Introduction

In preparing the Regional Strategic Profile (RSP) for the Strategic Alliance between ARCAL and the IAEA, a prioritization methodology was selected whose approach has been used over the last 20 years by various public and private institutions, and by various international organizations involved in promotion and development work.

To assign priorities within a set of needs/problems of a strategic nature and identified within various areas of activity, the methodology envisages the use of specific attributes for which a graded scale of values is established for each need/problem, which, at the end of the process, allows a quantitative comparison among them.

It must be highlighted that any prioritization process involves assigning quantitative values to a qualitative evaluation, which always introduces a subjective component in the process. In this case, the mechanism that must be adopted to minimize this effect, and at the same time enrich it, is the justification of each need/problem and the justification of each grade assigned to the respective attributes. In addition, when a collective evaluation is made of the problems identified within the framework of the RSP, it is appropriate that there be discussion and debate among the participants until a consensus is achieved and a single value is decided on for each of the grades assigned to each attribute.

Another important aspect of the methodology is the choice of the profiles of the people participating in the process. In making this choice, technical training, professional experience and specific knowledge needed for the correct characterization of each problem must be taken into consideration.

In the case of the RSP, it is important to highlight the strategic nature of the document, which identifies regional needs/problems and is to be used to develop a strategic alliance between two parties — ARCAL and the IAEA. This alliance can only be achieved through a strategic planning process which allows appropriate identification and characterization of each need/problem.

Another aspect relevant to the preparation of the Regional Strategic Profile is that account must be taken of the various levels of development of each country in the region, in particular when considering the five sectors chosen for the preparation of the Profile: food safety, human health, environment, energy and industry, and radiation safety.

2.2. Attributes for prioritization

Five attributes were adopted for the evaluation of needs/problems, taking into account the strategic nature of the RSP. These are set out below:

SERIOUSNESS	This is a measure of the degree of severity of the need/problem, taking into account the negative impact of not addressing it.
TIME	This is related to the degree of urgency in addressing the need/problem, its likelihood of worsening and future consequences.
EXTENT	This determines the degree of regional impact of the need/problem, taking into account, for example, the number of countries affected.
RELEVANCE of/for nuclear techniques	On the one hand, this measures to what extent nuclear applications can contribute to addressing/solving the need/problem. On the other hand, it takes account of the extent to which solving the problem has relevance for nuclear applications.
LEVEL OF DIFFICULTY	This measures the degree of difficulty of implementing the solution to the need/problem identified, which can be related to: infrastructure, resources, technology, legislation, intergovernmental commitments, etc.

2.3. Scoring for prioritization and justification

To prioritize needs/problems by sector, prioritization grades are used for the attributes SERIOUSNESS, TIME, EXTENT and RELEVANCE. These grades range from **0** and **5**, as shown in the following table:

Grade	Meaning
0	Very low
1	Low
2	Average
3	Above average
4	High
5	Very high

The prioritization grade assigned to each attribute must be justified and entered in a table. Subsequently, these values are added together to obtain the TOTAL value, which corresponds to the prioritization scoring of the need/problem. This operation must be performed for each of the sectors under consideration.

Below is a table in which the needs/problems and attributes are entered. Once the need/problem has been described, the grades assigned to each attribute are entered in each cell along with their justification, and the sum of these grades is entered in the TOTAL column.

Table I. Prioritization in the sector.

Sector (and/or subsector, where appropriate).......................

Attributes / **Need/problem**	**Seriousness**	**Time**	**Extent**	**Relevance**	**Total**
1) (description)	**Grade:** 0 to 5 **Justification:** (text)	**Grade:** 0 to 5 **Justification:** (text)	**Grade:** 0 to 5 **Justification:** (text)	**Grade:** 0 to 5 **Justification:** (text)	Sum:
2) (name)	**Grade:** 0 to 5 **Justification:** (text)	**Grade:** 0 to 5 **Justification:** : (text)	**Grade:** 0 to 5 **Justification:** (text)	**Grade:** 0 to 5 **Justification:** (text)	Sum:

The TOTAL value corresponds to the priority scoring for the need/problem within the sector and can range from 0 to 20 points.

One important aspect that must be taken into account when evaluating the TOTAL is that the values in this field cannot be the same for two or more needs/problems. If this situation arises, adjustments must be made to the grades assigned to the attributes, including by using decimals if necessary.

The TOTAL score establishes the prioritization for the set of needs/problems in the sector.

Another attribute that is evaluated is the degree of DIFFICULTY in solving the need/problem. This is done by adding a column to the attributes table shown above, as shown in Table II.

Table II.

Sector (and/or subsector, where appropriate).......................

Attributes / **Need/Problem**	**Seriousness**	**Time**	**Extent**	**Relevance**	**Total**	**Difficulty**
1) (name)	**Grade:** 0 to 5 **Justification:** (text)	**Grade:** 0 to 5 **Justification:** (text)	**Grade:** 0 to 5 **Justification:** (text)	**Grade:** 0 to 5 **Justification:** (text)	Sum:	**Grade:** 1 to 5 **Justification:** (text)
2) (name)	**Grade:** 0 to 5 **Justification:** (text)	**Grade:** 0 to 5 **Justification:** : (text)	**Grade:** 0 to 5 **Justification:** (text)	**Grade:** 0 to 5 **Justification:** (text)	Sum:	**Grade:** 1 to 5 **Justification:** (text)

In this case, the range of values to evaluate the degree of DIFFICULTY is from **1** to **5**, as shown below:

Grade	Meaning
1	Low
2	Average
3	Above average
4	High
5	Very high

2.4 Quadrant graph

In analysing the data obtained, there are four possibilities which are defined relative to the values of the **RELEVANCE** and **DIFFICULTY** attributes.

1. HIGH **RELEVANCE** and LOW **DIFFICULTY**

   This corresponds to the first category of priorities and includes the needs/problems that should be chosen first.

2. HIGH **RELEVANCE** and HIGH **DIFFICULTY**

   This corresponds to the second category of priorities.

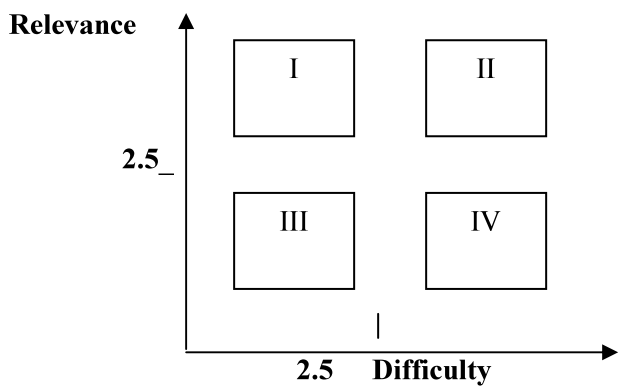
3. LOW **RELEVANCE** and LOW **DIFFICULTY**

   This third category includes needs/problems that are of relatively low importance but which may still be chosen because of their low level of difficulty to implement.

4. LOW **RELEVANCE** and HIGH **DIFFICULTY**

   This fourth category includes the last set of needs/problems which can, in principle, be eliminated and which should only be considered subject to specific interests or special situations.

These four possibilities can be represented in a quadrant graph where DIFFICULTY is placed on the X axis and RELEVANCE on the Y axis, as shown below:



As we can see in this graph, the quadrants correspond to the following categories:

Quadrant I — HIGH **RELEVANCE** and LOW **DIFFICULTY**;

Quadrant II — HIGH **RELEVANCE** and HIGH **DIFFICULTY**;

Quadrant III — LOW **RELEVANCE** and LOW **DIFFICULTY**;

Quadrant IV — LOW **RELEVANCE** and HIGH **DIFFICULTY**.

2.5 Final priority grade (FPG)

Once the data have been analysed in terms of the RELEVANCE and DIFFICULTY of the needs/problems, the next step is to determine the **final priority grade (FPG)**.

This is achieved using the values obtained from the following formula:

$$\text{Final priority grade: } FPG = TOTAL \times \frac{\text{Relevance}}{\text{Difficulty}}$$

where the TOTAL is the sum of all the attributes: SERIOUSNESS, TIME, EXTENT, and RELEVANCE for each need/problem in each sector (Table I), and the relevance/difficulty quotient is an adjustment factor, so that the final priority grade may be greater than, equal to or less than the TOTAL value.

Using the final priority grade values obtained, we can establish an order of priority for the needs/problems in all the sectors.

It should be emphasized that the methodology presented above is a support tool that provides decision-makers with a basis for comparison, although this is not necessarily the only consideration that may be taken into account when prioritizing a set of needs/problems.

IV. NEEDS/PROBLEMS IDENTIFIED AND PRIORITIZED BY SECTOR

The SWOT analyses allowed problems/needs to be identified, and use of the chosen prioritization methodology helped to fix the levels of the corresponding attributes for each sector.

These analyses, which also justify the selection of needs/problems, and the prioritization tables, can be consulted in the separate part of the publication for each of the five sectors of the RSP.

The identified problems/needs are presented in the following paragraphs. The number in brackets was assigned to each problem/need according to the priority attributed by the members of the sectorial Groups within each sector. These numbers can also be used as orientation for reading the tables which feature in the annex, as well as for other information or graphs contained in the respective sections.

Food safety (Sector A)

- Inadequate sustainability in the application of nuclear techniques in agriculture ***(A1)***.
- Restricted access to markets owing to the presence of chemical residues that pose a risk to human health in foodstuffs of animal and plant origin ***(A2)***.
- Deficient agricultural soil management practices and inadequate use of fertilizers, water and biological nitrogen fixation ***(A3)***.
- Presence of areas with a high prevalence of fruit flies ***(A4)***.

- Loss of agricultural areas through soil degradation caused by extensive agricultural activity ***(A5)***.
- Incidence of exotic transboundary diseases in animals ***(A6)***.
- Low productivity, and susceptibility to biotic and abiotic stress, of traditional basic food crops *(A7)***.**
- **Presence of areas infested with New World screwworm** *(A8)***.**
- Vulnerability of livestock species at risk of extinction ***(A9)***.
- Low productivity of native plants with nutritional and/or medicinal potential in areas of biodiversity ***(A10)***.
- Limited development of aquaculture owing to health and genetic factors ***(A11)***.
- Presence of areas with a high prevalence of codling moths ***(A12)***.

Human health (Sector S)

- Regional deficit in trained human resources in terms of both quality and quantity (medical physicists, technicians, oncological radiotherapists, nuclear medicine specialists, molecular biologists, radiopharmacists and specialists in nuclear applications in nutrition) ***(S1)***.
- Lack of protocols (mainly clinical) and procedural manuals that have been evaluated, adapted and adopted by the region, for the application of nuclear techniques in human health ***(S2)***.
- The processes for the technological management of the infrastructure for application of nuclear techniques in human health in the region, including planning, incorporation and sustained operation of new technologies, are generally not implemented in accordance with international requirements ***(S3)***.
- Lack or non-adoption of quality management systems in many centres in the region ***(S4)***.
- Insufficient awareness among national and international decision-makers and in the scientific community about the usefulness and safety of nuclear techniques in preventing and resolving public nutrition problems ***(S5)***.
- Lack of institutionalization of the position and functions of the medical physicist in radiotherapy and imaging services (nuclear medicine and radiology), and to a lesser degree of other professionals associated with medical practices, by health ministries in many countries in the region ***(S6)***.
- Limited application of molecular isotopic techniques in the region for the diagnosis of emerging infectious and contagious diseases such as SARS (severe acute respiratory syndrome) and avian influenza, and re-emerging ones such as dengue, malaria and tuberculosis, and lack of a regional laboratory network ***(S7)***.
- Unequal access in the region to radionuclides, radiopharmaceuticals, reagent kits and stable isotopes for diagnostic and therapeutic procedures in nuclear medicine, nutrition and medicine ***(S8)***.
- Insufficient human resources in the region trained in predictive, preventive and corrective maintenance of laboratory, diagnostic and treatment equipment employing nuclear technology that is many years old ***(S9)***.
- Regional databases on infrastructure in nuclear medicine, radiopharmacy, molecular biology, radiotherapy and radiology, which can assist with planning and investment, are not up to date or do not exist ***(S10)***.

Environment (Sector M)

- Lack and/or inadequacy of systems for early warning, diagnosis and evaluation of the environmental impact of pollution with pesticides, persistent organic compounds, heavy metals and other pollutants of anthropogenic and natural origin in foodstuffs and environmental matrices at basin level ***(M1)***.
- Inadequate systems for management, protection and knowledge of the availability and quality of water resources ***(M2)***.
- Lack of regional systems for early prediction and evaluation of the toxicity of harmful algal blooms, via radiotoxicological tests and bioassays ***(M3)***.
- Limited knowledge of the processes that occur in the coastal area (loss of habitats, transfer of pollutants, sedimentation, nutrient cycles, climate changes and effects of the El Niño

phenomenon), to establish regional management programmes that reduce its degradation ***(M4)***.

- Inadequate diagnosis and evaluation of the impact on human health of atmospheric pollution with trace elements in urban and rural areas and in enclosed spaces ***(M5)***.
- Inadequate assessment of the hydrological and hydrogeological risk in hydraulic structures and lack of systematic monitoring of sedimentation in the region's artificial and natural water bodies ***(M6)***.

Energy and industry ***(Sector E)***

Nuclear power

- Need to improve the provision to the public of objective and extensive information on nuclear energy ***(E1)***.
- Need to expand and strengthen training of qualified personnel to manage nuclear power projects and nuclear power plants ***(E7)***.
- Shortage of long-term energy and electricity supply and demand scenarios and analyses to decide on possible inclusion of nuclear power in order to diversify efficient and sustainable energy sources and provide power to areas with no supply ***(E10)***.
- Expediency of countries having nuclear fuel cycle policies covering everything from mining of energy resources to disposal of radioactive waste ***(E12)***.
- Lack of statistical databases and procedures and adequate indicators for use in energy assessment and planning studies ***(E13)***.
- Need to strengthen exchange and transfer of experience and knowledge in the nuclear power sector ***(E14)***.
- Insufficient energy integration in the region ***(E16)***.

Experimental reactors

- Need to exchange experience in order to enhance reactor safety, operation and maintenance ***(E2)***.
- Need to train highly qualified personnel in the management and operation of experimental and production reactors and to replace professional staff who are retiring ***(E5)***.
- Need to upgrade the region's reactors to improve their safety and extend their operating lifetime ***(E8)***.
- Insufficient use of experimental and production reactors ***(E9)***

Applications in industry

- Need to disseminate the benefits of applications to end users, making use of existing capabilities and experience in the region ***(E3)***.
- Need to strengthen the training of personnel who assist in the development of the required applications ***(E6)***.
- Insufficient use of nuclear applications in industry which affects its competitiveness ***(E4)***.
- Restrictions on trade and transport of radioactive material among countries in the region ***(E11)***.
- Limited indigenous technology development for transfer to industry ***(E15)***.

Radiation safety ***(Sector R)***

- Lack of regulatory control standards in potentially high-risk practices (linear accelerators, interventional radiology) ***(R1)***.
- Lack of standardized training requirements for occupationally exposed workers in various practices ***(R2)***.

- Deficiencies in control over materials to be recycled to ensure the absence of radioactive material ***(R3)***.
- Limited coverage of the demand for postgraduate training in radiation protection ***(R4)***.
- Difficulties with the application of the concepts of exemption, exclusion, declassification or clearance ***(R5)***.
- Insufficient individual internal monitoring coverage ***(R6)***.
- **Insufficient knowledge of the radiological impact of NORM (naturally occurring radioactive material) industries** *(R7)***.**
- Lack of effective regional coordination to provide assistance in emergencies ***(R8)***.

The outcome of the prioritization of **needs and/or problems** can be used to establish criteria that allow us to determine which of the 52 needs/problems identified could be chosen for attention first in the next project submission cycle.

In this connection, we note that only quadrants I and II contain **needs/problems**, because of the high level of relevance assigned to them (all above 2.5).

On the other hand, on the difficulty axis the lowest value is 1.6, and the highest almost 5.0. Therefore, this first value of 1.6 can be used as the origin on this axis, adjusting the quadrants proportionally.

Applying this procedure, quadrant I corresponds to the difficulty range from **1.6** to **3.3** and quadrant II **3.3** to **5.0** (quadrant graph below with priority for all sectors from Annex V). This procedure normalizes the difficulty axis from the lowest value obtained in the prioritization process.

With the new range, quadrant I includes other needs/problems that were previously in quadrant II.

For the final selection of needs/problems, in the new quadrant I a selection was made starting with those with the highest level of relevance until a set of needs/problems which was sufficiently representative of all sectors present was arrived at. A total of 30 needs/problems was obtained which are shown in the following table.

FIRST 30 NORMALIZED PRIORITIES OF NEEDS AND/OR PROBLEMS

Need/problem	Description	Order of priority	Final grade
E2	Need to exchange experience in order to enhance reactor safety, operation and maintenance.	1	41.08
S1	Regional deficit in trained human resources in terms of both quantity and quality (medical physicists, technicians, oncological radiotherapists, nuclear medicine specialists, molecular biologists, radiopharmacists and specialists in nuclear applications in nutrition).	2	40.15
S2	Lack of protocols (mainly clinical) and procedural manuals that have been evaluated, adapted and adopted by the region, for the application of nuclear techniques in human health.	3	37.22
E3	Need to disseminate the benefits of applications to end users, making use of existing capabilities and experience in the region.	4	36.21
E5	Need to train highly qualified personnel in the management and operation of experimental and production reactors and to replace professional staff who are retiring.	5	33.62
A4	Presence of areas with a high prevalence of fruit flies.	6	32.43
A3	Deficient agricultural soil management practices and inadequate use of fertilizers, water and biological nitrogen fixation.	7	31.03
A7	Low productivity, and susceptibility to biotic and abiotic stress, of traditional basic food crops.	8	29.70
E6	Need to strengthen the training of personnel who assist in the development of the required applications.	9	28.74

Need/problem	Description	Order of priority	Final grade
E1	Need to improve the provision to the public of objective and extensive information on nuclear energy.	**10**	**28.54**
E7	Need to expand and strengthen training of qualified personnel to manage nuclear power projects and nuclear power plants.	**11**	**25.49**
M1	Lack and/or inadequacy of systems for early warning, diagnosis and evaluation of the environmental impact of pollution with pesticides, persistent organic compounds, heavy metals and other pollutants of anthropogenic and natural origin in foodstuffs and environmental matrices at basin level.	**12**	**25.48**
S5	Insufficient awareness among national and international decision-makers and in the scientific community about the usefulness and safety of nuclear techniques in preventing and resolving public nutrition problems.	**13**	**23.66**
E14	Need to strengthen exchange and transfer of experience and knowledge in the nuclear power sector.	**14**	**23.09**
A1	Inadequate sustainability in the application of nuclear techniques in agriculture.	**15**	**22.57**
E8	Need to upgrade the region's reactors to improve their safety and extend their operating lifetime.	**16**	**22.55**
A12	Presence of areas with a high prevalence of codling moths.	**17**	**22.40**
A2	Restricted access to markets owing to the presence of chemical residues that pose a risk to human health in foodstuffs of animal and plant origin.	**18**	**20.90**
E9	Insufficient use of experimental and production reactors.	**19**	**20.71**
R2	Lack of standardized training requirements for occupationally exposed workers in various practices.	**20**	**20.0**
E10	Shortage of long-term energy and electricity supply and demand scenarios and analyses to decide on possible inclusion of nuclear power in order to diversify efficient and sustainable energy sources and provide power to areas with no supply.	**21**	**19.90**
A5	Loss of agricultural areas through soil degradation caused by extensive agricultural activity.	**22**	**19.83**
S9	Insufficient human resources in the region trained in predictive, preventive and corrective maintenance of laboratory, diagnostic and treatment equipment employing nuclear technology that is many years old.	**23**	**19.50**
M5	Inadequate diagnosis and evaluation of the impact on human health of atmospheric pollution with trace elements in urban and rural areas and in enclosed spaces.	**24**	**18.35**
E13	Lack of statistical databases and procedures and adequate indicators for use in energy assessment and planning studies.	**25**	**17.53**
M6	Inadequate assessment of the hydrological and hydrogeological risk in hydraulic structures and lack of systematic monitoring of sedimentation in the region's artificial and natural water bodies.	**26**	**16.89**
A10	Low productivity of native plants with nutritional and/or medicinal potential in areas of biodiversity.	**27**	**15.88**
S10	Regional databases on infrastructure in nuclear medicine, radiopharmacy, molecular biology, radiotherapy and radiology, which can assist with planning and investment, are not up to date or do not exist.	**28**	**15.20**
R5	Difficulties with the application of the concepts of exemption, exclusion, declassification or clearance.	**29**	**13.3**
R8	Lack of effective regional coordination to provide assistance in emergencies.	**30**	**12.4**

ANNEX 1. TERMS OF REFERENCE FOR PREPARATION OF THE REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN FOR 2007–2013

(ARCAL-IAEA Strategic Alliance)

1. INTRODUCTION

The document proposes the preparation of the Regional Strategic Profile (RSP), which will be used to develop cooperation activities among countries in the region under the Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) and regional programming of the Department of Technical Cooperation in general, in order to improve mutual collaboration and collaboration with partners, in particular the International Atomic Energy Agency (IAEA), as part of the ARCAL-IAEA strategic alliance.

One of the factors which is being taken into consideration in this work is the Technical Cooperation Strategy of the International Atomic Energy Agency, which is one of ARCAL's main collaborators. In this context, work to develop regional cooperation modalities in an effective and efficient manner should address regional needs and problems which, from a regional perspective, require active cooperation among countries, which is one of the premises of ARCAL.

In preparing the Regional Strategic Profile, we are attempting to consolidate the strategic alliance between ARCAL and the IAEA through an ongoing process of consultation and improvement of cooperation activities under the Agreement, pursuant to the documents[1] approved both by the Board of ARCAL Representatives and the advisory and governing bodies of the IAEA, in order to determine the most appropriate way of pursuing work to benefit countries participating in ARCAL.

- **Regional Cooperation Plan (RCP) — 2004**
  (*Approved by* **BAR**, *document* **BAR 2004-07**, *section* **IV.10**)

  This document establishes for ARCAL the mission, vision, objectives, goals and framework for cooperation with the IAEA and among countries, and the elements of technical cooperation programming, and identifies sectors where nuclear technology can provide solutions.

- **Plan and ARCAL-IAEA Strategic Alliance — 2005**
  (*Approved by* **BAR**, *document* **BAR 2005-07**, *section* **IV.12**)

  This document includes the Strategic Plan, providing an analysis of the situation, reviews — as approved in the RCP — the mission and vision, and defines strategic objectives. Measures are laid down to strengthen cooperation among ARCAL members, and the bases for the ARCAL-IAEA Strategic Alliance (commitments and requirements) are laid.

  In carrying out this work, account was taken of the responses of countries to the questionnaire that was sent to all parts of the ARCAL system: ARCAL Representatives (BAR), BAR Working Group (BAR-WG) and National Coordinators (ATCB) of all countries.

- **Action Plan — 2006**
  (*Approved by* **BAR**, *extraordinary meeting*, **March 2006**, *document* **BAR 2006 EXT-05**, *section* **III.1**)

- **Action Plan Implementation — 2006**
  (*Approved by* **BAR**, *document* **BAR 2006-07**, *section* **IV.9**)

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[1] Available at http://arc.cnea.gov.ar

- **SAGTAC[2] report on regional programming of the IAEA technical cooperation programme** (to be submitted in February 2007)

This document states that the preparation of the Regional Strategic Profile is a prerequisite for defining the strategy and the regional programme of IAEA technical cooperation with Member States and the relevant regional agreements. It is recommended that it be prepared jointly with the IAEA, the relevant regional agreement and Member States, so that it can serve as a basis for the preparation and negotiation of the respective regional cooperation programmes.

The Regional Strategic Profile will serve as a basis for the preparation of regional programmes to be undertaken using nuclear technology and, in turn, as an aid in the process of project submission and selection under ARCAL, in accordance with its specific procedures.

2. OBJECTIVE OF THE REGIONAL STRATEGIC PROFILE (RSP)

The objective of the RSP is to establish cooperation under ARCAL on the basis of a descriptive analysis of the most pressing regional problems, needs and priorities which, in the regional context, can be addressed with the help of nuclear technologies within the framework of the ARCAL-IAEA Strategic Alliance.

The RSP will also facilitate regional cooperation with other ARCAL partners, international organizations and Governments of Agency Member States.

3. SCOPE OF THE RSP

This profile covers the following priority sectors for the application of nuclear techniques.

1. Food safety: agriculture, food, veterinary science

a) Mutation induction and genetic improvement of plants.
b) Integrated management of soils, water, plants and fertilizers.
c) Integrated pest management.
d) Animal production and health.
e) Nutrition and environmental protection.

2. Human health: nuclear medicine, radiotherapy, medical physics, radiopharmacy, nutrition, patient protection

Establishment of a descriptive analytical profile of available resources, recipient and donor conditions, and the most pressing priorities and needs of the region (including subregions) in the human health sector which can be addressed with the help of available nuclear technologies with the cooperation of the IAEA and countries that can contribute, and with the cooperation of other international organizations, Governments of Member States and other potential partners. The aim is to resolve human health problems in countries in need of regional assistance with the development of human resources, training (new techniques to be learned), technology development, technology operation (technicians), transfer of technology (engineers, physicists).

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[2] IAEA Standing Advisory Group on Technical Assistance and Cooperation

3. Terrestrial and marine environment: atmosphere, water resources, terrestrial environment, marine environment

a) *Marine environment* (quality of seawater, evaluation of various sources of pollution, e.g. hydrocarbons, pesticides, underwater discharges, pollution from terrestrial sources, red tide).
b*)* *Water resources* (water availability and quality, transboundary basins and aquifers).
c*)* *Atmosphere* (air quality in urban areas).
d*)* *Terrestrial environment* (soil erosion, pollutant and pesticide mobilization, integrated management of transboundary basins).

4. Energy and industry: nuclear energy and nuclear technology applications in industry

a) Energy: The IAEA can help countries in the region by strengthening capacity for integrated analysis of energy systems and by providing analytical tools, databases and methodology for that purpose, taking into consideration existing resources (including the nuclear power option, where appropriate), infrastructure and technological capabilities, and the socio-economic and cultural factors that drive energy demand. This analysis should focus on the subregional and regional level.

b) Industry: Covers tracer applications in the mining and oil industry, and other applications such as the use of intense radiation sources, accelerators, cyclotrons.

5. Radiation safety: regulatory aspects of protection of patients, the public and the environment

Particularly as regards this sector, the strategy with the IAEA seeks to promote the establishment and strengthening of a sustainable radiation safety infrastructure.

Survey of needs and definition of priorities for the Latin America and Caribbean region in thematic safety areas (TSA), in line with the horizontal cooperation vision:

TSA 1: Regulatory infrastructure;
TSA 2: Occupational radiation protection;
TSA 3: Radiation protection of the patient;
TSA 4: Radiation protection of the public and radioactive waste;
TSA 5: Radiological emergency preparedness and response;
TSA 6: Education and training.

4. CONTENT OF THE RSP

- ***Regional priorities in the application sector which are to be addressed using existing regional capacity***

(a) Improvement needs.
(b) Countries that can provide and countries that require regional support.

- ***Regional priorities in the application sector which require the creation of capacity in the region (TC project) and development of technology (CRP)***

5. PARTICIPANTS IN THE RSP PREPARATION AND APPROVAL PROCESS

The formal bodies of ARCAL participate in the whole process, i.e.:

- The Board of ARCAL Representatives (BAR), which is the highest-level decision-making body under the Agreement and comprises its representatives, whose number include the so-called BAR Working Group;

- The ARCAL Technical Co-ordination Board (ATCB), which comprises the ARCAL National Coordinators responsible for coordinating the programmes and activities under the Agreement that have been approved by the BAR;

- The ARCAL Directive Group, which comprises the Coordinators of Colombia, Venezuela and Bolivia for the period May 2006 to May 2007.

To coordinate the preparation of the Regional Strategic Profile, an **Advisory Committee** has been designated comprising the following:

1. General Coordinator: Mr Jorge Vallejo Mejía, National Coordinator of Colombia;
2. Expert with ARCAL experience: Ms Angelina Díaz, National Coordinator of Cuba;
3. Director of the Division for Latin America: Mr Juan Antonio Casas;
4. Programme Management Officer for the country holding the Chairmanship of the BAR as operational assistant to the Division Director, who has assumed the function of the ARCAL Secretariat: Ms Jane Gerardo-Abaya;
5. Expert with experience in the BAR and BAR Working Group: Mr Sergio Olmos;
6. One representative of the Chairman of the Board of ARCAL Representatives (Colombia).

To prepare the profile, **sectoral working groups** have been established for each sector comprising:

1. One member of the ARCAL Technical Co-ordination Board, preferably selected for his experience and technical expertise in the sector in question. The names of these experts have also been endorsed by the relevant technical departments of the IAEA. As far as possible, an effort was made to achieve geographic balance, but recognized technical capacity endorsed by the technical departments of the IAEA was the deciding factor;

2. IAEA staff: The Programme Management Officer (PMO) dealing with the subject area will collaborate with the Technical Officer (TO) to ensure that technical contributions are included. The TO will also be able to act as a focal point in the working group for the relevant technical programme;

3. Three experts in the sector in question (providing for a balance of technical specialties within the same field and, if possible, a balance of countries to ensure broad participation. It should be stressed that precedence will be given in the selection process to recognized capacity in the international sphere endorsed by the relevant technical departments of the IAEA).

The whole process will be overseen by the strategic planning experts Mr Hadj Slimane Cherif, Director of the Office of Programme Development and Performance Assessment (IAEA), and Mr Francisco Rondinelli (Brazil).

6. ROLES AND RESPONSIBILITIES OF THE MEMBERS OF THE SECTORAL WORKING GROUPS

I. Member of the ARCAL Technical Co-ordination Board (ATCB) in each group

- The member of the ARCAL Technical Co-ordination Board (ATCB) with sufficient experience and knowledge of the sector will be responsible for coordinating the relevant group of international experts from the region.
- He or she will act as leader in preparing the sectoral contribution and ensure that the contributions from the members of the working group are transmitted to the IAEA through the relevant PMO.
- He or she will propose the general process for preparing sectoral contributions to the RSP.
- He or she will elaborate the sectoral terms of reference during the workshop to be held in January, in close coordination with the Programme Management Officers and the focal points from the relevant technical departments.
- He or she will establish the final composition of the working groups for subsequent implementation of the process, in consultation with IAEA staff.

II. Experts

Competencies of the expert

1) Broad knowledge and regional vision of his or her special field and skills area.
2) Participation as an expert in the Agency's activities during the preceding five years.
3) Knowledge and experience of applications of nuclear and related techniques in his or her special field.
4) Availability to participate in the whole process, including meetings and electronic discussions.

Task of the expert

To prepare the draft regional diagnostic report on the sector/subsector relating to his or her skills area in accordance with the following specifications:

- General analysis of sector/subsector;
- Identification of strengths and weaknesses from a regional perspective;
- Identification of opportunities for using nuclear techniques to solve problems or needs identified;
- Finding of as yet unidentified opportunities for using nuclear techniques;
- Review of trends in the development of each subsector;
- Formulation of recommendations as regards priorities within each subsector in the region;
- Identification of existing capacity in the region and opportunities for horizontal collaboration;
- Preparation of his or her report with the following content.

CONTENT OF EXPERT'S REPORT

1. Analysis of problems and needs in the subsector that could be addressed in the regional context.
2. Description of the comparative advantages of nuclear technologies or how they complement other technologies.
3. Identification of regional trends in the use of nuclear techniques in the subsector.
4. Description of opportunities for using nuclear techniques.
5. Analysis of the potential for regional cooperation employing nuclear technologies in the subsector:
    a) Transboundary problems;
    b) Situations where regional cooperation has added value;

c) Common needs;
d) Essential common requirements to facilitate regional cooperation.

6. Annex (information to be prepared together with IAEA staff and National Coordinators):
   a) Trained staff working in the field;
   b) Equipment operating in a sustainable manner;
   c) Qualified institutions;
   d) Existence of regional networks;
   e) Regionally harmonized and standardized procedures;
   f) Regional projects in the sector in the last 20 years (countries involved);
   g) ARCAL projects in the sector in the last 20 years (countries involved);
   h) Actual capacity that has been strengthened in the region as part of IAEA technical cooperation in its various forms: national, regional (ARCAL and non-ARCAL) and interregional projects, coordinated research programmes and programmes contributed by governments of ARCAL countries.

REFERENCE DOCUMENTS[3]

1. Regional Cooperation Plan (RCP) — 2004
   (Approved by BAR, document BAR 2004-07)
2. Plan and ARCAL-IAEA Strategic Alliance — 2005
   (Approved by BAR, document BAR 2005-07)
3. Action Plan — 2006
   (Approved by BAR, extraordinary meeting, March 2006)
4. Action Plan Implementation — 2006
   (Approved by BAR, document BAR 2006-07)
5. Radiation and Waste Safety Infrastructure Profiles (RaWaSIP), prepared by *NSRW-TC IAEA*
6. ARCAL Report on Designated Centres.
7. Proposal for Regional Cooperation in Radiation Safety, 2007–2008 technical cooperation cycle.
8. Guidelines for evaluating safety requirements (*performance indicators*).
9. Generic action plan for thematic safety areas.
10. INIS database.
11. The ARCAL Programme: Over Two Decades of Cooperation in Science and Technology (in English), INFCIRC/686, 21 November 2006.
12. Analysis of the World Bank, regional and sectoral studies. Publications of the UNDP, UNEP, FAO, WHO, PAHO, etc. IAEA thematic plans by sectors.
13. Nuclear Technology Review, IAEA.

III. IAEA staff (PMOs and TOs)

- The IAEA will facilitate all the work with a view to completing and approving the RSP by providing support for the analysis, calling and coordinating meetings and preparing the final documents, with the participation of Programme Management Officers (PMOs) and Technical Officers (TOs).

- The PMO assigned to the respective sector will be responsible for coordination with the corresponding TO designated for that purpose. The PMO must provide support on regional perspectives, identification of regional issues and development trends in the region, in accordance with the criteria of the Agency’s technical cooperation programme. He/she will be the main focal point for the members of the sectoral group in the Agency. Though the members of the working group will, primarily, need to interact with the members of the ATCB, the PMO may also be contacted by them. The PMO must

[3] List of recommended publications, among other publications and documents that may be consulted.

collaborate with the TO and ensure that the necessary technical contributions to the document are supplied.

- The TOs must provide support for the implementation of this initiative in matters relating to their special field, in particular the identification of regional issues, development trends in the region and the applicability of nuclear technology in aspects relating to their special field. The TO can suggest groups of experts that can make an additional contribution to the specific sector. The TO must provide contributions to the document when requested, and review it to ensure its technical integrity in line with the Agency's parameters.
- The PMO and TO must ensure that the contributions from international organizations are requested and reflected in the RSP.
- In addition, the IAEA will be able to provide support to the region through the International Nuclear Information System (INIS) to strengthen existing networks and knowledge management in the nuclear sector.

7. WORKING METHOD

Comprises:

- Meetings and electronic exchange of information among sectoral working groups and participants throughout the process of preparing and approving the RSP;
- Carrying out of a survey of national institutions in countries in the region and international organizations, in order to identify from a regional perspective the problems, needs and priorities that can be addressed using nuclear technology applications; and
- Contacts with relevant international organizations in the region for each sector to invite them to participate in the process via the survey and, in particular, the meeting that will be held on 12–16 March in Santa Cruz de la Sierra, Bolivia, where they will be requested to present the regional vision for their area of competence, focusing on problems, needs, priorities and opportunities for regional cooperation.

International organizations to be contacted by the Programme Management Officers and Technical Officers of the IAEA: FAO, IICA [Inter-American Institute for Cooperation on Agriculture], PAHO, UNEP, OLADE [Latin American Energy Organization] and ECLAC [United Nations Economic Commission for Latin America and the Caribbean].

In sectors and subsectors that overlap in scope, coordination of activities will be encouraged during the preparation of the RSP and at the stage of diagnosis, identification of common needs and prioritization.

8. WORK SCHEDULE FOR THE PREPARATION AND APPROVAL OF THE RSP

1st meeting (preparatory)
Place: Vienna
Date: 22–24 January 2007
Duration: Three days
Participants: Members of the ATCB from each group, focal points from IAEA technical departments, Advisory Committee, Mr H.S. Cherif, Director of the IAEA Office of Programme Development and Performance Assessment, the ATCB Directive Group and Mr Francisco Rondinelli, strategic planning expert.

The objectives of the meeting are the preparation and approval of the terms of reference by the groups' technical experts and the preparation of a preliminary document which will continue to take shape through virtual consultations among all the members of each group. In order to facilitate these consultations, the IAEA will adapt the Livelink discussion platform.

The questionnaire will be drawn up which will be sent officially through the ARCAL Chairman to all countries and international organizations, requesting the information needed to carry out the subsequent work.

2nd meeting
Place: Santa Cruz de la Sierra
Date: 12–16 March 2007
Duration: 1 week
Participants: Members of the sectoral working groups, Advisory Committee. Representatives of international organizations of interest for each sector, ATCB Directive Group, Mr Francisco Rondinelli and Mr H.S. Cherif, Director of the IAEA Office of Programme Development and Performance Assessment.

The main aim of this meeting is to present a draft diagnostic report on each sector (the Advisory Committee will prepare the required contents of this report), to train all members of the various groups in modern strategic planning processes and to develop the skills required for priority selection.

3rd meeting
Place: Research Centre for Energy, Environment and Technology (CIEMAT), Spain
Date: 16–20 April 2007
Duration: 1 week
Participants: Members of the sectoral working groups, Advisory Committee, ATCB Directive Group, Mr Francisco Rondinelli, Mr H.S. Cherif, Director of the IAEA Office of Programme Development and Performance Assessment, and focal points from IAEA technical departments.

The outcome of this meeting will be the identification of regional priorities for each application sector (food safety, human health, terrestrial and marine environment, energy and industry and radiation safety) to be addressed using existing regional capacity, and priorities requiring the creation of capacity in the region and the development of new technology. An important factor in the analysis in both cases will be the distinction between countries that can provide and countries that require regional support.

4th meeting (conclusions)
Place: IAEA Headquarters in Vienna
Date: 23–27 April 2007
Duration: 1 week
Participants: Advisory Committee, ATCB Directive Group, Mr Francisco Rondinelli.
Mr H.S. Cherif, Director of the IAEA Office of Programme Development and Performance Assessment. Staff from the Division for Latin America designated by their Director, designated focal points from technical departments.

The objective of this meeting will be to finalize the results of the various working groups and prepare a single document to be presented at the VIII meeting of the ATCB to be held in Venezuela.

9. RSP APPROVAL PROCESS

1. Review at the VIII meeting of the ATCB in Venezuela, 21–25 May 2007. Approval of the document by National Coordinators for submission to the VIII meeting of the BAR.

2. Dispatch of the Regional Strategic Profile approved by the ATCB as a proposal to the BAR Working Group and to ARCAL Representatives (immediately following the VIII meeting of the ATCB).

3. Approval at the VIII meeting of the Board of ARCAL Representatives in Vienna on 17 September 2007, during the IAEA's 51st General Conference.

ANNEX 2. QUESTIONNAIRE FOR PREPARATION OF THE REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN FOR 2007–2013
(ARCAL-IAEA Strategic Alliance[4])

BACKGROUND

Within the framework of the ARCAL-IAEA strategic alliance, the signatory countries are conducting this survey in support of the task of identifying the priority needs and available resources in the region, as well as the approaches to shared problems which are being resolved with the help of nuclear techniques to the benefit of the population.

The objective of the RSP is to establish cooperation under ARCAL on the basis of a descriptive analysis of the most pressing problems, needs and priorities which, in the regional context, can be addressed with the help of nuclear technologies within the framework of the ARCAL-IAEA Strategic Alliance.

In accordance with the above, this survey focuses on identifying, from the regional perspective:

- Common problems and needs of the region;
- Transboundary aspects;
- Essential needs for other types of cooperation in the region.

The survey covers the following sectors of interest, identified previously, where the application of nuclear techniques is significant:

1. **Food safety:** Of particular interest is information on the potential use of nuclear techniques on a regional scale in the following subsectors: mutation induction and genetic improvement of plants; integrated management of soils, water, plants and fertilizers; integrated pest management; animal production and health; nutrition and environmental protection.

2. **Human health:** Establishment, for regional cooperation, of a descriptive analytical profile of available resources, recipient and donor conditions, and the most pressing priorities and needs of the region (including subregions) in the sector. The aim is to resolve human health problems in countries in need of regional assistance in the development of human resources, training (new techniques to be learned), technology development, technology operation (technicians), transfer of technology (engineers, physicists).

3. **Environment:** This relates to the compilation of data on the marine environment (quality of seawater, evaluation of various sources of pollution, e.g. hydrocarbons, pesticides, underwater discharges, pollution from terrestrial sources, red tide), water resources (water availability and quality, transboundary basins and aquifers), atmosphere (air quality in urban areas), terrestrial environment (soil erosion, pollutant and pesticide mobilization, integrated management of transboundary basins).

4. **Energy and industry:** *Energy* includes integrated analysis of energy systems and providing analytical tools, databases and methodology for that purpose, taking into consideration existing resources (including the nuclear power option, where appropriate), infrastructure and technological capabilities, and the socio-economic and cultural characteristics that drive energy demand. The intention is to elaborate a diagnosis of regional needs and problems based on an analysis of the status and trends of the energy situation in the region. *Industry* includes

[4] **ARCAL**: Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean. (http://arc.cnea.gov.ar).

IAEA: International Atomic Energy Agency (www.iaea.org).

tracer applications and nucleonic control systems in mining, the oil industry, etc.: use of intense radiation sources in irradiation (gamma radiation, accelerators).

5. **Radiation safety:** Survey of needs and definition of priorities for the region in thematic safety areas (TSA), in line with the horizontal cooperation vision: regulatory infrastructure, occupational radiation protection, radiation protection of the patient, radiation protection of the public and radioactive waste, radiological emergency preparedness and response, education and training.

The questionnaire is directed at:

1) National bodies and institutions;
2) International organizations.

In particular, high-level officials with strategic vision and broad knowledge of the sector are invited to respond to this questionnaire.

Note — Please respond by 22 February 2007.

QUESTIONNAIRE

Note — Please answer the questions fully and concisely in order to provide sufficient information to establish the RSP.

Each response should not exceed 1500 characters.

Please mark the sector that corresponds to your area of activity (complete one form for each sector):

☐ Food safety
☐ Human health
☐ Environment
☐ Energy and industry
☐ Radiation safety

Body/institution/international organization	
Name	
Position	
Email	

1. What are the main regional needs and problems in your area of activity?
(Please provide information available to your institution, identifying, as appropriate, the subsectors.)

2. In your opinion, how can these needs and problems be addressed through regional cooperation?
(Please give information on the integration mechanisms, regional networks and cooperation programmes your institute is currently participating in.)

3. Which elements of your current international cooperation policy do you consider could be used within the framework of a regional cooperation programme?
(Please mention current guidelines and programmes in your institution that are suitable for further development through regional cooperation.)

4. What needs can you identify in the other sectors covered by this questionnaire?
(Please mention possible needs in sectors other than your area of activity.)

	Sectors	**Needs**
☐	1. Food safety	
☐	2. Human health	
☐	3. Environment	
☐	4. Energy and industry	
☐	5. Radiation safety	

5. Is there any sector or subsector that you consider should be included in this analysis?
(Please provide a list of sectors other than those included in this questionnaire, justifying their inclusion in no more than one paragraph.)

ANNEX 3. BIBLIOGRAPHY USED IN PREPARING THE RSP

Food safety

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- Safety Reports Nos 38, 39 and 40: Applying Radiation Safety Standards in Radiotherapy, Nuclear Medicine and Radiodiagnostics; Fundamental Safety Principles — SF-1.
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- RS-G-1.5 — Radiological Protection for Medical Exposure to Ionizing Radiation.
- RS-G-1.7 — Application of the Concepts of Exclusion, Exemption and Clearance.
- RS-G-1.8 — Environmental and Source Monitoring for Purposes of Radiation Protection.

ANNEX 4. PARTICIPANTS IN THE RSP PROCESS

Advisory Committee and ATCB Directive Group

1. Jorge Vallejo (**Chairman of the ATCB**) General Coordinator — Colombia
2. Juan Antonio Casas Zamora — Director of the Division for Latin America at the IAEA
3. Ángel Díaz (**Vice-Chairman of the ATCB**) — Venezuela
4. Alberto Miranda (**Secretary of the ATCB**) — Bolivia
5. Hadj Slimane Cherif — Director of the Office of Programme Development and Performance Assessment at the IAEA
6. Jane Gerardo-Abaya — Programme Management Officer supporting DIR-TCLA
7. Francisco Rondinelli — strategic planning expert
8. Angelina Díaz — expert with ARCAL experience
9. Sergio Olmos – expert with experience in the BAR and BAR Working Group

Group 1. Food safety (mutation induction and genetic improvement of plants; integrated management of soils, water, plants and fertilizers; integrated pest management; animal production and health; nutrition and environmental protection)

1. Silvia Fascioli (**member of the ATCB**) — Uruguay
2. Luz Gómez Pando (**mutation induction and genetic improvement of plants**) — Peru
3. Jesús Reyes (**pest control**) — Mexico
4. Segundo Urquiaga (**integrated management of soils, water, plants and fertilizers**) — Brazil
5. José Fernando García (**animal sciences**) — Brazil
6. Cecilia Urbina (Programme Management Officer)

Focal points from IAEA technical departments

1. Jorge Hendrichs (NAFA)
2. Walther Enkerlin (NAFA)
3. Pierre Lagoda (NAFA)
4. Tatiana Rubio Cabello (NAFA)
5. Ian Ferris (NAFA)

Group 2. Human health (nuclear medicine, radiotherapy, medical physics, radiopharmacy, nutrition, radiation protection of patients, nuclear molecular biology — infectious diseases)

1. Angel Díaz (**member of the ATCB**) — Venezuela
2. Pilar Orellana (**nuclear medicine**) — Chile
3. Rolando Camacho (**radiotherapy**) — Cuba
4. Esperanza Castellanos (**medical physics**) — Colombia
5. Henia Balter (**radiopharmacy**) — Uruguay
6. José Luis San Miguel Simbrón (**nutrition**) — Bolivia
7. Mari Carmen Franco (**radiation protection of patients**) — Mexico
8. Henia Balter (**nuclear medicine and radiopharmacy**) — Uruguay
9. *Hugo Marsiglia* (**radiotherapy**) — *France*
10. Octavio Fernandes (**nuclear molecular biology — infectious diseases**) — Brazil
11. José Antonio Lozada (Programme Management Officer)

Focal points from IAEA technical departments

1. Pedro Andreo (NAHU)
2. Eduardo Zubizarreta (NAHU)

Group 3. Environment (atmosphere, water resources, terrestrial environment, marine environment)

1. César Tate (**member of the ATCB**) — Argentina
2. Carlos Alonso (**marine environment**) **—** Cuba
3. Samuel Hernández (**water resources**) — Venezuela
4. Rita Pla (**atmosphere**) — Argentina
5. Elizabeth Carazo (**terrestrial environment**) — Costa Rica
6. Jane Gerardo-Abaya (Programme Management Officer)

Focal points from IAEA technical departments

1. Luis Araguás (NAPC)
2. Joan Albert Sánchez Cabeza (NAML)
3. Gabriele Voigt (NAAL/SEIB)

Group 4. Energy and industry (nuclear power, experimental reactors and applications in industry)

1. Raúl Ortiz Magaña (**member of the ATCB**) — Mexico
2. Gonzalo Torres Oviedo (**energy planning**) — Chile
3. Betonus Pierre (**energy planning**) — Haiti
4. Gustavo Molina (**industrial applications**) — Mexico
5. Ana Fittipaldi (**nuclear energy**) — Argentina
6. *Félix Barrio — Spain*
7. Javier Guarnizo/Alain Cardoso (Programme Management Officer)

Focal points from IAEA technical departments

1. Iván Vera (NE) *
2. Ismael Concha (NE)
3. Taghrid Atieh (INIS)

Group 5. Radiation safety (regulatory infrastructure, occupational radiation protection, regulatory aspects of exposure in medical practices, radiation protection of the public, radiological emergency preparedness and response, and education and training)

1. Maria Cristina Lourenço (**member of the ATCB**) — Brazil
2. Alejandro Náder — Uruguay
3. Gustavo Massera — Argentina
4. Paulo Ferruz — Chile
5. Tsu Chia Chao (Programme Management Officer — IAEA)

Focal points from IAEA technical departments

1. Ronald Pacheco (NSRW) *
2. Christer Viktorsson (NSNI)
3. María Josefa Moracho Ramírez (NSNI)

* Also participated in the working groups of the RSP preparation and prioritization workshops.

International organizations represented at the workshop in Santa Cruz de la Sierra, Bolivia

Food safety
Food and Agriculture Organization of the United Nations (FAO)
Gonzalo Flores Céspedes, Assistant to the FAO Representative in Bolivia

Human health
Pan American Health Organization (PAHO)
Pablo Jiménez, Regional Advisor for Radiological Health

Environment
United Nations Environment Programme (UNEP)
Antonio Villasol Núñez, Director General of the Centre for Engineering and Environmental Management of Bays and Coasts

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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

Food Safety in Latin America and the Caribbean in the Light of the RSP

ARCAL

IAEA
International Atomic Energy Agency

PUBLICATIONS RELATED TO THE RSP

To facilitate review of the material generated by the RSP preparation process, it has been published in separate parts covering the following aspects:

Regional Strategic Profile for Latin America and the Caribbean (RSP) 2007–2013
Background, Methodology and Process for the Preparation of the RSP for Latin America and the Caribbean
Food Safety in Latin America and the Caribbean in the Light of the RSP
Human Health in Latin America and the Caribbean in the Light of the RSP
Environment in Latin America and the Caribbean in the Light of the RSP
Energy and Industry in Latin America and the Caribbean in the Light of the RSP
Radiation Safety in Latin America and the Caribbean in the Light of the RSP

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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013
ARCAL-IAEA Strategic Alliance

FOOD SAFETY IN LATIN AMERICA AND THE CARIBBEAN IN THE LIGHT OF THE RSP

CONTENTS

REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013
ARCAL-IAEA Strategic Alliance

FOOD SAFETY IN LATIN AMERICA AND THE CARIBBEAN IN THE LIGHT OF THE RSP

I. BACKGROUND AND IMPLEMENTATION OF WORK

In the food safety sector, it was decided to consider the following subsectors:

- *Mutation induction and genetic improvement of plants;*
- *Integrated management of soils, water, plants and fertilizers;*
- *Integrated pest management;*
- *Animal production and health;*
- *Nutrition and environmental protection.*

21 responses were received to the RSP preparation questionnaire and the results were evaluated by the experts at the meeting:

Argentina — National Food Safety and Quality Service (SENASA);
Argentina — Department of Agriculture, National Atomic Energy Commission;
Argentina — Department of Agronomy, National Southern University;
Chile — University of Chile, Faculty of Medicine, Marine Toxins Laboratory;
Chile — Chilean Nuclear Energy Commission;
Chile — Livestock Protection Division, Agriculture and Livestock Service;
Colombia — National University of Colombia;
Cuba —Plant Health Research Institute (INISAV), Ministry of Agriculture (MINAGRI);
Cuba — National Institute of Agricultural Sciences;
Cuba — Soils Institute, Ministry of Agriculture;
Cuba — CESIGMA, S.A.;
Ecuador — General Directorate for Nuclear Energy;
Ecuador — Central University of Ecuador, Faculty of Agricultural Sciences;
Mexico — Advanced Studies Research Centre, National Polytechnic Institute;
Uruguay — Nuclear Research Centre, Faculty of Sciences, University of the Republic;
Venezuela — National Agricultural Research Institute (CENIAP);
Venezuela — Simón Rodríguez National Experimental University;
FAO (regional headquarters in Santiago de Chile) — 4 surveys.

First of all, each member of the group presented a diagnostic report, prepared in advance, and a general discussion was held on each report. This was used as a basis to harmonize the reports with a view to preparing the sectoral group report, in accordance with the format established in the terms of reference.

Next, the region's *needs* in terms of use of nuclear technology were defined.

The following presentations by group 3 relating to sector 1 were attended:

- Carlos Alonso (CUBA) — *Diagnosis of the Marine Environment in Latin America and the Caribbean;*
- Elizabeth Carazo (COSTA RICA) — *Pesticides in Latin America;*
- Antonio Villasol Núñez (UNEP) — *Environmental problems in the Latin America and Caribbean region;*

- In addition, Mr Gonzalo Flores, representing Mr José Graciano, FAO Regional Director in Santiago, Chile, gave a presentation on *Latin America and the Caribbean without Hunger — Regional Action Plan 2007–2008.*

II. GENERAL ANALYSIS OF THE REGIONAL SITUATION

The world population is estimated to be 6400 million, of whom approximately 10% live in Latin America and the Caribbean (UNFPA, ECLAC). Owing to the increasing rural exodus to urban areas, only 22% of these on average live in rural areas, whereas the proportion is over 43% in the poorest countries (ECLAC, 2006), hence this sector is unquestionably a fundamental source of subsistence and economic progress for millions of people in the region.

Latin America and the Caribbean account for 15% of the world's surface area (UNEP) and have 100 million hectares of arable land, which is 7% of the world's surface area (FAO, 2007). It is recognized that Latin America and the Caribbean have great potential for food production and they are therefore considered a bulwark of world food safety. As regards their contribution to world food production, Latin America and the Caribbean account for 21% of world fruit production (FAOSTAT), 7.68% of cereal production, 7.73% of root and tuber production and 11.97 % of grain legume production (FAO 2003). Latin American livestock herds are estimated at 500 million head, i.e. approximately one head per inhabitant. These figures convincingly demonstrate that agriculture continues to be a strategic sector for regional development.

In recent decades, the contribution of the agricultural sector to regional GDP has exceeded 8% and in some countries has been greater than 20%. However, from the point of view of economic accounting, the real contribution of the agricultural sector to GDP is viewed more broadly, since, in addition to its share in terms of the primary products it generates, the contribution from its intersectoral links must also be taken into account, in particular its links with the container and packaging manufacturing industry, food processing, textiles, and transport and trade services. It is estimated that, in the region, for every dollar generated in the agricultural sector, an average of three to six dollars are added to the country's economy, the figure being even higher in the relatively more developed countries (Argentina, Brazil, Chile, Mexico and Uruguay). These figures reflect the fact that the agricultural sector is an important driving force for regional progress.

However, positioning agricultural activity as a net provider of food and as a strategic sector for regional development has brought with it negative consequences in return. Among these may be highlighted: a progressive degradation of arable soils owing to intensive use and poor fertilization and irrigation practices; the continual reduction in the area of natural woodland in order to increase the area available for production of industrial crops for export; and, in general, a deterioration in the environment reflected in loss of biodiversity owing to the substitution of native species crops with crops of high commercial value, as well as pollution by agrochemicals used in pest control and in post-harvest treatment of agricultural products.

Furthermore, in rural areas the scourges of hunger and undernutrition are present, eroding and concealing the intrinsic value of agricultural and stockbreeding activities. Latin America and the Caribbean mirror the global distribution in terms of the poor and malnourished: 80% in rural areas and 20% in urban areas. The highest indicators of poverty and undernutrition in the region are found in the rural areas of the Andean subregion, Mesoamerica, the Caribbean and the tropical areas of South America (FAO, 2007).

In short, though the sector in the region exhibits generally positive results, it also faces a series of crucial challenges which must be overcome in the coming years to opt for sustainable food development compatible with higher levels of growth and social welfare, combined with conservation and use of biological diversity without harming natural resources. For this development to occur, the condition sine qua non is that regional agricultural activity must increase significantly.

Numerous specialists in economic development have identified technological change as the variable which contributes most to economic growth. In Latin America and the Caribbean, for example, it is calculated that approximately 40% of the improvements achieved in agricultural production are attributable to technological change (IICA, Seixas, 2004). In this connection, the use of nuclear techniques for genetic improvement of plants and animals, improvement of soil management and of the efficient use of fertilization and irrigation, suppression and eradication of agricultural pests, and the early diagnosis of animal diseases, stands out.

However, technological change in the region is insufficient to respond successfully to global trade liberalization and to exploit the opportunities this offers, assuming as a paradigm sustainable agricultural development founded on increasing production and export of agricultural products without concomitant effects for human health or damage to the environment.

There is a lack of technological change in which nuclear technology could play a role in the fields of: genetic improvement of agricultural and livestock species, both traditional and non-traditional; development of good practices in the use and management of soil and water resources; prevention, suppression or eradication of transboundary agricultural and livestock pests; management of health and genetic limitations in the rearing of livestock species and captive aquatic organisms; post-harvest treatments as an alternative to the use of chemicals; prevention of residues posing a risk to human health in food; and strengthening of networks and capacity for supporting agricultural analysis services.

1. SWOT analysis

1.1 Strengths

a) Thanks to its edaphoclimatic diversity, the region is a major world supplier of an extensive range of agricultural products of importance for food and in industry. It accounts for a significant percentage of world trade in agricultural and livestock products such as soya, sugar, coffee, cereals, fruit, vegetables, meat and dairy products.

b) The region boasts extremely high biodiversity levels and can offer the world community new species of agricultural products with a high nutritional and medicinal value (grains, roots, tubers, fruit, etc.). According to UNEP, five of the ten megacentres of biodiversity are located in Latin America and the Caribbean (Brazil, Chile, Mexico, Paraguay and Peru). There are also production networks for medicinal plants and organic agriculture.

c) Biological nitrogen fixation (BNF) technology developed in the region allows 35 million hectares of soya to be grown in the Southern Cone subregion without use of nitrogen fertilizer. BNF also ensures production of animal protein in the region. This technology contributes to conservation of the environment.

d) The existence of scientific and technological institutions with trained personnel facilitates exchange of information and technology.

e) The existence of national services and subregional agreements for the prevention and control of transboundary pests and diseases can facilitate the suppression or eradication at subregional level of agricultural pests (fruit flies, codling moth, etc.) and livestock diseases (foot-and-mouth disease, botulism, rabies, etc.), including the New World screwworm.

1.2 Weaknesses

a) Scientific and technological institutions work in isolation and duplicate activities, and it is well known that there is a lack of ongoing networked studies and research at regional level. Moreover, there is a lack of continuity in research into and spread of technologies owing to frequent leadership changes in research programmes and in national health and plant health services.

b) Significant foreign currency expenditure on imports of basic foodstuffs in certain countries owing to imbalances in the availability of natural, technical and economic resources in the region. Especially in the Andean subregion, yields in the agriculture sector are at their lowest where the rural population is high.

c) Inadequate application of international quality standards with regard to food products for domestic consumption, involving potential risk to human health, and for the purposes of satisfactory compliance with market requirements.

d) Possible obstacles to horizontal cooperation among countries to improve health and plant health conditions at regional or subregional level, because countries view themselves as competitors in the same international market for agricultural products.

e) Lack of policies to promote economic involvement from the private sector in national or subregional programmes aimed at preventing and controlling transboundary health and plant health pests.

1.3 Threats

a) Introduction into the region of exotic pests and diseases (fruit fly, codling moth, oriental moth, highly pathogenic avian influenza, bovine spongiform encephalopathy) and the potential emergence of new pests and diseases owing to the indiscriminate use of agrochemicals.

b) Risks of loss of genetic diversity owing to the introduction of genetically modified organisms in centres of origin of plants in the region.

c) Imposition of health and plant health restrictions as non-tariff barriers by the international market, in spite of the international trade facilitation principles promoted by the World Trade Organization (WTO).

d) Reduction in agricultural productivity due to global climate change.

1.4 Opportunities

a) The demand for alternative renewable energy sources in the world opens up prospects for the development of sustainable agro-energy in the region.

b) Increase in the international market for traditional and non-traditional agricultural and aquatic products with high-value nutraceutic properties, thanks to the recent recognition by the World Trade Organization of health and plant health mechanisms which facilitate trade in such products.

c) Existence of international agreements regulating the use and conservation of plant and animal genetic resources.

d) Potential demand for nuclear technologies in the agricultural field to address the problems of global warming.

III. REGIONAL NEEDS/PROBLEMS AND JUSTIFICATION

The following needs/problems were identified by the working group, together with their respective justifications:

1. <u>Inadequate sustainability in the application of nuclear techniques in agriculture</u> (A1)

Despite the fact that most of the nuclear techniques used in the region for agriculture development are widely known and disseminated, there is an urgent need to build and/or update available human resources and laboratory capacities.

Virtually all the surveys received mention this need, and from the information received it may be inferred that the low level of application of nuclear techniques for technological development of agriculture in the region is a result of the fact that trained personnel have been replaced by young staff who lack adequate training. Much the same may be said of the laboratories in the majority of countries in the region, which are obsolete. Many laboratories have old equipment, most of it disused, and in other cases laboratories have been closed down entirely. Currently, only a few laboratories in Argentina, Brazil, Chile, Mexico and Peru are operational, in some cases with limitations; in particular, some of the equipment needs to be replaced.

Laboratories offering services with a certain level of specialization need to be established, which would improve the quality and speed of analyses. It is important to note that, for several years, the IAEA has been monitoring the quality of analysis of some of the isotopes most widely used in agriculture in the region, which has contributed significantly to ensuring the quality of the work done based on these analysis results.

If this need for training and modernization of laboratories is not addressed, it will be difficult to extend and disseminate nuclear techniques as the highly valuable tools they are to support technological development in agriculture in the region.

2. <u>Restricted access to markets owing to the presence of chemical residues that pose a risk to human health in foodstuffs of animal and plant origin</u> (A2)

Within the region, the application of advanced technology to crops and animal products for export, such as coffee, bananas, grapes and other temperate climate fruits, vegetables and citrus fruits, flowers, pineapple, other crops (wheat, maize, rice, soya), meat and milk, has contributed to the massive use of various kinds of input (pesticides, hormones and antibiotics).

The use of fumigants to resolve plant health problems and overcome quarantine barriers is a common practice in countries in the region. Many of these fumigants have been banned, or are in the process of being banned, since it has been shown scientifically that their use has negative effects on human health and on the environment. They include ethylene dibromide, which was banned in the 1980s in most countries, seriously affecting trade in fruit and vegetables. A similar situation is now occurring with methyl bromide. As a result, alternative treatments are being sought in the region. Ionizing radiation is one of the viable alternatives.

One of the biggest advantages of food irradiation is that this technology has been shown to be safe by decades of research, which is why United Nations bodies such as the WHO, FAO and IAEA, and a host of other national and international scientific organizations, recommend its use.

To date, more than 60 countries have approved this technology for one or more products or classes of products and international standards exist such as those of the Codex Alimentarius Commission (WHO/FAO) and the Commission on Phytosanitary Measures (CPM), FAO. There is an urgent need in the region for harmonized regulations and standards for the proper use of this technology.

In addition, countries in the region face a series of problems with pesticide residues in foodstuffs intended both for local consumption and export. Thus, analytical methods for monitoring pollutants need to be developed, applied and standardized.

The main beneficiaries of the programme will be industrial sectors throughout the region involved in the processing and marketing of agricultural products, plus consumers, who will have access to better quality products.

3. <u>Deficient agricultural soil management practices and inadequate use of fertilizers, water and biological nitrogen fixation</u> (A3)

The Latin America and Caribbean region currently has a population of approximately 600 million (10% of the world population), of whom around 85% live in the tropical and subtropical zone. On average, only 22% of the region's population live in rural areas, though in some countries such as Guatemala, Nicaragua, Honduras and Paraguay the figure exceeds 43% (ECLAC, 2006). Excluding subtropical and temperate zone countries in the region, the vast majority of countries in the Andean and tropical zones (especially Brazil and Central America) have agricultural soils which are naturally poor or very poor in nutrients, setting aside the problems of toxicity owing to high levels of aluminum, iron and manganese, a situation which results in low food yields, causing poverty, hunger and undernutrition (Urquiaga et al., 2006). The highest poverty and undernutrition indices are found in the rural parts of Central America, the Andean zone, the Caribbean and the tropical zone (Urquiaga et al., 2005a; Urquiaga and Zapata, 2000). It is thought that nearly 30% of children aged 0–5 in the region have high rates of chronic undernutrition — serious problems which require an urgent solution (Oyarzun, M.T. — FAO, Regional Office for Latin America and the Caribbean, personal communication).

In practice, the region's extractive agriculture, based only on the natural fertility of soils, is causing increasing soil impoverishment. Consequently, marginal areas are increasingly being exploited for 'migratory' agriculture, areas with a steep gradient which are being deforested, causing serious environmental problems, in particular erosion and greenhouse gas emissions (Lal et al., 2006; Urquiaga et al., 2005a).

One of the indicators of the level of agricultural technification is the use of fertilizers. The region consumes 12% of the world's fertilizers, Brazil and Mexico alone accounting for 74%, which shows there is a serious regional imbalance (IFA, 2007). It should be noted that, in virtually all countries in the region, agricultural technology is geared primarily towards industrial or export crops (soya, sugar cane, coffee, fruit and vegetables being some of the main ones) and very little towards food crops (beans, rice, maize, potato, cassava and sweet potato) (FAO, 2007; IFA, 2007; Urquiaga and Zapata, 2000). One regional technology which has a major impact on agriculture is biological nitrogen fixation (BNF) in soya, a typically regional technology enabling more than 37 Mt of protein to be produced annually without the use of N fertilizer over an area of 36 million hectares distributed across Brazil, Argentina and Paraguay (Alves et al., 2002; 2003; Urquiaga et al., 2004). Use of this technology for basic food crops such as beans and peas, etc., lags far behind. There is also a clear need to improve nitrogen availability in the poor soils of small farmers through the use of green manure (Urquiaga et al., 2005b).

The above shows that there is an urgent need to develop agricultural soil management practices (direct sowing, etc.) to increase food production in a sustainable manner, based on the rational and efficient use of fertilizers, BNF, green and organic manure, and water resources.

Nuclear techniques offer the best prospects here. Use of ^{15}N as a tracer is a fast and economical way of producing recommendations for efficient fertilizer management (dose factors, sources, localization, fractionation and application methods) (Urquiaga and Zapata, 2000). The ^{15}N isotope dilution and ^{15}N natural abundance techniques are also extremely useful for evaluating the efficiency of BNF in legume production systems, allowing more efficient varieties and inoculants to be selected (Boddey et al., 2000; Urquiaga et al., 1987). In such studies, the ^{15}N, ^{13}C, ^{137}Cs and neutron probe techniques are also needed to evaluate changes in soil fertility, moisture retention, soil organic matter dynamics and soil loss due to erosion (Andrello et al., 2003; Alves et al., 2006). Such studies can also be used to produce agricultural management recommendations to help maintain or increase the production capacity of production systems and protect the environment (Alves et al., 2006; Lal et al., 2006; Urquiaga et al., 2004).

The direct beneficiaries will be large and small farmers who will obtain higher yields at lower cost, and society in general through the availability of larger quantities of nutritious food and through the reduced risk of environmental degradation.

4. Presence of areas with a high prevalence of fruit flies (A4)

Fruit flies are the pests which cause most damage to the region's fruit and vegetable growers. In countries where they are not controlled, or control is deficient, they can cause 20–40% losses in production. Moreover, owing to the phytosanitary requirements imposed by the international market, the presence of the pest in a country severely limits that country's fruit and vegetable exports and, given the transboundary nature of the problem, it sometimes also restricts exports of neighbouring countries. It is no coincidence that Argentina, Chile, Brazil and Mexico, which have fruit fly control and prevention programmes, are the leading Latin American suppliers of fruit and vegetables on the regional and world market.

In addition to the economic losses caused by direct damage, reduced production causes a drop in per capita consumption of fruit, particularly in the most marginalized socio-economic group. By way of example, per capita production of fruit consumed fresh in Central America is below that in many other regions of the world, including the Middle East, even though Central America has favourable conditions for fruit and vegetable production. In addition, intensive control of fruit flies using insecticides pollutes the environment and affects beneficial organisms, and gives rise to residues in fruit and vegetable products which pose risks to human health and limit access to some export markets.

To reduce losses and insecticide use, and to safeguard the fruit and vegetable industry and promote its development, to give it the capacity to meet current and future regional and world market needs, fruit-fly-free and low-prevalence areas need to be established.

Once a fruit-fly-free or low-prevalence area has been established, it must be certified by importer countries, thus granting unrestricted access to the international market for fruit and vegetables grown in the areas concerned. The certification process involves a number of factors that determine its duration; on average, certification takes four to six years. This demonstrates the urgent need for regional action.

To establish fruit-fly-free or low-prevalence areas, the phytosanitary approach used worldwide, since it is a tried and tested technology, is wide-area integrated pest management to suppress, eradicate or prevent pests, one of the main components being use of the sterile insect technique (SIT). This technological package is currently the most effective and environmentally friendly option for development of these areas and it is not envisaged that it could be replaced in the near future.

Argentina, Chile, Guatemala, Mexico and Peru have extensive experience in the successful use of the SIT to control fruit flies. Brazil and Costa Rica are in the process of joining this group, but the remaining countries in the region need to implement it.

The transboundary nature of the pest means that regional collaboration is needed to control it. Countries where the pest is present need to control it, and those that are pest-free benefit if it is suppressed in neighbouring countries. Moreover, the Joint FAO/IAEA Division has been providing assistance and has experience in solving this regional problem. This scenario offers a unique opportunity for cooperation among organizations and countries to eliminate a pest which is both transboundary in nature and of relevance to the entire region.

The beneficiaries are the environment and consumers, and sectors of the population involved in the production, marketing and export chain for fruit and vegetables in the region.

5. <u>Loss of agricultural areas through soil degradation caused by extensive agricultural activity</u> (A5)

The history of agricultural exploitation in Latin America and the Caribbean has involved a change from exploitation of native vegetation (savannahs and woodland), followed for several years by the establishment of annual crops or pasture that draw on the limited reserves of mineral nutrients and degrade the soil organic matter (SOM), the main source of soil fertility. Later, when yields decline drastically, the area is abandoned and farming activity moves on to new deforested areas (Boddey et al., 2003). Consequently, nowadays the region has vast degraded and abandoned areas of little use for agriculture, especially in the Andean and tropical zone, and these areas may amount to over 250 Mha (Lal, 2006). A substantial proportion of these areas has fallen into the hands of small farmers who try and earn their living growing maize, beans, potatoes and cassava without using fertilizers, impoverishing and impairing the fertility and integrity of the soils even further. In some countries (Brazil and Andean countries), some extensive areas are owned by large-scale farmers who use the land for stockbreeding activities with very low production levels and very low profitability. This practice is more a form of land occupancy than effective participation in the production of meat, etc., of animal origin. It is estimated that, in Brazil alone, over 200 million hectares (25% of the country) suffer some form of degradation (Dias L.E. et al. (eds), 1997, National Symposium on Recovery of Degraded Areas (III SINRAD) [in Portuguese], Ouro Preto, MG, Federal University of Viçosa). Land degradation not only causes a reduction in the production capacity of soils through excessive uptake of nutrients by crops or stockbreeding activities, but also through erosion, and pollution of water resources. Recovery of these areas for agriculture requires urgent attention, since degradation encourages continued deforestation, even in ecological reserves, as is currently occurring in the Amazon, with serious environmental consequences.

Recovery of these areas is viable, but there are few technology packages that have been disseminated and implemented, owing partly to the lack of economic resources but also to the lack of support from governments for the implementation of such technologies. Much attention is focused on legal protection of native reserves, but currently there are practically no incentives for recovering degraded areas.

Owing to the low cost and the effectiveness in terms of soil carbon sequestration, all the available technologies for recovering these tropical zone areas involve the use of legumes capable of acquiring nitrogen through biological nitrogen fixation (BNF) and carbon through photosynthesis. Nuclear techniques are highly important tools for developing, implementing and monitoring these technologies. The nitrogen-15 natural abundance technique is essential for evaluating uptake of N from air in field crops via BNF (Shearer and Kohl, 1986; Boddey et al., 2000). Evaluation of the natural abundance of carbon-13 in soil profiles indicates the degradation rate of native organic matter and the accumulation rates of carbon from legumes and grasses (Balesdent et al., 1988; Neill et al., 1997). Lastly, soil loss through erosion caused by degradation can be assessed from changes in caesium-137 activity in the soil (Andrello et al., 2003).

The direct beneficiaries will be small farmers in particular, who will be able to recover the production capacity of their land and produce food while helping preserve the environment. This benefit will extend to society as a whole as well since, thanks to the technologies for recovering degraded land for agriculture, the availability of farming land will increase, promising increases in the production of food for which there is currently such a need.

6. <u>Incidence of exotic transboundary diseases in animals</u> (A6)

The countries of the American continent are separated by approximately 50 000 km of land borders, many of them put in place for political reasons taking no account of movement of diseases. The Global

Frontiers — Trans-Boundary Animal Diseases (GF-TADs) initiative, the outcome of an official agreement between the OIE and FAO, addresses the challenge of combating animal diseases from a regional and hemispheric perspective. As a result, any action taken must be in line with two fundamental principles: i) the presence of disease — and the capacity to eliminate it — in a country is influenced in large measure by the health status of neighbouring countries, suggesting that joint action going beyond frontiers is absolutely essential; and ii) those countries best positioned to improve their national health status, confront current disease challenges and meet future needs, should continually develop their veterinary services focusing on four basic components: technical capacity, human and financial resources, links with the private sector and capacity building for market access and retention (World Organisation for Animal Health/OIE, 2004).

In this regard, a number of isolated actions have been taken recently in the region to develop and/or improve epidemiological monitoring and control services for emerging transboundary animal diseases of economic importance, such as foot-and-mouth disease (PAHO/WHO, 2006), highly pathogenic avian influenza— H5N-1 (ECLAC-United Nations, 2006), and spongiform bovine encephalopathy — BSE (FAO, 2003).

However, a wide technology gap exists between countries in the region, despite the transboundary nature and major relevance of this issue for the regional economy. In the event of an outbreak of one of these diseases, economic barriers imposed by countries that import animal products and animal-derived products would lead to incalculable losses and cause irreversible damage to stockbreeding and economic activities in the entire region (FAO, 2006).

Laboratories in all countries in the region need to be prepared to provide swift and accurate diagnosis of emerging diseases using modern and adequately validated technologies. Nuclear energy is utilized in the development and use of radioactive DNA probes for high-sensitivity processes (such as DNA and RNA blotting) to detect pathogens in field samples, and these should serve as a reference to validate other detection methods involving the analysis of nucleic acids.

In addition, the use of vaccines and sera which have been deactivated using ionizing radiation (gamma radiation) is an important application of nuclear energy in this subsector, since it allows reference samples to be exchanged among countries and subregions, facilitating standardization of methods between zones with different health classifications, in line with current international standards (Joint FAO/IAEA Programme, 2007).

The primary beneficiaries of this work will be the economies of all countries in the region, whose epidemiological monitoring services will obtain more swift, accurate and efficient methods of detecting these types of pathogenic agent, allowing their technical and managerial competence in the animal health field to be verified vis-à-vis countries that import their livestock products, as regards the prevention and control of emerging diseases. Secondly, livestock producers will benefit directly since control of these diseases maintains their commercial capacity at sustainable levels.

7. Low productivity, and susceptibility to biotic and abiotic stress, of traditional basic food crops (A7)

A large number of countries in the region, especially those with areas where subsistence farming predominates, are deficient in cereal and legume production, causing poverty and undernutrition in rural areas. It is essential to recognize that poverty and food insecurity combined with disease and undernutrition constitute a high-impact socio-economic loss.

The fundamental causes of this food deficit include low yields due to the use of traditional varieties susceptible to diseases and insects (biotic factors), and global climate change which has a radical effect on crop production owing to the higher temperatures and reduced rainfall (abiotic factors).

One way to reduce the region’s food deficit is to develop improved varieties of crops with a higher yield which are tolerant/resistant to biotic and abiotic stress factors and are of the appropriate quality.

In recent decades, genetic improvement of crops has brought about significant increases in productivity, resistance to diseases and pests, tolerance to drought, adaptation to mechanized harvesting and uniformity of grains and fruits.

There are a number of recognized methods for genetically improving plants: a) intraspecific and interspecific hybridization; b) mutation induction; c) genetic engineering. Each has its advantages and disadvantages, but it is important to bear in mind that these methods complement each other.

Mutation induction using nuclear energy allows the molecular make-up of genes to be altered, modifying characteristics of economic interest in plants. Between 1969 and 2002, 2252 mutant varieties of 163 species were registered in 62 countries. 910 of these were obtained using gamma rays, 61 using chronic gamma radiation, 48 using fast neutrons and 22 using thermal neutrons (IAEA, 2007). The varieties obtained by mutation can be used directly or as parents in cross-breeding programmes. Furthermore, mutation induction provides gene variations and recombinations not recorded in cultivated varieties and their wild relatives, thus helping increase genetic variability.

All countries in the region will benefit from genetic improvement of crops.

8. <u>Presence of areas infested with New World screwworm</u> (A8)

In South American countries and on most of the islands of the Caribbean, livestock development is severely hampered by the myiasis caused by the New World screwworm (NWS) *(Cochliomyia hominivorax)*, which causes major commercial losses in the livestock herd, estimated at over 450 million head (cattle, horses, pigs, sheep, goats, etc.). Its importance can be gauged from the fact that NWS myiasis is ranked among the six main transboundary diseases officially recognized by the OIE (along with foot-and-mouth disease, classical swine fever, bovine spongiform encephalopathy, highly pathogenic avian influenza — Asian H5N1, and rabies). Addressing this disease is a priority, given that the negative impact on the livestock sector in the region is clearly on the rise.

In order to reduce losses in the livestock sector and develop production capacity, technical information needs to be collected and shared, feasibility studies carried out and the capacity created to suppress and eradicate the New World screwworm (NWS) in the long term in the countries of the Caribbean region and South America through integrated use of the sterile insect technique (SIT). To achieve this, it is imperative to include the countries of the Southern Cone and the Caribbean in a feasibility and pre-implementation project to collect and share technical information, jointly develop capacity in national animal health bodies, and prepare for the long-term eradication of the NWS.

The NWS is the first insect pest on which the SIT was successfully trialled. It has been eradicated in the southern USA, Mexico, Central America and Libya. The technology is therefore proven, although much information is needed on the ecology and genetics of populations of the pest in the region, as well as human, legal and physical infrastructure, before the operational phase of an eradication programme can be initiated. To date, no other technology for the eradication of this pest is known that is sustainable, nor is it anticipated that the technique could be replaced in the future.

Mexico and the countries of Central America have extensive experience in the successful use of the SIT to eradicate the NWS. In Mexico and Panama there are plants for mass production of sterile NWS and specialized personnel who could be used as a platform to launch an initiative like the one proposed. In addition, the Joint FAO/IAEA Division is supporting research into population genetics in Brazil, Uruguay and Venezuela, is assessing the status of the pest in the Caribbean and will subsequently do so in Colombia, Ecuador and Peru. These conditions afford an excellent opportunity for cooperation among organizations and countries with a view to transferring the technology for the long-term elimination of this regional pest.

The beneficiaries are the affected sectors of the population, namely consumers of livestock products and subproducts, and the production, marketing and export chain for meat and dairy products in the countries of South America and the Caribbean.

9. Vulnerability of livestock species at risk of extinction (A9)

Agricultural biodiversity is a broad term that covers all components of biological diversity of relevance to agriculture, including domestic animals and plants, and maintenance thereof is essential to the key functions of the agro-ecosystem (CBD — UNEP — United Nations, 2005).

Latin America and the Caribbean have large populations of the main livestock species distributed across the various subregions and providing the economic basis for a number of sectors — both local and regional trade and large-scale industrial exploitation and export of animal-derived products. Owing to the fact that they are indigenous (as in the case of South American camelids) or were introduced at least a hundred years ago by European colonizers (as in the case of cattle, sheep, goats and buffaloes), they have special and select gene pools which gives them the combination required to adapt to the different agro-ecological zones in the region (FAO, 2006).

The need to reduce the vulnerability of domestic animals is both subregional (South American camelids in the Andean region) and regional ('creole' breeds of cattle, sheep, goats and buffalo) and requires the establishment of plans for the genetic characterization, conservation and use of these breeds in a manner that would allow the germplasm to be preserved in situ, and the identification of the genes that give these animal populations their adaptive characteristics and that might be used in the selection of other breeds, improving their productivity levels in specific environments in the region (UNEP/FAO, 1997).

Nuclear energy is extremely important in genetic characterization processes for generating (X-ray) irradiated cell hybrid DNA panels for genetic mapping, and/or owing to its use in radioactive labelling processes (^{32}P and ^{33}P) for synthesis of radioactive DNA probes in microsatellite analysis of genome regions. In addition to these recognized applications, for a better understanding of the processes that control gene activation in animals that have adapted to the different agro-ecological zones in the region, the use of radioactive DNA probes in DNA microarray systems for analysis of gene expression is a major potential application of nuclear energy in this sector. Once the genes involved in the adaptation process are known, their expression in different physiological and/or environmental conditions can be studied simultaneously, generating useful information for the development of tools for genetic selection of superior animals, and appropriate management strategies for these genetic resources.

The human population in general will benefit from the conservation of these biodiverse livestock populations. However, small- and large-scale livestock producers throughout the region will benefit directly from this technology, since the use of animal germplasm with the genetic characteristics of adaptation and high productivity in a sustainable environmental management context helps increase the value of the animals and their subproducts and, consequently, increases the earnings of farmers and the foreign currency revenue of the countries concerned.

10. Low productivity of native plants with nutritional and/or medicinal potential in areas of biodiversity (A10)

Traditional agriculture and the low technology level limit production of native plants traditionally sown by small farmers. In addition, the splitting up of holdings, the fact that they are located in marginal zones with adverse climatic conditions, and single-crop farming have contributed to the loss of diversity of native foods and creole varieties grown in the region.

Globalization forces the less developed countries in the region to compete in the short term with the more developed countries, leading them to sow genetically uniform varieties required by the market. These varieties are replacing native varieties in areas with a high genetic diversity of traditional crops, with the direct result that valuable genes present in local varieties which are useful for plant improvement are being lost.

Indigenous communities use the plants they have lived with for thousands of years in their day-to-day life. 25% of these plants have medicinal properties, others are of nutritional and energy value, while others produce pigments and oils. Potatoes, maize, beans, gourds, cocoa, chillies and tomatoes are major examples of the region's contribution to the world's food and there is thus undoubtedly an opportunity for small/poor farmers from zones with high biodiversity to become involved in producing and marketing new roots, tubers, grains, fruits and vegetables with a high nutraceutic content.

The prospects for global consumption of new native plants are very bright. New high-value products could be produced which could make the agriculture practised by small farmers viable, boosting the economy of rural areas. The earnings derived from these new crops could be used by the farmers to invest in appropriate equipment and technologies to make their holdings sustainable and profitable.

These native species have low yields and a long life cycle, and are susceptible to attack by diseases and insects. Moreover, they are prone to seed shedding and flattening. These undesirable characteristics can easily be corrected using plant improvement techniques. The most appropriate method is surely mutation induction, as it allows one or a few traits to be modified leaving the rest of the genome intact. The existing genetic combination in these traditional varieties should not be disturbed at first as it is indispensable for their continued cultivation and use.

Mutation induction can assist with the gradual domestication of native species, as occurs in nature, but in a more rapid and controlled manner. Mutation induction using gamma rays can alter any gene and is thus a suitable mechanism in any attempt to improve these species.

The direct beneficiaries will be the native communities in countries in the region where there are centres of origin and/or diversity of plants. The indirect beneficiaries will be society at large, which will have access to new nutraceutic products.

11. Limited development of aquaculture swing to health and genetic factors (A11)

Aquaculture, possibly the fastest growing food production sector, accounts for nearly 50% of the world's fisheries products used for food. The need to exchange reliable information on all fisheries-related subjects is becoming crucial for responsible management of aquaculture (FAO, 2006).

Aquaculture is gaining increasing importance in the region. According to preliminary estimates, production in 2004 amounted to 1.24 million tonnes, with an average growth rate of 10% in the production and sales of captive freshwater and seawater aquatic organisms (shellfish and fish) during the last decade (Latin American Organization for Fisheries Development (OLDEPESCA), 2005).

The promotion and development of rural and coastal aquaculture could provide an important alternative to address food and nutrition deficits among the inhabitants of our countries, and help alleviate extreme poverty (FAO, 2002).

However, for the sector to succeed, among other actions it is necessary to develop in an appropriate manner structured programmes to control recurrence of disease problems in cultivated species (Central American Organization for the Fishing and Aquaculture Sector (OSPESCA) — FAO, 2006). New biotechnologies are being used to promote health in the sector through conventional selection for resistance to disease and through molecular and diagnostic characterization of different pathogen strains. These analyses can provide information on the origin of the pathogen and its presence in tissues, whole animals, water and even in soils. Molecular techniques have been used to detect viral diseases in shrimps and to detect bacteria and fungi in fish in various parts of the world. Data from the World Organisation for Animal Health (OIE) (2006) indicate that there is a need to develop laboratories with the skills to provide this type of service, and to establish rules for control of transit of these organisms and their products between countries.

In view of the relatively scant knowledge of the biology of these organisms and their pathogens (compared to terrestrial domestic animals), the creation of a network of laboratories qualified to provide high-quality diagnostic services in this sector is highly important. In this instance, nuclear technology is important for the development of tests to detect pathogenic agents, which should serve as a reference method to validate other detection tests involving the analysis of nucleic acids.

On the other hand, the cultivation of various aquatic species of economic importance depends on the collection of 'seed' propagation material in natural populations in the environment. Shrimps (*Penaeus* spp.) are the most important group of species whose cultivation is dependent on natural populations and Latin America and the Caribbean are the regions where the largest number of these organisms are caught in the environment. Furthermore, owing to the genetic deterioration which fish and shellfish can suffer from in intensive cultivation systems, there is an urgent need to establish monitoring and genetic improvement programmes (FAO, 2006). Nuclear technologies offer great scope for application and can be used to produce microsatellite genome region DNA probes with radioactive labelling (^{32}P and ^{33}P) for use in gene mapping.

The immediate beneficiaries of the programme would be the inhabitants of coastal areas and regions with water resources, who would have access to accurate and rapid services for monitoring of health and production conditions in their systems which as yet do not exist in several subregions.

12. <u>Presence of areas with a high prevalence of codling moths</u> (A12)

Codling moths are a major economic pest affecting production of apples, pears, quinces and other commercial crops. They reduce production volumes, increase production costs owing to the large quantities of broad-spectrum insecticides needed for control purposes and, consequently, cause serious residue problems in the fruit which limit sales and affect human health. Codling moths are reported as being present in the subregion comprising Argentina, Brazil (zone in Río Grande do Sul), Chile, Paraguay and Uruguay. Apple production alone in these countries exceeds 3 million tonnes.

In order to promote development of the apple, pear, quince and nut industry and reduce the volume of pesticides currently used for control, with a view to increasing fruit production and exports, low-prevalence areas need to be established for this pest by suppressing them through integrated use of the sterile insect technique (SIT). In the specific case of Río Grande do Sul, the desired result is to eradicate the pest.

The SIT has been used successfully in Canada and its implementation as part of wide-area integrated pest management is thus considered one of the main alternatives to the current use of insecticides. If the present insecticide-based control practices continue, the problems of marketing these products, the adverse effects on human health and environmental pollution, and the pest's resistance to various insecticides, will get worse. Addressing these problems must therefore be considered a subregional priority in fruit farming.

Argentina has taken the first steps towards using the SIT against codling moths. In addition, the Joint FAO/IAEA Division has conducted compatibility studies in populations of different geographic origin and is supporting research related to the mass production of sterile moths. These factors create a propitious climate for immediate cooperation between countries and international organizations aimed at effective control of the pest in the Southern Cone. Initially, efforts should focus primarily on the preparation of technical and economic feasibility studies, the development of a workforce through training, and the gathering of basic information, particularly on population ecology.

The beneficiaries are the environment and consumers in the region, and sectors of the population involved in the production, marketing and export chain for apples, pears, quinces and nuts in Argentina, Brazil, Chile, Paraguay and Uruguay.

IV. PRIORITIZATION OF NEEDS/PROBLEMS IN THE SECTOR

These are the attributes which were considered for prioritization, following the selected methodology. More information on the subject may be found in the separate part of the RSP publication on the topic in question.

SERIOUSNESS	This is a measure of the degree of severity of the need/problem, taking into account the negative impact of not addressing it.
TIME	This is related to the degree of urgency in addressing the need/problem, its likelihood of worsening and future consequences.
EXTENT	This determines the degree of regional impact of the need/problem, taking into account, for example, the number of countries affected.
RELEVANCE of/for nuclear techniques	On the one hand, this measures to what extent nuclear applications can contribute to addressing/solving the need/problem. On the other hand, it takes account of the extent to which solving the problem has relevance for nuclear applications.
DEGREE OF DIFFICULTY	This measures the degree of difficulty of implementing the solution to the need/problem identified, which can be related to: infrastructure, resources, technology, legislation, intergovernmental commitments, etc.

1. VALUES ASSIGNED TO EACH NEED/PROBLEM

The identified problems/needs are presented in the following Table according to the grade given by the members of the respective sectorial Group, as may be seen under TOTAL.

	Need / problem	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	Final grade
A 1	Inadequate sustainability in the application of nuclear techniques in agriculture through networks and training	3.60	4.00	4.20	4.00	**15.80**	2.80	**1.43**	**22.57**
A 2	Restricted access to markets owing to the presence of chemical residues that pose a risk to human health in foodstuffs of animal and plant origin	3.80	3.80	4.00	3.80	**15.40**	2.80	**1.36**	**20.90**
A 3	Deficient agricultural soil management practices and inadequate use of fertilizers, water and biological nitrogen fixation	3.80	3.60	3.80	3.40	**14.60**	1.60	**2.13**	**31.03**
A 4	Presence of areas with a high prevalence of fruit flies	3.50	2.80	3.20	4.60	**14.10**	2.00	**2.30**	**32.43**
A 5	Loss of agricultural areas through soil degradation caused by extensive agricultural activity	4.00	3.60	3.00	3.40	**14.00**	2.40	**1.42**	**19.83**
A 6	Incidence of exotic transboundary diseases in animals	3.60	3.60	3.60	2.60	**13.40**	2.00	**1.30**	**17.42**
A 7	Low productivity, and susceptibility to biotic and abiotic stress, of traditional basic food crops	3.00	3.00	3.60	3.60	**13.20**	1.60	**2.25**	**29.70**
A 8	Presence of areas infested with New World screwworm	2.72	2.80	3.20	4.40	**13.12**	3.40	**1.29**	**16.98**
A 9	Vulnerability of livestock species at risk of extinction	3.64	3.40	3.20	2.80	**13.04**	2.20	**1.27**	**16.60**
A 10	Low productivity of native plants with nutritional and/or medicinal potential in areas of biodiversity	3.30	3.40	3.00	3.20	**12.90**	2.60	**1.23**	**15.88**
A 11	Limited development of aquaculture owing to health and genetic factors	3.20	2.80	3.20	2.80	**12.00**	2.40	**1.17**	**14.00**
A 12	Presence of areas with a high prevalence of codling moths	2.40	2.20	2.20	4.40	**11.20**	2.20	**2.00**	**22.40**

2. JUSTIFICATION OF ASSIGNED VALUES

The needs/problems are listed in order of priority based on the values assigned.

FOOD SAFETY					
NEED	**SERIOUSNESS**	**TIME**	**EXTENT**	**RELEVANCE**	**DIFFICULTY**
A1) Inadequate sustainability in the application of nuclear techniques in agriculture.	Regional agricultural development is being affected by the significant reduction in trained personnel and the closing down of laboratories employing nuclear techniques.	Without appropriate attention, this problem will worsen in the near future.	The majority of countries in the region note the existence of this problem.	The application of nuclear techniques is indispensable for the development of agricultural technologies for food production.	Implementation requires the coordination of a large number of academic, technical and financial institutions, both national and international.
A2) Restricted access to markets owing to the presence of chemical residues that pose a risk to human health in foodstuffs of animal and plant origin.	Limited application of quality and safety standards for the region's agricultural and seafood products. Risk to human health and the environment caused by the use of pesticides.	The increasing importance attributed by society to the quality and safety of foodstuffs requires the urgent establishment of standards and systems to monitor the presence of chemical residues in food.	Throughout the region.	Processes involving nuclear techniques used for post-harvest treatment and monitoring of pesticide residues in agricultural products have been developed and are in universal use.	Limited infrastructure and harmonization of regulations for the use of ionizing radiation in food. There is a lack of awareness in certain sectors of society of the seriousness of consuming food products contaminated with pesticides.
A3) Deficient agricultural soil management practices and inadequate use of fertilizers, water and biological nitrogen fixation.	The region is dominated by agricultural soils that are extremely poor in nutrients.	There is an urgent need for the development of rational soil management and fertilizer use systems to compensate for the insufficient availability of food.	The great majority of the region's agricultural soils require sustainable agricultural technologies.	Isotopic tracer techniques are essential for evaluating the efficiency of management systems from the point of view of sustainability. They allow the fate of different agricultural inputs to be determined in production systems, rationalizing the use of organic and manure fertilizers.	Proven isotopic tracer methodologies exist and are in widespread use in the region.

NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
A4) Presence of areas with a high prevalence of fruit flies.	Causes losses of up to 40% in the production of fruit and vegetables. Restricts the export of over 100 species of fruit and vegetables.	For the urgently needed improvement of socio-economic conditions in countries, foreign exchange income is needed which can be obtained by increasing exports through control of fruit flies.	The problem is present in all countries except Chile and is of a transboundary nature	Nuclear technology is the only tool capable of eliminating this problem without affecting the environment	Its implementation requires specialized training and coordination of a large number of technical and financial institutions.
A5) Loss of agricultural areas through soil degradation caused by extensive agricultural activity.	Food safety and preservation of the regional environment are at risk because of increasing loss of agricultural soils owing to erosion and the reduction of their production capacity.	Increasing deforestation and soil degradation require urgent attention.	The degradation of agricultural soils is an issue of regional scope, being particularly critical in Andean and tropical zones.	Isotopic tracer techniques are essential for evaluating the extent and level of degradation, as well as for monitoring recovery processes.	Proven isotopic tracer methodologies exist and are in widespread use in the region. However, preliminary work is required on characterization and applicability of techniques.
A6) Incidence of exotic transboundary diseases in animals.	Diseases such as avian influenza, bovine spongiform encephalopathy and foot-and-mouth disease are emerging and are transboundary in nature. They pose a high potential risk of causing major damage to human and animal health, and of destroying production chains.	Prevention of this kind of threat requires immediate initiatives to harmonize diagnostic methods and promote regional integration in order to coordinate rapid and effective response.	Present throughout the region and transboundary in nature.	The nuclear component of the processes used to address this need forms part of an extensive chain of other complex biotechnological processes.	Requires optimization of techniques and integration among the competent authorities of countries in the region with a view to coordinated action in epidemic situations.
A7) Low productivity, and susceptibility to biotic and abiotic stress, of traditional basic food crops.	The deficit in the production of basic foodstuffs in the region has repercussions for poverty and undernutrition levels, particularly in rural agricultural areas. 80% of poor and undernourished people live in rural areas.	Urgent need to reduce the region's vulnerability as regards its dependence on basic food products.	Rural areas throughout the region.	Induction of mutations is an internationally established and accepted method of genetic improvement of plants.	Methodology established for 162 species of plants in 62 countries giving rise to 2300 varieties.

NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
A8) Presence of areas infested with New World screwworm.	The region has livestock herds of almost 450 million head which are subject to potential infestation with a resulting reduction in productivity.	It is important to ascertain, in the near future, the distribution and scale of infestation in order to plan suppression or eradication methods.	The problem exists in all countries in the region except the subregion of Mesoamerica. It is transboundary in nature.	Nuclear technology is the only tool capable of eliminating this problem without affecting the environment	Its implementation requires preliminary studies of how widespread and serious the infestation is in the field. Its implementation requires highly specialized training and the coordination of a large number of technical and financial institutions.
A9) Vulnerability of livestock species at risk of extinction.	There is a limited infrastructure in the region for scientific research and technological development capable of ensuring conservation and exploitation of the genetic resources of livestock at risk of extinction.	Action to preserve these livestock species should be taken in the near future to avoid the risk of extinction of the germplasm of animals of great interest for humanity.	Throughout the region.	Little is known about the characteristics of these breeds of animal at molecular biochemical level and the use of nuclear techniques is a fundamental component for development of this field.	Lack of recognition of the vulnerability of livestock species at risk of extinction. There are not enough groups using nuclear techniques to conserve livestock species at risk of extinction..
A10) Low productivity of native plants with nutritional and/or medicinal potential in areas of biodiversity.	Degradation of genetic diversity owing to extractive exploitation of native species. Replacement of native plants with genetically uniform commercial crops.	Increasing cultural and genetic erosion leads to the loss of native species of importance for food and pharmaceuticals.	Five of the world’s ten megacentres of biodiversity are located in the region.	As native plants generally do not possess desirable characteristics as regards productivity, induction of mutations is the appropriate genetic improvement method to change features which limit the use of native species, preserving their nutritional and/or medicinal value.	Preliminary work on characterization of native species is required.
A11) Limited development of aquaculture owing to health and genetic factors.	Genetic deterioration and the severity of epidemics caused by infectious diseases are magnified by the exponential growth of aquaculture.	The disorganized growth of parts of the aquaculture sector calls for urgent attention to avoid the collapse of aquaculture owing to the occurrence of epidemics of infectious diseases and the deterioration of genetic resources.	Throughout the region.	Little is known about the molecular characteristics of the various aquatic organisms reared in the region and their main pathogens and the use of nuclear techniques is a fundamental component for development of this field.	Requires integration and training of the existing competencies in countries in the region for the application of nuclear technologies. The region does not have a sufficient number of laboratories devoted to this topic.

NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
A12) Presence of areas with a high prevalence of codling moths.	They cause significant losses in the production of apples, pears, quinces and nuts. Current control methods cause environmental pollution owing to extensive pesticide use.	Although this pest does not restrict exports of the affected agricultural products, the excessive use of pesticides calls for the use of non-polluting techniques.	The problem is subregional since it is present in the countries of the Southern Cone.	Nuclear technology is the only tool capable of eliminating this problem without affecting the environment	Its implementation requires highly specialized training and the coordination of a large number of technical and financial institutions.

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- 21 surveys received from various institutions or their legal representatives, and from FAO advisers and teaching institutions in the region.

VI - COMPOSITION OF THE WORKING GROUP

Food safety (mutation induction and genetic improvement of plants; integrated management of soils, water, plants and fertilizers; integrated pest management; animal production and health; nutrition and environmental protection)

1. Silvia Fascioli (**member of the ATCB**) — Uruguay
2. Luz Gómez Pando (**mutation induction and genetic improvement of plants**) — Peru
3. Jesús Reyes (**pest control**) — Mexico
4. Segundo Urquiaga (**integrated management of soils, water, plants and fertilizers**) — Brazil
5. José Fernando García (**animal sciences**) — Brazil
6. Cecilia Urbina (Programme Management Officer)

Focal points from IAEA technical departments

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2. Walther Enkerlin (NAFA)
3. Pierre Lagoda (NAFA)
4. Tatiana Rubio Cabello (NAFA)
5. Ian Ferris (NAFA)

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RSP Advisory Commitee and ATCB Directive Group

1. Jorge Vallejo **(Chairman of the ATCB)** General Coordinator — Colombia
2. Juan Antonio Casas Zamora — Director of the Division for Latin America at the IAEA
3. Ángel Díaz (**Vice-Chairman of the ATCB**) — Venezuela
4. Alberto Miranda (**Secretary of the ATCB**) — Bolivia
5. Hadj Slimane Cherif — Director of the Office of Programme Development and Performance Assessment at the IAEA
6. Jane Gerardo-Abaya — Programme Management Officer supporting DIR-TCLA
7. Francisco Rondinelli — strategic planning expert
8. Angelina Díaz — expert with ARCAL experience
9. Sergio Olmos — expert with experience in the BAR and BAR Working Group

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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

Human Health in Latin America and the Caribbean in the Light of the RSP

ARCAL

IAEA
International Atomic Energy Agency

PUBLICATIONS RELATED TO THE RSP

To facilitate review of the material generated by the RSP preparation process, it has been published in separate parts covering the following aspects:

Regional Strategic Profile for Latin America and the Caribbean (RSP) 2007–2013
Background, Methodology and Process for the Preparation of the RSP for Latin America and the Caribbean
Food Safety in Latin America and the Caribbean in the Light of the RSP
Human Health in Latin America and the Caribbean in the Light of the RSP
Environment in Latin America and the Caribbean in the Light of the RSP
Energy and Industry in Latin America and the Caribbean in the Light of the RSP
Radiation Safety in Latin America and the Caribbean in the Light of the RSP

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ARCAL-IAEA Strategic Alliance

HUMAN HEALTH IN LATIN AMERICA AND THE CARIBBEAN IN THE LIGHT OF THE RSP

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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

ARCAL-IAEA Strategic Alliance

HUMAN HEALTH IN LATIN AMERICA AND THE CARIBBEAN IN THE LIGHT OF THE RSP

I. BACKGROUND AND IMPLEMENTATION OF WORK

Within the framework of the ARCAL-IAEA Strategic Alliance, the signatory countries are identifying, from a regional perspective, priority needs and available resources in the region in the area of human health with a view to addressing common problems which could be solved with the help of nuclear techniques and where efforts are being integrated with those of other international organizations, serving as a basis for the development of cooperation activities among countries in the region, within the framework of the ARCAL agreement.

In order to fulfil this task, the working group decided to divide itself as follows to address the different subsectors:

Nuclear medicine and radiopharmacy
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Radiotherapy
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Nuclear molecular biology — infectious diseases
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II. ANALYSIS OF PROBLEMS IN THE REGIONAL CONTEXT

1. Nuclear Medicine and Radiopharmacy

Introduction

As living conditions have improved, reflected in better access to education, potable water and sanitation, primary health care, availability of cost-effective technologies and extended immunization coverage, communicable and non-communicable diseases that have a major impact on health have been brought under control. Furthermore, the decline in the birth rate and increased life expectancy have resulted in the predominance of chronic non-communicable diseases. This has been reflected in an improvement in almost all average health indicators in the majority of countries in the region. The Latin American population is undergoing a process of demographic and epidemiological transition, exhibiting considerable variation in its health situation. This has resulted in a complex situation in which problems related, on the one hand, to underdevelopment, such as enteric, communicable and deficiency-related diseases, and, on the other hand, to urban lifestyles and economic development, such as chronic and degenerative diseases, cancer, accidents and mental health problems, coexist. For some years now, the main causes of death have been associated with pathologies closely linked to lifestyles and the ageing of the population, such as diseases of the circulatory system, cancer, accidents and violence. The ageing of the population constitutes a major challenge in terms of health and the increase in the prevalence of chronic diseases that affect older people. According to the statistics for

2006, the 10 main causes of death in 31 countries in the region account for between 43.1% and 59.8% of the deaths recorded in these countries and include cardiovascular diseases, ischaemic cardiopathy, and various types of cancer (prostate, lung, breast, cervico-uterine, inter alia)[1].

In this context, diagnostic and therapeutic applications of nuclear medicine techniques are of vital importance and have considerable impact on the management of these patients.

The main objective of radioisotope techniques is to provide for cost-effective management of pathologies, allowing for early diagnosis and the delivery of appropriate and timely therapy. In recent decades, the technology used has become increasingly complex. Efficient and safe implementation of diagnostic and treatment procedures employing open radiation sources requires that the multidisciplinary staff involved are adequately trained, with ongoing learning and training, as new equipment and radiopharmaceuticals are introduced. There is a body of experience demonstrating the benefits of having networks of professionals that can support national policies related to health services — including nuclear medicine — and can improve the quality of the services provided.

Nuclear medicine is a specialty characterized by the use of open radiation sources for diagnostic and therapeutic purposes. Nuclear medicine is the only imaging diagnostic specialty that allows both physiological and morphological studies to be performed. Positron emission tomography (PET), introduced in the last decade, has become an essential tool for localization, staging, evaluation of treatment response, and monitoring of different neoplasias.

Several disciplines come together in the specialty, with the following considered essential: trained human resources (including nuclear medicine specialists, medical technologists and medical physicists), technological infrastructure, standardized protocols to ensure best practice, and compliance with quality and safety standards. Moreover, since new technologies and radiopharmaceuticals are being developed all the time, it is essential that professionals receive ongoing education.

There is extensive scientific evidence of the usefulness of nuclear medicine radioisotope procedures in the diagnosis, monitoring and treatment of these pathologies whose prevalence in the region is high. However, owing in large part to the magnitude and distribution of public health spending, investment in nuclear medicine has been limited.

In recent decades, there has been considerable development in the specialty in the Latin America and Caribbean region. However, development and growth have been uneven among the countries in the region, which has had a negative impact on equitable access to this technology for low-income sectors and people living far from major cities and/or capitals.

The objective of the International Atomic Energy Agency, in addition to promoting peace, is to contribute to the socio-economic development of the world. This objective should be achieved through the following function set forth in Article III.A of the Statute: *"To encourage and assist research on, and development and practical application of, atomic energy for peaceful uses throughout the world; and, if requested to do so, to act as an intermediary for the purposes of securing the performance of services or the supplying of materials, equipment, or facilities by one member of the Agency for another; and to perform any operation or service useful in research on, or development or practical application of, atomic energy for peaceful purposes ..."*

There has been sustained support from the governments of countries in the region for applications of nuclear techniques in the health field, as shown by their record of participation in IAEA programmes related to human health, either through technical assistance projects, ARCAL projects, or through funding of training of professionals, the ultimate objective being to improve the quality of life of

[1] Pan American Health Organization, Health Statistics from the Americas, 2006, Washington D.C., PAHO, 2006, http://www.paho.org.

individuals suffering from diseases whose prevalence is high by strengthening nuclear medicine techniques that offer comparative advantages over other procedures.

The development of nuclear medicine in the region has been uneven; in some countries it has run parallel to the developed countries from a scientific and technological point of view, while in others it is still non-existent.

The total number of gamma cameras in the region is 1116. Argentina and Brazil are the countries with the highest number: 326 and 450 respectively. Haiti has no nuclear medicine equipment.

31% of the gamma cameras are planar, 58% are single-head tomographic gamma cameras and the remaining 11% are dual-head tomographic gamma cameras. The technological characteristics also vary among countries: in Colombia 93% of the equipment has tomographic capacity while in Guatemala 75% is planar.

The number of gamma cameras per million inhabitants varies between 8.3 and 0.2, the average in the region being 2 gamma cameras per million inhabitants.

These resources are heavily concentrated in private health systems, where over 70% of them are to be found; the exception is Bolivia, where 71% of gamma cameras belong to the public health sector.

With regard to geographical distribution, we note that in the majority of countries resources are heavily concentrated in capitals and big cities, where over 60% of installed equipment is to be found. In Bolivia, 77.8% of the installed capacity is outside La Paz, and in Colombia, 55.9% of the capacity is not in Bogotá.

The number of nuclear medicine specialists certified to use gamma cameras varies between 1.5 and 0.4 professionals per gamma camera, the geographical and health system distribution being the same as that indicated for the technology.

93% of actions are diagnostic procedures. The bone scintigram is the most common procedure, accounting for 44% of the total, followed by nephro-urological and endocrinological studies. It is important to point out that these global figures do not necessarily reflect the reality in different countries and centres since, in some of these, cardiological studies account for at least 20% of all procedures.

With regard to PET technology, there are currently 31 installed units in the region; six of these are dedicated PET units and 25 PET-CT units, located in Argentina, Brazil, Chile, Colombia, Mexico and Venezuela. All these countries have cyclotrons.

In the opinion of those surveyed, the existing equipment is underutilized and a greater number of procedures could be carried out and the quality of the services provided improved.

Duly accredited training centres that certify doctors specializing in nuclear medicine exist in Argentina, Brazil, Colombia, Chile, Uruguay and Mexico. Venezuela has a radiotherapy/nuclear medicine training programme. Currently, around 20 doctors in the region are postgraduate nuclear medicine students. There are medical technologist training programmes at university level in Costa Rica, Chile and Uruguay. Currently, there are plans to introduce distance learning courses with the support of the IAEA.

A committee for ongoing education exists within the framework of the Latin American Association of Societies of Nuclear Medicine and Biology (ALASBIMN) whose activities have regularly been implemented in national and regional congresses.

The estimated growth rate over the next 5 years was 21.5% (range 0–50%).

Radioisotopes and radiopharmaceuticals contribute greatly to improving human health care. In recent years, we have seen a global increase in the number of medical procedures involving the use of isotopes and, at the same time, a commensurate increase in the number of procedures requiring different isotopes, for example in nuclear medicine for diagnostic and therapeutic purposes employing radiopharmaceuticals labelled with beta-emitting radionuclides. There are more than sixty research reactors in the world performing an essential function in producing medical radioisotopes, and at least eleven reactors are under construction, or plans have been made for their construction, in various countries. In Latin America, there are four countries with research reactors that produce radionuclides used in the preparation of radiopharmaceuticals.

Furthermore, as is indicated in a recent IAEA study (Directory of Cyclotrons used for Radionuclide Production in Member States, 2006, IAEA-DCRP/CD), it is estimated that there are also some three hundred and fifty cyclotrons available, many of them dedicated to isotope production for positron emission tomography (PET). Although there are ten cyclotrons in Latin America concentrated in six countries (Argentina, Brazil, Colombia, Chile, Mexico and Venezuela), this number is expected to double in the coming years and it is anticipated that they will be installed in other countries (Ecuador, Peru and Uruguay).

Recently, the most significant increases in the recorded demand for isotopes have been for cyclotron-produced ^{18}F, mainly, for use in fluorodeoxyglucose synthesis (FDG/^{18}FDG), PET applications for detection, staging and treatment monitoring for various types of cancer, and applications in neurology.

An increase in the demand for radionuclides for therapy has also been confirmed. One example is the production of ^{177}Lu in reactors for use in the preparation of radiopharmaceuticals based on biospecific molecules, such as peptides for the treatment of neuroendocrine tumours, or for labelling of phosphates for palliative treatment of pain caused by bone metastases. There is also a great demand for ^{90}Y for the preparation of radiopharmaceuticals based on monoclonal antibodies and on peptides for use in internal radiotherapy. Consequently, interest is increasing in isolating and purifying the parent radionuclide, ^{90}Sr, from spent nuclear fuel. The increase in PET units at medical centres is also arousing more interest in positron-emitting radionuclides available from isotope generators, in particular $^{68}Ge/^{68}Ga$. The availability of these generators in developed countries not only facilitates the performance of PET studies in centres without cyclotrons, but also improves the quality of information derived from tumour images obtained using PET with ^{68}Ga radiopharmaceuticals; however, at present we do not have them in Latin America.

In recent years, there has been a trend towards advanced technology development, installing cyclotrons for the production of positron emitters, in particular ^{18}F, which are used at the clinical level in positron emission tomography (PET), the applications being mainly in oncology.

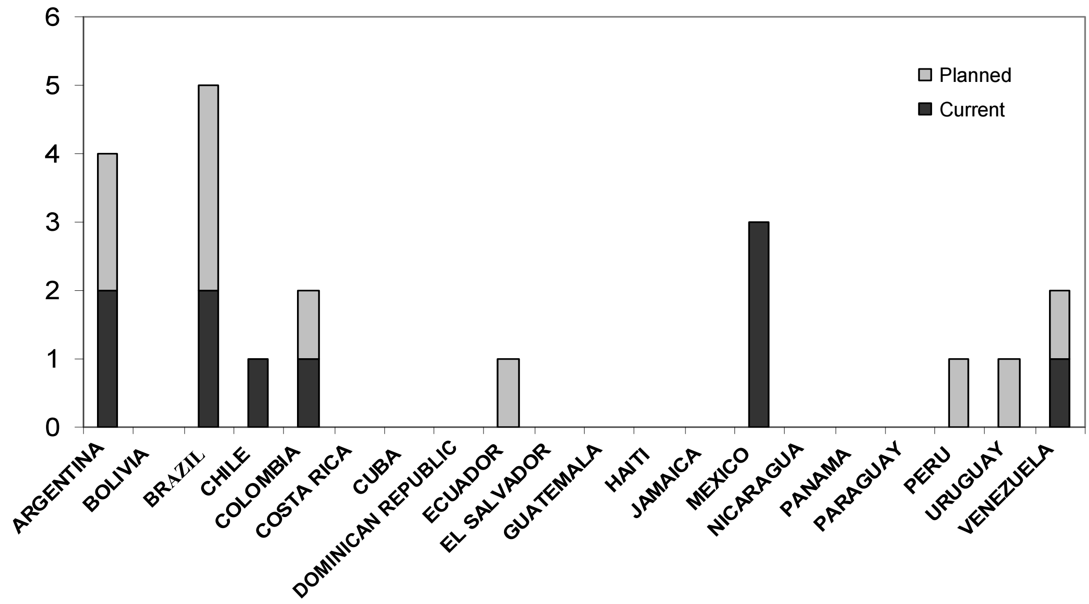


Fig.1. Number of cyclotrons installed and planned in ARCAL member countries

In the Latin America and Caribbean region, production of radioisotopes and radiopharmaceuticals is developing at an uneven rate. Some countries, like Argentina, Brazil, Mexico and Peru, have research reactors allowing national production of radionuclides for the preparation of radiopharmaceuticals for use in diagnosis and therapy.

These countries also produce $^{99}Mo/^{99m}Tc$ generators for supply of $^{99m}TcO_4^-$ at laboratory level, or solutions using the solvent extraction method. In some cases, the generators are exported to other countries.

As regards the production of radiopharmaceuticals and reagent kits for the preparation of radiopharmaceuticals, there are three types of facility:

1. Hospital radiopharmacy: This is the unit within the nuclear medicine service where various types of operation are carried out, such as dispensing of individual doses of radiopharmaceuticals for patients, labelling of reagent kits with radionuclide precursors or generator eluates, and preparation of radiopharmaceuticals based on the labelling of blood components;

2. Industrial radiopharmacy: This is a pharmaceutical establishment where reagent kits or radiopharmaceutical kits are produced using good manufacturing practices for sale or distribution to nuclear medicine services;

3. Centralized radiopharmacy: This is the entity that prepares radiopharmaceuticals and/or dispenses doses using commercial products. The radiopharmaceuticals are supplied in multi-dose or single-dose vials or in syringes. This type of radiopharmacy offers a number of advantages by comparison with traditional hospital radiopharmacies, since it allows for optimization of the potential costs involved in such a facility (good manufacturing practices) within each hospital or nuclear medicine service. The preparation of radiopharmaceuticals in ready-to-use single doses involves the procurement, control and traceability of all the components and substances required for their production.

As regards local production of reagent kits for the preparation of radiopharmaceuticals, primarily for diagnosis, the range of countries which have laboratories for local production (applying good radiopharmaceutical and manufacturing practices) of freeze-dried reagent kits is increasing (e.g. Argentina, Brazil, Chile, Peru and Uruguay, etc). In other countries, these reagent kits are prepared at hospital level or at centralized radiopharmacy level (Colombia). Fig. 2 shows the percentages of countries that have the different types of radiopharmacy.

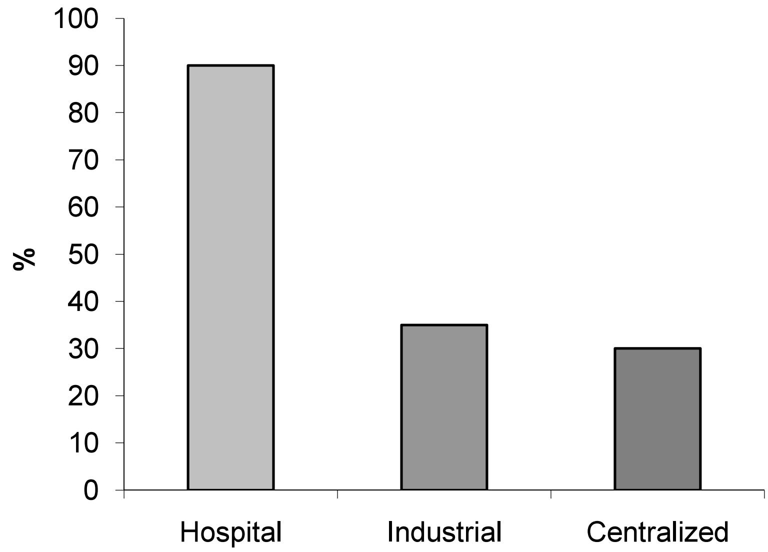


Fig 2. Percentage of ARCAL countries that have the different types of radiopharmacy.

Various countries in the region are producing and using at clinical level therapeutic radiopharmaceuticals for palliative pain treatment, radiosynovectomy, hepatic tumours and neuroendocrine tumours. Fig. 3 shows the countries that produce and/or use radiopharmaceuticals labelled with ^{131}I, ^{153}Sm, ^{188}Re and ^{90}Y; in the case of ^{177}Lu, envisaged use in the current year is shown.

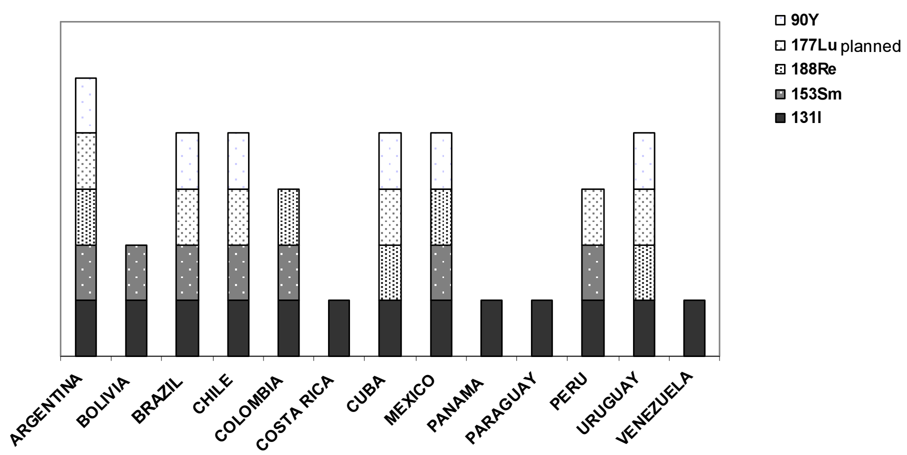


Fig.3. Main therapeutic radionuclides produced or used. In the case of ^{177}Lu, *planned production or use for 2007 is shown.*

In terms of training, the situation in the region is uneven, as some countries, like Argentina, Brazil and Uruguay, inter alia, have training programmes in the radiopharmaceutical field with university-level courses held annually and master's degrees and doctorates taken in this discipline. In the majority of countries there are no courses, and training of professionals working in radiopharmacy is conducted abroad through training fellowships or participation in courses or workshops with teachers from the region.

It is highly important to organize training leading to a qualification in radiopharmacy, which should be recognized at regional and international level; this could be achieved through the development of harmonized study programmes for a licentiate degree course in radiopharmacy and horizontal coordination among university centres, together with work experience in production, development and research centres.

2. Radiotherapy

General

Cancer in Latin America is currently a public health problem: it is the second most important cause of death at regional level[2] (Table 1).

The region has a population of approximately 572 million and there are 833 000 cancer cases per year (167 cases per 100 000 inhabitants)[3].

	Population (millions)			*Population in 2050 (millions)*			
Major area	*1950*	*1975*	*2007*	*Low*	*Medium*	*High*	*Constant*
World	2 535	4 076	6 671	7 792	9 191	10 756	11 858
More developed regions	814	1 048	1 223	1 065	1 245	1 451	1 218
Less developed regions	1 722	3 028	5 448	6 727	7 946	9 306	10 639
Least developed countries	200	358	804	1 496	1 742	2 002	2 794
Other less developed countries	1 521	2 670	4 644	5 231	6 204	7 304	7 845
Africa	224	416	965	1 718	1 998	2 302	3 251
Asia	1 411	2 394	4 030	4 444	5 266	6 189	6 525
Europe	548	676	731	566	664	777	626
Latin America and the Caribbean	168	325	572	641	769	914	939
Northern America	172	243	339	382	445	517	460
Oceania	13	21	34	42	49	56	57

Table 1. Population in Latin America 2007

The estimate of incidence does not reflect the reality: the national registers in some countries in the region show a higher cancer rate per 100 000 inhabitants, close to the incidence in developed countries, i.e. 500 cases per 100 000 (subregisters).

Most common are lung cancer for both sexes and, depending on sex, cervical cancer, breast cancer and prostate cancer, which are frequently diagnosed late and at advanced stages.

2 Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2006 Revision, United Nations, New York, 2007.
3 Globocan, 2002.

Radiotherapy is the non-surgical therapy which produces the most cancer cures (surgery 49%, radiotherapy 40% and chemotherapy 11%). It is used for curative purposes in 60% of cases and is even more effective in combination with surgery and/or chemotherapy and, more recently, biological therapies. It is an effective option for alleviation and control of symptoms in advanced cancer. In many cases, it replaces supraradical surgery, achieving higher rates of anatomical and functional preservation of organs and improving the quality of life of the cancer patient.

Since it is a complex specialty from a technological point of view, major investment is needed and the active and ongoing involvement of the State to maintain the quality of its procedures. It is heavily dependent on the availability of technology: both external radiotherapy with new generations of accelerators and the installation of networks integrating all processes in the therapy sequence, and brachytherapy with remote source afterloaders and three-dimensional planning with CAT.

The region has been affected by the constant development of these technologies, resulting in growing demands in terms of maintenance, quality control, human resources and treatment safety.

Inventory of resources

Radiotherapy should be distributed equitably, it should be effective, efficient, high-quality and have high safety standards. Needs should be prioritized in the light of what is already in place: what we have, what care we can provide, how much more we need to meet needs, what quality and safety levels we must meet and, finally, how much must be invested.

A — Current technology availability

The survey used to quantify technology availability in the external radiotherapy field is the result of work undertaken within the framework of ARCAL projects[4] (Table 2). These figures are worth updating in the short term owing to the procurement rate imposed by modern radiotherapy (for example, in Venezuela the number of accelerators increased by more than 100% in 2006).

Population, total number of radiation oncology departments, megavoltage machines, and relationships between population/departments and machines/population in each country

Country	Population[a]	Centres	Cobalts[b]	LINACs[c]	Million/centre	Mv/million
Argentina	38	89	72	54	0.43	3.32
Bolivia	8.7	6	5	1	1.45	0.69
Brazil	175	151	112	158	1.16	1.54
Chile	15.6	22	15	16	0.71	1.99
Colombia	43.8	38	39	17	1.15	1.28
Costa Rica	4.2	3	3	3	1.40	1.43
Cuba	11.3	9	10	2	1.26	1.06
Dom. Rep	8.7	3	3	1	2.90	0.46
Ecuador	13.1	8	7	5	1.64	0.92
El Salvador	6.5	2	3	0	3.25	0.46
Guatemala	12	6	6	2	2.00	0.67
Haiti	8.7	0	0	0		
Mexico	101.8	75	82	20	1.36	1.00
Nicaragua	5.3	1	1	0	5.30	0.19
Panama	3	3	2	4	1.00	2.00
Paraguay	5.8	4	4	2	1.45	1.03
Peru	26.8	12	9	8	2.23	0.63
Uruguay	3.4	8	9	5	0.43	4.12
Venezuela	25	30	14	16	0.83	1.20
Total	516.7	470	396	314	1.10	1.37

[a] Population in millions.
[b] Cobalt 60 machines.
[c] Linear accelerators.

Table 2. (taken from Ref. 3)

[4] Zubizarreta E., Poitevin A., Levin C., *Overview of radiotherapy resources in Latin America: a survey by the International Atomic Energy Agency (IAEA)*, Radiotherapy and Oncology 73 (2004) 97–100.

Distribution of the equipment is not equitable and varies among countries from 0.1 to 3.3 treatment units per million inhabitants. These figures are well below international guidelines[5] that advocate an average of 5.5 units per million inhabitants in Latin America.

As indicated in Ref. 3, most treatment units are cobalt units and linear accelerators and are concentrated mainly in countries with a high GNI per capita (Fig. 4).

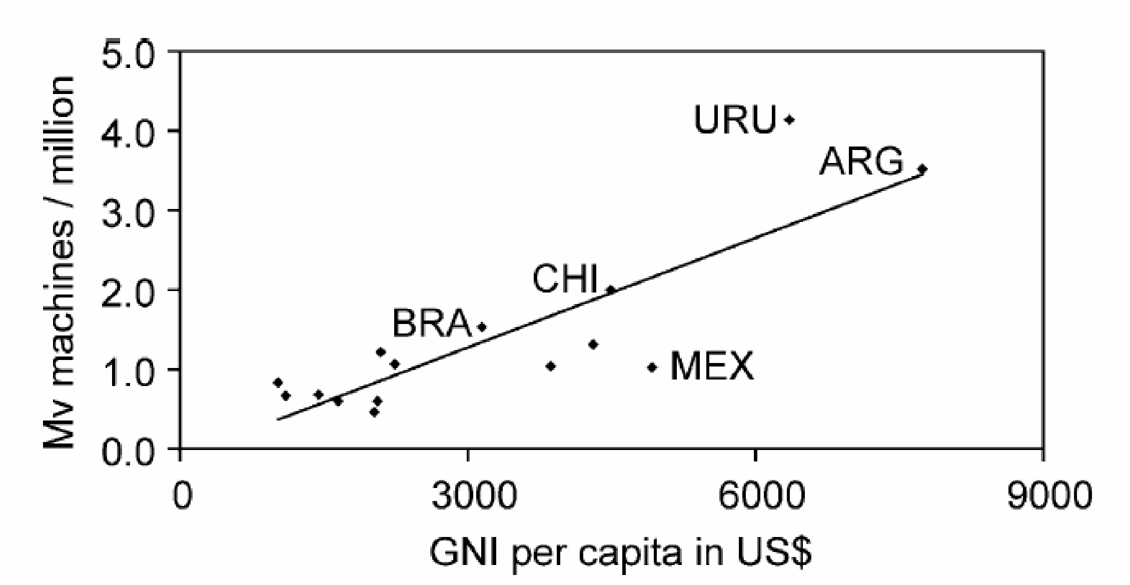


Fig 4. (taken from Ref. 3)

As regards brachytherapy equipment, simulators and planning systems, the results of the survey are shown in Tables 4 and 5.

It should be emphasized that uterovaginal brachytherapy increases the cure rates for advanced stage III cervical cancer (which has a high incidence in some countries in the region) from 30% to 68% in 5 years when combined with high-quality external radiotherapy. If it is not used or poorly applied, this has a drastic effect on local control and survival rates for locally advanced cervical cancer. However, the analysis of the survey with respect to brachytherapy does not reflect the importance of brachytherapy in the treatment of cancer: the strategic importance of equipment availability is not analysed and no consideration is given to advanced technology development which has made it possible, within a decade, to move from manual afterloading or remote afterloading procedures (low-dose rate iridium or caesium sources) to high-dose rate remote treatments and three-dimensional planning.

The availability of conventional simulators for 2D techniques, of tomographs for virtual simulation and planning systems is a reflection of the quality of radiotherapy in the region.

Country	Population	LDR man	LDR RCAL	MDR RCAL	HDR RCAL
Argentina	38	59		1	3
Bolivia	8.7	4	3		
Brazil	175	8			61
Chile	15.6	44			9

[5] Slotman B., Cottier B., Bentzen S., Heeren G., Lievens Y., y van den Bogaert W., *Overview of national guidelines for infrastructure and staffing of radiotherapy, ESTRO-QUARTS: Work package 1*, Radiotherapy and Oncology 75 (2005) 349.e1–349.e6.

Country	Population	LDR man	LDR RCAL	MDR RCAL	HDR RCAL
Colombia	43.8	20	4	4	11
Costa Rica	4.2				2
Cuba	11.3	8			3
Dom. Rep	8.7				
Ecuador	13.1	3	7	1	2
El Salvador	6.5	3	1		
Guatemala	12	8		1	1
Haiti	8.7	0			
Mexico	101.8	62	3	1	5
Nicaragua	5.3			1	
Panama	3	6	1		2
Paraguay	5.8	1	2		
Peru	26.8	20			2
Uruguay	3.4	7	1	1	
Venezuela	25	16	1	1	2
Total	516.7	269	23	11	103

Table 3. Equipment availability in brachytherapy (taken from Ref. 3)

			Simulation		
Country	**Population**	**GNI/cap**	**Conv.**	**CT**	**TPS**
Argentina	38	7737	22	10	28
Bolivia	8.7	1027	2		3
Brazil	175	3147	20	14	50
Chile	15.6	4492	4	5	15
Colombia	43.8	2092	8	5	34
Costa Rica	4.2	3865	2	1	5
Cuba	11.3	2240	3	0	11
Dom. Rep	8.7	2112			
Ecuador	13.1	1103	7	3	12
El Salvador	6.5	2024	1		1
Guatemala	12	1650	1		4
Haiti	8.7	536			
Mexico	101.8	4924	10		20
Nicaragua	5.3	459	1		1
Panama	3	3398	1		4

Country	Population	GNI/cap	Conv.	CT	TPS
Paraguay	5.8	1444	0		2
Peru	26.8	2060	4		5
Uruguay	3.4	6356	2	2	7
Venezuela	25	4312	3	1	9
Total	516.7	3054	91	41	211

Table 4. Simulators and planning systems (taken from Ref. 3)

B — Available human resources (Ref. 3)

Most radiotherapists have been trained within the region: 12 out of 18 countries have 3- to 4-year postgraduate programmes. For the most part, technicians are not trained at universities.

Country	Population	GNI/cap	Centres	Rad Onc	Med Phys	Dosim.	RTTs
Argentina	38	7737	89	130	50	11	264
Bolivia	8.7	1027	6	14	5		18
Brazil	175	3147	151	350	120	0	1500
Chile	15.6	4492	22	48	5		49
Colombia	43.8	2092	38	52	12	23	55
Costa Rica	4.2	3865	3	6	3	6	6
Cuba	11.3	2240	9	37	22	12	47
Dom. Rep	8.7	2112	3	5	3	1	11
Ecuador	13.1	1103	8	10	6		30
El Salvador	6.5	2024	2	6	2		8
Guatemala	12	1650	6	9	5	0	17
Haiti	8.7	536	0	0	0	0	0
Mexico	101.8	4924	75	141	40	0	160
Nicaragua	5.3	459	1	3	3	0	6
Panama	3	3398	3	6	6	7	18
Paraguay	5.8	1444	4	7	5	1	12
Peru	26.8	2060	12	19	9	1	40
Uruguay	3.4	6356	7	24	3	2	28
Venezuela	25	4312	30	66	11	6	57
Total	516.7	3054	469	933	310	59	2326

Table 5. Human resources in Latin America (taken from Ref. 3)

C — Classification of centres according to resources

An example of a model for classifying centres according to their technological infrastructure and human resources was proposed in Ref. 3. The centres are divided into 4 levels and it is concluded that, in Latin America, 51% of centres are level I, 25% are level II, and only 3% are level III. It should be noted that a significant number of centres are level 0 (21%); these do not have a medical physicist and, paradoxically, are to be found mainly in Argentina, Colombia and Venezuela, which have good technology availability as regards accelerators.

Requirements

A — Clinical

Radiotherapy is indicated in a high proportion of the most common cancers in Latin America[6] (Table 6).

Optimal Radiotherapy Utilization Rate by Cancer Type

Tumor type	Proportion of all cancers	Proportion of patients receiving radiotherapy	Patients receiving radiotherapy (% of all cancers)	Reference
Breast	0.13	83	10.8	Delaney et al.[12]
Lung	0.10	76	7.6	Delaney et al.[13]
Melanoma	0.11	23	2.5	Delaney et al.[14]
Prostate	0.12	60	7.2	Delaney et al.[16]
Gynecologic	0.05	35	1.8	Delaney et al.[18,19]
Colon	0.09	14	1.3	Delaney et al.[15]
Rectum	0.05	61	3.1	Delaney et al.[15]
Head and neck	0.04	78	3.1	Delaney et al.[17]
Gall bladder	0.01	13	0.1	Delaney et al.[15]
Liver	0.01	0	0.0	Delaney et al.[15]
Esophageal	0.01	80	0.8	Delaney et al.[15]
Stomach	0.02	68	1.4	Delaney et al.[15]
Pancreas	0.02	57	1.1	Delaney et al.[15]
Lymphoma	0.04	65	2.6	Featherstone et al.[20]
Leukemia	0.03	4	0.1	Featherstone et al.[21]
Myeloma	0.01	38	0.4	Featherstone et al.[21]
Central nervous system	0.02	92	1.8	Delaney et al.[22]
Renal	0.03	27	0.8	Delaney et al.[16]
Bladder	0.03	58	1.7	Delaney et al.[16]
Testis	0.01	49	0.5	Delaney et al.[16]
Thyroid	0.01	10	0.1	Delaney et al.[22]
Unknown primary	0.04	61	2.4	Delaney et al.[22]
Other	0.02	50	1.0	See citations in text
Total	1.00	-	52.3	

Table 6. (taken from Ref. 5)

B — Equipment

According to the data presented in earlier sections, 1111 treatment units are needed in Latin America. The last survey carried out in 2003 (Ref. 3) counted a total of 396 cobalt units and 315 accelerators,

[6] Delaney G., Jacob S., Featherstone C., and Barton M., *The Role of Radiotherapy in Cancer Treatment: Estimating Optimal Utilization from a Review of Evidence-Based Clinical Guidelines,* Cancer 104 (2005) 1129–37.

indicating that there is a shortage of 400 treatment units in the region; this causes waiting lists which go beyond international guidelines, and inequitable treatment.

The number of patients who should be treated per external radiotherapy unit per year (in 12-hour operating shifts) is estimated at 500; this figure could be increased if accelerators with multileaf collimators and/or dynamic wedges were available. However, it should be noted that, in the initial stages, the number of patients treated per hour tends to be lower. The equipment requirements in Latin America are shown in Table 7.

Country	Population	Centres	Cancers	for RT (60%)	Mv needs
Argentina	38	89	102500	61500	123
Bolivia	8.7	6	7000	4200	8
Brazil	175	151	294000	176400	353
Chile	15.6	22	34000	20400	41
Colombia	43.8	38	55500	33300	67
Costa Rica	4.2	3	5200	3120	6
Cuba	11.3	9	25100	15060	30
Dom. Rep	8.7	3	10500	6300	13
Ecuador	13.1	8	17800	10680	21
El Salvador	6.5	2	8000	4800	10
Guatemala	12	6	12300	7380	15
Haiti	8.7	0	9200	5520	11
Mexico	101.8	75	121800	73080	146
Nicaragua	5.3	1	4816	2889.6	6
Panama	3	3	4500	2700	5
Paraguay	5.8	4	4800	2880	6
Peru	26.8	12	29400	17640	35
Uruguay	3.4	7	12400	7440	15
Venezuela	25	30	28600	17160	34
Total	516.7	469	787416	472449.6	945
			Globocan	60%	1/500

Table 7. Teletherapy equipment needed in the region (Ref. 3)

Brachytherapy needs are estimated on the basis that 12% of cancer patients require this procedure (for cancer of the cervix, this number is estimated to be around 70%). It is also assumed that a low-dose rate unit treats 2–3 patients per week and that a high-dose rate unit can treat 6 patients in an 8-hour day.

In Latin America, one brachytherapy unit per centre (470) is needed, which amounts to approximately 400 units, taking into account the fact that use of manual brachytherapy should be replaced by remote units, and that the level 0 centres should be excluded for the time being (as they have no medical physicist).

In addition, each radiotherapy centre should be equipped with at least one conventional simulator and one 2D planner, which means that approximately 500 simulators and/or CAT units, and the same number of planners, are required.

C — Human resources

In accordance with IAEA recommendations[7], one radiotherapist is needed per 250 patients, one medical physicist per 400, and five technicians per unit in two shifts. This results in the needs set out in Table 8.

Country	Population	Centres	Cancers	for RT (60%)	RO needs	MP needs	RTT needs
Argentina	38	89	102500	61500	246	154	615
Bolivia	8.7	6	7000	4200	17	11	42
Brazil	175	151	294000	176400	706	441	1764
Chile	15.6	22	34000	20400	82	51	204
Colombia	43.8	38	55500	33300	133	83	333
Costa Rica	4.2	3	5200	3120	12	8	31
Cuba	11.3	9	25100	15060	60	38	151
Dom. Rep	8.7	3	10500	6300	25	16	63
Ecuador	13.1	8	17800	10680	43	27	107
El Salvador	6.5	2	8000	4800	19	12	48
Guatemala	12	6	12300	7380	30	18	74
Haiti	8.7	0	9200	5520	22	14	55
Mexico	101.8	75	121800	73080	292	183	731
Nicaragua	5.3	1	4816	2889.6	12	7	29
Panama	3	3	4500	2700	11	7	27
Paraguay	5.8	4	4800	2880	12	7	29
Peru	26.8	12	29400	17640	71	44	176
Uruguay	3.4	7	12400	7440	30	19	74
Venezuela	25	30	28600	17160	69	43	172
Total	516.7	469	787416	472449.6	1890	1181	4724

Table 8. Need for radiation oncologists, medical physicists and technicians

Currently, 2 technicians per unit per 6- to 7-hour shift may be recommended, 1 technician per simulator per shift, 1 brachytherapy technician per shift, and 1 technician per mould workshop. Administrative support is important and there should be one administrative assistant per 500 patients to ease the work time burden on health-care staff.

[7] IAEA-TECDOC-1040

D — Education and training

Bearing in mind that, in the region, there has been a rapid increase not only in the quantity of centres and equipment but also in their complexity, the deficit in the number of professionals has been aggravated by the additional need for training related to new demand and greater complexity. At present there are 35 institutions in the region offering training, of which 50% are in Argentina, Brazil and Cuba.

In this connection, we must not lose sight of a phenomenon which is not unique to Latin America, namely multiple employment, i.e. the fact that each radiotherapist and medical physicist works in 2 or 3 institutions simultaneously. Thus, just analysing the number of professionals could give an inaccurate picture of the real situation. The figures assume that each professional works a full working day (8 hours) in the same institution. Thus, the shortage appears less but, since it is the same number of professionals working part time in each centre, this can have a negative impact on treatment quality. In future studies, staff should be calculated using the Full-Time Equivalent (FTE) criterion.

The data in the RSP show that the current number of radiation oncologists only meets 50% of current needs, and the number of medical physicists only 30%.

Furthermore, in order to facilitate cross-accreditation and mobility of professionals, one might suggest that existing leading centres pool their resources with a view to creating a regional cancer education network. This network would, inter alia, seek to harmonize the content of study programmes, adapting them to the specific needs of the region.

3. Medical physics and radiation protection of the patient

Radiotherapy is a complex procedure and over a century of experience in this field has resulted in the establishment of stages, procedures and technological infrastructure without which high-quality treatment is impossible.

According to the recommendations in Report No. 24 (1) of the International Commission on Radiation Units and Measurements (ICRU), an accuracy level of ± 5% is required (in a context where uncertainties were estimated with 95% confidence intervals) for dose delivery to a target volume if the aim was to eradicate the primary tumour. In a modern context, this would correspond to a criterion of ± 2.5%, which is very strict given the complexity of the radiotherapy process (2). This means aiming for a radiotherapy situation where systematic errors in each stage of the process are eliminated and random errors reduced through good techniques and procedures.

Radiotherapy is a form of treatment requiring a highly complex technological infrastructure which usually includes dosimetry systems for characterization and calibration of the radiation beams, simulation systems (conventional, computerized tomography or virtual), computerized planning systems, treatment units (megavoltage and brachytherapy), verification systems and internal networks for managing and transmitting technical and administrative information.

In view of the complexity of the technology involved and the associated risks of patient irradiation (3), the support of a specialized team of staff is needed comprising radiation oncologists, medical physicists, radiotherapy technologists and nurses, and the support of a technical maintenance team responsible for ensuring that the equipment is in good working order.

The quality of radiotherapy treatment is closely linked to clinical factors (diagnosis, tumour localization, selected treatment strategy, ongoing verification and monitoring of the patient) and physical factors (uncertainty in dose calculation, dose optimization and verification, adequacy of dosimetric, calculation, and treatment delivery equipment, inter alia). The level of knowledge and experience of each member of the team will significantly affect treatment quality (2) and patient protection (3).

Data collected by the International Atomic Energy Agency for 18 countries in Latin America with radiotherapy facilities and published in 2004 (4) indicated that there were a total of 710 teletherapy units (MV) for 508 million inhabitants, with an average of 1.37 MV/million within a range of 0.19 to 3.32 MV/million. Since the annual cancer incidence is close to 200 new cases per 100 000 inhabitants (5), approximately 2 MV/million would be required.

The results in publication (4) show that, of the 470 centres studied, more than 21% are level 0 (centres equipped only with a teletherapy unit), 51% are level 1 (centres with teletherapy and brachytherapy units, treatment planning systems, patient immobilization, a radiation oncologist, and at least one part-time medical physicist), 25% are level 2 (centres that also have simulation systems, the ability to make field-specific blocks and a full-time medical physicist), and only 3% are level 3 (with the capacity to offer the patient special techniques such as intensity-modulated radiotherapy, stereotactic radiotherapy and intra-operative radiotherapy).

This indicates that the overall quality of 21% of the radiotherapy centres in Latin America is below the advisable minimum (6) and that these centres do not meet the requirement stipulated by the Basic Safety Standards (BSS) of having an expert qualified in radiotherapy physics. In addition, another 51% of the services should be equipped with simulation systems and have the ability to make field-specific blocks (2), which means that a total of 72% of radiotherapy centres in the region should be improved substantially to enhance radiation protection of the patient.

Another aspect that affects treatment quality is the average age and state of the technology installed. Assessments performed by the IAEA and PAHO have revealed the existence of very low-activity cobalt sources and of old and remanufactured equipment for which maintenance support is inadequate.

The developing countries face various challenges in adopting health-care technologies since the majority of medical devices are designed to be used in industrialized countries. As a result, approximately 30% of the complex equipment remains unused, while that which is in use is out of service for 25% to 35% of the time owing to poor maintenance capacity. One main cause identified is inefficient management of these technologies, including planning, procurement and subsequent operation (7).

As regards human resources, it is recommended there should be one medical physicist specializing in radiotherapy for every 400 new patients per year (8,9). While this recommendation is generally accepted when planning a new radiotherapy service, the current guidelines in European countries (10) set different criteria: in Holland — 1 medical physicist for each linear accelerator and 1 medical physicist for every 650 new patients per year; in Luxemburg — 1 medical physicist for every 600 patients; and in Belgium — 1 medical physicist for every 750 new patients per year (6). However, for the purposes of comparison, it should be pointed out that, according to the information in the DIRAC database, there are 5 medical physicists per 1 million inhabitants in the industrialized countries, while in the Latin America and Caribbean region the figure stands at 0.7.

One of the recognized problems in the region is the shortage of medical physicists — not only in terms of their number but also in terms of their level of education — which can be seen in some countries. According to data published in 2004, from the assessment performed by the International Atomic Energy Agency in 19 countries in Latin America (4), of the 357 medical physicists reported, 241 had a qualification specifically in medical physics (concentrated primarily in Argentina and Brazil). This shows that, in the rest of the region, most physicists working in medicine have been trained while working in hospitals.

This situation is changing thanks to the establishment of postgraduate programmes in radiotherapy physics or medical physics (Argentina, Brazil, Colombia, Cuba, Venezuela and Mexico) and the strengthening of national legislation on certification of radiotherapy services. According to the ARCAL LXXXIII reports, there are 11 postgraduate programmes in medical physics or with a research element in medical physics in the region; however, the number of graduates from these programmes does not meet current needs in the region.

The preliminary results of the survey performed under project ARCAL LXXXIII indicate that around 400 physicists currently work in radiotherapy services, though some 800 are needed given the technical infrastructure and the type of procedures applied.

Given that the number of qualified medical physicists is insufficient or zero in many centres in the region, the BSS requirements relating to calibration, dosimetry and quality assurance in radiotherapy are not being met, to the detriment of radiation protection of the patient.

The incidence of severe exposure of patients (3) globally, and particularly in the region (11,12), indicates that it is due to a lack of properly structured and functional quality assurance programmes. The lessons learned from these accidents reveal faults in the application of procedures (in particular no double verification of treatment time), faults in mechanisms for communication of information between members of the work team, problems relating to inadequate training of staff (particularly in medical physics), lack of patient monitoring and non-compliance with acceptance and commissioning protocols for equipment and calculation programmes (6).

In all cases, the initiating events were related to a physical aspect of the process, demonstrating the urgent need for sufficiently thorough training and clinical education for the region's medical physicists, as well as for rigorous work guided by codes of practice and technical guidelines.

Conventional (basic and specialized) diagnostic radiology, interventional radiology, echography and diagnostic nuclear medicine currently play an essential role in clinical health-care processes (1). These diagnostic imaging services have a broad spectrum of clinical applications, ranging from the diagnosis and monitoring of diseases and situations that are very common and whose incidence is high among the population, such as respiratory diseases, traumatisms, digestive complaints, monitoring of gestation or breast complaints, inter alia, to more complex diseases such as tumour-related diseases, AIDS, disorders of the central nervous system, cardiovascular diseases (2) and tuberculosis.

Access to diagnostic imaging services in the region is not only low but also inequitable. We are awaiting specific data for Latin America in the UNSCEAR report to be published in 2007; however, it is known that access in the region is very limited and that the majority of imaging services are to be found in big cities, while most rural populations and poor urban populations have no access at all (3).

The clinical efficiency of imaging services and patient protection are closely linked to the concept of *optimization* of exposure. When the justification criterion is met, a conscious effort should be made to conduct the diagnostic study in such a way as to obtain the most diagnostic information possible with the least exposure.

The importance of quality assurance for clinical efficiency, cost-effective operation and patient protection in imaging is extensively documented in the developed countries and in the IAEA's Basic Safety Standards (BSS).A multicentre study carried out by PAHO in Argentina, Bolivia, Colombia, Cuba and Mexico showed that a direct link existed between the level of certainty in radiological interpretation and the quality of the radiographic images. At the same time, image quality was directly related to the level of education and training of radiology technicians, among other equipment requirements (4). The conclusions of this study confirm the importance of ongoing education of personnel and the implementation of quality assurance programmes supervised by a medical physicist specializing in imaging.

The shortage of medical physicists in imaging in Latin America is more acute than in radiotherapy. Although exact figures still do not exist, based on the preliminary survey performed for project ARCAL LXXXIII it is estimated that hardly a quarter of the human resources in the region in the medical physics field are working in this area. The establishment of postgraduate programmes which we have seen in the region over the last 10 years provides an incipient opportunity to alleviate this situation since we know that, if not all, at least some of these programmes include diagnostic imaging content and practices.

The preliminary results of the project ARCAL LXXXIII survey show that there are generally several reasons for the shortage of medical physicists: the profession is a relatively new one in the region, there is a lack of legal recognition by health ministries in the majority of countries, the status of physicists in hospitals is low, and in many countries the position does not exist in the classification system of health or labour ministries. The situation is even worse as regards imaging, given the low level of recognition of the role of the physicist in quality assurance and the radiation protection of patients.

In order to help resolve the problems of quality assurance and radiation protection of patients in imaging, the IAEA is promoting the establishment of national regulations and legislation based on the Basic Safety Standards, and is developing training projects on quality assurance, dosimetry in radiodiagnosis and application of codes of practice. The Pan American Health Organization is also promoting and developing training programmes (for radiologists and technologists) and quality assurance programmes aimed at evaluating imaging services in Latin America and the Caribbean with a view to documenting the situation and developing global quality assurance programmes tailored to the regional situation (5).

Project ARCAL LXXV on the determination of guidance levels for conventional and interventional radiography is another example of support initiatives with considerable potential for improving practice and promoting the role of the medical physicist. Whatever the clinical reason for an imaging study, the image quality/dose balance is influenced by the functioning of the imaging system and the performance of the medical and technical personnel conducting the study. Specific guidance levels for the region will provide a valuable point of reference for systematic optimization of the image acquisition chain, a task which is only possible with the advice of medical physicists specializing in imaging.

Accelerated technological development in the design and manufacture of imaging systems in the last ten years has led to the gradual integration in our region of more complex technologies in all types of imaging. One of the challenges this trend poses for the region is the general lack of management and planning processes for the incorporation of technology. This usually results in underuse of imaging systems and — in cases such as digital radiography, multislice helical tomography and fluoroscopy-guided intervention-systems — in increased risk of unnecessarily high exposure of patients, among whom children are a group of particular concern..

The availability of digital imaging systems (particularly in radiography and digital mammography) also offers the possibility of using teleradiology as a means of remote participation by radiology specialists in order to minimize the problem of access in regions remote from urban centres. This possibility has already been envisaged by PAHO (5). However, in addition to the installation and maintenance difficulties in these regions, the lack of medical physics professionals capable of providing advice and supervision for this type of facility is another factor which makes the implementation of such solutions difficult.

4. Nutrition

A well-fed population is more healthy, has lower fertility and mortality rates, enhanced mental development and cognitive capacity, better education, and is consequently a more productive population, which has an impact on the country's development. However, in Latin America and the Caribbean economic and developmental imbalances have given rise to two realities in the health sphere in the region: **malnutrition owing to excess and malnutrition owing to deficit**. The fight against undernutrition has progressed much more slowly than anticipated. Although the goal of the 1996 World Food Summit was to reduce by half the number of people suffering from food insecurity by 2015, the undernutrition rate went down by only 4 million per year during the 1990s.

The International Food Policy Research Institute estimates that, at this rate, the number of undernourished children under 6 (weight/age = -2SD) will only fall to 150 million in the year 2020, while James et al. (2000) estimate that, if the envisaged goal is to be achieved, the number would have to fall by 22 million per year (James et al., 2000).

Data on causes of death are an approximate indicator of the type of malnutrition present in the population. As obesity increases, so do deaths due to cardiovascular diseases and cancer. Conversely, where infections are the predominant cause of death, undernutrition tends to be high and obesity low. The pattern of mortality in Latin America has been influenced by demographic and epidemiological transition. As the infant mortality and fertility rate falls, the population ages and the level of chronic non-communicable diseases increases. **Currently, chronic non-communicable diseases account for almost two thirds of all deaths**.

A brief description of the main problems in the region is given below:

- In low-income countries, **infant undernutrition and infant mortality** continue to be the greatest problems. In our region, there are 77 million poor people, which is unacceptable in a region that has the highest GDP of the developing nations. Chronic undernutrition affects 16.5% of children under five in the region (8.8 million).

- Currently, there are more than 20 million **children with a low birth weight** in the world and, in Latin America, around one million children are born with a low birth weight. The figures for Latin America may be underestimated since only 50% of births are reported, which probably impacts on poorer communities. This could be avoided if maternal nutrition before and during pregnancy and breastfeeding was adequate.

- **Chronic undernutrition** — i.e. small size for age — produces irreversible effects and is directly linked to extreme poverty. The situation is serious in Central American countries such as Guatemala (46% of children under five in the period 1995–2002), exceeding the averages in Asia, Africa and Honduras (29%) and in Andean countries (Ecuador 27%, Bolivia 26% and Peru 25%). Appropriate intake of food and micronutrients would help solve the problem.

- As fertility decreases, **the population over 65 increases, as does the level of non-communicable diseases**. Latin America is beginning to attach importance to interventions that could prevent the high prevalence of chronic disease risk factors.

- The causes of chronic diseases are multiple: pattern of food consumption, pattern of physical activity and exercise. The current President of the IUNS (International Union of Nutritional Sciences) asserts that these predisposing factors "are transmitted like virtual infectious agents accompanying modern life; they are spread by the mass media and marketing strategies. The displacement of traditional foods from our diets, the increasing consumption of energy-dense and nutrient-poor foods, the explosive increase in the number of motor vehicles, the proliferation of gadgets that save physical work, and the physical inactivity characteristic of work and recreation nowadays are the real vectors of the obesity epidemic affecting us".

– **The strategy on diet and physical activity** approved by the World Health Assembly provides basic guidance; more leadership and political will are required in countries to include the prevention of chronic diseases in primary health-care systems with an integrated focus on life history.

Table 9 shows the change, in absolute values, in various pathologies and risk factors in the region.

Table 9. Percentage change for the main pathologies over the decade 1990–2000.

	1990	**2000**	**Change**
Cardiovascular diseases	9 538	8 617	- 9.7
Ischaemic diseases	**2 733**	**2 928**	**7**
Cerebrovascular diseases	**2 725**	**3 052**	**12**
Cancer	5 375	4 938	- 8.1
Stomach	375	482	**28**
Colon and rectum	258	286	10.9
Breast	469	433	- 7.6
Prostate	163	166	
Diabetes	**1 011**	**2 193**	**46.6**
Nutritional deficiencies	**4 710**	**2 666**	**- 43.4**
Malnutrition	985	1 002	1.7
Iodine deficiency	520	9	
Anaemia	978	4	
Vitamin A deficiency	**1 414**	**1 578**	**11.6**
Diarrhoea	**5 884**	**2 720**	**- 53.8**

Sources: C. J. L. Murray and A. D. López, 1993. The Global Burden of Disease, WHO, 2001.
The World Health Report 2001, Mental Health: New Understanding, New Hope, Geneva.

	1 quintile (poorest)	2quintile	3 quintile	4 quintile	5 quintile (richest)	Ratio Q1/Q5
Brazil	23.2	8.7	5.0	3.9	2.3	10.1
Bolivia	39.2	29.0	22.3	11.1	6.0	6.5
Colombia	23.7	16.7	13.4	7.7	5.9	4.0
Dominican Republic	21.5	10.3	7.8	5.6	2.5	8.6
Peru	45.6	30.8	18.8	9.9	5.2	8.8
Guatemala	64.6	61.6	53.5	33.5	12.1	5.3
Haiti	45.5	33.0	32.3	25.2	12.8	3.6
Paraguay	22.5	19.0	12.5	6.3	3.0	7.5
Nicaragua	38.1	29.1	22.7	13.0	8.3	4.6

Table 10. Relation between poverty and undernutrition

Micronutrient malnutrition and food fortification programmes in the region

– The World Bank estimated that the losses caused by **micronutrient malnutrition** alone account for 5% of gross domestic product, while the economic cost of solving this problem is less than 0.3%, i.e. the cost-benefit ratio is close to 20. Food fortification has proved to be an effective strategy, where the main factors to be considered are the choice of the food to be used as 'carrier' and the correct selection of the compound used as fortifier. Latin America and the Caribbean are world leaders in food fortification.

– **Iron deficiency** may cause an increase in premature births, maternal and foetal mortality, and a decrease in intellectual and psychomotor development.

– **Zinc deficiency** causes significant growth retardation in children, mental lethargy and changes in immune response, inter alia.

Fortification of flour and foods

– **Fortification of foods for mass consumption** (iron, vitamin A, iodine, B-complex) and distribution of micronutrient-rich foods promoted by PAHO in the previous decade are having a significant impact on saving lives and promoting better physical growth and mental development in young children. In this regard, progress has been made in the region in the selection of the best fortifying agents and appropriate carriers, and data on the bioavailability of some foods have also been evaluated.

– Fortification of salt with iodine is widespread in the region, which has reduced levels of endemic goitre.

Fortification of maize flour

– This is done in the Opportunities Programme in Mexico: voluntary fortification of refined common maize flour with vitamins B1 and B2, niacin, folate, iron and zinc. A process has also been developed for the fortification of 'nixtamalized' maize flour (i.e. flour treated with lime), which is being implemented. This programme is one of the few that has been evaluated and optimized in line with the country's nutritional needs.

Fortification of wheat flour

- The majority of countries in Latin America have fortified wheat flour; however, the main problem is that, except in Chile, **no assessment has been made either of the bioavailability of the fortifying agents, or much less of the impact on the specific population at which the fortification is aimed**.

- In Bolivia, since 1996 flour has been fortified with reduced iron together with riboflavin, niacin, folate and folic acid.

- In the Caribbean, all the following countries have fortified wheat flour: Barbados, Belize, Curaçao, Grenada, Guyana, Haiti, Jamaica, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Cuba, Guadalupe, Puerto Rico, the Dominican Republic.

- Central America has a similar formula to all countries in the region, with ferrous fumarate, niacin, riboflavin and folic acid. In Mexico, wheat flour is fortified with riboflavin, niacin, folate and folic acid (El Salvador, Honduras, Nicaragua, Guatemala).

- In South America, practically all countries, with the exception of Uruguay, have fortified wheat flour with iron and riboflavin, niacin, folate and folic acid. In Venezuela, vitamin A is added to the mixture of vitamins and minerals.

- In Chile, all flours, in whatever form, have been fortified since the 1950s with 30 mg/kg of flour, supplied via the complementary food programme. In 1996, this programme was extended to all children between 6 and 18 months, pre-school children and pregnant mothers (milk fortified with ferrous sulphate, zinc, copper and folate). The prevalence of anaemia in children aged between 6 and 18 months fell from 28% to 8% as a result of complementary food fortification programmes.

Special fortification programme for the elderly

A number of options for the food programme have also been created. Golden Years soup for the elderly (Golden Years, Chile) is a food made with cereals and vegetables and enriched with ten vitamins and five minerals (calcium, phosphorus, magnesium, vitamins C and E, zinc, iron, B-complex vitamins and vitamin D). It also has a low sodium content and is cholesterol-free. The impact of this programme is due to be evaluated.

Infectious and contagious diseases. With regard to infectious diseases, approximately 40 million people live in areas where there is a risk of contagion from malaria and dengue, particularly in the tropical and Amazonian zones. However, this issue lies more in the field of epidemiological prevention, though nutrition helps promote better conditions in the host.

Tuberculosis remains a problem in the Caribbean and in Andean zones (over 200 000 cases).

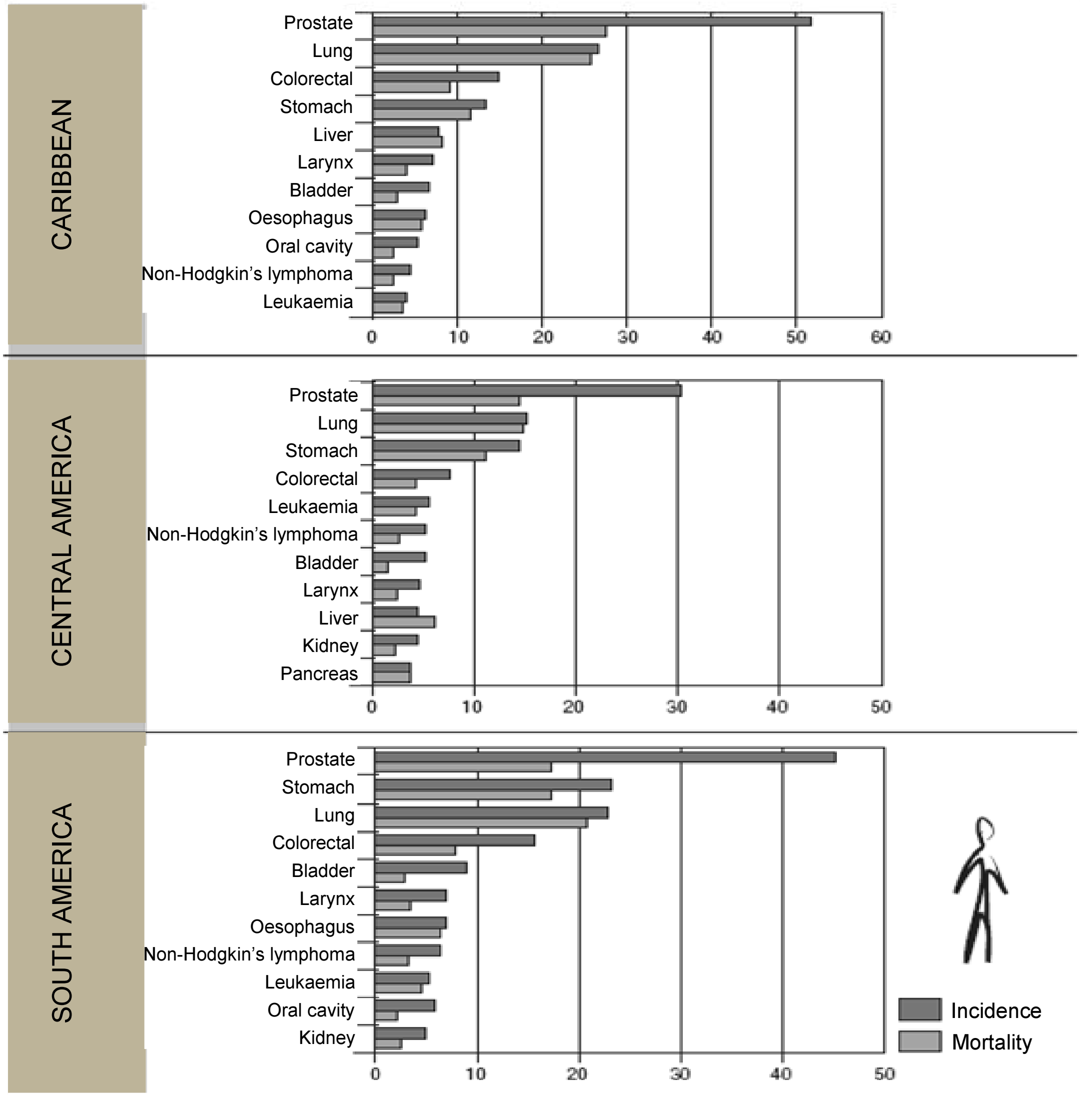
AIDS is a pathology that affects two million people in the region, particularly in the Caribbean where it is an emerging problem; nutrition plays an important role in the recovery of the patient.

Mental health. The number of people in the Americas with mental disorders is expected to increase from 114 million in 1990 to 176 million in 2010. In the year 2000, they accounted for 24% of the disease burden in the region, depression being the main component.

Cancer. This chronic pathology is the second most important cause of death in the region. As of 2002, it was estimated that there were 800 000 new cases and half a million deaths in the region (see

Fig. 3 (Fig. 5) for incidence by cancer type). Diet and nutrition account for 30% of the disease burden. The prevention of cancer is linked to the regular consumption of fruit and vegetables, body weight and an active life. Dietary factors that are negatively associated with cancer are: consumption of salty or smoked foods, consumption of maize kept in damp conditions, alcoholic drinks and fried foods.

Fig. 3. Incidence and mortality for the main cancers in men - rates adjusted for age (standard world population) and expressed in cases per 100 000



Source: Globoscan 2002

Fig. 5. Cancer epidemiology. Enrique Barrios, Yaima Galan, Helene Sancho–Garr, Graciela Sabini, Jose Miguel Musri.

Millennium Development Goals

The United Nations has set Millennium Development Goals (MDGs) that should be attained by the year 2015. These goals constitute a set of agreed priorities to focus the international community's development efforts.

- To eradicate extreme poverty and hunger
- To achieve universal primary education
- To promote gender equality and empower women
- To reduce child mortality
- To improve maternal health
- To combat HIV/AIDS, malaria and other diseases
- To ensure environmental sustainability
- To develop a global partnership for development

Latin America and the countries of the Caribbean have the highest GDP per capita of all developing regions, as well as the highest life expectancy at birth (70 years). The shift from undernutrition to chronic non-communicable diseases has been very rapid, resulting in excessively high health-care costs in the region. This shift has also resulted in an increased coexistence of undernutrition and chronic diseases (Guatemala, Bolivia, Brazil, Peru, Mexico). In many countries, mortality rates have fallen before birth rates, in some cases by two or more decades, with a consequent increase in population (3% or more per year).

Latin America produces enough food, on average, to meet the energy and protein needs of the entire world population. However, 53 million people have insufficient access to food. The reason for this is that the highest population quintile takes 50% of products of animal origin, while the lowest quintile has access to less than 10%. What is more, 40% of global grain production is destined for animal feed, and the meat produced is used for human consumption.

Environment. The Global Burden of Disease (Harvard University Press, 1996), based on work on the global disease burden, suggests that premature death and disease due to **major environmental threats** to health account for one fifth of the disease burden in the developing world — which is comparable to undernutrition and more than all other avoidable risk factors and causal groups of disease. By contrast, these threats account for less than 5% of the disease burden in rich countries, despite much higher levels of urbanization, industrial development and energy consumption, which are generally associated with environmental pollution and health problems.

Importance of the use of nuclear technology to solve nutritional problems in the region.

Stable isotopes are safe and sensitive enough for the diagnosis of risk factors or nutritional problems prevalent in the region. They therefore constitute the reference methodology for evaluating:

- Excess body fat and appropriate fat-free mass;
- Appropriate energy requirements;
- Nutrient absorption (carbohydrates, fats and proteins);
- Bioavailability of iron, zinc and copper in fortified foods;

– Volume of breast milk transferred to the baby;

– Contamination with *Helicobacter Pylori*;

– Pathology of the digestive system;

– Level of physical activity.

Radioactive isotopes. One example of the use of this type of isotope is in the evaluation of the impact of foods fortified with iron, which procedures are usually performed on adults and are adapted — if necessary — for children using stable isotopes. The advantage is that radioactive isotopes are cheap and are measured using scintillation counters, which lowers the costs considerably. Furthermore, there is no ICP-MS equipment in the region to measure metal tracers, or that has been fitted out for this purpose.

It is hoped that Mexico will buy a unit of this kind.

Laboratories in the region

1. Applications of nuclear techniques in nutrition, through ARCAL projects (RLA/7/008, RLA/6/052), ARCAL Designated Centre: the Institute of Nutrition and Food Technology is contributing through IRMS analysis and training of professionals in the field of isotope applications for all of the above-mentioned problems.

2. IRMS laboratories in Brazil and Mexico that specialize in nutrition studies.

3. Infrared spectroscopy laboratories to verify carbon-13 concentration in Bolivia, Cuba and Mexico. These units are cheaper ($25 000) and easy to operate.

Application of nuclear techniques in the region

There is a stable isotope applications network that originated in an excellent course on isotopes in nutrition which was held in Lima in 1997, with the participation of the world's best specialists in the field, and was organized by the Nutritional and Health-related Environmental Studies Section at the IAEA. This network presents the results of ARCAL projects at all Latin American Nutrition Congresses, which has helped raise awareness of the advantages and applicability of this methodology.

Final comments

The description of proposed needs helps focus efforts on tackling the problems that are most prevalent in the region, and involving the countries in most difficulties. Another point to be borne in mind is that nutritional problems cannot be solved with one project only; they need to be addressed on a global level over time if the main risk factors and pathologies in the region are to be eradicated effectively.

5. Nuclear molecular biology – Infectious diseases

Introduction

Emerging infectious diseases are a cause for concern at global level. The agents causing infections in humans have increased in incidence or are expected to do so in the near future. The emergence of infectious agents can be due to the appearance and dissemination of a new agent, the recognition of an infectious disease which had so far passed unnoticed, or the discovery that a known disease has an infectious agent as its aetiology. The term emerging can also be used to describe the reappearance (or re-emergence) of a known infection which increases in incidence from very low levels achieved in the past.

Infectious diseases are a significant health problem in Latin America. Many infectious agents are emerging or re-emerging every year, increasing the region's economic problems and infecting a population already suffering from other social factors. Many efforts are being made at the initiative of the international community to control this problem, but ecological, social and economic factors are having an impact on the persistence of such diseases as malaria, leishmaniasis, HIV, dengue, Chagas' disease, hantavirosis, hepatitis A and many others. A further coordinated effort should be made to improve the state of public health in Latin America.

Analysis of the problems and needs that may arise in a regional context

Environmental and climate changes have created conditions conducive to the proliferation of the mosquito *Aedes aegypti*, vector of dengue and yellow fever. In 1946, eradication of the mosquito *A. aegypti* began following the 1st Meeting of the Directing Council of PAHO, and a hemispheric-scale programme was launched to combat yellow fever. By 1958, ten countries had eradicated the mosquito and by 1970 eighteen countries on the continent and several Caribbean island nations had managed to eradicate it. Later on, efforts waned and this was coupled with an improvement in the conditions for reproduction of the mosquito as a result of climate change. These factors facilitated reinfestation by the mosquito which, by 1998, had spread, leading to new cases of dengue across the whole continent by 2007. In 1996, PAHO called for the preparation of national plans to expand and intensify efforts to eradicate the mosquito, but this did not have the same effect as the previous campaign. One possible reason for this failure is that the social, economic and environmental situation is not the same as it was 50 years ago in Latin America, and this is affecting the results of the programmed activities. Additional activities will need to be undertaken to improve detection of the patients affected and to identify disease reservoirs. The IAEA is already contributing to these activities through a regional project (RLA/6/050 – BOL, BRA, ECU, PAN, PER and URU) and a national project (PAN/6/010), thanks to which reference laboratories have been installed, staff trained and the materials needed to begin activities supplied. However, the efforts undertaken in the region need to be better coordinated with other international organizations and this should be a major objective in the years to come.

Natural reservoirs and asymptomatic patients are a significant factor in the spread of vectors or infectious agents. In the case of the parasite which causes malaria, asymptomatic infected patients are capable of infecting new mosquitoes, promoting the spread of the disease. In the specific case of the malaria parasite, asymptomatic infected patients in contact with the mosquito vector are significant factors in the persistence of the disease in the region. Molecular techniques improve detection of such cases, allowing for their timely treatment and reducing the chances of infection of new mosquitoes feeding on the blood of these patients.

It is also necessary to be prepared from a strategic point of view, for the emergence of infectious diseases which could affect the region. In the case of such infectious diseases as SARS (severe acute respiratory syndrome) and avian influenza, there is a need to join forces with other international organizations in order to prepare the region for a possible future outbreak. Setting up reference laboratories for these globally significant diseases is appropriate in the context of regional public health.

Mycobacterium tuberculosis is the causal agent of tuberculosis, a disease which, having been brought under control in the past, has emerged in recent decades and has worsened following the regional economic crisis. According to PAHO, 40 new cases per hour are recorded in Latin America, 352 000 people are infected and 50 000 die from this disease every year. Traditional methods of diagnosis take at least 3 weeks, but the use of molecular methods has reduced this time to 24–48 hours. The polymerase chain reaction (PCR) is a sensitive and specific technique for detecting *M. tuberculosis* for both positive and negative bacillus microscopy samples. This is a particularly important advantage when early diagnosis is essential to establish patient prognosis, or in cases where an organ transplant is involved. Molecular techniques are also useful in the study of *M. tuberculosis* drug resistance. In conventional procedures for detecting resistance, the sample has to be cultured, which takes 4 to 6 weeks, and then the susceptibility to therapeutic drugs is determined, which takes three weeks more. The IAEA has already begun to undertake activities aimed at combating tuberculosis in Africa (regional project RAF/6/025) and this experience could be transferred to Latin America through the establishment of molecular reference laboratories for the diagnosis and study of the disease.

Progress in molecular biology and the extensive availability of methods employing nucleic acids have permitted the development of fast and reliable diagnostic methods, as well as genotyping techniques for infectious agents. Application of these molecular techniques in the study and diagnosis of infectious diseases has increased in the past decade and techniques have even been developed for nucleic acid amplification with isothermal incubation for field work. Developing countries have expressed their need to benefit from the spread of the progress made and from the application of these techniques to solve their own public health problems. The application of molecular methods in medicine facilitates the development of the health interventions needed for control and improved management of human diseases.

PAHO has identified a number of measures to prevent the spread of emerging diseases in Latin America. Some of the actions proposed are listed below:

- Countries should prepare themselves and have a plan to deal with a potential pandemic;
- They should develop instruments and methods for the detection, diagnosis and control of emerging diseases, and prepare a compliance matrix in line with the objectives stipulated at annual meetings;
- They should adopt specific protocols and standardized procedures for the management of information;
- They should encourage performance evaluation with a view to including the public health laboratories of each country in regional networks. Standardized protocols for these methodologies should be implemented in all countries;
- The most important emerging diseases in Latin America, in view of their incidence, the lack of vaccines and their geographical distribution, are dengue, visceral leishmaniasis, malaria, giardiasis, cryptosporidiosis, drug-resistant tuberculosis, drug-resistant *aureus*, influenza, and Chagas' disease for Amazonian countries.

The IAEA has assisted with the introduction and maintenance of molecular techniques for the diagnosis of infectious diseases in many Latin American countries in the past. Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Guatemala, Panama, Peru, Ecuador, Mexico, Venezuela and Uruguay are some of the countries involved in these activities. The projects have united regional efforts in real applied research networks using the approaches proposed for the diagnosis of infectious diseases (PCR coupled with molecular hybridization). The IAEA has also provided the basic infrastructure in terms of equipment for this specific objective to many Latin American laboratories. The end result has been the dissemination of this technique for the diagnosis of various infectious agents.

Quality control and assurance (QA/QC) and good laboratory practices (GLP) have also been included in recent ARCAL projects, as they are essential for the laboratories that issue results on clinical samples. Recognizing the need for a network of molecular diagnosis laboratories for infectious diseases, the IAEA has promoted the implementation of a quality control system in network laboratories over the last three years. One consequence of this project has been the initiation of monitoring of the capacities of participating laboratories as regards the preparation of standardized procedures and quality control standards.

Comparative advantages of nuclear techniques in the diagnosis of infectious diseases

A network for the diagnosis and typification of emerging diseases will need to be established in the near future. In this regard, the methodology to be used will centre around PCR amplification coupled with nuclear molecular hybridization. The analytical specificity of molecular methods depends on the manner in which the probes are aligned with the target molecule relative to other non-specific regions of the nucleic acid sequence. The probes used in the diagnosis of infectious diseases are generally aimed at the detection of microorganisms and there is no cross-hybridization with the human genome; they are therefore adequate for clinical use. On the other hand, the sensitivity of the PCR technique is assured thanks to the exponential amplification of a specific target molecule. The combination of the sensitivity of PCR and the specificity of isotopic molecular hybridization using probes make this method an ideal tool for the diagnosis of infectious diseases.

The combination of these aspects allows the pathogenic organism of interest to be detected, which, in the past, could only be achieved through in vitro culture of the pathogens. Furthermore, since exponential amplification via PCR is catalysed by a simple cyclical biochemical process with each cycle taking only a few minutes, it has become a promising tool to replace culture of the pathogen, where days or weeks are often needed to arrive at a final diagnosis. What is more, pathogens that cannot be propagated in vitro cannot be studied using culture detection.

To sum up, the use of a robust and sensitive technique like the molecular isotopic technique allows results to be obtained that are potentially more accurate in the diagnosis of emerging diseases.

Identification of regional trends in the use of nuclear techniques applied to infectious diseases

Despite the fact that use of ^{32}P has been replaced in a number of laboratories by chemiluminescence and other non-isotopic systems for labelling molecules, isotopic systems are considered robust, reproducible and an alternative with a good cost-benefit ratio for the labelling of DNA molecules. The IAEA has contributed significantly to equipping and training the staff of several molecular isotopic laboratories in at least 14 Latin American countries; some of these, such as those in Panama, Peru, Colombia, Uruguay and Brazil, may be considered leaders in terms of infrastructure for the handling of isotopes.

Description of opportunities for the use of nuclear molecular techniques

The following steps and use of isotopes can be identified within the framework put forward for the projects envisaged: (i) creation of a network of laboratories to evaluate diagnosis of emerging diseases in the region using molecular isotopic techniques; (ii) a set of primers for possible PCR amplification of emerging infectious agents will be distributed to enable national laboratories to prepare for the appearance of the agents identified; (iii) probes will be distributed to increase the sensitivity of the test using isotopic hybridization; (v) standardized protocols (SOP) will be provided and external and internal quality controls; (vi) radiation safety and biosafety manuals will be developed.

Analysis of the regional scope for cooperation using nuclear molecular techniques

a) Transboundary problems

Despite the existence of geographic boundaries, infectious agents and their vectors do not respect such legal borders. Globalization, frequent air transport, migration processes and invasion of recently deforested areas have contributed to the spread of many pathogens in the region. It would be artificial to view health problems as exclusively national and not take into account a regional context. Thus, a regional plan should be implemented to control these diseases.

Malaria is a good example. There are more than 1 000 000 cases of malaria annually in the Americas, caused primarily by *Plasmodium vivax* and *Plasmodium falciparum*. The management and control of malaria depend primarily on medication. The emergence and spread of resistant parasites is a major problem in the region. What is more, control programmes in the Americas are based on timely diagnosis and appropriate treatment of clinical cases of malaria. As a result, asymptomatic infection, which has recently been discovered thanks to the high sensitivity level of molecular methods, could be a significant challenge to be taken into consideration in disease control. Asymptomatic patients who are under the supervision of national control programmes frequently cross borders, promoting change of the genotypes circulating in a given period of time.

b) Value-added conditions for regional cooperation

South-South collaboration is definitely more sustainable as the problems are similar and the diseases the same. Latin American countries often have common objectives as regards public health because of the homogeneity of disease in the region. In this context, advantage can be taken of the different experience of each country involved.

Peru, Panama, Brazil, Mexico, Argentina and Colombia have laboratories with infrastructure linked to the Ministry of Public Health and have premises for the application of molecular isotopic techniques; they could act as technology donors for other less developed countries in the region.

Sustainable operation of equipment

All the equipment needed for the implementation of molecular isotopic techniques has been provided by the IAEA: centrifuge, refrigerator to -20ºC, chromatography equipment, incubators, electrophoresis units, gamma counters, safety hoods, thermocyclers, hybridization ovens, heating blocks, refrigerators to -80ºC, refrigerated centrifuges, spectrophotometer, autoclaves, ultrasonic baths, fraction collectors, balances, ice machines, laminar flow hoods, CO_2 incubator, microscopes, UV transilluminators, gel documentation systems, pH meters, -20ºC bench refrigerators and manual sequencing systems.

Qualified institutions

- Institute for Research in Genetic Engineering and Molecular Biology (INGEBI), Vuelta de Obligado 2490, 1428 Buenos Aires, Argentina.
- Institute for Diagnostic Laboratory Services and Health Research (SELADIS), La Paz, Bolivia.
- Ministry of Health and Sport, National Malaria Programme, La Paz , Bolivia.
- Department of Biochemistry and Molecular Biology, Oswaldo Cruz Institute, Rio de Janeiro, Brazil.
- Institute of Haematology, Valdivia, Chile.
- Department of Biochemistry, Faculty of Medicine, University of Chile, Chile.
- Laboratory of Microbiology and Parasitology, Department of Biological Sciences, University of the Andes, Santa Fe de Bogota, Colombia.
- University of Valle Microbiology Department, Cali, Colombia.
- National Health Institute, Biochemistry Group, Bogota, Colombia.
- National Health Institute, Parasitology Group, Colombia.
- Costa Rican Institute for Research and Training in Nutrition and Health, Tres Ríos, Costa Rica.
- University of Costa Rica (UCR), Health Research Institute (INISA), San José, Costa Rica.
- Ministry of Health, National Service for the Eradication of Malaria, Guayaquil, Ecuador.
- "Leopoldo Izquieta Pérez" National Institute for Hygiene and Tropical Medicine, Quito, Ecuador.
- Directorate of the School of Biological Chemistry, University City, Guatemala.
- Department of Experimental Pathology of the National Polytechnical Institute, Mexico.
- Department of Immunology, Biomedical Research Institute, Mexico.
- Gorgas Memorial Institute for Health Studies, National Health Institute, Lima, Peru.
- Centre for Research and Diagnosis of Tropical Diseases (CIDEP), University of Panama.
- University of the Republic, Faculty of Sciences, Montevideo, Uruguay.
- Ministry of Public Health, Pereira Rossell Children's Hospital, Montevideo, Uruguay.
- Central University of Venezuela (UCV), National Hygiene Institute, Laboratory for Malaria Studies, Caracas, Venezuela.

Existence of regional networks

Local and regional networks have been established among the laboratories participating in projects.

Regionally harmonized and standardized procedures

SOP for amplification of *Plasmodium falciparum* (Malaria).
SOP for amplification of leishmania.
SOP for diagnosis of amoebiasis.
SOP for amplification of the hepatitis B virus.
SOP for amplification of the hepatitis C virus.

Regional projects in the sector in the last 20 years

BRA/7/009	Establishing Reference Centres for Molecular Diagnosis of Communicable Diseases
COL/6/005	Application of DNA Probes for Diagnosis of Malaria
MEX/7/006	Radioactive Probes for Detection of Parasites
PAN/6/006	Use of DNA Probes in Diagnosis of Tropical Diseases
CHI/6/016	DNA Probes in Malignant and Infectious Diseases
COL/6/007	Drug Resistance in Malaria Parasites
RLA/6/026	Diagnosis and Epidemiology of Chagas and Leishmaniasis
RLA/6/039	Screening and Diagnosis of Hepatitis C (ARCAL Xl)
RLA/6/044	Application of Molecular Biology for the Diagnosis of Infectious Diseases (ARCAL LVI)
URU/7/006	Applying Diagnostic Molecular Biology
RLA/6/050	Implementation of a Quality Assurance and Quality Control Network for Molecular Diagnosis of Insect-borne Diseases (ARCAL LXXXII)
RLA/6/055	Use of Molecular and Radioisotope Techniques to Strengthen the Malaria Surveillance and Control Programme

Current capacities that have been strengthened in the region through IAEA technical cooperation in its various forms: national, regional and interregional projects, coordinated research programmes and programmes contributed by governments of ARCAL countries.

The activities undertaken in the region have allowed molecular radioisotopic techniques for amplification of *Plasmodium falciparum* (malaria), leishmania, trypanosomosis, dengue virus, hepatitis B virus and hepatitis C virus, and also diagnosis of amoebiasis, to be strengthened. Typing and subtyping of these infectious agents has also been undertaken.

6. SWOT analysis

6.1. Strengths

1. In some countries the available installed capacity in conventional nuclear medicine and isotopic techniques for nutrition is sufficient to meet demand. In some countries there is installed infrastructure for the production of radionuclides and radiopharmaceuticals. Some PET-cyclotron units have been installed in the region and there are a number of projects to be carried out over the next few years. There are radiotherapy and imaging services with a high technological and

scientific standard, and there has been a gradual significant increase in resources in some countries in the region.

2. Radiotherapy produces high cure rates and has a major impact on survival for some pathologies. Radiotherapy is low in cost by comparison with chemotherapy. Various diagnostic and therapeutic procedures in nuclear medicine have a good cost-benefit ratio. Studies employing nuclear techniques have helped solve problems in the health and nutrition field.

3. In some countries in the region, governments support applications of nuclear techniques in the health field. There is interest from the public and private sector in investing some resources in radiation medicine as a tool to combat prevalent diseases.

4. In many countries, national legislation exists which takes into account the requirement for radiotherapy and imaging services to have a medical physicist, and requirements for quality control and fitting out of services. Currently, many radiotherapy and imaging services are acquiring dosimetry and quality control equipment to comply with regulations.

5. More political and programmatic State support is being seen in terms of investment, resources and training in nuclear applications in the health sector.

6. There are inter-institutional, national and regional agreements in place, resulting in better regional integration. There are national and regional professional societies in the various disciplines in the health sector and functional scientific and strategic support networks.

7. The vast majority of radiotherapy centres take part in dose audits, and studies of guidance dose levels in radiology have been undertaken in some countries. There are studies in the region on the relationship between image quality in radiotherapy, quality control of equipment and diagnostic accuracy.

8. In some countries there are training programmes for medical specialists in imaging (radiology and nuclear medicine) and in radiotherapy and medical physics. The number of academic programmes in medical physics that have a radiotherapy and imaging content has increased and there is a regional standard for curriculum content that is being revised. Currently, an assessment is being made of needs and the incorporation of medical physicists in radiotherapy and imaging diagnosis services in the region.

9. In the region there are university-level training centres offering undergraduate and postgraduate courses in radiochemistry and radiopharmacy.

10. In the region there are centres with the capacity to offer skills improvement programmes (short-stay) and experts in all disciplines relating to applications of radiation in the health sector. National and regional scientific events are held periodically for refresher training, sharing of experience and ongoing education.

11. There is capacity for horizontal cooperation, and cooperation from countries with a higher level of development, for training and for the supply of inputs, including radiopharmaceuticals and reagent kits.

12. There is a designated centre for isotopic applications in nutrition.

13. Nuclear technology provides a reference standard for various types of nutritional assessment throughout the life cycle, particularly in children, pregnant mothers and the elderly.

14. Isotopic techniques have the advantage that they can be used for detection of a nutritional problem, design of the solution, subsequent measurement of the impact and validation of simple indicators — for population monitoring — with comparative advantages vis-à-vis traditional indicators.

15. We share a common language, which facilitates exchange, ongoing training and access to scientific information.

16. There is a network of laboratories for molecular diagnosis of infectious diseases, including a regional quality control programme.

6.2. Weaknesses

1. Inequitable and generally poor access to diagnostic and therapeutic procedures employing radiation.

2. Uneven availability and regional development: in some countries it has run parallel to developed countries from a scientific and technological point of view, while in other countries (those that have greater needs) it is still non-existent.

3. Heterogeneous geographical distribution, with the greatest concentration of technological and human resources in big cities.

4. Inadequate promotion of the benefits of nuclear applications in health among health administrators and professionals, and other sectors of the community.

5. Inadequate evaluation of high-cost national nutritional intervention programmes.

6. Migration of trained human resources in the region to more attractive labour markets, whether abroad or to other specialties within the country of origin.

7. Lack of national policies for the development and implementation of radiotherapy and imaging techniques in some countries in the region.

8. Specialty of applications of nuclear techniques in health practised by uncertified professionals.

9. Limited availability of protocols, particularly clinical protocols, adapted to the situation in the region.

10. Lack of compliance with protocols and quality assurance programmes, and failure to comply with existing regulations.

11. Obsolescence and inadequate maintenance of the technological resources installed in many countries in the region.

12. Shortage of reliable and updated databases.

13. Shortcomings in the management of units, services and departments.

14. Underutilization of technological resources installed in some countries in the region.

15. Lack of standardized programmes for certification of specialists and accreditation of training centres.

16. Shortage of regional reference centres (RRC).

17. Inadequate content on radiation medicine and nutrition in undergraduate courses.

18. Shortage of formal education programmes for professionals in radiotherapy and imaging (doctors, technologists, physicists).

19. Technical staff with minimal training or no formal training.

20. Shortage of medical physicists in imaging services.
21. Lack of acquaintance with, or incorrect interpretation of international standards (BSS)
22. Unevenness in the structure and application of regulations in force.
23. Incidents and accidents that occur during clinical practice are not always reported properly.

6.3. Threats

1. In some countries, national health authorities are not aware of the importance of quality assurance programmes in radiotherapy and imaging for radiation protection of patients and workers.
2. Health service and system administrators underestimate nuclear medicine and radiotherapy procedures as cost-effective tools.
3. A culture of prevention and early diagnosis in oncology and cardiovascular and neurological diseases, inter alia, is still lacking.
4. In some countries in the region, investment in health and research in nuclear techniques in the sector is insufficient and inefficient and this undermines the continuity of the programmes and the motivation of professionals to practice.
5. The lack of administrative and governmental continuity can result in instability in the smooth running of projects.
6. The media exaggerate radiological accidents and incidents, generating a negative perception among the public and government authorities of the benefits of using nuclear techniques.
7. Speculative overpricing by providers of equipment and inputs.
8. Shortcomings in the regulations concerning safety and prevention of accidents for patients receiving radiotherapy and nuclear medicine therapy.
9. Poaching of specialized human resources by other specialties or other regions.

6.4. Opportunities

1. The increase in clinical applications of nuclear techniques, not only for diagnosis and treatment but also for risk stratification, staging, treatment selection, assessment of treatment response and restaging, allows for more cost-effective and rational management of patients.
2. The comparative advantages of diagnostic nuclear techniques in functional and metabolic studies are scientifically recognized.
3. A number of medical specialties have a need for new nuclear medicine diagnostic and therapeutic procedures, including PET, for the management of pathologies prevalent in the region.
4. Cancer, cardiovascular disease, obesity and diabetes, owing to their high incidence and mortality rate, are recognized by the health authorities of countries in the region as serious public health problems.
5. There has been progress, albeit insufficient, as regards the awareness of health authorities of the importance of radiation medicine in diagnostic and therapeutic management of prevalent diseases, and of the need for an adequate technological and staffing environment to provide high-quality services.

6. In some countries in the region there is support for large-scale projects such as the establishment of PET-cyclotron and radiotherapy centres.

7. Gradual progress is taking place as regards provision for nuclear medicine procedures, including PET, by health systems and insurance companies, and new procedures are being included in the list of services provided by health systems.

8. National professional societies in the region have the opportunity to participate in legislative processes and the development of public policies relating to the health sector.

9. International professional societies give ongoing support to national and regional societies as regards training.

10. Access to the international (IAEA-WHO-PAHO) postal dose audit system.

11. The availability of manuals, guides and protocols, etc., developed by regional and international bodies would facilitate their introduction, improving the quality of services.

12. The existence of a database, such as DIRAC, allows for global evaluation of existing resources and thus of regional needs for the management and planning of radiotherapy and imaging services.

13. The introduction of recent technologies in imaging in the region creates a need for medical physicists specializing in clinical practice.

14. There is scope for improving management of nuclear medicine, radiopharmacy and radiotherapy services through audits performed by groups of trained regional experts.

15. Participation in ARCAL projects provides an opportunity to arrange coordinated training programmes in nuclear disciplines, with a view to harmonized training of a critical mass of human resources. The region will shortly have a recommendation from the IAEA on clinical training and education of medical physicists and promotion of the specialty.

16. The possibility of including in biological science courses training in nuclear technologies at undergraduate and postgraduate levels would help promote nuclear techniques.

17. The possibility of training specialists in radiotherapy, medical physics, nuclear medicine, radiopharmacy, molecular biology and nutrition, and technologists, with the support of international organizations, in particular the IAEA and PAHO.

18. Use of the isotopic hybridization technique helps increase detection of asymptomatic cases of malaria that act as reservoirs, contributing to the infection of new mosquitoes; treatment of these cases allows the spread of the disease to be controlled.

III. REGIONAL NEEDS/PROBLEMS AND JUSTIFICATION

GENERAL PROBLEMS

– ***Cardiovascular diseases and cancer are the main causes of death in the region (43%-60%).***

– ***There are shortcomings as regards access, coverage, quality and safety of care in the prevention, diagnosis and treatment of these diseases.***

PROBLEMS SPECIFIC TO THE APPLICATION OF NUCLEAR TECHNIQUES IN HEALTH

1. **Regional deficit in trained human resources in terms of both quantity and quality (medical physicists, technicians, oncological radiotherapists, nuclear medicine specialists, molecular biologists, radiopharmacists and specialists in nuclear applications in nutrition) (S1)**

Justification

- Lack of governmental and institutional incentives for the education and training of these resources.

- Curriculum content varies in existing education programmes which, in many cases, do not meet the minimum requirements to ensure proper professional practice.

- Increasing demand for more specialists and ongoing training programmes for existing human resources in connection with the procurement of new technologies in the region.

- No accreditation of training centres for professionals and specialists which would provide a guarantee that quality parameters are being met: teaching hours, infrastructure, minimum programmes, number of procedures performed, etc.

- Lack of specific content on quality assurance and radiation protection of patients in training programmes for specialized human resources.

- Specialty of applications of nuclear techniques in health practised by uncertified professionals (e.g. radiotherapy of cervical and uterine cancer by a gynaecologist).

- Insufficient training of human resources in the production of cyclotron radiopharmaceuticals labelled with ^{18}F and ^{11}C and in routine procedures such as FDG, to meet demand due to the rapid growth in the use of positron emission tomography (PET).

- In the countries with the greatest nutritional problems, training of human resources in the evaluation and solution of these problems using nuclear techniques is inadequate.

2. **Lack of protocols (mainly clinical) and procedural manuals that have been evaluated, adapted and adopted by the region, for the application of nuclear techniques in human health (S2)**

Justification

- Clinical and epidemiological practices in the region are very heterogeneous;

- There is a lack of adherence to protocols anchored in evidence-based medicine;

- Shortage of procedural manuals tailored to the situation in the region;

- Regional or country-level research projects and tests cannot be validated without shared protocols;

- No culture of working with protocols and procedural guides in medical and laboratory practice; this adversely affects homogeneity of patient care in each service and, at regional level, evaluation of results and the scope for coordinated research projects.

3. **The processes for the technological management of the infrastructure for application of nuclear techniques in human health in the region, including planning, incorporation and sustained operation of new technologies, are generally not implemented in accordance with international requirements (S3)**

Justification

– A major increase in equipment availability in the region is planned in the next few years in view of the high prevalence of cancer and cardiovascular diseases and the proven effectiveness of nuclear technologies in the management of these diseases.

– Taking into account the high costs of incorporating new technology, planning helps optimize investment and ensure adequate and ongoing operation of facilities, and more homogeneous coverage.

– Appropriate planning in all countries would help ensure that the entire population has access to basic radiology services (echography, conventional radiology, mammography), nuclear medicine for basic diagnosis and radiotherapy.

– Data from PAHO show that approximately 30% of complex equipment remains unused and that the installed equipment that is in operation is out of service for 25% to 30% of the time.

– There have been cases in the region of major investment to procure high-cost equipment without prior planning of the human resources needed for its use, and the auxiliary equipment and infrastructure required for its operation, including maintenance.

– The delay in the installation and commissioning of the equipment procured causes problems in terms of patient care.

4. **Lack or non-adoption of quality management systems in many centres in the region** (S4)

Justification

– Practices do not meet minimum quality requirements, making it difficult to ensure uniformity among centres within the same country and in the region.

– Lack of requirements for quality assurance programmes in national legislation in some countries.

– There is a lack of reference centres in various subsectors in the human health area.

– Operation of imaging and radiotherapy facilities without quality assurance programmes compromises the effectiveness of clinical procedures and radiological protection of patients.

– Research projects and tests undertaken without quality assurance programmes lack support for validation of the results obtained.

– Many countries in the region do not have protocols and the minimum infrastructure required for the preparation of reagent kits and radiopharmaceuticals in line with good manufacturing practices, resulting in a total dependence on imported products or the production of products that do not meet minimum quality standards.

– Nuclear medicine, radiotherapy, radiodiagnosis and radiopharmacy practices are not standardized or subject to ongoing quality control. This has a negative impact on patient care. In some centres, these practices are performed by non-specialized doctors or physicists.

– Few services and laboratories in the region are accredited. Accreditation of services and laboratories will help establish quality standards for practices, which helps standardize and improve centres.

5. **<u>Insufficient awareness among national and international decision-makers and in the scientific community about the usefulness and safety of nuclear techniques in preventing and resolving public nutrition problems</u> (S5)**

Justification

– Delay in preventing and resolving serious nutritional problems in the region.

– Difficulty in implementing nutritional assessment projects for children, pregnant women and the elderly, particularly when they are evaluated by ethics committees.

– Mistaken notion of possible side effects of the use of nuclear techniques employing stable isotopes.

– Despite the fact that isotopic methods are reference methods for evaluating body composition, energy requirements, bioavailability of nutrients in food, and in various pathologies, they are still not widely accepted by the community.

6. **<u>Lack of institutionalization of the position and functions of the medical physicist in radiotherapy and imaging services (nuclear medicine and radiology), and to a lesser degree of other professionals associated with medical practices, by health ministries in many countries in the region</u> (S6)**

Justification

– The role of the medical physicist in radiotherapy, radiodiagnosis and nuclear medicine is not recognized by the majority of health and labour authorities in countries in the region.

– The medical physicist is not recognized as a health specialist and the position does not exist in the staffing table of most hospitals in the region. Until now, national and regional professional medical physics societies have not had the necessary interaction with governments to promote recognition.

– In national regulations and manuals dealing with roles in institutions with radiotherapy and imaging services, no clear distinction is made between the roles of the radiotherapy physics or imaging expert and the radiation protection officer. This leads to duplication problems or lack of clarity with respect to roles and competencies.

7. **<u>Limited application of molecular isotopic techniques in the region for the diagnosis of emerging infectious and contagious diseases such as SARS (severe acute respiratory syndrome) and avian influenza, and re-emerging diseases such as dengue, malaria and tuberculosis, and lack of a regional laboratory network</u> (S7)**

Justification

– A regional laboratory network, with staff prepared for rapid response to emerging diseases, is needed to allow implementation of coordinated action and to prevent frequent failures in the process for controlling the agents or vectors of infection. In Latin America, the conditions exist for the establishment of this network, thanks to previous training and the existence of laboratories in various countries.

– The region needs to prepare itself for rapid action in the event of outbreaks of infectious diseases. Molecular monitoring of the arrival of SARS or avian influenza in the region could shorten the response time in the event of an outbreak of the disease.

– The dengue virus and its vector, the *A. aegypti* mosquito, have spread dramatically in the region in recent years. Regional project RLA/6/050 has trained staff in techniques to detect the virus in patients and vectors, facilitating rapid diagnosis and determination of the incidence of infection in the vector.

– Regional project RLA/6/055 identified asymptomatic patients who received treatment. The impact of this procedure will be of relevance for prevalence indicators in the future; this will allow the number of new mosquitoes infected to be reduced, leading in turn to a decrease in the number of new patients infected.

– Detection, using isotopic techniques, of drug resistance of *M. tuberculosis* facilitates early treatment of patients with drug-resistant disease, reducing mortality and morbidity rates.

8. Unequal access in the region to radionuclides, radiopharmaceuticals, reagent kits and stable isotopes for diagnostic and therapeutic procedures in nuclear medicine, nutrition and medicine (S8)

Justification

– Although in some countries in the region there is a high level of development of radiopharmacy activities for the production of radionuclides, reagent kits and radiopharmaceuticals for diagnosis and therapy, other countries do not have the necessary infrastructure for this.

– There are few hospitals with centralized radiopharmacy laboratories.

– The lack of knowledge on the part of some referring doctors of diagnostic and therapeutic nuclear techniques does not generate demand for traditional radiopharmacy.

– Increasing demand for new radiopharmaceuticals and radionuclides for use in diagnostic and therapeutic nuclear medicine procedures.

– Increasing demand for stable isotopes and radionuclides for applications in nutrition and medicine.

9. Insufficient human resources in the region trained in the predictive, preventive and corrective maintenance of laboratory, diagnostic and treatment equipment employing nuclear technology that is many years old (S9)

Justification

– The existing technological resources in the region vary and include equipment that has been in use for a longer time than that recommended by the manufacturers.

– There is a shortage of professionals specializing in the maintenance of laboratory equipment employing nuclear technology and old-generation nuclear medicine equipment, which results in prolonged operational outages and service interruptions.

– Not all centres in the region have the capacity for planned equipment replacement.

– Human resources trained under ARCAL projects for this purpose require generational replacement.

10. **Regional databases on infrastructure in nuclear medicine, radiopharmacy, molecular biology, radiotherapy and radiology, which can assist with planning and investment, are not up to date or do not exist (S10)**

Justification

– Lack of a database on the infrastructure of subsectors such as radiodiagnosis, radiopharmacy and molecular biology.

– International databases exist on radiotherapy and nuclear medicine which, while they have constituted a great step forward in terms of maintaining an overview of the situation in these subsectors, are not regularly updated. Bodies responsible for acquiring and submitting on a regular basis the information required to update these databases have not been identified in each country.

– The availability of up-to-date and ongoing information on infrastructure allows regional resources and needs to be quantified and evaluated, in the light of existing international recommendations, facilitating strategic investment and planning, and optimization of resources.

IV. PRIORITIZATION OF NEEDS/PROBLEMS IN THE SECTOR

These are the attributes which were considered for prioritization, following the selected methodology. More information on the subject may be found in the instalment on the topic in question.

SERIOUSNESS	This is a measure of the degree of severity of the need/problem, taking into account the negative impact of not addressing it.
TIME	This is related to the degree of urgency in addressing the need/problem, its likelihood of worsening and future consequences.
EXTENT	This determines the degree of regional impact of the need/problem, taking into account, for example, the number of countries affected.
RELEVANCE of/for nuclear techniques	On the one hand, this measures to what extent nuclear applications can contribute to addressing/solving the need/problem. On the other hand, it takes account of the extent to which solving the problem has relevance for nuclear applications.
LEVEL OF DIFFICULTY	This measures the degree of difficulty of implementing the solution to the need/problem identified, which can be related to: infrastructure, resources, technology, legislation, intergovernmental commitments, etc.

1. VALUES ASSIGNED TO EACH NEED/PROBLEM

The identified problems/needs are presented in the following Table according to the grade given by the members of the respective sectorial Group, as may be seen under TOTAL.

	NEED/PROBLEM	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	FINAL PRIORITY GRADE
S 1	Regional deficit in trained human resources in terms of both quantity and quality (medical physicists, technicians, oncological radiotherapists, nuclear medicine specialists, molecular biologists, radiopharmacists and specialists in nuclear applications in nutrition).	5.00	4.60	4.00	4.80	**18.40**	2.20	**2.18**	**40.15**
S 2	Lack of protocols (mainly clinical) and procedural manuals that have been evaluated, adapted and adopted by the region, for the application of nuclear techniques in human health.	4.60	4.20	4.40	4.60	**17.80**	2.20	**2.09**	**37.22**
S 5	Insufficient awareness among national and international decision-makers and in the scientific community about the usefulness and safety of nuclear techniques.	4.40	4.15	4.15	4.20	**16.90**	3.00	**1.40**	**23.66**
S 3	The processes for the technological management of the infrastructure for application of nuclear techniques in human health in the region, including planning, incorporation and sustained operation of new technologies, are generally not implemented in accordance with international requirements.	4.60	4.00	4.55	4.55	**17.70**	3.60	**1.26**	**22.37**
S 6	Lack of institutionalization of the position and functions of the medical physicist in radiotherapy and imaging services (nuclear medicine and radiology), and to a lesser degree of other professionals associated with medical practices, by health ministries in many countries in the region.	4.70	4.20	3.70	4.20	**16.80**	3.40	**1.24**	**20.75**
S 8	Unequal access in the region to radionuclides, radiopharmaceuticals, reagent kits and stable isotopes for diagnostic and therapeutic procedures in nuclear medicine, nutrition and medicine.	3.75	3.75	3.80	4.40	**15.70**	3.40	**1.29**	**20.32**
S 9	Insufficient human resources in the region trained in predictive, preventive and corrective maintenance of laboratory, diagnostic and treatment equipment employing nuclear technology that is many years old.	4.00	4.00	3.60	4.00	**15.60**	3.20	**1.25**	**19.50**
S 4	Lack or non-adoption of quality management systems in many centres in the region.	4.80	4.00	4.20	4.00	**17.00**	3.60	**1.11**	**18.89**
S 7	Limited application of molecular isotopic techniques in the region for the diagnosis of infectious and contagious diseases.	3.60	4.20	4.00	4.00	**15.80**	3.40	**1.18**	**18.59**
S 10	Regional databases on infrastructure in nuclear medicine, radiopharmacy, molecular biology, radiotherapy and radiology.	4.00	3.80	4.40	3.00	**15.20**	3.00	**1.00**	**15.20**

2. JUSTIFICATION OF ASSIGNED VALUES

The needs/problems are listed in order of priority based on the values assigned.

HUMAN HEALTH					
NEED	**SERIOUSNESS**	**TIME**	**EXTENT**	**RELEVANCE**	**DIFFICULTY**
S1) Regional deficit in trained human resources in terms of both quantity and quality (medical physicists, technicians, oncological radiotherapists, nuclear medicine specialists, molecular biologists, radiopharmacists and specialists in nuclear applications in nutrition).	The lack of availability and quality of education and training for human resources in all areas of application of nuclear techniques for managing human health has a 100% negative impact on the safety and quality of practices.	Although in the past ten years the number of centres for education and training of specialists in various fields in the region has increased and their graduates are addressing the problem to an extent, this is not enough.	The current coverage of existing education and training programmes in the region is very heterogeneous. Even in more developed countries they do not meet the need, as these are increasing their available technology.	Adequate education and training of human resources requires the existence of reference centres suitably equipped with nuclear technology. Centres with cutting-edge nuclear technology already exist in the region and could have a great impact on solving the problem, but support is required to improve the less developed centres.	Difficulty is low owing to the existence of programmes approved by the competent authorities and the presence in the region of training centres for some specialties, but with limited capacity to receive fellows to provide education and training of the required quality.
S2) Lack of protocols (mainly clinical) and procedural manuals that have been evaluated, adapted and adopted by the region, for the application of nuclear techniques in human health.	The lack of protocols and procedural manuals in human health results in practices and products with an unsatisfactory diagnostic and therapeutic impact, which impairs the cost-benefit ratio and radiation protection of the patient.	The lack or shortage of protocols, combined with the incorporation of new technologies makes the resolution of this issue a matter of even greater urgency.	Independent of the level of development of the sector in the region, this problem is present in all countries and is tending to become chronic.	The application of nuclear techniques in health in line with protocols and procedures improves the quality and homogeneity of public care; their absence leads to a negative impact on morbidity and mortality for the pathologies prevalent in the region.	Difficulty is low owing to the fact that development and/or adaptation of protocols and procedural manuals is easy to achieve; however, for them to be adopted and implemented at regional level requires the collaboration of organizations.
S3) The processes for the technological management of the infrastructure for application of nuclear techniques in human health in the region, including planning, incorporation and sustained operation of new technologies, are generally not implemented in accordance with international requirements.	It is essential to incorporate processes for the technological management of the infrastructure used in human health.	It is necessary in the short to medium term to incorporate these processes in order to improve and ensure optimal use of existing technological resources and those to be installed.	Incorporation and application of technological management is needed in all countries in the region.	Their incorporation allows optimization of investment, ensures adequate and ongoing operability of installations and more homogeneous coverage of public needs.	Difficulty is moderately high since, while it is true that the development of guides, manuals and other reference documents for directors of centres and high-ranking officials in the health sector is reasonably simple to achieve through expert group meetings, their effective use by decision-makers is a rather complex matter.

NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
S4) Lack or non-adoption of quality management systems in many centres in the region.	Significant advances have been made in the region in the dissemination and establishment of infrastructure and implementation of quality assurance systems. However, implementation has been limited, owing in part to the investment required and the need for specialized professionals.		The problem is heterogeneous in the region and among countries. However, global impetus is needed in this area, particularly as regards the legal requirements for the existence and effective implementation of quality assurance systems.	The safe use of nuclear technology requires planning, management, control and safety. Quality management systems, although they are demanding in terms of financial and human resources, are indispensable.The lack of protocols and procedural manuals has a negative impact on morbidity and mortality in the pathologies in which nuclear techniques are indispensable.	Difficulty is high, since the development and implementation of training programmes in quality management systems are relatively easy to carry out, but their adoption and application by users (both public and private regional centres) can be rather difficult.
S5) Insufficient awareness among national and international decision-makers and in the scientific community about the usefulness and safety of nuclear techniques in preventing and resolving public nutrition problems.	Lack of knowledge among decision-makers about the benefit and safety of these techniques has a direct impact on increasing risk factors which directly impact on the diseases prevalent in the region.	The problem needs to be solved in the short term since its persistence has a direct impact on prolonging the nutritional disorder or low efficiency in nutritional interventions.	Though this problem affects the majority of countries in the region, Mexico and Chile have partially solved it thanks to IAEA support.	The problem is highly relevant, because isotopic techniques have the advantage of detecting small changes earlier and more accurately, reducing the cost of a nutritional intervention.	Average difficulty. The tools for public communication and building opinion are relatively well known and health sector professionals have, in general, a high degree of influence in countries in the region.
S6) Lack of institutionalization of the position and functions of the medical physicist in radiotherapy and imaging services (nuclear medicine and radiology), and to a lesser degree of other professionals associated with medical practices, by health ministries in many countries in the region.	The lack of this type of professional leads to the provision of services without appropriate guarantees of patient safety.	The problem needs to be resolved in the short term because of the growing demand for medical physicists in health services.	This problem affects many countries since, while some of them have relevant legislation, it is not always applied.	Medical physicists and other professionals involved in medical practices are the persons responsible for ensuring the safe use of sources and equipment which generates ionizing radiation.	Difficulty is moderately high owing to the lack of awareness of national authorities and hospital and service management of the importance of the functions of medical physicists and other professionals involved in medical practices.

NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
S7) Limited application of molecular isotopic techniques in the region for the diagnosis of emerging infectious and contagious diseases such as SARS and avian influenza, and re-emerging ones such as dengue, malaria and tuberculosis, and lack of a regional laboratory network.	Infectious and contagious diseases are a cause of death in part of Latin America and, along with new pathologies (SARS and avian influenza), pose a high risk of widespread epidemics.	The problem needs to be resolved in the very short term because of the potential risk of pandemics.	This problem affects the entire region.	The problem is highly relevant because isotopic techniques have the advantage of early detection and allow the various strains of viruses and bacteria to be characterized.	Difficulty is moderately high owing to the need for equipment and supply of inputs and materials to the regional laboratory networks of WHO/PAHO and FAO.
S8) Unequal access in the region to radionuclides, radiopharma-ceuticals, reagent kits and stable isotopes for diagnostic and therapeutic procedures in nuclear medicine, nutrition and medicine.	The lack of availability of radionuclides, radiopharma-ceuticals and reagent kits impedes public access to diagnostic and therapeutic methods.	There is a growing demand for new radio-pharmaceuticals and radionuclides for use in diagnostic and therapeutic procedures.	While some countries in the region have a high level of development in radiopharmacy, others do not have the infrastructure needed for it. Few countries in the region have centralized radiopharmacy laboratories.	The use of radionuclides is an indispensable tool for the preparation and application of radiopharmaceuticals for diagnosis and therapy. The stable isotopes used in the evaluation of nutritional parameters in the population are of enormous importance for evaluating metabolic processes, intake of nutrients, etc.	Average to high difficulty. While training of staff is a relatively simple task, import of basic inputs by countries which have less access to them is difficult owing to logistical and customs problems, though, for the most part, they can be obtained in the region's more developed countries.
S9) Insufficient human resources in the region trained in predictive, preventive and corrective maintenance of laboratory, diagnostic and treatment equipment employing nuclear technology that is many years old.	A significant proportion of the technological infrastructure is not operational or is subject to long operational outages, which directly affects services and laboratories.	The problem needs to be solved immediately and permanently to ensure adequate care for the public.	Affects all countries in the region.	These are highly qualified personnel and the lack of them has a direct impact on operation of a major part of the nuclear instrumentation in human health in the region.	Difficulty is moderately high owing to the fact that training and active retention of personnel in these areas is not such an easy task as it might seem at first sight.
S10) Regional databases on infrastructure in nuclear medicine, radiopharmacy, molecular biology, radiotherapy and radiology, which can assist with planning and investment, are not up to date or do not exist.	Existing databases are not up to date and do not have mechanisms for ongoing submission of information by centres and countries. As a result, they are not useful for evaluating the current state of technology, human resources and the quality of laboratory services in the region.	The definition of secure mechanisms for updating databases requires solutions and agreements in the near future. These databases must be functional and useful when quality systems have improved in the region.	There are databases in countries in the region, but there is no updating of international databases.	The use of up-to-date data on the region's infrastructure facilitates coherent planning and strategic and timely management of the region's resources.	Difficulty is average owing to the fact that some databases have already been established and there is the necessary expertise to develop those which are required, but there is a problem with ensuring that the region's institutions give the required priority to the goal of keeping information up to date.

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VI. COMPOSITION OF THE WORKING GROUP

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4. Esperanza Castellanos (**medical physics**) — Colombia
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7. Francisco Rondinelli — strategic planning expert
8. Angelina Díaz — expert with ARCAL experience
9. Sergio Olmos — expert with experience in the BAR and BAR Working Group

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ARCAL

Co-operation Agreement for the Promotion of Nuclear Science
and Technology in Latin America and the Caribbean

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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

Environment in Latin America and the Caribbean in the Light of the RSP

ARCAL

IAEA
International Atomic Energy Agency

PUBLICATIONS RELATED TO THE RSP

To facilitate review of the material generated by the RSP preparation process, it has been published in separate parts covering the following aspects:

Regional Strategic Profile for Latin America and the Caribbean (RSP) 2007–2013
Background, Methodology and Process for the Preparation of the RSP for Latin America and the Caribbean
Food Safety in Latin America and the Caribbean in the Light of the RSP
Human Health in Latin America and the Caribbean in the Light of the RSP
Environment in Latin America and the Caribbean in the Light of the RSP
Energy and Industry in Latin America and the Caribbean in the Light of the RSP
Radiation Safety in Latin America and the Caribbean in the Light of the RSP

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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

ARCAL-IAEA Strategic Alliance

ENVIRONMENT IN LATIN AMERICA AND THE CARIBBEAN IN THE LIGHT OF THE RSP

CONTENTS

REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013
ARCAL-IAEA Strategic Alliance

ENVIRONMENT IN LATIN AMERICA AND THE CARIBBEAN IN THE LIGHT OF THE RSP

I. BACKGROUND AND IMPLEMENTATION OF WORK

Within the framework of the ARCAL-IAEA Strategic Alliance, the signatory countries are identifying, from a regional perspective, priority needs and available resources in the region in the area of environment with a view to addressing common problems which could be solved with the help of nuclear techniques and where efforts are being integrated with those of other international organizations, serving as a basis for the development of cooperation activities among countries in the region, within the framework of the ARCAL agreement.

The three elements — earth, water and air — that make up the planet are interrelated, hence Group 3's decision to regard these three elements of the environment as an integrated whole.

This report aims to describe the environmental conditions in the Latin America and Caribbean region and identify areas for improvement through international cooperation.

A review was conducted of environmental literature and the development trends covered in reports by UNEP and other organizations, plus information provided by the group members. Projects implemented within the framework of ARCAL and the IAEA, via thematic planning and the cooperation programme in Member States, also served as a reference for the applicability of nuclear technology to environmental issues.

Account was also taken of the nine responses received to the survey sent to institutions in the region which are related to the environment theme and reflect the main needs and problems in that area, namely:

- Lack of characterization of environmental matrices, indicators, harmonized procedures, staff and installed capacity;
- Lack of technical training, regulators and authorities;
- Lack of studies assessing the impact of pollutants on health;
- Lack of regional coordination on the development and implementation of projects and on assistance programmes;
- Lack of established environmental priorities at local and regional level and of proper management of transboundary problems.

II. GENERAL ANALYSIS OF THE REGIONAL SITUATION

The Latin America and Caribbean region covers 15% of the planet's surface, has a great topographic and climatic diversity, reflected in a great variety of ecosystems — from tropical forests to cold Andean high plateaux — and major socio-political, cultural and economic differences. Many of the world's ecologically richest ecoregions are in this region, such as the second largest coral reef in the world off the coast of Belize. Land used for agriculture (excluding pasture) occupies 19% of the region's total area and contributes 10% of the countries' GDP; a substantial proportion of the population (30–40%) is involved in this activity (1). Over 77% of the population, estimated at approximately 551 million in 2004 and projected to reach 838 million by 2050 (2), live in urban areas and over 43% live in poverty. The region also has the greatest disparity in income distribution in the world: 5% of the population receive 25% of all national income and 10% receive 40% (3).

The Latin America and Caribbean region comprises four subregions (3):

1) The Andean subregion (Bolivia, Colombia, Ecuador, Peru and Venezuela): Covers an area of 4.7 million km^2, comprising 25% of the region, with 230 million hectares of forest, which is 35% of the region's total;

2) The Caribbean subregion (Anguilla, Antigua and Barbuda, Netherlands Antilles, Bahamas, Barbados, Cayman Islands, Cuba, Dominica, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, Montserrat, Puerto Rico, Saint Vincent and the Grenadines, Saint Martin, Saint Lucia, Saint Kitts and Nevis, Turks and Caicos, Trinidad and Tobago, British Virgin Islands and United States Virgin Islands): The islands are a wide variety of sizes, from Anguilla at 91 km^2 to Cuba at 110 860 km^2, and have a broad diversity of marine coastal habitats (coral reefs, seaweed meadows, mangrove swamps, marshes and rocky coasts;

3) The Central American subregion (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama) and Mexico: Has an area of 2.5 million km^2 and is the bridge between North and South America. Has a broad biodiversity, extensive chains of mountains and mangrove swamps, and 8000 km of coast;

4) The Southern Cone subregion (Argentina, Brazil, Chile, Paraguay and Uruguay): Has an area of 12.6 million km^2, a highly varied topography and 629 million hectares of forest. Has the lowest population density in the region and the highest rate of urbanization.

The Latin America and Caribbean region's greatest environmental problems are as follows.

1. Use, availability and pollution of water resources

The Latin America and Caribbean region has one third of the world's renewable water resources, which should ideally meet the demand of its population which comprises 9% of the world population. It has tropical and subtropical ecosystems producing a significant volume of water; hence it has major river systems which are used for water supplies, electricity generation, transport, recharging aquifers, and as a source of food resources via the products obtained from these major rivers and tributaries. The region has the largest pluvial system in the world, the Amazon, which is 7.5 million km^2 in extent and which, together with other pluvial systems such as the Paraná-Plata and the Orinoco, carries more than 30% of the planet's fresh water to the Atlantic Ocean (1). More than 70% of the region's hydrographic basins are shared by two or more countries. 60% of the territory of South America is made up of transboundary basins.

Moreover, the region has a significant volume of groundwater resources which are intensively used by some countries. The Guaraní aquifer deserves to be highlighted as one of the largest bodies of groundwater in the world, 1200 km^2 in extent, with an average thickness of 300 metres, and located in Brazil, Paraguay, Uruguay and Argentina.

Groundwater sources depend on precipitation, which varies in the region from very high levels in the jungle, at over 1000 mm per month in the rainy season, to insignificant levels in the arid zones. In deforested areas, aquifer recharge is not effective.

40% of the population live in areas that have 10% of the potable water (5), since water resources in the Latin America and Caribbean region are poorly distributed. In forested areas such as the Amazon, where the population density is low, recharge is high and there is less demand in terms of consumption, thus resources are abundant; in arid and semi-arid areas, such as the north of Mexico, which have a high population density, resources are scarce (6).

Furthermore, 7% of the urban population and 39% of the rural population do not have access to potable drinking water and 60% of urban and rural homes lack a regular water supply and are heavily dependent on groundwater (6). 13% of the urban population and 52% of the rural population do not have access to sanitation services (7, 12) and only 5% of sewage from cities receives any kind of treatment, so waste water is a source of pollution for water sources and soils. Indeed, ECLAC (1999), cited by San Martin (8), states that the main sources of surface water pollution in the Latin America and Caribbean region are municipal discharges and industrial effluents, so the main problems are around major cities. This pollution also affects groundwater.

Management of potable water — particularly in coastal aquifers — and waste water is a problem for many cities. The intensive and uncontrolled extraction of groundwater seriously affects the delicate saltwater/freshwater balance, causing changes in flow patterns, a drop in water tables, saltwater intrusion and leaching of pollutants. Regular landslides in urban areas caused by filtration of run-off water, waste water or poorly drained local rainfall, are now commonplace. Saltwater intrusion is reported in Argentina, Uruguay, the Caribbean islands and coastal cities in Central and South America. The aquifers on the Pacific coast are small and subject to intensive use owing to tourism in particular.

Although the demand for water is intensive in the food, chemicals and textile industries, water consumption in agriculture accounts for over 70% of the total extracted, so agricultural production exerts an extraordinary pressure on water resources (7). In March 2006, the World Water Forum reported that around 70% of water extracted in the region is used for irrigation, livestock production and aquaculture and most of it (64%) comes from surface water sources (7, 12). Uncontrolled agricultural use is a problem, since it leads to pollution of surface water and groundwater by pesticide residues from run-off and leaching of these residues from soils. These come from aerial applications and/or evaporation of these products and their transport by wind, and from unauthorized uses such as illegal fishing or washing of equipment used for applications in rivers and streams (9, 10). Other pollutants, such as fertilizers, metals, hydrocarbons and pollutants from industry and mining, including POPs, are found in water and sediments (11).

Water resources in Latin America are also intensively used as a source of energy in hydroelectric and geothermal power generation. Water as a source of electricity generation makes a very significant contribution to national and regional development and hydroelectric power in the region has a potential amounting to 22% of world output (700 000 MW). Currently, hydroelectric power sources produce between 64% and 70% (~153 000 MW) of energy consumed (8), offering all the benefits of 'clean' energy and available via regional and interregional connections; however, it also causes environmental problems.

Paraguay, Brazil, Argentina, Uruguay and Venezuela have major hydraulic structures, including the largest in the world: the Itaipú hydroelectric power plant between Paraguay and Brazil and the Guri hydroelectric power plant in Venezuela.

These large dams and their reservoirs are subject to both climate variation and climate change, which may affect the reservoirs' regulation and storage capacity and, consequently, reduce the volume which may be used for electricity generation, drinking water supplies and flood control, causing frequent rationing of these basic public services. Large hydraulic structures have a major impact on the environment and can make the downstream populations highly vulnerable, for example through changes in the flow regime of the rivers, higher water tables and, if a dam fails, catastrophic flooding. This justifies characterization of the interrelation of surface water and groundwater, in order to evaluate these effects in a systematic way and ensure better levels of structural and functional safety in hydraulic structures where required. Filtration and leakage of water in large dams must be addressed at the design, construction and operational stages, though these generally have more resources and monitoring than drinking water supply reservoirs.

In addition to this we would add the outdated juridical and institutional frameworks which regulate the management of water resources in countries, and then we can see the seriousness of the situation in the region.

2. Pollution of other environmental compartments and foodstuffs

Since 2003, consumption of agrochemicals in the region has risen significantly by around 30%. In 2004, 14% of the world total was sold and, in 2005, 17% (13), and at least 5% growth is anticipated over the coming years (14). The distribution of consumption of these products in Latin America is as follows: Brazil — 63%, Argentina — 12%, Mexico — 7%, Colombia — 6%, Ecuador — 3%, Chile — 2%, and others — 7%.

Countries in the region are faced with a series of problems related to pesticide residues in food for local consumption and export, though the latter tends to be given greater importance since, in these cases, the hold-up of products in importing countries' ports of entry causes losses of exports and/or markets. For example, in the period November 2004 – October 2005, there were 937 instances of products from the region being held up on account of infringements related to pesticide residues (15). Residues in products for local consumption can affect public health and, in several countries, the percentage of samples containing levels exceeding the legal limits has been found to be high (16, 17).

Persistent organic compounds such as dioxins and furans, DDT, HCB, PCB, pentachlorophenol, etc., are highly persistent toxic compounds of anthropogenic origin that accumulate in human and animal tissue. POPs are widespread in the world, polluting soil and water. Some are volatile and evaporate from the soil and are carried long distances by air currents. Their characteristics enable them to enter the food chain easily. Some of these compounds, such as DDT, were used in past decades for agricultural production in Latin America. Currently, their use in agricultural activities is banned and use of DDT to control malaria is restricted. Studies conducted in Latin America have found POP pollution in soil, vegetation, birds and humans (10). The use of fertilizers causes massive nitrification of soils. The Latin America and Caribbean region consumes 9% of all the world's fertilizers, with an annual growth rate of 4% (18). Salination caused by irrigation practices seriously affects Cuba, Argentina, Mexico, Peru, some areas of north-east Brazil, northern and central Chile, and various parts of Central America (16). Increased agricultural production has intensified use of natural resources in general, and the loss of nutrients caused by intensification of agriculture has led to soil depletion. It is estimated that in South America 628.2 million hectares are depleted (18).

As regards metals, the region's long history of mining has brought with it various and severe environmental problems (19). The majority of mining sites are in Andean countries, so high concentrations of metals in soils and associated problems of pollution affecting the environment and public health are to be expected. By contrast, in certain industrial areas soils are polluted by heavy metals as a result of atmospheric deposition, or by waste rich in metals, fertilizers, pesticides, etc. Unfortunately, there is no complete inventory of these sites, but some examples can be found in Bolivia (Au, Sn, Sb), Brazil (Hg), Chile (Cu, As), Ecuador (As, Cu, Zn, Cd, Hg), Mexico (As, Pb), Peru (Cu, As, Zn, Cd) and Uruguay (Pb) (20). It should be noted that small-scale gold mining has caused serious cyanide pollution in soils and water, and other sites are also polluted owing to the use of copper-based pesticides, e.g. certain areas of Costa Rica.

The Latin America and Caribbean region has 8.6% of the world's population and has two megacities with over 15 million inhabitants (São Paulo and Mexico City), two with more than 10 million and four with a population of over 5 million, and management of the urban environment is one of the greatest environmental threats (5). Urban and population growth and migration from rural areas to cities have caused an explosive increase in the urban population, from 163.9 million in 1970 to 399.2 million in 2001 (5). The increase in energy consumption by industry and for domestic use, and the consequent need to generate more of it, the lack of emission control technology, and traffic are the main causes of atmospheric pollution in urban areas. Combustion processes produce a complex mixture of pollutants, including both primary emissions, such as particulate matter and lead, and atmospheric transformation products, such as ozone and sulphate particles, from fuels with a high sulphur content. This has led to a rise in atmospheric pollution, poorer air quality and associated health problems (21), and many cities in the Latin America and Caribbean region have particulate matter levels which exceed the standards. However, it is not only urban centres which suffer from environmental problems; rural areas are also exposed to anthropogenic and natural emissions, both of local origin and transported over a large distance. Contributions from other sources must also be taken into account, such as agricultural activities, soil erosion, resuspension of urban dust, and natural sources such as marine aerosol and volcanic eruptions, inter alia.

The serious consequences of exposure to high levels of urban air pollution came to light in the mid-20th century when a number of cities in Europe and North America experienced serious pollution episodes. This led to legislation on air pollution and action to reduce it in many regions. However, recent epidemiological studies have identified serious health effects from air pollution caused by combustion processes, even in low concentrations (22). These problems include a wide range of acute and chronic effects that vary depending on the pollutants present. Pollution with particulate matter (e.g. particles small enough to be inhaled into the lungs — PM10 and PM2.5 — and that can contain toxic pollutants such as heavy metals) is consistently and independently associated with the most serious effects, which include lung cancer and cardiorespiratory mortality. Other constituents, such as ozone and lead, are also associated with serious health effects and contribute to the set of diseases attributable to urban environmental pollution. The increase in the concentration of lead in the air is linked to industrial development, in particular the use of petrol with lead additives, though there are other sources that are hard to control such as earthenware or ceramic pottery, piping and paints. According to a list published by The Lead Group http://www.lead.org.au/(23) based on a UNEP document updated to September 2006, all countries in Latin America and the Caribbean have been gradually eliminating leaded fuels. Owing to the differing dates on which this decision was taken, it is likely that in some of them there are still children with a high lead concentration in their blood, not counting those cases of chronic and acute poisoning associated with other sources such as foundries or recycling of batteries.

Studies based on determinations of particulate matter estimate that air pollution causes 5% of cases of cancer of the trachea, bronchi and lungs, 2% of cardiorespiratory mortality and around 1% of mortality from respiratory infections throughout the world, and this occurs predominantly in developing countries (22). The populations of Latin America are exposed to growing levels of air pollution which often exceed those experienced by the industrialized countries in the first half of the 20th century (22). In the region, air pollution is the cause each year of 2.3 million cases of chronic respiratory disease in children and 100 000 cases of chronic bronchitis in adults (21).

The World Health Organization (22) also highlights the importance of pollution in enclosed spaces, in connection with the use of traditional fuels for cooking and heating which emit breathable particles, carbon monoxide, oxides of sulphur and nitrogen and benzene. Between 50% and 75% of the population in certain parts of Latin America are still using solid fuels for cooking and their exposure may be much higher than the ambient (outside) level for highly polluted cities.

Many cities in Latin America have a high population density, a large number of vehicles and heavy industry. These latter two emit — among other pollutants — high levels of particulate matter which cause a deterioration in air quality, respiratory problems and impairment of quality of life, and affect the economy through absence from work and lower productivity. While it is known that lead levels have dropped, in most cases there is not enough information on the presence of other toxic elements. Brazil, Chile and Mexico have good atmospheric aerosol characterization in their major urban centres, São Paulo, Santiago and Mexico City; but this is not generally the case in the other countries in the region. In these cities, the main sources of emissions are traffic and industry, often exceeding the PM10 standard. In the case of Santiago, the concentration of particulate matter and the toxins present in it exhibits a characteristic seasonal variation that makes it difficult to improve atmospheric pollution in absolute terms, despite the existing legislation, though progress has been made in identifying the sources of emissions and in understanding their behaviour in conjunction with meteorological factors. In the case of Mexico City, inventories of atmospheric emissions in the metropolitan area in 1994 revealed annual averages of 451 614 tonnes of total particulate matter and, since 1990, the average annual concentration of total particulate matter in suspension has constantly been above the reference level. In all these cities, an increase has been observed in respiratory problems and mortality associated with air pollution (22). The other countries in the region have insufficient or no information on PM10 or PM2.5 particulate matter composition, or on emissions inventories (22).

In general, the whole region has poor-quality management of solid and liquid waste, both urban and industrial. The amount of rubbish generated per person in the region has doubled. In the Latin America and Caribbean region, some 424 000 tonnes of rubbish are produced per day and less than 35% is disposed of in sanitary landfills (25). Most rubbish is disposed of in open dumps or semi-controlled landfills with no environmental protection or prior treatment (26). Municipal solid waste is made up of organic and recyclable materials, domestic hazardous materials, medical and industrial waste, and construction debris. The effects on public health are clear, in the increased incidence of certain diseases, pollution of soils, water, air, flora and fauna, and disasters such as floods (26). There is very little or no information on the presence of many other pollutants such as hormones, antibiotics, natural radioactive emissions, fuel additives, etc., and their effect on the public and the environment is not quantified.

3. Overexploitation of living resources, including the soil, and modification of habitat and communities

The Latin America and Caribbean region has the largest reserves of cultivable land on the planet; however, the 2000 UNEP report indicates that the region has 16% of all the planet's degraded soils. The causes are indiscriminate logging, overgrazing, expansion of agricultural areas and fires. Deforestation is one of the factors which contributes most to soil erosion and is one of the region's greatest challenges.

The Latin America and Caribbean region has 22% of the world's forests (7), but over the past 30 years it has lost 40% of its tropical forests at an accelerated pace, endangering its biodiversity. The region has 40% of the planet's plant and animal species and it is considered to have the greatest diversity of flora in the world, but habitat destruction is driving many species into extinction. For example, it is estimated that 1244 species of vertebrate are in danger of extinction (6).

In Brazil, even though the government authorities are taking measures to reduce the rate of deforestation, an average of 2.3 million hectares a year have been lost, followed by Mexico with over 600 000 ha a year (6). Over the period 1990–2005, the forested area grew by 11% in the Caribbean and fell by 19% in Central America and 7% in South America. Although the forested area grew in Chile, Costa Rica, Cuba and Uruguay over the same period, it fell from 51% to 47% of the region's total land area (4). In the Caribbean, Cuba, the Dominican Republic and Trinidad and Tobago, an average of 140 to 325 fires a year were reported, with 4000 to 5000 ha/a destroyed by fire from 2000 to 2003 (4).

Deforestation has also caused an increase in the sediment load in rivers, lakes and reservoirs, which is becoming an ever more frequent problem, manifesting itself in the accelerating rate at which sediment accumulates, in a much shorter time than the operating lifetime of the structures which regulate flow for supply, electricity generation and flood control. Biodiversity is also affected. Other equally important factors contributing to soil degradation are: non-sustainable use, loss of organic matter and/or nutrients, salinization, acidification and pollution, with the subsequent danger of desertification (7, 27).

In 2001, agriculture grew by 3% or more; in the case of Argentina, the projections for 2003–2010 indicate that the agricultural area will grow by 16%, and by 9% over the period 2010–2016 (28). The increase in agricultural production brings with it an increase in the use of agrochemicals, fuels and other chemical compounds; all these pollutants eventually reach the soil, which also receives other pollutants not only from agriculture but also from industry, such as metals and POPs. Thus, this not only pollutes the soil but also water sources, causing innumerable problems, including eutrophication. This, coupled with the fact that most countries in the region have no soil use planning, clearly explains the high percentage of degraded soils.

The Latin American coastal zone is 64 000 km long and covers an area of 16 million km^2. For many countries, such as the island nations of the Caribbean, Panama, Costa Rica and others, this territory accounts for over 50% of the total area under the national jurisdiction. Fishing has increased by 600%

in 100 years and 34 of the 51 production systems in the Central Caribbean are at risk of commercial overexploitation of valuable species (4).

In 1995, Latin America accounted for 22% of world shrimp production (29). In Ecuador shrimp mariculture is the third most important export sector, after oil and bananas. In 1994, this sector of industry brought in revenue to the value of US $539 million and employed 260 000 people. Recently, in Chile, substantial progress has been made in mariculture (mainly of salmon and shellfish), spurred on by the existence of attractive export markets and facilitated by environmental conditions favourable to growth (water, temperature, etc.). Shrimp mariculture is acquiring a prominent position in Central America; Honduras, Panama and Nicaragua being the main producers. In 1993, in the south of Honduras some 11 500 ha of mariculture ponds were set up for semi-intensive shrimp mariculture. These fish farms put the shrimp in third place of importance among Honduran exports, after bananas and coffee. Colombia, Mexico and Peru also have a large shrimp mariculture industry. In these countries, as well as in Ecuador and Central America, shrimp mariculture is a catalyst for the transformation of estuaries, lagoons and bays. Over the past 15 years, in Ecuador, Colombia and Honduras alone over 70 000 ha of mangrove swamps have been converted into shrimp lagoons. However, there are growing concerns regarding the negative environmental effects of mariculture, owing principally to habitat loss, eutrophication related to the discharge of effluents, other changes in quality of estuarine waters and the introduction of exotic species. Over the past 20 years, Mexico has lost 65% of its mangrove swamps, while mangrove deforestation rates in Ecuador, Colombia, Guatemala and El Salvador exceed 20%. In a recent regional assessment, 55% of all coastal mangrove swamps in Latin America and the Caribbean were classed as being in a critical state or in danger of extinction, with 30% in the vulnerable category and only 15% in the stable category. Coral reefs near to population centres in the Caribbean, Central America and north-east Brazil show signs of accelerated deterioration owing to sedimentation and other effluents, overfishing, discolouration and disease. Epidemic outbreaks of diseases transmitted by shellfish in 1994 in Peru, Ecuador, Honduras and México are dramatic indicators of the costs of coastal pollution.

Technical Report No. 33 of the UNEP Caribbean regional programme, “Regional overview of land based sources of pollution in the wider Caribbean region”, states that, from point sources of pollution alone, the Caribbean receives 3.8 million tonnes of BOD_5 and 0.4 million tonnes of nutrients, identifying red tides — also known as harmful algal blooms (HABs) — as one of the most serious problems affecting the coastal area.

One of the most significant manifestations of HABs is the production of toxins by certain species of algae that can accumulate in seafood products and constitute a health risk to consumers. The effects on humans range from slight discomfort to long-term debilitating illnesses and even death, from poisoning syndromes described as paralytic, neurotoxic, amnesic and diarrhetic shellfish poisoning and ciguatera fish poisoning.

Harmful algal blooms have a wide range of negative economic impacts which include: the cost of implementing routine monitoring programmes for shellfish and other affected resources; the short-term or permanent cutting off of stocks of harvestable fish and shellfish; reduction in sales of seafood, death of wild and farmed fish, shellfish, underwater vegetation and coral reefs; the impact on tourism and related businesses; and medical treatment for the exposed population.

Losses through individual HAB events are significant and, in areas where the shellfish, fish and mariculture industry is extensive, often exceed $5–10 million per event, the problem being that there has been a significant increase in red tides/HABs in recent decades. Almost all countries with coasts throughout the world are now affected, often by multiple toxic or dangerous species affecting several fishery resources.

The Caribbean region is not exempt from HABs which have increasingly been reported over the past twenty years. The gradual increase in mariculture farms, uncontrolled releases of nutrients into the sea, whether from sewers or industry, and the increased frequency and intensity of hurricanes which bring sediment back into suspension, thereby germinating the cysts of many toxic species, are HAB-related phenomena that should be taken into account for the proper management of HABs.

For example, in Latin America, especially in Chile, recent data indicate that the dinoflagellate *Alexandrium catenella* has moved towards the north of the country where most of the major mariculture producers are located. This dinoflagellate has caused deaths and paralytic poisoning in the southern region. Diarrhetic and amnesic poisoning have been reported in the country, the former caused by dinoflagellates of the genus *Dinophysis* and the latter by diatoms of the genus *Pseudonitzschia* (31).

In Central America, mainly on the Pacific coast, there have been various reports of toxic outbreaks caused by microalgae. Toxic red tides caused by the dinoflagellate *Gymnodinium catenatum* have been associated with paralytic poisoning and death of fish on the west coast of the Gulf of California, Mexico (32). There have been reports of toxicity caused by this dinoflagellate on the coasts of Venezuela.

In 1987, on Guatemala's Pacific coast, there were 26 fatal cases of paralytic poisoning caused by blooms of the dinoflagellate *Pyrodinium bahamense* var. *compressum*, which has also been observed to form blooms on the Mexican coasts (33).

In the Gulf of Mexico, the Mexican east coast has been affected by cases of neurotoxic poisoning caused by the dinoflagellate *Karenia brevis*, which has also been linked to death of fish in that area.

In the Caribbean islands, ciguatera is the main type of poisoning caused by eating certain tropical fish. To date it has been caused by benthic dinoflagellates. This poisoning is a serious problem for tourism, the fishing industry and public health in these countries, cases being estimated to number 50 000 to 500 000 a year on the Caribbean islands and in the Pacific (34).

In addition to HABs caused by dinoflagellates and diatoms, there is evidence of toxic events caused by cyanobacteria. Since 1970, an increase has been observed in blooms of toxic cyanobacteria in the coastal lagoons of the Colombian Caribbean that are probably responsible for the death by poisoning of fish, shellfish, birds, reptiles and domestic mammals (35).

In Latin America, though a basic knowledge of the microalgae species causing toxic outbreaks exists, there is a lack of knowledge of the biology and diversity of toxic species and their complete life cycles, including the formation of cysts in sediments. Moreover, many geographical areas have not been studied sufficiently.

Furthermore, the determination and quantification of microalgal toxins is a problem in Latin America. In the majority of countries in the region there are no experts or analytical instruments for detection of toxins.

4. Global changes most relevant at the regional level

The Latin America region is remarkably heterogeneous as regards climate, ecosystems, distribution of human population and cultural traditions. Changes in land use are the main cause of the trend in ecosystem changes. Complex climatic patterns, which are the result in part of interactions of atmospheric flow with topography, and changes in land use make it difficult to identify common patterns of vulnerability to climate change in the region. Water resources, ecosystems, agriculture, rising sea levels and human health may be viewed as the most important sectors which could be affected by climate change.

Some changes in regional atmospheric circulation have been detected in Latin America. For instance, the South Atlantic anticyclone has intensified. These phenomena may be a sign of changes linked to climate change, if we bear in mind the fact that the region is affected by the El Niño phenomenon and extreme events.

The cryosphere in Latin America, which comprises the high Andean glaciers and three areas of ice in southern South America, may be seriously affected by global warming. It has been reported that the glaciers in Latin America, particularly along the tropical Andes, have receded in recent decades.

Climate change in the region is causing an increase in the number and intensity of tropical storms. It has also been suggested that climate change will lead to conditions more favourable to the appearance of the El Niño phenomenon. In Mexico and on the Caribbean coast of Central America, there is evidence of higher precipitation in winter and lower precipitation in summer, linked to the frequency of the El Niño phenomenon in recent decades.

Latin America contains a large percentage of the world's biodiversity and climate change could accelerate the losses in biodiversity which are already taking place. Some adverse impacts have been observed on species that may be linked to regional changes in the climate. Recent studies show that the changes are affecting small mammals in Central America too.

Over timescales of decades, changes in precipitation and run-off can have significant impacts on mangrove communities. Rising sea levels would eliminate the habitat of the mangrove at an approximate rate of 1% per year. The rate is higher in the Caribbean (around 1.7% per year). This problem is causing a decline in some of the region's fisheries at a similar rate, as most commercial shellfish use the mangroves as nurseries or shelters.

The magnitude of the impact of climate change on health in Latin America depends mainly on the size, density, situation and wealth of the population. It has been established that exposure to heat or cold waves has an influence on mortality in risk groups in the region. The projected rise in temperature in polluted cities, such as Mexico City or Santiago, may have an influence on human health. There is evidence that the geographical distribution of vector-borne diseases (such as malaria and dengue) in Brazil, Colombia, Argentina and Honduras, and infectious diseases (such as cholera and meningitis) in Peru and Cuba, is changing as temperature and precipitation increase.

The economies of Latin American countries could be severely affected by the variability of the natural climate. More than 700 natural disasters were recorded in the region between 1980 and 1998. For instance, in 1998 Hurricane Mitch caused economic losses of around 40% and 70% of gross domestic product (GDP) in Nicaragua and Honduras respectively. Over the past 15 years, climate change has affected over 1.8 million people and caused economic losses of over 8.5 million in countries in the region.

Despite the magnitude of these problems, the region does not have the infrastructure and adequate technical capacity for the research needed to understand these phenomena.

5. SWOT analysis

5.1 Strengths

- **Existence of regional reference centres for the management of some environmental areas:** examples of such centres are the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC), the Pesticides and their Alternatives Action Network for Latin America (RAP-AL), the Basel Convention Coordinating Centre for Training and Technology Transfer in Hazardous Wastes for the Latin America and Caribbean Region.

- **Existence of international conventions and protocols on environmental issues to which countries in the region are parties:** examples of the above include the Basel Convention, the Stockholm Convention, the Regional Seas Programme, and the Environment Ministers Forum.

- **Nuclear techniques are available in the region:** we have laboratories applying environmental and activable radiotracer techniques, various types of spectrometry and nuclear analytical techniques such as NAA, XRF, PIXE and ICP-MS.

- **Accredited laboratories exist, with limited equipment and trained personnel, for the quantification of radiotracers and pollutants in environmental samples:** in line with the IAEA's objective of promoting the peaceful use of nuclear energy and increasing the application of nuclear techniques, following an initial stage of improving regional analytical capacity by providing equipment and training, the Agency assisted with the implementation of quality systems in laboratories working in various fields, including environment, which are essential for mutual recognition of analysis results.

- **The region has experience of and standardized protocols for the application of nuclear techniques in certain environmental areas:** ARCAL projects related to environmental topics are an example of experience in the area and in many cases have resulted in the adoption of harmonized protocols.

- **History of collaboration between groups carrying out research on environmental issues and nuclear techniques:** the ARCAL projects on environmental studies are clear examples of collaboration between laboratories applying nuclear techniques to resolve these issues.

5.2. Weaknesses

- **Marked separation between the institutions which manage the environment and those generating knowledge of nuclear applications:** in addition to the customary lack of knowledge of nuclear technology in the institutional sector, there is very little contact between it and the scientific sector. For improved diagnosis and monitoring of environmental issues and mitigation strategies, better communication is needed between the scientific sector, regulatory agencies and the bodies responsible for devising policy, with more sharing of information and resources.

- **Lack of knowledge of environmental problems in the region:** there is very little scientific information to serve as a basis for understanding the environmental problems affecting the region and their impacts, and thus many efforts tend to address the symptoms rather than the causes of the problems.

- **Lack of or failure to comply with environmental quality standards:** there is a lack of data to substantiate the need to monitor pollution problems and to have proper environmental quality standards. Even where these do exist, no great effort is made to ensure compliance with them.

- **Lack of continuity in policies applied and in efforts made, especially from the government sector:** compared with social problems such as hunger, lack of potable water or communicable diseases, environmental problems such as pollution tend to be regarded as secondary. For effective handling of environmental problems there need to be monitoring networks, reliable regional data and, in the long term, harmonized legislation and policies, political will and intra- and interregional control structures.

- **Little interaction between ARCAL and other agencies of the United Nations system on topics related to environmental protection**

- **Limited promotion of the scope for use of nuclear techniques:** the characteristics of nuclear techniques make them an ideal, and often the only tool for achieving the objectives of environmental studies, but their potential is often restricted to the academic field; there is therefore a need to raise awareness of them among the general public and government departments responsible for the environment.

- **Insufficient personnel trained in environmental issues and application of nuclear techniques to integrated environmental management:** though the region has existing capacity in the area of nuclear techniques, in many cases it is insufficient to cope with the magnitude of the task, or staff need specific training in the application of the technique to environmental studies.

5.3 Threats

- **Migration of qualified personnel, especially in nuclear fields:** there is a need to ensure that qualified personnel stay by improving salaries, opportunities for obtaining research grants, etc., in their fields of work.

- **Negative social perception and lack of understanding of the use of nuclear techniques:** the peaceful uses of atomic energy and applications of nuclear techniques should be better publicized not only among the public but also in government circles.

- **Lack of commitment on the part of governments and institutions to the sustainability of technical assistance projects:** to solve environmental problems, long-term efforts are needed which are not dependent on any political changes that may affect the region.

5.4 Opportunities

- **Existence of global environment programmes:** examples of these are the Millennium Development Goals (MDGs), Agenda 21 and the IAEA environmental challenges.

- **Existence of other United Nations agencies and international institutions interested in the topic:** examples of these are UNEP, UNIDO, GEF, UNESCO/IOC, FAO, WHO, the Inter-American Development Bank, the IAEA and regional agreements such as ARCAL.

- **Environmental problems in the region and problems common to all countries in the area have been identified:** the results of the surveys conducted and the participants' reports, plus the details given in this report on the major environmental issues for Latin America and the Caribbean under the heading Characteristics of the Region, are proof of this.

- **Technical assistance and technology transfer by laboratories associated with the IAEA:** such as the Marine Environment Laboratories in Monaco and the Seibersdorf laboratories in Austria.

- **Institutions that manage the environment are starting to ask for nuclear techniques:** an example is the requirements for biomonitoring of air pollution in connection with certain emission sources using NAA, performed by the Secretariat for Environmental Policy of the Province of Buenos Aires (Argentina).

III. ANALYSIS OF AVAILABLE NUCLEAR TECHNIQUES APPLICABLE TO THE ENVIRONMENT IN THE REGION

The IAEA, mainly through its technical cooperation programme, has helped set up, develop and maintain many laboratories for the application of nuclear techniques in a number of sectors, including environment. This support has taken the form of training opportunities, and provision of technical experts and equipment, establishing a capability to compete with non-nuclear techniques and, in many cases, solving problems that can only be tackled using nuclear techniques. Furthermore, emphasis has been placed on implementing quality systems and adopting international standards such as ISO 17025 (30). Nuclear techniques available in the region include NAA, PIXE, XRF, XRD, ICP-MS, mass and laser spectrometry, gamma and alpha spectrometry and liquid scintillation. The decision was taken to analyse nuclear and isotopic techniques used in environmental problems, grouping them into three activity groups and describing them for each group:

1. Diagnoses and basic studies of the environmental situation in the region;
2. National, regional and global programmes and monitoring networks;
3. Remediation of environmental problems.

1. Diagnoses and basic studies of the environmental situation in the region

- Environmental radiotracers (^{14}C, ^{210}Pb, ^{137}Cs, ^{7}Be, ^{241}Pu) in studies of erosion and sedimentation processes.

- Stable isotopes (O, N, P, S, etc.) in the interpretation of the environment.

- Artificial radionuclides in studies of accumulation processes, losses and the final fate of pollutants in controlled conditions.

- Activable tracers using NAA.

- Nuclear analytical techniques in the determination of sources and dynamics (transport of pollutants over long distances and across borders, and climate change), and in quantification of environmental pollution, as well as in validation of conventional analysis methods, validation of environmental models and as a reference technique.

- Isotopic techniques in hydrology and hydrogeochemistry using ^{18}O, ^{2}H, ^{3}H, ^{13}C, ^{14}C and ^{34}S to validate models, in dating of groundwater and attempts to understand the interaction between surface water and groundwater.

2. National, regional and global programmes and monitoring networks

- Nuclear analytical techniques in the quantification of pollutants to achieve various environmental objectives.

- Isotopic techniques in the determination of recharge and fossil water.

- Nuclear techniques in the determination of toxicity in harmful blooms.

- Field radiometry techniques (ambient radiological background, geology, seismology, etc.).

- Artificial radiotracers in geochemical studies of pollutants and in the search for bioindicators.

3. Remediation of environmental problems

- Radiotracer techniques in the design of effluent treatment systems.

- Isotopic techniques in the leaching dynamics of sanitary landfills and groundwater interrelation.

- Radiosterilization of urban waste.

- Isotopic characterization of hydrographic basins, aquifers, rivers, reservoirs and hydraulic structures in environmental impact studies.

IV. REGIONAL NEEDS/PROBLEMS AND JUSTIFICATION

Following an analysis of the problems mentioned in the progress report submitted by the group, and of the applicability of nuclear techniques to solving them, the following needs were identified:

1. Lack and/or inadequacy of systems for early warning, diagnosis and evaluation of the environmental impact of pollution with pesticides, persistent organic compounds, heavy metals and other pollutants of anthropogenic and natural origin in foodstuffs and environmental matrices at basin level (M1)

Seriousness
Countries in the region are faced with problems related to pesticide residues in food for local consumption and export, exceeding the legal limits in many cases. 17% of the world total of pesticides and over 10% of the world total of fertilizers are sold in the region. A significant proportion of the region's soils are polluted with heavy metals and various polluting compounds are present in water, soils, flora and fauna. Moreover, only 5% of the region's urban and industrial waste water receives any kind of treatment and only 35% of solid waste is managed in sanitary landfills, causing pollution of soils and water sources and affecting human and animal health.

There is not enough information and/or analytical capacity to determine pesticide residues, persistent organic compounds, heavy metals or other pollutants of anthropogenic or natural origin in foodstuffs, or their behaviour in surface water, groundwater and soils and their impact on the human health, flora and fauna.

Time
The problem has existed for some time and is becoming rapidly worse.

Extent
All countries in the region: extensive and inappropriate use of pesticides and fertilizers relative to world levels; high percentage of soils polluted with heavy metals and treatment of a very low percentage of waste water and solid waste.

Relevance
Application of radioisotopes to validate pollutant analysis methods (^{14}C or ^{3}H) in studies of degradation, metabolism and behaviour of pollutants, and in validation of models in soils and plants; use of ^{137}Cs, ^{210}Pb and ^{7}Be to determine the origin of nitrate and phosphate pollution in water deriving from agricultural practices, and of ^{13}C and ^{15}N as indicators in soil studies in connection with activities related to land use. Analysis of heavy metals using nuclear analytical techniques (NAA, XRF, PIXE and ICP-MS). Capacities and expertise exist in the majority of countries in the Latin America and Caribbean region. IAEA thematic plan on river basin management, which is related to this need.

Difficulty
Average owing to the fact that the region lacks sufficient access to advanced technology and/or human resources to quantify these pollutants and has few laboratories that are accredited or have adequate quality assurance and control systems.

2. Inadequate systems for management, protection and knowledge of availability and quality of water resources (M2)

Seriousness:
Latin America and the Caribbean have one third of the world's renewable water resources, which should ideally meet the demand of 9% of the world population. Water consumption in agriculture accounts for over 70% of the total extracted. Water demand in the food, chemicals and textile industries is also intensive.
However, 7% of the urban population and 39% of the rural population do not have access to potable water and 60% of urban and rural houses lack a regular water supply and are highly dependent on groundwater.

Overexploitation of limited water resources causes irreversible damage, such as: falling water tables, saltwater intrusion and leaching of pollutants.

Time
Urgency is high because the problem becomes irreversible and it therefore must be prevented before it arises. Current water demand is high owing to the rising population, which is expected to increase even further in the future. Furthermore, there is serious deforestation in many countries, so recharge is lower there.

Extent
Overexploitation of water is a problem affecting the whole region, especially in densely populated areas where water demand outstrips supply and exploitation causes problems of reduced water levels and saltwater intrusion at the coast.

Relevance:
Mass and laser spectrometry employing ^{18}O, ^{2}H, ^{3}H and ^{14}C provide unique information on the origin, age and interrelation of types of water, recharge and validation of flow and circulation models. IAEA thematic plans on integrated river basin management and isotope hydrology in groundwater applications.

Difficulty
Average owing to the fact that programmes to manage and conserve groundwater resources are limited, especially as regards characterization of available resources, use of a systematic approach to understand flow dynamics, reserves and the impact of extraction. Moreover, there is insufficient integration of water managers and technicians.

3.Lack of regional systems for early prediction and evaluation of the toxicity of harmful algal blooms, via radiotoxicological tests and bioassays (M3)

Seriousness
Aquaculture accounts for 2.2% of the region's GDP and there are losses of US $300 million per year owing to the effect on the human population and loss of marine resources caused by red tide in the region.

Time
Action must be taken urgently since, once the problem has arisen, its negative impact is immediate.

Extent
They affect the majority of the region's countries, e.g. Argentina, Chile, Colombia, Cuba, Haiti, Honduras, Jamaica and Mexico.

Relevance
^{3}H-STX with LSC facilitates early prediction, accuracy and quantification of toxicity in shellfish and fish in a short time and at low cost. IAEA thematic plan on coastal zone management problems reflecting the relevance of nuclear technologies to this type of environmental problem.

Difficulty
High for the implementation of nuclear technology, because of the poor availability of suppliers of the required reagents. Insufficient personnel, technology and infrastructure to quantify the toxicity of blooms and manage them adequately.

4. Limited knowledge of the processes that occur in the coastal area (loss of habitats, transport of pollutants, sedimentation, nutrient cycles, climate changes and effects of the El Niño phenomenon), to establish regional management programmes that reduce its degradation (M4)

Seriousness
Environmental pollution and its negative effects on human health, loss of biodiversity, erosion of beaches and coastlines, overexploitation of marine resources, increased marine aquaculture, dependence on tourism for development, increased maritime transport, and climate change, inter alia, have caused significant deterioration of the coastal area of Latin America, undermining the development of countries in the area. 49% of the GDP of countries in the region is dependent on the coastal zone and the lack of databases, and of knowledge of the environmental processes in these areas, have been identified by UNEP and national environmental authorities in the region as the main limitations on the establishment of integrated coastal zone management programmes.

Time
Degradation of the coastal area is rapidly increasing and urgent action is therefore essential to improve understanding of the phenomena and generate information to solve the problems.

Extent
With the exception of Paraguay and Bolivia, all countries in the region have coastal areas affected by this phenomenon.

Relevance
Isotopic and nuclear techniques have a key role in the reconstruction of ecological databases and in gaining an understanding of how marine ecosystems work. Environmental radiotracers (^{210}Pb, ^{137}Cs, ^{7}Be, ^{239}Pu and ^{226}Ra), stable isotopes and nuclear analytical techniques (XRF, XRD, γ-α spectrometry and mass spectrometry) are techniques that are available, mature and easily transferable to the region. The IAEA thematic plan describes the scope of each of these applications.

Difficulty
High, owing to insufficient technological capacity and trained personnel in the region in the area of nuclear techniques applied to the topic, the high cost of oceanographic monitoring programmes and the high level of cooperation needed between national and regional environmental institutions.

5. Inadequate diagnosis and evaluation of the impact on human health of atmospheric pollution with trace elements in urban and rural areas and in enclosed spaces (M5)

Seriousness
75% of the region's population lives in cities with serious atmospheric pollution problems, caused mainly by rising energy consumption by industry and for domestic use, the lack of emission control technology and traffic. Rural areas are also exposed to anthropogenic and natural emissions. In all cases, the emission sources may be local, regional or transboundary. The deterioration in air quality, increase in health problems, and insufficient information on the chemical profile of atmospheric particulates and their emission sources have an impact on human health.

Time
The deterioration in air quality and its impact on health are becoming more severe and there is a need for reliable information to substantiate the need to monitor pollution problems and establish appropriate standards.

Extent
All countries have rural and urban areas affected by air pollution which causes 2.3 million cases a year of chronic respiratory disease in children and 100 000 cases of acute bronchitis in adults, plus the health problems caused by pollution in enclosed spaces.

Relevance
Nuclear analytical techniques (NAA, PIXE, XRF, ICP-MS) are the only tools for chemical characterization of atmospheric aerosol as they can analyse small samples with very low detection limits. They provide reliable information on the levels of pollutants in particulate matter, facilitating identification of their emission sources, establishment of temporal or spatial trends and transport phenomena, and detection of elements responsible for diseases. IAEA thematic plan on air pollution monitoring.

Difficulty
Average, since, though many countries in the region have the experience, installations and human resources to apply nuclear analytical techniques to atmospheric pollution, distribution thereof is not uniform and there is a need to improve integration between scientific circles and the authorities responsible for environmental management.

6. Inadequate assessment of the hydrological and hydrogeological risk in hydraulic structures and lack of systematic monitoring of sedimentation in the region's artificial and natural water bodies (M6)

Seriousness
Hydroelectric power in the region accounts for 22% of world output, producing between 64% and 70% of the energy consumed. Large hydraulic structures have a major impact on the environment and can make the downstream populations highly vulnerable, for example through changes in the flow regime of the rivers, higher water tables and, if a dam fails, catastrophic flooding. This justifies characterization of the interrelation of surface water and groundwater, in order to evaluate these effects in a systematic way and ensure better levels of structural and functional safety in hydraulic structures.

Time
The vulnerability of populations downstream of dams continues to grow.

Extent:
There are hydraulic structures in all countries in the region. For integrated management of the region's water resources, hydrological, isotopic and environmental databases need to be integrated and expanded to enable relationships to be established with regional phenomena (El Niño, La Niña, ENSO) and their local impacts.

Relevance
Isotopic techniques supply unique information on the origin and age of, and interrelations between water types, which can only be determined by measuring environmental isotopes (^{18}O, ^{2}H, ^{3}H and ^{14}C), so we need to incorporate their use in exploration, design, applied research and standards to ensure better operating and maintenance conditions for hydraulic structures.

Difficulty
Low, since the application of nuclear techniques is usually immediate; the transfer takes place through projects with experts from the region and the necessary analytical capacity exists in the region.

For all specific needs identified and detailed above, it is important to take account of the following common strategies that are regarded as essential:

1. Effective integration among national groups with the capacity to apply nuclear techniques in the environment field and groups, institutions or programmes responsible for environmental management;
2. Greater outreach, promotion and preparation of society with respect to the socio-economic impacts of applying nuclear techniques in the environment field.

Effective mechanisms for integration among the various United Nations agencies and the IAEA in this field.

V. PRIORITIZATION OF NEEDS/PROBLEMS IN THE SECTOR

These are the attributes which were considered for prioritization, following the selected methodology. More information on the subject may be found in the part of the RSP publication on the topic in question.

SERIOUSNESS	This is a measure of the degree of severity of the need/problem, taking into account the negative impact of not addressing it.
TIME	This is related to the degree of urgency in addressing the need/problem, its likelihood of worsening and future consequences.
EXTENT	This determines the degree of regional impact of the need/problem, taking into account, for example, the number of countries affected.
RELEVANCE of/for nuclear techniques	On the one hand, this measures to what extent nuclear applications can contribute to addressing/solving the need/problem. On the other hand, it takes account of the extent to which solving the problem has relevance for nuclear applications.
LEVEL OF DIFFICULTY	This measures the degree of difficulty of implementing the solution to the need/problem identified, which can be related to: infrastructure, resources, technology, legislation, intergovernmental commitments, etc.

1. VALUES ASSIGNED TO EACH NEED/PROBLEM

The identified problems/needs are presented in the following Table according to the grade given by the members of the respective sectorial Group, as may be seen under TOTAL.

	Need / problem	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	Priority grade
M 1	Lack of and/or inadequacy of systems for early warning, diagnosis and evaluation of the environmental impact of pollution with pesticides, persistent organic compounds, heavy metals and other pollutants of anthropogenic and natural origin in foodstuffs and environmental matrices at basin level.	5.00	4.20	4.80	4.20	**18.20**	3.00	**1.40**	**25.48**
M 2	Inadequate systems for management, protection and knowledge of the availability and quality of water resources	4.50	4.50	4.60	4.50	**18.10**	3.67	**1.23**	**22.21**
M 3	Lack of regional systems for early prediction and evaluation of the toxicity of harmful algal blooms, via radiotoxicological tests and bioassays	4.50	4.30	4.20	4.30	**17.30**	4.17	**1.03**	**17.85**

	Need / problem	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	Priority grade
M 4	Limited knowledge of the processes that occur in the coastal area (loss of habitats, transport of pollutants, sedimentation, nutrient cycles, climate change and effects of the El Niño phenomenon), to establish regional management programmes that reduce its degradation	4.20	4.00	4.70	4.00	**16.90**	4.83	**0.83**	**13.99**
M 5	Inadequate diagnosis and evaluation of the impact on human health of atmospheric pollution with trace elements in urban and rural areas and in enclosed spaces	4.20	3.80	4.30	3.80	**16.10**	3.33	**1.14**	**18.35**
M 6	Inadequate assessment of the hydrological and hydrogeological risk in hydraulic structures and lack of systematic monitoring of sedimentation in the region's artificial and natural water bodies	4.20	3.30	3.70	3.30	**14.50**	2.83	**1.16**	**16.89**

2. JUSTIFICATION OF ASSIGNED VALUES

The needs/problems are listed in order of priority based on the values assigned.

ENVIRONMENT					
NEED	**SERIOUSNESS**	**TIME**	**EXTENT**	**RELEVANCE**	**DIFFICULTY**
M1) Lack and/or inadequacy of systems for early warning, diagnosis and evaluation of the environmental impact of pollution with pesticides, persistent organic compounds, heavy metals and other pollutants of anthropogenic and natural origin in foodstuffs and environmental matrices at basin level.	A significant proportion of the region's soils are polluted with heavy metals and various polluting compounds are present in water, soils, flora and fauna. There is not enough information and/or analytical capacity.	The problem has existed for some time and is becoming rapidly worse.	All countries in the region.	Capacities and expertise exist in the majority of countries in the region.	Average owing to the fact that the region lacks sufficient access to advanced technology and/or human resources to quantify these pollutants.

NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
M2) Inadequate systems for management, protection and knowledge of the availability and quality of water resources.	A third of the world's renewable water resources are to be found in Latin America and the Caribbean. Overexploitation of limited water resources causes irreversible damage such as: falling water tables, saltwater intrusion and leaching of pollutants.	Urgency is high because the problem becomes irreversible and it therefore must be prevented before it arises.	Affects the whole region.	Mass and laser spectrometry provide unique information.	Average owing to the fact that programmes to manage and conserve groundwater resources are limited.
M3) Lack of regional systems for early prediction and evaluation of the toxicity of harmful algal blooms, via radiotoxicological tests and bioassays.	Aquaculture accounts for 2.2% of the region's GDP and there are losses of US $300 million per year owing to the effect on the human population and loss of marine resources caused by red tide in the region.	Action must be taken urgently since, once the problem has arisen, its negative impact is immediate.	The majority of the region's countries.	^{3}H-STX with LSC facilitates early prediction.	High for the implementation of nuclear technology, because of the poor availability of suppliers of the required reagents. Insufficient personnel, technology and infrastructure to quantify the toxicity of blooms and manage them adequately.
M4) Limited knowledge of the processes that occur in the coastal area (loss of habitats, transfer of pollutants, sedimentation, nutrient cycles, climate changes and effects of the El Niño phenomenon), to establish regional management programmes that reduce its degradation.	Significant deterioration of the coastal area of Latin America.	Degradation of the coastal area is rapidly increasing and urgent action is therefore essential.	With the exception of Paraguay and Bolivia, all countries in the region have coastal areas affected by this phenomenon.	Isotopic and nuclear techniques have a key role in the reconstruction of ecological databases.	High, owing to insufficient technological capacity and trained personnel in the region.
M5) Inadequate diagnosis and evaluation of the impact on human health of atmospheric pollution with trace elements in urban and rural areas and in enclosed spaces.	75% of the region's population lives in cities with serious atmospheric pollution problems. Rural areas are also exposed to anthropogenic and natural emissions.	The deterioration in air quality and its impact on health are becoming more severe.	All countries have rural and urban areas affected by air pollution.	Nuclear analytical techniques are the only tools for chemical characterization of atmospheric aerosol.	Average, since many countries in the region have the experience, installations and human resources to apply nuclear analytical techniques to atmospheric pollution.
M6) Inadequate assessment of the hydrological and hydrogeological risk in hydraulic structures and lack of systematic monitoring of sedimentation in the region's artificial and natural water bodies.	Large hydraulic structures have a great impact on the environment.	Continues to grow.	All countries in the region.	Isotopic techniques supply unique information.	Low, since the application of nuclear techniques is usually immediate.

VI. CONCLUSIONS: NEED FOR REGIONAL COOPERATION

Many of the problems and needs mentioned, and the strengths, threats, weaknesses and opportunities, affect the whole region. In the case of atmospheric pollution and its impact on health, regional cooperation is needed to attempt to even out the differences in human and financial resources among countries. However, not only must there be the will to collaborate among the scientific groups involved in studies of this type; it is also indispensable to have a firm commitment from the governments of all countries in the region to solving the environmental problems that affect it. To this should be added training of human resources, the existence of agreements and projects at regional level, and access to financing for studies and projects.

Environmental protection and monitoring are priority issues for all Latin American governments and have a bearing on the well-being of present and future generations. Accordingly, information generated by projects on the application of nuclear techniques to environmental studies may be used by national and regional bodies to elaborate legislation and environmental policy, to set emissions limits and environmental quality standards and control pollutant emission, and in areas relating to public health. Though mitigation strategies do exist, such as programmes to restrict vehicular traffic, or others for industry, they often have no proper scientific basis. Therefore, all the countries of Latin America and the Caribbean must endeavour to achieve a better understanding of the situation and use this information to devise appropriate policies. Existing information on future scenarios allows us to understand environmental and development trends and to use them as a starting point for discussion of future IAEA programmes related to the environment in which nuclear technology plays a significant role in complementing and enhancing the programmes of environmental authorities at local, regional or global level.

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ARCAL

Co-operation Agreement for the Promotion of Nuclear Science
and Technology in Latin America and the Caribbean

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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

Energy and Industry in Latin America and the Caribbean in the Light of the RSP

ARCAL

IAEA
International Atomic Energy Agency

PUBLICATIONS RELATED TO THE RSP

To facilitate review of the material generated by the RSP preparation process, it has been published in separate parts covering the following aspects:

Regional Strategic Profile for Latin America and the Caribbean (RSP) 2007–2013
Background, Methodology and Process for the Preparation of the RSP for Latin America and the Caribbean
Food Safety in Latin America and the Caribbean in the Light of the RSP
Human Health in Latin America and the Caribbean in the Light of the RSP
Environment in Latin America and the Caribbean in the Light of the RSP
Energy and Industry in Latin America and the Caribbean in the Light of the RSP
Radiation Safety in Latin America and the Caribbean in the Light of the RSP

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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

ARCAL-IAEA Strategic Alliance

ENERGY AND INDUSTRY IN LATIN AMERICA AND THE CARIBBEAN IN THE LIGHT OF THE RSP

CONTENTS

REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013
ARCAL-IAEA Strategic Alliance

ENERGY AND INDUSTRY IN LATIN AMERICA AND THE CARIBBEAN IN THE LIGHT OF THE RSP

I. BACKGROUND

In carrying out the work, the energy and industry group divided the sector into three subsectors:

- Nuclear power;
- Experimental reactors;
- Applications in industry.

The responses obtained via the survey which was carried out prior to the meeting in March 2007 were considered.

Those elements and factors in each subsector which constitute part of a platform for the undertaking of new growth and progress initiatives were identified as strengths. Aspects related to qualitative and quantitative shortcomings from which each subsector currently suffers were identified as weaknesses. Those current or foreseeable conditions which could be made use of, either because they harmonize with growth and progress prospects or because they trigger such prospects, were identified as opportunities. Conditions which could impede or retard such growth and progress prospects were identified as threats.

II. ANALYSIS OF THE REGIONAL SITUATION

1. Summary of the current situation

The Latin America and Caribbean region comprises 45 countries [1] in an area covering 20.4 million km^2. The population was a little over 550 million as of 2005 and is growing at a rate of 1.3% per year. The gross domestic product of the region is approximately US $2456 thousand million [2]. The annual per capita income (2005) is US $4008. The life expectancy at birth is 72 years. The enrolment rate for primary education is 94.7%.

Primary energy consumption has doubled over 25 years, between 1980 and 2005, reaching a little over 30 EJ [3]. Electricity generation has grown over the same period at a similar rate, reaching 1184 TW·h in 2005, which is 6.5% of global production. The region's electricity is produced mainly by hydroelectric plants (58.37%). Burning of fossil fuels comes in second, contributing 38.31%. Nuclear power is in third position with 2.42%, and renewables make up scarcely 0.9% [1].

The main oil producers are Mexico and Venezuela. The region's production went from 5.8 to 12.7 million barrels per day between 1980 and 2005 [4]. The peak of known reserves was apparently reached in 1997, when they were recorded as amounting to 141 thousand million barrels. As of 2005, they were estimated at 117 thousand million, i.e. a similar level to that estimated in 1985.

As regards natural gas, Mexico, Argentina, Venezuela and Trinidad and Tobago have traditionally been the region's main gas producers. Production has increased by 279% over 25 years. Known reserves apparently began to decline around 1995. The most recent figure (2005) estimates reserves at 7.43×10^{12} m^3, after reaching a peak of 7.88×10^{12} m^3 in 1995. The most significant national increase in known natural gas reserves between 1995 and 2005 was in Bolivia, where they increased by almost 6 times going from 0.13×10^{12} m^3 to 0.74×10^{12} m^3 (Fig. 1) [4].

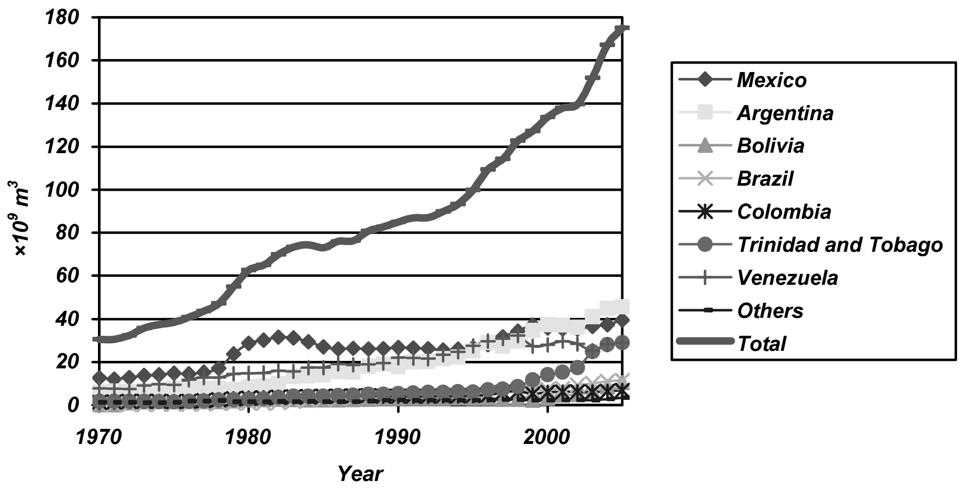

Fig. 1. Natural gas production in the region

As regards CO_2 emissions relative to total energy consumption, though the volume of emissions increased by 25% between 1994 and 2004, from 1140 to 1427 million tonnes of CO_2 (Mt), these figures could still be considered reasonable, since in Europe they are 3.26 times higher, reaching 4635 Mt CO_2 in 2004 (Fig. 2) [3].

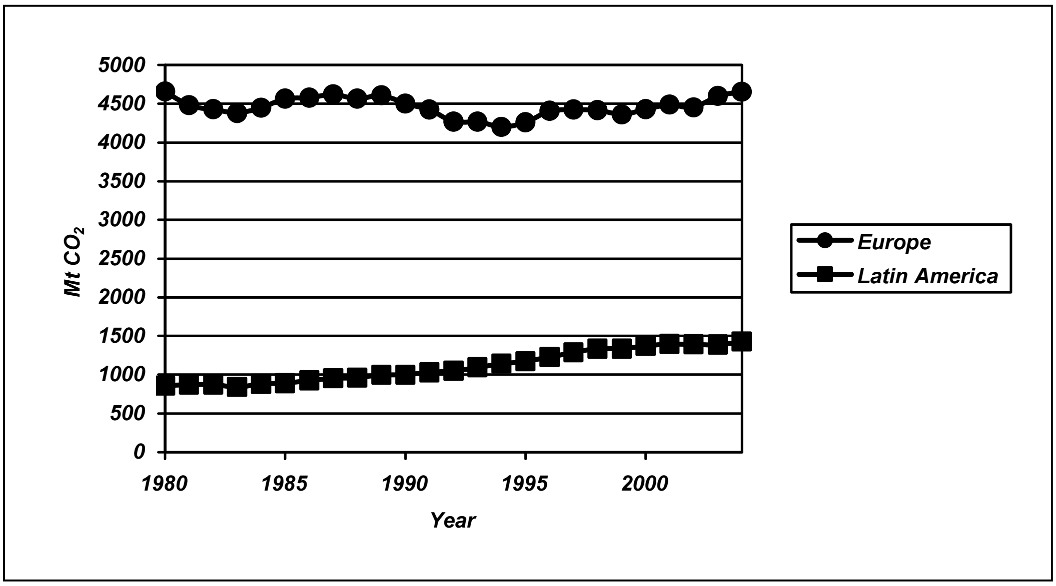

Fig. 2. — CO_2 emissions in the region compared with Europe

Whether in terms of per capita income or in terms of human welfare, energy and, in particular, electricity constitute a platform without which progress is significantly more difficult for a society. The correlation between per capita income and per capita electricity consumption in the region indicates, if compared with a typical European Union country (e.g. Spain), that there is still much to be done to meet the welfare needs of our societies. The average levels for the region in 2003 were US $3300 and 1500 kW·h per year respectively, whereas the corresponding income and consumption values in Spain were US $18 000 and 6000 kW·h, i.e. four times higher than those for the region (Fig. 3) [2].

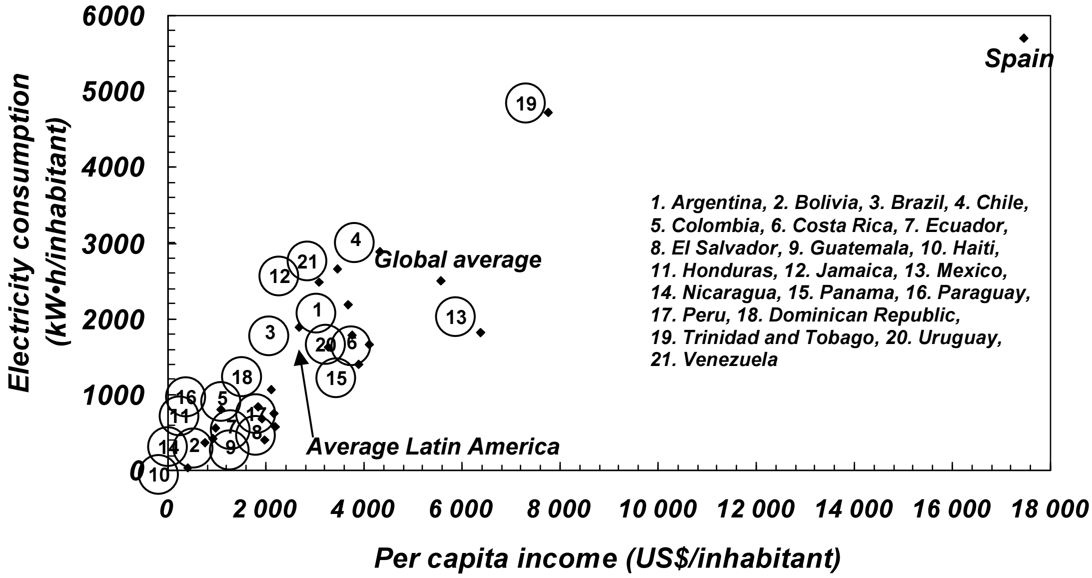

Fig. 3. Electricity consumption relative to per capita income (2003)

An analysis carried out using the human development index reveals a similar situation. This index is used by the United Nations system to measure the welfare of people in different countries of the world and it is made up of fundamental factors affecting quality of life such as health, life expectancy, education and income [6]. That is to say, a high level of electricity consumption per person may correspond with better levels and quality of life, in an equation where the contrary could also be considered to be true.

It is forecast that the region's population will rise to around 720 million by 2030. Growth scenarios suggest that, from having practically the same number of inhabitants in 2000 as European countries belonging to the OECD, by 2030 Latin America will outstrip them by 28%, which poses an enormous challenge for the establishment of the necessary conditions to meet the welfare requirements of such a population size (Fig. 4).

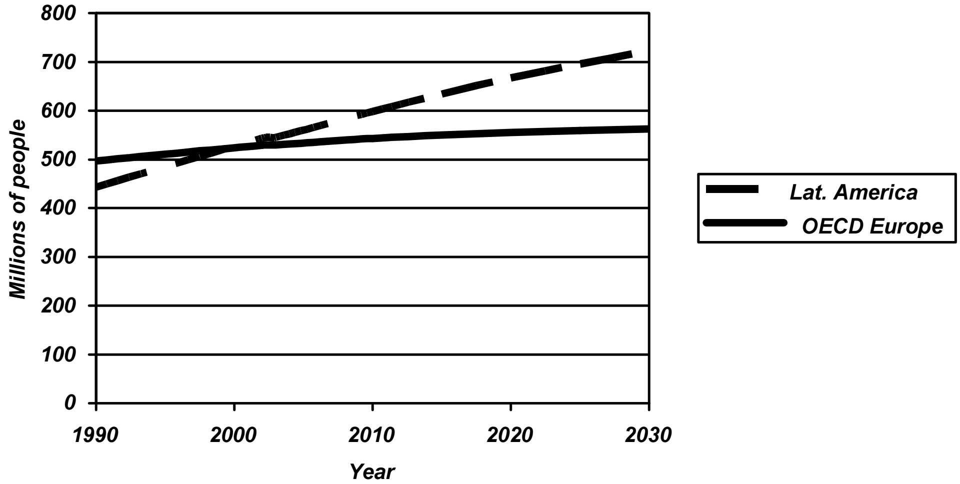

Fig. 4. Population growth scenario

The Energy Information Administration (EIA) of the United States Department of Energy proposes a reference economic growth scenario for Latin America (3.8% sustained annual growth) and low- and high-growth scenarios (2.8% and 4.7% respectively). In the reference scenario, gross domestic product would reach US $11 196 thousand million by 2030, and it would reach $9079 and $13 891 thousand million in the low- and high-growth scenarios respectively by the same year (Fig. 5).

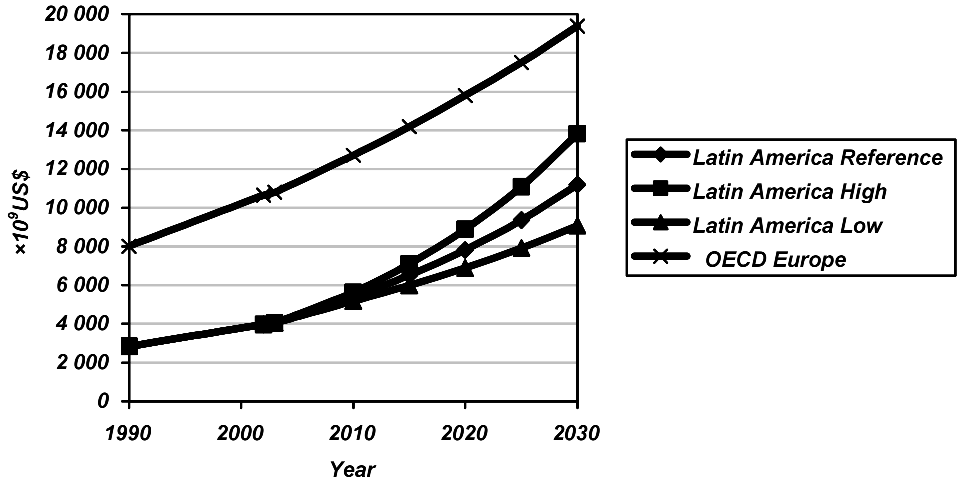

Fig. 5. Gross domestic product growth scenarios for the region, compared with OECD Europe

The corresponding consumption of total primary energy would rise by 2030 to 52.1 EJ (low), 62.1 EJ (reference) and 72.1 EJ (high). Accordingly, electricity consumption would rise to 2108 TW·h (low), 2621 TW·h (reference) and 3313 TW·h (high), which would be double the current level or more. Similarly, as regards CO_2 emissions, the scenarios predict figures of 2294 Mt CO_2 (low), 2680 Mt CO_2 (reference) and 3208 Mt CO_2 (high). The IAEA estimates that installed capacity will rise from the current level of 276 GWe to 485 GWe by 2030 in a low-growth scenario, and to 802 GWe in a high-growth scenario, which confirms the need to expand current capacity by between 75% and 190% over 25 years.

The Latin American region has 22 years' experience in the generation of electricity by nuclear means. Installed nuclear capacity is now at 4171 MWe, distributed among six units in three countries. In Argentina, the share of nuclear power is highest, contributing 6.9% of electricity generated. In Mexico, the share of nuclear power is 5% and in Brazil 3.3%. Argentina is also continuing to build its third reactor, Atucha 2, which will add a further 692 MWe. Almost 26 TW·h were generated in 2005, which is over 2% of all electricity in the region.

As regards the nuclear fuel cycle, Brazil is one of the leading countries where international uranium reserves are concerned. It reported a total of 278 700 tonnes of uranium in 2005, standing in seventh place in the world for this commodity [5]. In the region, Brazil and Argentina have traditionally maintained very high-level nuclear research and development programmes in terms of the resources allocated to them and their development, which has enabled them, among other achievements, to set up nuclear fuel cycle facilities. Argentina has a UF_6 conversion facility and a heavy water production facility, while Brazil has a facility which manufactures fuel elements for light water reactors and a uranium enrichment plant. In the middle of the 1990s, Mexico also succeeded in constructing a pilot fuel fabrication plant, which has been a success as a pilot technology.

The renewed interest in nuclear energy in the world has become very significant in several countries in recent years.

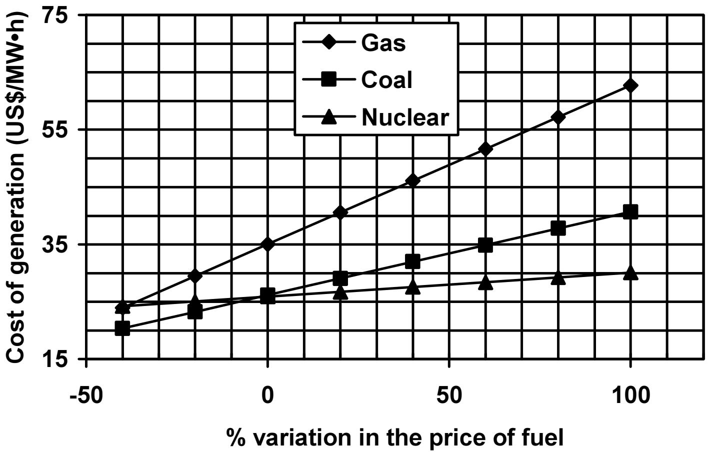

Fig. 6. Sensitivity of the cost of generation to variations in fuel prices for different sources

It should be added that the price of the energy generated is not very sensitive to variations in fuel prices, so even in high-volatility scenarios electricity prices would remain within reasonable margins, which is very different from the case of fossil fuels (Fig. 6).

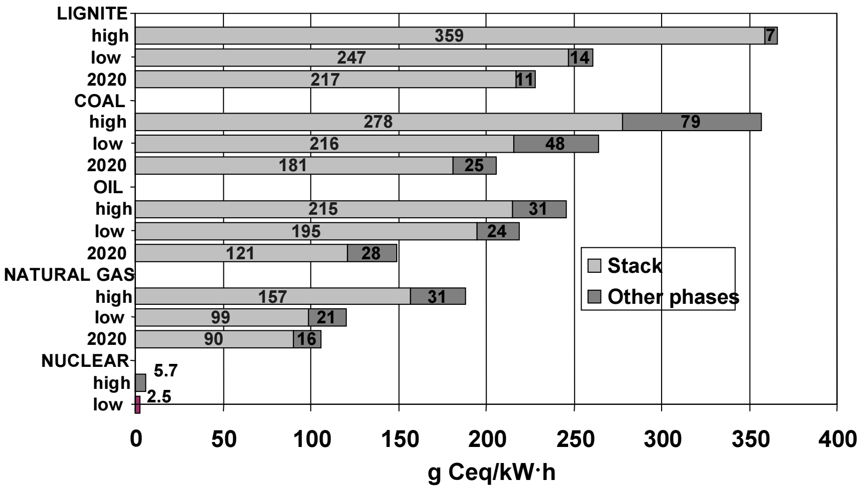

Fig. 7. Greenhouse gas emissions: fossil fuels vs nuclear

In addition, nuclear power plants do not discharge greenhouse gases into the environment during operation and, in the phases before and after generation, the emission values are extremely competitive when compared with those of so-called renewable energy sources, plus they have a very high capacity (i.e. with no interruptions in supply), making nuclear power generation very attractive for base load supply (Fig. 7).

2. Questions to be considered

a. Should the energy problems of Latin America and the Caribbean be considered at regional, subregional or national level? (i.e. should each country establish its own portfolio of energy resources independently, or is it possible to organize regional or subregional networks of countries which would analyse and resolve aspects of energy security jointly?)

b. Can the existing portfolio of resources stay as it is, either in each country or in the region, to meet future electricity demand, or will it be necessary to consider changes?

c. Could the environmental issue be important in addressing the region's energy problems?

d. In what way could the share of nuclear energy affect any of the issues mentioned above?

e. Independent of the previous questions, is it possible to establish networks of experts in the Latin America and Caribbean region on energy security and planning, and nuclear power generation, who would assist the regional community by contributing to the development of solutions to the energy issue for the region?

Observation.- As regards security of nuclear installations, the Division of Nuclear Installation Safety (NSNI), which is responsible for this issue at the IAEA, has noted the need for programmes in this area in the future. This concern is based on the fact that there are already, at present, nuclear power plants and nuclear research reactors in various countries in the region.

3. SWOT Analysis

Table 1 contains the strategic analysis of the region's profile in the form of a summarized list of the strengths, weaknesses, opportunities and threats identified for each of the subsectors. A detailed description of the analysis by subsector follows the table.

3.1 Table of strategic analysis of subsectors

	NUCLEAR POWER	EXPERIMENTAL REACTORS	APPLICATIONS IN INDUSTRY
STRENGTHS	1. The existence of various energy resources in the region in considerable quantity: oil, water, natural gas, geothermal, uranium, biofuel and other renewable resources. 2. The existence of technological and professional capacity in certain nuclear reactor technologies and in the nuclear fuel cycle. 3. Operating experience in certain types of nuclear power plant which could be shared. 4. Existence of training centres for specialists in the nuclear field. 4. Advanced development of energy technologies, in particular innovative nuclear reactors and the fuel cycle (CAREM, nuclear fuel fabrication). 5. The Latin America and Caribbean region is a nuclear-weapon-free zone.	1. Consensus at the level of nuclear institutions on joint collaborative action. 2. There are 13 reactors in 7 countries in the region operating under safe conditions with the capacity to produce radioisotopes and radiopharmaceuticals and to be extended to other applications (e.g. BNCT). 3. High design, construction, operation and maintenance capacity for reactors and fuel. 4. Wide range of power and use of experimental and production reactors, from critical facilities to over 10 MW. 5. The region has the human capacity to carry out complex nuclear projects. 6. The advantage of having experience and capacities (especially having highly qualified human resources) for mutual integrated support.	1. All countries have some kind of nuclear application in industry. 2. Experience in the licensing, import and use of radioactive material. 3. Several countries in the region (Argentina, Brazil, Colombia, El Salvador, Mexico and Peru) have industrial gamma irradiators, and development of indigenous technology. 4. There are specialists in nuclear applications in industry: industrial gamma irradiation, accelerators, use of nucleonic control gauges; PGNAA for studies of wear, multiphase meters, CAT. 5. Experience in the use of radioactive tracers for diagnosis of industrial processes. 6. There is exchange of experience among the region's specialists in applications.

WEAKNESSES	1. Shortage of companies which back technological innovation. 2. Disparity in energy, social and economic development indices among countries in the region, which hampers integration. 3. Lack of political awareness to support the development of nuclear energy technologies. 4. Large land area which hampers integration processes. 5. Weak statistical database and analytical tool infrastructure for energy planning. 6. There are populations in remote areas with no access to electricity services. 7. Insufficient regional technological and regulatory infrastructure for management of radioactive waste. 8. Insufficient public information activities on the uses, benefits and risks of nuclear energy in order to promote favourable perception. 9. Financial limitations in some countries as regards large investments.	1. Insufficient budget for management, cooperation and maintenance of experimental reactors. 2. Reactors which are so old that they require modernization and renovation of systems. 3. Lack of knowledge at the social level, and in many cases among potential users, of the uses of experimental reactors. 4. Lack of human resources in general, and imbalance in human resources between operation and maintenance in particular. 5. Weakness of the regulatory authorities in some countries as regards standards. 6. Underuse of experimental reactors by users (lack of knowledge of the uses of experimental reactors on the part of scientists).	1. Insufficient training of human resources in the field of industrial applications. 2. Insufficient promotion of the benefits of the applications, disinterest or lack of knowledge among companies.

OPPORTUNITIES	1. The growing demand for electricity, illustrated by the activation of nuclear power programmes by several countries (Argentina, Brazil, Mexico, Chile). 2. International cooperation authorities and organizations exist for the region: IAEA, OLADE [Latin American Energy Organization], CIEMAT [Research Centre for Energy, Environment and Technology], ECLAC, CIER [Regional Energy Integration Commission], etc. 3. The increase in fossil fuel prices and their high CO_2 emissions work in favour of the nuclear option. 5. The reactivation of nuclear programmes (Argentina, Brazil) opens up possibilities for the training and development of human resources in the nuclear field.	1. A market for radioisotopes and radiopharmaceuticals exists in the region and these could be supplied by the region's experimental reactors. Self-sufficiency in the supply of radioisotopes for the whole region. 2. Possibility of use of experimental and production reactors by countries which do not possess them. 3. Possibility of access to external funding by services to complement State support. 4. International organizations (IAEA, ARCAL) exist to strengthen analytical capacities in energy, environment, etc. 5. There is international support for regional agreements (ARCAL-IAEA) on the peaceful use of nuclear technology.	1. Growing areas of demand for industrial applications to improve the competitiveness of industry.
THREATS	1. Public opinion is unfavourable owing to a negative perception of the risks related to waste management and safety. 2. The difficulty of resolving the issue of waste disposal in the region in the long term.	1. Insecure financial support for management of reactors and inability of institutions to provide the best work prospects in order to retain highly qualified human resources. 2. Reactions from international commercial companies which supply radioisotopes and radiopharmaceuticals. 3. Restrictions on and resistance to international transport of radioactive material.	1. Public fear of consuming irradiated products. 2. Expansion of the potential terrorist threat as regards use of radioactive sources.

3.2 SWOT description by subsector

3.2.1 Nuclear power

Strengths

- **The existence of various energy resources in the region in considerable quantity: oil, water, natural gas, geothermal, uranium, biofuel and other renewable resources.**

The existence of a vast volume of energy resources of a very varied nature provides a suitable platform for planning expansion of the use of nuclear resources in a climate of strategic planning with a view to ensuring energy security for the region by diversifying the mix of energy resources.

- **The existence of technological and professional capacity in certain nuclear reactor technologies and in the nuclear fuel cycle.**

The region has training institutions and companies which develop nuclear technologies both for power reactors and experimental reactors. Technologies and trained personnel have also been developed for the nuclear fuel cycle. The existing capacity in Argentina, Mexico and Brazil could be shared with other countries in the region which are considering starting up nuclear programmes.

- **Operating experience in certain types of nuclear power plant which could be shared.**

The ongoing experience in Argentina, Brazil and Mexico at PHWR, PWR, BWR and CANDU nuclear power plants has resulted in fairly wide experience which could be shared with other countries in the region interested in starting up nuclear power generation programmes.

- **Advanced development of energy technologies, in particular innovative nuclear reactors and the fuel cycle.**

Countries such as Brazil and Argentina have developed reactors and innovative fuel cycle technologies. For example, in Brazil a uranium enrichment system has been developed, as has the fabrication of new types of fuel such as biofuels and ethanol from sugar cane for transport. Nuclear fuels are produced at the new CAREM facilities in Argentina. Brazil has demonstrated the capacity to develop new techniques to prospect for hydrocarbons in very deep offshore areas. In Argentina there are heavy water concentration plants.

- **The Latin America and Caribbean region is a nuclear-weapon-free zone.**

Latin America became the first region of the world to be declared a nuclear-weapon-free zone in 1967. Thus, the region offers a good framework for the development of the peaceful nuclear industry.

Weaknesses

- **Shortage of companies which back technological innovation.**

In general it could be said that a tradition of technological innovation has not been successfully established among companies in the region as it is difficult for them to become accustomed to assuming the risks of such investments.

- **Disparity in the energy, social and economic development indices among countries in the region.**

One of the most important problems for the integration of Latin America is the great disparity in social, economic and energy development indices. Some of the region's countries require special conditions for them to be integrated.

- **Lack of political awareness to support the development of nuclear energy technologies.**

This is a weakness which is not limited only to countries in the region but is also found in other parts of the world. Discussions on the viability of the use of nuclear resources to generate electricity are frequently muddied by arguments of a political nature. For example, in the rules of the clean development mechanism (CDM) there is an express prohibition on the use of nuclear plants.

- **Large land area which hampers integration processes.**

The Latin America and Caribbean region covers an extremely large area which could make aspects of integration more expensive at first.

- **Weak statistical database and analytical tool infrastructure for energy planning.**

The region has no generalized approach to the compilation and keeping of statistics which could be used as data in energy planning exercises.

- **There are populations in remote areas with no access to electricity services.**

The lack of coverage of the regional electricity network could perhaps be seen as a weakness prior to planning what the mix of energy resources will be.

- **Insufficient regional technological and regulatory infrastructure for management of radioactive waste.**

There are still countries in the region which do not have autonomous regulatory bodies, or which do not have either national policies or specialized bodies for the management of radioactive waste.

- **Insufficient public information activities on the uses, benefits and risks of nuclear energy in order to promote favourable perception.**

Neither the establishment of policies to promote the benefits of nuclear energy, nor the incorporation of social actors in decision-making processes, which could help promote favourable public perception, have been addressed in a comprehensive manner.

- **Financial limitations in some countries as regards large investments.**

The majority of the countries in the region operate with budgetary restrictions on their research, technological development and energy investment programmes and projects,.

3.2.2. Experimental reactors

Seven countries in the Latin America and Caribbean region have experimental nuclear reactors of various types and power levels, as shown in Table 2. The purpose of these reactors is to provide neutron sources for research, experimentation, training of human resources and radioisotope production.

For more than 60 years, experimental reactors have been centres of innovation and productivity for nuclear science and technology. The reactors have assisted multidisciplinary research covering new developments in the production of radioisotopes for medical and industrial uses, research involving neutron beams, human medicine, development of materials, testing and qualification of components, computer code validations, etc.

There have been various cooperation projects and activities involving reactors in different countries in the fields of reactor physics, radioisotope production, training courses and commissioning of reactors, through regional, bilateral and national projects with the support of the IAEA. A couple of projects have also been implemented under ARCAL.

At the bilateral level, the collaboration between Argentina and Peru on the design and construction of the RP 0 and RP 10 reactors stands out.

In the field of fuel development and fabrication, there has been collaboration among Argentina, Brazil and Chile.

Research reactors in the region

Country	*Reactor*	*Type*	*Power kW*	*Enrichment %*	*Regime h/month*	*Owner*
ARGENTINA	***RA-0***	***Pool***	**0.001**	**19.8**	**16**	***University of Cordoba***
	RA-1	***Pool***	**40**	**19.8**	***Not available***	***National Atomic Energy Commission (CNEA), Buenos Aires***
	RA-3	***Pool***	**10000**	**19.7**	**266**	***CNEA, Ezeiza Buenos Aires***
	RA-4	***Pool***	**0.001**	**19.8**	**16**	***University of Rosario***
	RA-6	***Pool***	**500**	**93**	**180**	***CNEA, San Carlos de Bariloche***
	RA-8	***Pool***	**0.01–0.1**	**1.8–4.3**	**0**	***CNEA, Pilcaniyeu, Río Negro***
BRAZIL	***ARGONAUT***	***Pool***	**0.5–5**	**19.9**	**Not available**	***Nuclear Engineering Institute (IEN)-National Nuclear Energy Commission (CNEN), Rio de Janeiro***
	IEA-R1	***Pool***	**2000–5000**	**19.9**	**256**	***Nuclear and Energy Research Institute (IPEN)-CNEN, São Paulo***
	MB-01	***Pool***	**0.1**	**4.3**	**Not available**	***IPEN-CNEN, São Paulo***
	IPR-R1	***Pool***	**250**	***Triga* 19.9**	**Not available**	***Nuclear Technology Development Centre (CDTN)-CNEN, Belo Horizonte***
CHILE	***RECH-1***	***Pool***	**5000**	**19.75**	**96**	***Chilean Nuclear Energy Commission (CCHEN)-La Reina-Santiago***
	RECH-2	***Pool***	**10000–15000**	**90**	**0**	***CCHEN-Lo Aguirre-Santiago***
COLOMBIA	***IAN-R1***	***Pool***	**100**	***Triga* 19.9**	**0**	***Colombian Institute of Geology and Mining (INGEOMINAS), Bogota***
JAMAICA	***SLOWPOKE***	***Pool***	**20**		**Not available**	***International Centre for Environmental and Nuclear Sciences (ICENS), Kingston***
MEXICO	***TRIGA***	***Pool***	**1000–2000**	***Triga* 20-70**	**55**	***National Nuclear Research Institute (ININ), Mexico City***
PERU	***RP 0***	***Pool***	**0.001**	**19.75**	**96**	***Peruvian Institute of Nuclear Energy (IPEN)-Headquarters, Lima***
	RP 10	***Pool***	**10000**	**19.75**	**30**	***IPEN-Huarangal, Lima***

In the field of design and construction of experimental and production reactors, several reactors have been designed and constructed in Argentina (RA-3, RA-6 and RA-8) and reactors have also been exported to Peru (RP-10, 10 MW, 1988), Algeria (NUR, 1 MW, 1989), Egypt (ETR-2, 22 MW, 1997) and Australia (OPAL, 20 MW, 2006).

The region's reactors are converting to low-enriched fuel, in the course of which several of them have had power increases and/or have upgraded their instrumentation and control systems.

Within the framework of the IAEA, from 2001 to date, several meetings have been held to promote, make closer and external regional cooperation on reactor utilization, safety and fuel.

Experimental and production reactors are simpler than reactors for electricity generation and operate at lower pressures and temperatures. They consist of a core made up of fuel elements with uranium enriched up to 20% (in ^{235}U), though there are some which use 90% enriched uranium.

The range of applications these reactors can be used for depends on the power level or neutron flux. In general terms, reactors under 250 kW may be categorized as low-power and those over 2 MW as high-power.

Human resources development, which includes activities such as outreach, education and training, can be conducted at any of the region's reactors.

In the field of operation, maintenance and radiation protection of experimental and production reactors, regional mutual cooperation could be achieved in order to improve standard practices and provide mutual assistance in these tasks.

As regards documentation and quality assurance, given that there are new versions of the IAEA Safety Series guides which are being adopted in due course by Member States' respective regulatory authorities, joint cooperation in implementing the modifications to these guides at experimental and production reactors would be advisable.

In the instrumentation and control field, given that most of the instrumentation of these experimental and production reactors is obsolete and there is a lack of components available for purchase on the market, we would propose developing and manufacturing parts using labour from different countries, based on experience in ARCAL projects in which Argentina, Brazil, Chile, Colombia, Mexico and Peru have taken part, putting together a reliable instrumentation and control group.

As regards fuel, nuclear fuels are being designed and manufactured in the region.

Neutron calculation: There is capacity in the region as regards calculation tools and experimental techniques, in connection with design optimization and use of experimental reactors, for problems such as:

- Core management;
- Design and characterization of irradiation devices and experimental configurations;
- Shielding;
- Dosimetry;
- Configuration of irradiation beams;
- Design and characterization of irradiation facilities (BNCT, NR, PGNAA);
- Critical combination as regards the arrangement of irradiated fuel elements;
- Management of the life cycle of experimental and production reactors;
- Calculation validation tools.

Process control: There is capacity in the region for technological management related to design and development, and this capacity could be shared.

Compatibility of standards used in operation, maintenance and radiation protection.

3.2.3 Applications in industry

All countries in the region have some kind of nuclear application in industry, which can range from filling bottled drinks to irradiators or accelerators for the sterilization of disposable medical products.

The most important applications are as follows:

a) Non-destructive testing:

Industrial radiography with radiation sources such as ^{192}Ir and ^{60}Co, X-rays or neutrons;
Gamma logging of industrial components such as pipes, distillation/absorption towers, etc.;
Tomography for industrial components using radiation sources or particle accelerators;
Radiography at customs, on roads and at prisons to control trafficking of drugs, contraband and arms;
Elemental analysis using X-ray fluorescence, neutron activation or PGNAA;
Density gauges employing gamma backscattering in oil well probes;
Moisture gauges in the construction industry using neutron sources;

b) Gamma, electron, X-ray or heavy ion radiation processing:

Industrial irradiation of food, disposable medical products, cosmetics and other products such as tyres, cables and electronic circuits;

c) Nucleonic control gauges:

Control of thickness using gamma, electron or alpha transmission in paper, metal plates, plywood, etc.;
Control of filling of bottles, cans, storage tanks, etc. using X-rays or gamma rays;
Control of mineral content using PGNAA or X-ray fluorescence in the mining and cement industries;
Multiphase meters for oil, gas, water and solids in the oil industry (and other industries);

d) Radioactive tracers:

Connections in oil or gas wells;
Diagnosis of industrial processes employing residence time distribution (RTD), dead volumes, short circuits, poor flow distribution, etc.;
Leaks in underground pipes;
Flow measurements in rivers, dams, ducts, etc.;

e) Other applications:

Interfaces in tanks employing neutron backscattering;
Studies of wear employing high-energy proton activation (TLA).

III. REGIONAL NEEDS/PROBLEMS AND JUSTIFICATION

In this section, the analysis of needs/problems in the nuclear power, experimental reactors and applications in industry subsectors is presented.

NUCLEAR POWER SUBSECTOR

1.- Need to improve the provision to the public of objective and extensive information on nuclear energy (E1)

The nuclear option as an energy alternative is discredited using the arguments of lack of safety, uncontrolled emissions of harmful radiation, or the danger of long-lived radioactive waste.

We therefore see a need to conduct honest, transparent and objective information programmes which would gradually bring home to the public the validity of using nuclear energy to produce electricity, and the fact that the decision as to its use should be based on objective and timely analysis.

It should be pointed out that there have been regional projects (2004/2005) on nuclear energy and radioactive waste outreach which could be expanded.

2.- Need to expand and strengthen training of qualified personnel to manage nuclear power projects and nuclear power plants (E7)

There can be no doubt that use of nuclear technology for electricity generation requires highly qualified professionals. The special characteristics of these installations leave little margin for error for the professionals that work at them and, therefore, extensive and sound training is an essential requirement for all personnel involved.

One important point is that many specialists in many different fields — operation, maintenance, instrumentation, radiation protection, security, etc. — are involved in the operation of a nuclear power plant. This variety also means that a significant effort is needed to diversify the training provided to them.

At present, countries in the region which already make use of nuclear energy to produce electricity have training programmes at universities and other training centres, and even some which do not have power plants have courses at their universities which train students to work at such installations. However, there are countries which do not offer such courses and in any programme backing nuclear power this deficiency must be taken into account.

3. Shortage of long-term energy and electricity supply and demand scenarios and analyses to decide on possible inclusion of nuclear power in order to diversify efficient and sustainable energy sources and provide power to areas with no supply (E10)

According to data supplied by international bodies, the forecast growth in energy demand in Latin America is estimated to range from 2.8% to 5% per year. However, there is a high level of uncertainty or imprecision in forecasts of future energy demand and supply.
Therefore, more detailed studies are needed using integrated models which predict demand and supply in order to develop national, subregional and regional scenarios based on different assumptions in such highly variable areas as fuel prices, economic growth, demographic growth and the structure of the energy system.

In particular, it is necessary to determine the role that nuclear energy can play in supplying electricity, since the nuclear option could be of great value in providing the electricity supply the public needs.

4.- <u>Expediency of countries having nuclear fuel cycle policies covering everything from mining of energy resources to disposal of radioactive waste</u> (E12)

Political decisions on the stages of the fuel cycle are a necessary part of the nuclear power option. In particular, there is a need in the region to ascertain uranium potential, and for decisions regarding spent fuel management and waste disposal.

It should be noted that this problem arises from the moment the possibility of using the nuclear option is considered and analysed.

5.- <u>Lack of statistical databases and procedures and adequate indicators for use in energy assessment and planning studies</u> (E13)

Many countries in the region lack statistical data and evaluation mechanisms, limiting the scope for analysis of the supply situation and energy planning, which allow for better definition and understanding of possible present and future scenarios.

Strengthening of analytical capacity involves:

- Expanding and improving statistical programs and databases relating to energy and the environment;
- Incorporating sustainable development energy indicators into statistical programs;
- Developing possible energy supply and demand scenarios for the medium and long term;
- Elaborating national energy profiles for sustainable development;
- Elaborating an integrated energy profile for Latin America within the framework of sustainable development.

6.- <u>Need to strengthen exchange and transfer of experience and knowledge in the nuclear power sector</u> (E14)

Nuclear programmes should not be developed in isolation. On the contrary, first of all the development of the whole support infrastructure, which takes time to establish, should be considered. This infrastructure includes the technical capacity available from universities, industry and national or regional research centres, long-term decisions by governmental organizations and electricity companies and international cooperation agreements.

It is desirable that the experience and knowledge acquired by experts in the Latin America region, and in particular in Argentina, Brazil and Mexico, be shared with experts in countries which are considering starting up nuclear power programmes.

This infrastructure must cover the following elements:

- Legal framework;
- Regulatory framework;
- International and multinational agreements;
- Facilities;
- Financial resources;
- Human resources;
- Siting feasibility studies;
- Security of supply of certain inputs;
- Public support.

7. Insufficient energy integration in the region (E16)

Energy integration processes in the region could be established as platforms with extension to the nuclear power field. The possible slowness of the integration process makes the establishment of favourable conditions difficult.

Nevertheless, as an intergovernmental agreement, ARCAL should be a means of promoting progress in the nuclear field in nuclear energy integration.

As regards expansion of the use of nuclear power in the region, there is a need for analysis, for example of the possibilities of connecting up networks supplied by nuclear power plants.

EXPERIMENTAL REACTORS SUBSECTOR

1. Need to exchange experience in order to enhance reactor safety, operation and maintenance (E2)

There is little exchange of information in the region among operations and maintenance personnel working at experimental reactors. Exchange of information would help improve reactor safety conditions, for example implementation of the Code of Conduct on the Safety of Research Reactors and formulation of strategic utilization plans.

2. Need to train highly qualified personnel in the management and operation of experimental and production reactors and to replace professional staff who are retiring (E5)

Highly qualified personnel work at the region’s experimental reactors. However, these human resources need to be renewed to ensure preservation of knowledge as a new generation takes over operations. Training of human resources for experimental reactors takes at least three years.

3. Need to upgrade the region’s reactors to improve their safety and extend their operating lifetime (E8)

Most of the region’s reactors are over 30 years old, which in many cases means that there is a need for modernization of instrumentation and control systems, mechanisms, exchange of detectors, etc., to allow continued efficient and safe operation.

4. Insufficient use of experimental and production reactors (E9)

The need to expand use of experimental reactors was identified as early as 2002 at an IAEA regional meeting entitled "Updating and Regional Use of Research Reactors", after which efforts were made at regional level to realize this goal.

In this context, the need arises to identify users, promote possible uses, activate cooperation networks in countries in the region, and spread use of reactors to countries which do not have experimental and production reactors.

The reactor situation is such that some are underused, and there is:

- a lack of a national strategic framework for use of these facilities;
- a low number of users of the facilities;
- a lack of resources within operating organizations to subsidize research, services or production tasks;
- a lack of a regional plan for the production and application of radioisotopes which would exploit available capacity;
- a lack of a regional plan for the development of fundamental and applied research capacity.

There is therefore a pressing need to take joint regional action to increase and improve the efficient use of research and production reactors in the region, exploiting accumulated capacity and experience by training working groups that would formulate various projects, assign the tasks and development activities needed to implement those projects, and coordinate the internal activities of each country with a view to implementing the projects or recommending to national authorities the steps to be taken in each case.

APPLICATIONS IN INDUSTRY SUBSECTOR

1. Need to disseminate the benefits of applications to end users, making use of existing capabilities and experience in the region (E3)

As with the previous issue, there is a lack of information on the benefits of using nuclear techniques and a lack of channels to supply such information.

2. Insufficient use of nuclear applications in industry which affects its competitiveness (E4)

The region is an exporter of raw materials, with little penetration of nuclear techniques in industry. The use of these techniques has been shown in developed countries to contribute to improving the competitiveness of industry, etc.

3. Need to strengthen the training of personnel who assist in the development of the required applications (E6)

The lack of training centres for specialists in nuclear applications in industry results in a shortage of professionals specializing in the use of these applications.

4. <u>Restrictions on trade and transport of radioactive material among countries in the region</u> (E11)

The conditions for international transport of radioactive material discourage or restrict exchange of radioactive sources as and when required. It would be beneficial to adapt these conditions in a way that would facilitate the use of radioisotopes with a short half-life and increase regional exchange.

5. <u>Limited indigenous technology development for transfer to industry</u> (E15)

The assimilation and development of technology facilitates rapid and viable transfer to local industry, with the advantage of having indigenous knowledge. For some applications providers have been identified; in other cases, technology needs to be developed for specific application situations, or in order to improve on what exists on the market. Priority should be given to those projects where end users have been identified and which could be sustainable in the long term.

IV. PRIORITIZATION OF NEEDS/PROBLEMS IN THE SECTOR

These are the attributes which were considered for prioritization, following the selected methodology. More information on the subject may be found in the part of the RSP publication on the topic in question.

SERIOUSNESS	This is a measure of the degree of severity of the need/problem, taking into account the negative impact of not addressing it.
TIME	This is related to the degree of urgency in addressing the need/problem, its likelihood of worsening and future consequences.
EXTENT	This determines the degree of regional impact of the need/problem, taking into account, for example, the number of countries affected.
RELEVANCE of/for nuclear techniques	On the one hand, this measures to what extent nuclear applications can contribute to addressing/solving the need/problem. On the other hand, it takes account of the extent to which solving the problem has relevance for nuclear applications.
LEVEL OF DIFFICULTY	This measures the degree of difficulty of implementing the solution to the need/problem identified, which can be related to: infrastructure, resources, technology, legislation, intergovernmental commitments, etc.

1. VALUES ASSIGNED TO EACH NEED/PROBLEM

The identified problems/needs are presented in the following Table according to the grade given by the members of the respective sectorial Group, as may be seen under TOTAL.

	NEED/PROBLEM	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	FINAL PRIORITY GRADE
E1	**Need to improve the provision to the public of objective and extensive information on nuclear energy.**	5.00	4.14	4.43	4.14	**17.71**	2.57	1.61	**28.5**
E2	**Need to exchange experience in order to enhance experimental reactor safety, operation and maintenance.**	4.43	4.43	4.00	4.14	**17.00**	1.71	2.42	**41.1**
E3	**Need to disseminate the benefits of applications to end users, making use of existing capabilities and experience in the region.**	4.57	4.29	4.14	3.71	**16.71**	1.71	2.17	**36.2**
E4	**Insufficient use of nuclear applications in industry which affects its competitiveness.**	4.29	4.14	3.71	4.43	**16.57**	3.57	1.24	**20.5**
E5	**Need to train highly qualified personnel in the management and operation of experimental and production reactors and to replace professional staff who are retiring.**	3.87	4.00	3.71	4.71	**16.30**	2.29	2.06	**33.6**
E6	**Need to strengthen the training of personnel who assist in the development of the required industrial applications.**	4.29	4.00	3.71	4.29	**16.29**	2.43	1.76	**28.7**
E7	**Need to expand and strengthen training of qualified personnel to manage nuclear power projects and nuclear power plants.**	4.86	3.43	3.57	4.29	**16.14**	2.71	1.58	**25.5**
E8	**Need to upgrade the region's experimental reactors to improve their safety and extend their operating lifetime.**	4.00	4.00	3.57	4.43	**16.00**	3.14	1.41	**22.5**

	NEED/PROBLEM	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	FINAL PRIORITY GRADE
E9	**Insufficient use of experimental and production reactors.**	4.14	3.86	3.57	4.14	**15.71**	3.14	1.32	**20.7**
E10	**Shortage of long-term energy and electricity supply and demand scenarios and analyses to decide on possible inclusion of nuclear power in order to diversify efficient and sustainable energy sources and provide power to areas with no supply.**	4.29	4.43	3.57	3.29	**15.57**	2.57	1.28	**19.9**
E11	**Restrictions on trade and transport of radioactive material among countries in the region.**	3.86	3.86	4.14	3.71	**15.57**	4.57	0.81	**12.7**
E12	**Expediency of countries having nuclear fuel cycle policies covering everything from mining of energy resources to management of radioactive waste.**	3.57	3.43	3.71	4.71	**15.43**	4.29	1.10	**17.0**
E13	**Lack of statistical databases and procedures and adequate indicators for use in energy assessment and planning studies.**	4.14	3.86	4.00	3.14	**15.14**	2.71	1.16	**17.5**
E14	**Need to strengthen exchange and transfer of experience and knowledge in the nuclear power sector.**	4.14	3.27	3.57	4.14	**15.13**	2.71	1.53	**23.1**
E15	**Limited indigenous technology development for transfer to industry.**	3.57	3.14	3.43	4.29	**14.43**	4.29	1.00	**14.4**
E16	**Insufficient energy integration in the region.**	3.71	3.00	4.14	3.43	**14.29**	4.43	0.77	**11.1**

2. JUSTIFICATION OF ASSIGNED VALUES

The needs/problems are listed in order of priority based on the values assigned and divided in subsectors.

NUCLEAR POWER					
NEED	**SERIOUSNESS**	**TIME**	**EXTENT**	**RELEVANCE**	**DIFFICULTY**
E1) Need to improve the provision to the public of objective and extensive information on nuclear energy.	High social and political importance.	Urgently required before starting a nuclear programme.	All countries potentially involved should address this matter.	High for the development of nuclear power programmes.	Average. Achieving it requires political will.
E7) Need to expand and strengthen training of qualified personnel to manage nuclear power projects and nuclear power plants.	Essential for the viability of nuclear power.	In accordance with the rate of introduction of nuclear power.	Required in countries which are introducing nuclear power.	High for safe and efficient operation.	Average. It could be implemented through agreements with international organizations.
E10) Shortage of long-term energy and electricity supply and demand scenarios and analyses to decide on possible inclusion of nuclear power in order to diversify efficient and sustainable energy sources and provide power to areas with no supply.	Development of these scenarios is important as a starting point for planning with a high degree of certainty.	Urgent for definition of scenarios and programmes.	The majority of countries in the region.	Important for optimal combination of energy sources including nuclear power.	Average. Could be achieved with available energy models.
E12) Expediency of countries having nuclear fuel cycle policies covering everything from mining of energy resources to disposal of radioactive waste.	This is of environmental importance and is indispensable for the use of nuclear power.	Steps should be taken to achieve gradual but steady progress on this matter.	All countries should be involved.	Essential for the nuclear option.	High, there is public resistance. Essential for the nuclear option.
E13) Lack of statistical databases and procedures and adequate indicators for use in energy assessment and planning studies.	The integrity and quality of the data used in planning studies has a great impact on their results.	Databases and reliable indicators for use in analyses of scenarios used in planning are urgently required.	The majority of countries in the region.	Important for the nuclear option.	Average. Could be implemented based on processes already in use.

NEED	SERIOUSNESS	TIME	EXTENT	RELEVANCE	DIFFICULTY
E14) Need to strengthen exchange and transfer of experience and knowledge in the nuclear power sector.	This has a major impact. The nuclear option improves safety and reduces costs.	This activity could be developed gradually during the introduction of nuclear power.	Affects countries in line with their involvement in nuclear power programmes.	Is closely linked to the operation of nuclear power plants.	Average. Could be implemented through agreements with countries with experience.
E16) Insufficient energy integration in the region.	It is desirable to have a certain degree of energy integration in order to optimize systems and improve the economic aspect.	This is a step which could be taken gradually, as has in fact been happening.	Many countries would benefit from integration.	Highly relevant to the nuclear option.	Requires joint political decisions.

EXPERIMENTAL REACTORS					
NEED	**SERIOUSNESS**	**TIME**	**EXTENT**	**RELEVANCE**	**DIFFICULTY**
E2) Need to exchange experience in order to enhance reactor safety, operation and maintenance.	Important for the efficient use of infrastructure and cost reduction.	Safety is always urgent.	Countries with experimental reactors.	Would have great impact on the management and use of experimental reactors.	Low. Could be achieved through agreements with countries in the region which have reactors.
E5) Need to train highly qualified personnel in the management and operation of experimental and production reactors and to replace professional staff who are retiring.	Qualified personnel are an inescapable condition for the successful operation of experimental reactors.	Steps should be taken in a very firm but consistent manner to plan for replacement of personnel.	Countries which operate experimental reactors and those with programmes at the planning stage should be involved.	Of great impact for nuclear technology.	Average. Could be achieved through agreements with countries in the region.
E8) Need to upgrade the region's reactors to improve their safety and extend their operating lifetime.	This is a subject which should be analysed from a cost-benefit point of view, above all with respect to the financial aspects involved.	Draw up a schedule of activities.	Only countries with experimental reactors that have reached or are about to reach the end of their design operating life.	Of great impact for nuclear technology.	Average. Requires the availability of the necessary financial resources.
E9) Insufficient use of experimental and production reactors.	Experimental reactors provide a good foundation for extensive nuclear programmes.	Consistent promotion of the use of experimental reactors is considered to be urgent.	All countries which possess experimental reactors.	Important for health, science and technological applications.	Average difficulty.

APPLICATIONS IN INDUSTRY					
NEED	**SERIOUSNESS**	**TIME**	**EXTENT**	**RELEVANCE**	**DIFFICULTY**
E3) Need to disseminate the benefits of applications to end users, making use of existing capabilities and experience in the region.	This is imperative in order to ensure acceptance of their introduction.	Immediate.	All countries.	In order to spread the benefits, the relevant illustrative aspects of nuclear technology should be stressed.	Low. The majority of countries have the infrastructure.
E4) Insufficient use of nuclear applications in industry which affects its competitiveness.	The incorporation of nuclear applications with proven viability and advantages is very important.	The more quickly this technology is adopted, the better the opportunities for successful incorporation.	All countries.	Of enormous importance for technical and economic competitiveness.	High. Requires demonstration of value in cost/benefit terms.
E6) Need to strengthen the training of personnel who assist in the development of the required applications.	Qualified personnel are an indispensable requirement to guarantee the benefits of techniques.	Human resource training programmes should be developed.	Should be developed in all countries.	Important in order to be competitive in the market.	Average. Requires the support of international agencies.
E11) Restrictions on trade and transport of radioactive material among countries in the region.	Not doing this limits the expansion and spread of nuclear technologies.	Should be done in the short term.	All countries.	Very important for the timely availability of radioisotopes.	High, owing to the need for legislative harmonization.
E15) Limited indigenous technology development for transfer to industry.	Technology assimilation may bring significant financial benefits.	Technology assimilation can begin as soon as required.	Technology assimilation is within the scope of virtually all countries where nuclear applications are used.	Entirely linked to nuclear technology.	High. Important for competitiveness in the market.

V. BIBLIOGRAPHY USED BY THE WORKING GROUP ON ENERGY AND INDUSTRY IN PREPARING THE RSP

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VI. COMPOSITION OF THE WORKING GROUP

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3. Ángel Díaz (**Vice-Chairman of the ATCB**) — Venezuela
4. Alberto Miranda (**Secretary of the ATCB**) — Bolivia
5. Hadj Slimane Cherif — Director of the Office of Programme Development and Performance Assessment at the IAEA
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7. Francisco Rondinelli — strategic planning expert
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ARCAL

Co-operation Agreement for the Promotion of Nuclear Science
and Technology in Latin America and the Caribbean

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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

Radiation Safety in Latin America and the Caribbean in the Light of the RSP

ARCAL

IAEA
International Atomic Energy Agency

PUBLICATIONS RELATED TO THE RSP

To facilitate review of the material generated by the RSP preparation process, it has been published in separate parts covering the following aspects:

Regional Strategic Profile for Latin America and the Caribbean (RSP) 2007–2013
Background, Methodology and Process for the Preparation of the RSP for Latin America and the Caribbean
Food Safety in Latin America and the Caribbean in the Light of the RSP
Human Health in Latin America and the Caribbean in the Light of the RSP
Environment in Latin America and the Caribbean in the Light of the RSP
Energy and Industry in Latin America and the Caribbean in the Light of the RSP
Radiation Safety in Latin America and the Caribbean in the Light of the RSP

IAEA
International Atomic Energy Agency

ARCAL
Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean

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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

ARCAL-IAEA Strategic Alliance

RADIATION SAFETY IN LATIN AMERICA AND THE CARIBBEAN IN THE LIGHT OF THE RSP

CONTENTS

REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013
ARCAL-IAEA Strategic Alliance

RADIATION SAFETY IN LATIN AMERICA AND THE CARIBBEAN IN THE LIGHT OF THE RSP

I. BACKGROUND AND IMPLEMENTATION OF WORK

Acceptance in society of the risks associated with radiation is dependent on the net benefit from its multiple applications. Radiation safety aims to protect individuals, society and the environment from the harmful effects of ionizing radiation and ensure adequate protection of current and future generations from any activity which involves exposure to ionizing radiation.

Radiation safety principles stipulate that States should have a national system for effective control of all radiation sources, foreseeing the establishment of a regulatory authority with clear responsibilities, authority and resources which allow it to fulfil its mandate of regulation, control and sanction, and with clear authority to meet international commitments laid down in international agreements, protocols or conventions. States should also have the necessary arrangements in place so that, if needed, a capacity for intervention and mitigation in the event of accidents exists.

Efforts should be directed at ensuring that States establish a safety culture for radiation sources, starting with the commitment of governments to manage the regulatory authority, and the commitment of users of ionizing radiation to radiation safety by considering in their proposals protection of occupationally exposed staff, the environment and the patient through adequate use of the criteria for justifying a practice, optimization of protection and the application of dose limitation criteria, with the goal of minimizing individual and collective risk.

In order to cover the above fully, the decision was taken to evaluate radiation safety in six areas:

1: Regulatory infrastructure;
2: Occupational radiation protection;
3: Radiation protection of patients;
4: Radiation protection of the public;
5: Radiological emergency preparedness and response;
6: Education and training.

Based on the information presented by each group member responsible for each of the assigned areas, a first draft was drawn up during the meeting in Santa Cruz de la Sierra, Bolivia, where it was agreed to continue its preparation via email in order to progress towards a final version.

All correspondence was sent to the chairman of the committee who, based on the comments provided, drew up a final version which was adopted as a working document at the meeting in Madrid.

Each member of the group made comments on the document, which were discussed with a view to producing the SWOT matrix. This matrix was used to produce the list of regional needs/problems in the field of radiation safety. In carrying out the analysis, account was taken of the content of projects the IAEA is implementing in each of the thematic safety areas, in order to avoid any overlap of activities.

The following responses were received to the questionnaire for preparation of the RSP:

Brazil — National Nuclear Energy Commission
Colombia — National University of Colombia
Colombia — Colombian Institute of Geology and Mining (INGEOMINAS)

Colombia — School of Physics, Faculty of Sciences, National University of Colombia (Medellín campus)
El Salvador — Ionizing Radiation Regulatory and Advisory Unit, Ministry of Health
Guatemala — General Directorate for Energy, Department of Radiation Protection and Safety
Mexico — Mexican Social Security Institute, XXI Century National Medical Centre
Mexico — National Nuclear Safety and Safeguards Commission — 2 surveys
Dominican Republic — National Directorate for Nuclear Affairs, National Energy Commission (CNE)
Uruguay — National Regulatory Authority for Radiation Protection (ARNR)
Venezuela — Venezuelan Institute of Scientific Research (IVIC) — 2 surveys
Venezuela — Ministry of People's Power for Health — 2 surveys

Observation.- As regards security of nuclear installations, the Division of Nuclear Installation Safety (NSNI), which is responsible for this issue at the IAEA, has noted the need for programmes in this area in the future. This concern is based on the fact that there are already, at present, nuclear power plants and nuclear research reactors in various countries in the region.

II. GENERAL ANALYSIS OF THE REGIONAL SITUATION

In analysing the regional situation, information provided by the International Atomic Energy Agency (IAEA) was used as a reference point, e.g.: expert missions, reports from evaluation missions (RaSSIA, ORPAS, PRA, etc.), information from international meetings and congresses, country reports presented or regional coordination meetings, Radiation and Waste Safety Infrastructure Profiles (RaWaSIP), Country Programme Frameworks (CPFs), surveys and other sources of information.

All this information allows for a detailed and up-to-date knowledge of the situation of countries in the region with respect to each of the thematic areas mentioned. Based on this knowledge and an analysis of this information, a regional strategic profile for radiation safety can be erected.

Over the past decade, the International Atomic Energy Agency has supported the implementation of projects for each of the thematic safety areas. However, certain specific needs have been identified that would need to be taken into account in the next project formulation round. It is important to highlight that IAEA regional projects currently under way (2007–2008 biennium) also cover most of the region's needs in this field.

A group of regional experts was convened to perform a critical analysis of the available information and, following presentations by thematic safety area and some interaction, an evaluation of the prevailing situation in the region could be made applying the SWOT criteria.

The major aspects considered are summarized below:

- There is a need to improve or modernize regulatory frameworks in those countries where they already exist, and promptly to establish them in those countries where they still do not exist, in order to ensure protection of individuals and the environment. This will only be achieved if regulatory authorities have legal existence and the resources and infrastructure they need to fulfil their designated responsibilities in the regulatory framework.

- To establish an effective and sustainable occupational protection programme in line with international safety requirements and guidelines, it is necessary to have an infrastructure which ensures control over exposure of every occupationally exposed worker.

- It is important to keep the dose to the patient to a minimum while maintaining image quality and avoiding accidental exposure in therapeutic procedures. Radiation protection of the family members of a patient to whom radionuclides have been administered for therapy, and of anyone else who might be in close contact with the patient, should also be ensured.

- In this area, the fact that the majority of countries do not have defined national policies or strategies for radioactive waste management has been identified as a relevant issue. Even though the establishment of national policies and strategies is a recurrent theme in all international forums and in regional projects, this issue has not managed to get off the ground. This is probably due to a lack of clarity on the part of the relevant competent authorities regarding the significance, scope and profound importance of these concepts.

- The need for countries to implement in concrete terms radiological emergency response capacities, including coordination of regional support, is clear from the number of incidents involving orphan sources and accidents at facilities in recent years, and the threat of malevolent acts of a terrorist nature employing radioactive substances as a means of harming individuals and damaging property with the grave social consequences that would have.

- There is a need to increase the capacity of Member States to establish or improve education and training programmes on safety of radiation sources and transport and safety of radioactive waste, to ensure they are adequate, harmonized and sustainable, through various training mechanisms aimed at qualified experts, operators, administrators, regulators and trainers.

1. SWOT Analysis

1.1. Strengths

- A common language which facilitates exchange of experience, information and professional support, helping bring countries to the same level in the various thematic areas.
- Availability of organizations specializing in these fields that are prepared to support the development of radiation safety infrastructure in countries.
- Existence of important international instruments which countries have signed and agreed to implement, such as various international conventions, including the Early Notification and Assistance Conventions and the Code of Conduct.
- Existence of trained professionals with experience who can collaborate within a bilateral framework.
- The majority of countries have some type of legislation, regulations and an established regulatory body.
- Existence in many countries of an infrastructure for dissemination of information.
- Several countries have approved radioactive waste management regulations.
- Most countries already have interim national storage facilities for waste that cannot be kept by the user.
- Existence of regional projects and action plans which allow progress to be made in solving problems.
- Existence of safety and civil defence bodies that can assist during emergencies.
- Scope for provision of specialized medical support for emergencies by countries in the region.
- Existence of a regional training centre for postgraduate courses in radiation protection.
- Availability of training packages developed by the IAEA allowing standardization of the information imparted in training.
- Existence of an extensive set of international standards (IAEA) that can serve as a reference for countries in developing their national regulations.

1.2 Weaknesses

- High rotation rate of trained professionals, particularly within regulatory authorities.
- Unclear commitment on the part of governments with respect to support for, and strengthening and implementation of radiation safety programmes.
- Ageing of professionals working in regulatory authorities and lack of attractiveness for young professionals of starting a career in the field of radiation protection (in national regulatory authorities).

- Countries’ dependence on the support, resources and programmes of international organizations, especially the IAEA.
- Laboratories providing personal internal monitoring services are insufficient in number or irregularly distributed geographically, which makes it difficult to provide ample coverage for all exposed workers requiring it.
- Lack of clarity as regards the meaning and scope of national policy and strategy concepts pertaining to radioactive waste management, which makes implementation in this area difficult.
- Lack of information on the existence of NORM (naturally occurring radioactive material).
- Lack of clarity with respect to the regulation of the concepts of exemption, declassification and clearance, and their application.
- Some regulatory bodies do not have sufficient capacity in terms of infrastructure or trained human resources to meet fully the requirements which may be imposed as regards responsibility on operators, nor do they have the means of verification via effective inspections.
- There is no notification system with regulated coordination for all organizations which must be involved in emergency response.
- The regulatory frameworks in most countries do not include clear education and training requirements for all types of practices.
- Not always peaceful coexistence of more than one regulatory authority per country.
- Conflicts of interest in some countries where the regulators are themselves regulated.

1.3 Threats

- Changes in national authorities (changes in governments) which, owing to a lack of appropriate information and training, compromise the established infrastructure and the continuity of trained personnel, projects and programmes.
- Economic difficulties in countries in connection with the improvement or upgrading of infrastructure, with insufficient budgetary allocation and economic instability.
- Lack of commitment on the part of countries and working groups to ensuring there is a sustainable radiation protection system.
- Negative public perception of everything to do with radiation, which also has negative repercussions with respect to waste management.
- Rotation and/or lack of human resources in connection with the establishment of self-sustaining education and training programmes.
- Lack of multiplier effect with respect to knowledge acquired at specific courses provided by international organizations.
- Lack of awareness-raising on radiation protection issues among professionals working with ionizing radiation and the general public.

1.4 Opportunities

- Importance which radiation safety and security of radiation sources have acquired in the world.
- Clearer vision on the part of countries as regards their development needs with respect to regulation and control infrastructure.
- Constant pressure from ecological groups about the generation of radioactive waste, prompting governments to help find a solution to these problems.
- Public opinion in favour of environmental protection.
- Existence of international standards for safe waste management processes.
- Existing capacity in countries in the region for training of trainers and production of multiplier effects.
- Training packages developed by the IAEA which comply with the requirements of the Basic Safety Standards and other standards.
- Increased interest in the region in nuclear power generation, which raises awareness as regards a regulatory programme.

III. REGIONAL NEEDS/PROBLEMS AND JUSTIFICATION

1. **Lack of regulatory control standards in potentially high-risk practices (linear accelerators, interventional radiology) (R1)**

Justification: As these practices are similar in all countries, as is the potential associated risk, we see a need for the capacity to establish radiation safety standards that can be used throughout the region.

2. **Lack of standardized training requirements for occupationally exposed workers in various practices (R2)**

Justification: The surveys on education and training implemented in the region have shown that there are no standardized criteria as regards the content and duration of training for different practices.

3. **Deficiencies in control over materials to be recycled to ensure the absence of radioactive material (R3)**

Justification: One of the causes of radiological emergencies is the presence of orphan sources in materials to be recycled, principally in the metallurgical industry. That is why it is important to inform and train those involved in recycling processes so that they take the necessary measures to detect any type of radioactive material and act promptly to ensure safety.

4. **Limited coverage of the demand for postgraduate training in radiation protection (R4)**

Justification: It has been recognized that the demand for training in the region exceeds availability, which has implications for improvement of radiation protection infrastructure in the region.

5. **Difficulties with the application of the concepts of exemption, exclusion, declassification or clearance (R5)**

Justification: In general, the concepts of exemption, exclusion, declassification or clearance are regulated, but these concepts are not applied by users, as a result of which items are viewed as waste which may not be waste, or are stored unnecessarily when they could be released from regulatory control.

6. **Insufficient individual internal monitoring coverage (R6)**

Justification: There is a significant lack in the region of internal contamination monitoring of occupationally exposed workers, in particular in nuclear medicine. A high percentage of countries need to implement mechanisms to allow for this type of monitoring.

7. **Insufficient knowledge of the radiological impact of NORM (naturally occurring radioactive material) industries (R7)**

Justification: It is well known that NORM industries can cause considerable exposure of workers and the public and can affect the environment. Nevertheless, no action has as yet been taken in the region to evaluate the impact thereof, allowing relevant regulatory measures to be taken.

8. **Lack of effective regional coordination to provide assistance in emergencies (R8)**

Justification: Capacity does exist in the region which can be used in emergencies and which, if properly coordinated, could be made available quickly to the affected country.

IV. PRIORITIZATION OF NEEDS/PROBLEMS IN THE SECTOR

These are the attributes which were considered for prioritization, following the selected methodology. More information on the subject may be found in the part of the RSP publication on the topic in question.

SERIOUSNESS	This is a measure of the degree of severity of the need/problem, taking into account the negative impact of not addressing it.
TIME	This is related to the degree of urgency in addressing the need/problem, its likelihood of worsening and future consequences.
EXTENT	This determines the degree of regional impact of the need/problem, taking into account, for example, the number of countries affected.
RELEVANCE of/for nuclear techniques	On the one hand, this measures to what extent nuclear applications can contribute to addressing/solving the need/problem. On the other hand, it takes account of the extent to which solving the problem has relevance for nuclear applications.
LEVEL OF DIFFICULTY	This measures the degree of difficulty of implementing the solution to the need/problem identified, which can be related to: infrastructure, resources, technology, legislation, intergovernmental commitments, etc.

1. VALUES ASSIGNED TO EACH NEED/PROBLEM

The identified problems/needs are presented in the following Table according to the grade given by the members of the respective sectorial Group, as may be seen under TOTAL.

	NEED/PROBLEM	SERIOUSNESS	TIME	EXTENT	RELEVANCE	TOTAL	DIFFICULTY	R/D	FINAL PRIORITY GRADE
R1	Lack of regulatory control standards in potentially high-risk practices (linear accelerators, interventional radiology).	3.60	3.20	3.80	3.80	14.40	3.60	1.06	**15.2**
R2	Lack of standardized training requirements for occupationally exposed workers in various practices.	3.20	3.30	4.20	3.40	14.10	2.40	1.42	**20.0**
R3	Deficiencies in control over materials to be recycled to ensure the absence of radioactive material.	3.20	3.20	4.20	3.40	14.00	3.80	0.89	**12.5**
R4	Limited coverage of the demand for postgraduate training in radiation protection.	2.80	3.00	4.40	3.40	13.60	4.00	0.85	**11.6**
R5	Difficulties with the application of the concepts of exemption, exclusion, declassification or clearance.	3.00	3.00	3.80	3.10	12.90	3.00	1.03	**13.3**
R6	Insufficient individual internal monitoring coverage.	3.00	2.80	3.80	3.20	12.80	3.60	0.89	**11.4**
R7	Insufficient knowledge of the radiological impact of NORM (naturally occurring radioactive material) industries.	2.80	2.80	3.40	3.00	12.00	4.00	0.75	**9.0**
R8	Lack of effective regional coordination to provide assistance in emergencies.	2.40	2.40	3.80	3.00	11.60	2.80	1.07	**12.4**

2. JUSTIFICATION OF ASSIGNED VALUES

The needs/problems are listed in order of priority based on the values assigned.

RADIATION SAFETY					
NEED	**SERIOUSNESS**	**TIME**	**EXTENT**	**RELEVANCE**	**DIFFICULTY**
R1) Lack of regulatory control standards in potentially high-risk medical practices (linear accelerators, interventional radiology).	Severely affects patient protection.	It is to be recommended that these criteria be implemented as soon as possible.	This applies to the majority of countries in the region.	Implementation will increase protection of patients and of interventional radiologists.	Establishment and application of procedures.
R2) Lack of standardized training requirements for occupationally exposed workers in various practices.	Affects the level of safety for the workers themselves and installations.	It is to be recommended that these criteria be implemented as soon as possible.	This applies to the majority of countries in the region.	Crucial for occupational protection.	Designing the appropriate requirements.
R3) Deficiencies in control over materials to be recycled to ensure the absence of radioactive material.	Possibility of radiological emergencies occurring.	It is to be recommended that these criteria be implemented as soon as possible.	This applies to the majority of countries in the region.	Implementation will increase protection of the public and of workers.	Implementation of methodologies for the detection of orphan sources is complex.
R4) Limited coverage of the demand for postgraduate training in radiation protection.	Compromises the sustainability of radiation protection infrastructure.	Should be addressed as soon as possible to ensure the availability of trained personnel in the immediate future.	This problem affects the whole region.	Considerable, with the aim of having a pool of professionals trained in their functions.	There are difficulties in expanding existing quotas and there is little probability that another regional training centre will be established.
R5) Difficulties with the application of the concepts of exemption, exclusion, declassification or clearance.	The failure to apply these concepts makes regulatory oversight difficult.	It is to be recommended that these criteria be implemented as soon as possible.	This applies to the majority of countries in the region.	The application of these concepts is of substantial importance for regulation of practices.	Directly related to risk awareness.
R6) Insufficient individual internal monitoring coverage	There is a lack of knowledge of the internal doses received by a significant number of exposed workers.	Should be addressed in the relatively short term because of its seriousness.	This is a problem which affects almost all countries in the region.	It is relevant from a radiological point of view because of the large number of occupationally exposed workers.	Considerable difficulty in implementing monitoring methodology.
R7) Insufficient knowledge of the radiological impact of NORM (naturally occurring radioactive material) industries.	The level of radiological impact is of concern because of existing exposure which would require intervention.	Should be addressed in the relatively short term because of its seriousness.	This is a problem which affects almost all countries in the region.	It is relevant from a radiological point of view because of the large number of people exposed.	Implementation of the protection measures is fairly complex.
R8) Lack of effective regional coordination to provide assistance in emergencies.	Not a pressing matter owing to installed infrastructure.	Not an imminent need.	It is thought it would be good for the majority of countries to benefit from this coordination.	The coordination will improve the level of public protection.	Only requires coordination to take advantage of installed capacity.

V. BIBLIOGRAPHY USED BY THE WORKING GROUP ON RADIATION SAFETY IN PREPARING THE RSP

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3. Guidelines for evaluating safety requirements (performance indicators).
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7. Fundamental Safety Principles — SF-1.
8. IAEA-TECDOC-1423 — Optimization of the Radiological Protection of Patients Undergoing Radiography, Fluoroscopy and CT.
9. IAEA-TECDOC-1447 — Image Quality and Dose in Mammography.
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11. RS-G-1.5 — Radiological Protection for Medical Exposure to Ionizing Radiation.
12. RS-G-1.7 — Application of the Concepts of Exclusion, Exemption and Clearance.
13. RS-G-1.8 — Environmental and Source Monitoring for Purposes of Radiation Protection.

VI. COMPOSITION OF THE WORKING GROUP

Group 5. Radiation safety (regulatory infrastructure, occupational radiation protection, regulatory aspects of exposure in medical practices, radiation protection of the public, radiological emergency preparedness and response, and education and training)

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3. Ángel Díaz (**Vice-Chairman of the ATCB**) — Venezuela
4. Alberto Miranda (**Secretary of the ATCB**) — Bolivia
5. Hadj Slimane Cherif — Director of the Office of Programme Development and Performance Assessment at the IAEA
6. Jane Gerardo-Abaya — Programme Management Officer supporting DIR -TCLA
7. Francisco Rondinelli — strategic planning expert
8. Angelina Díaz — expert with ARCAL experience
9. Sergio Olmos – expert with experience in the BAR and BAR Working Group

*ANNEX 1: **STRATEGIC ANALYSIS MATRIX***

Internal / External	Strengths	Weaknesses
Internal **External**	1. A common language which facilitates exchange of experience, information and professional support, helping bring countries to the same level in the various thematic areas. 2. Availability of organizations specializing in these fields that are prepared to support the development of the radiation safety infrastructure in countries. 3. Existence of important international instruments which countries have signed and agreed to implement, such as various international conventions, including the Early Notification and Assistance Conventions and the Code of Conduct. 4. Existence of trained professionals with experience who can collaborate within a bilateral framework. 5. The majority of countries have some type of legislation, regulations and an established regulatory body. 6. Existence in many countries of an infrastructure for dissemination of information. 7. Several countries have approved radioactive waste management regulations. 8. Most countries already have interim national storage facilities for waste that cannot be kept by the user. 9. Existence of regional projects and action plans which allow progress to be made in solving problems. 10. Existence of safety and civil defence bodies that can assist during emergencies. 11. Scope for provision of specialized medical support for emergencies by countries in the region. 12. Existence of a regional training centre for postgraduate courses in radiation protection. 13. Availability of training packages developed by the IAEA allowing standardization of the information imparted in training. 14. Existence of an extensive set of international standards (IAEA) that can serve as a reference for countries in developing their national regulations.	1. High rotation rate of trained professionals, particularly within regulatory authorities. 2. Unclear commitment on the part of governments with respect to support for, and strengthening and implementation of radiation safety programmes. 3. Ageing of professionals working in regulatory authorities and lack of attractiveness for young professionals of starting a career in the field of radiation protection (in national regulatory authorities). 4. Countries' dependence on the support, resources and programmes of international organizations, especially the IAEA. 5. Laboratories providing personal internal monitoring services are insufficient in number or irregularly distributed geographically, which makes it difficult to provide ample coverage for all exposed workers requiring it. 6. Lack of clarity as regards the meaning and scope of national policy and strategy concepts pertaining to radioactive waste management, which makes implementation in this area difficult. 7. Lack of information on the existence of NORM (naturally occurring radioactive material). 8. Lack of clarity with respect to the regulation of the concepts of exemption, declassification and clearance, and their application. 9. Some regulatory bodies do not have sufficient capacity in terms of infrastructure or trained human resources to meet fully the requirements which may be imposed as regards responsibility on operators, nor do they have the means of verification via effective inspections. 10. There is no notification system with regulated coordination for all organizations which must be involved in emergency response. 11. The regulatory frameworks in most countries do not include clear education and training requirements for all types of practices. 12. Not always peaceful coexistence of more than one regulatory authority per country, which might affect the transparency and independence of the regulatory function. 13. Conflicts of interest in some countries where the regulators are themselves regulated.

Opportunities 1. Importance which radiation safety and security of radiation sources have acquired in the world. 2. Clearer vision on the part of countries as regards their development needs with respect to regulation and control infrastructure. 3. Constant pressure from ecological groups about the generation of radioactive waste, prompting governments to help find a solution to these problems. 4. Public opinion in favour of environmental protection. 5. Existence of international standards for safe waste management processes. 6. Existing capacity in countries in the region for training of trainers and production of multiplier effects. 7. Training packages developed by the IAEA which comply with the requirements of the Basic Safety Standards and other standards. 8. Increased interest in the region in nuclear power generation, which raises awareness as regards a regulatory programme. •	**S1–S12 / O6–O7**: ***Need 6.*** Limited coverage of the demand for postgraduate training in radiation protection.	W11–O7: ***Need 3.*** Lack of standardized training requirements for occupationally exposed workers in various practices. **W7 / O1–O2–O3**: ***Need 4:*** Insufficient knowledge of the impact of NORM industries on people and the environment.

Threats 1. Changes in national authorities (changes in governments) which, owing to a lack of appropriate information and training, compromise the established infrastructure and the continuity of trained personnel, projects and programmes. 2. Economic difficulties in countries in connection with the improvement or upgrading of infrastructure, with insufficient budgetary allocation and economic instability. 3. Lack of commitment on the part of countries and working groups to ensuring there is a self-sustaining radiation protection system. 4. Negative public perception of everything to do with radiation, which also has negative repercussions with respect to waste management. **5.** Rotation and/or lack of human resources in connection with the establishment of self-sustaining education and training programmes. **6.** No multiplication of knowledge acquired at specific courses provided by international organizations. **7.** Lack of awareness-raising on radiation protection issues among professionals working with ionizing radiation and the general public.		**W5 / T7** ***Need 2***: Insufficient individual internal monitoring coverage. ***W1–W9/T7 Need 7***: . Lack of regulatory control standards in potentially high-risk practices (linear accelerators, interventional radiology). W6–T1–T2 : ***Need 8:*** . Lack of control over materials to be recycled. **W10 / T3**: ***Need 5:*** Lack of effective regional coordination to provide first-line assistance in emergencies. **W8 / T4**: ***Need 1:*** Difficulty with the application of the concepts of exemption, exclusion, declassification or clearance.

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Co-operation Agreement for the Promotion of Nuclear Science
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REGIONAL STRATEGIC PROFILE FOR LATIN AMERICA AND THE CARIBBEAN (RSP) 2007–2013

EXECUTIVE SUMMARY

Background

As part of the ARCAL-IAEA Strategic Alliance established at the 6th meeting of the Board of ARCAL Representatives (BAR), held in September 2005, and in line with the objectives of its Action Plan, the decision was taken to prepare a *Regional Strategic Profile for Latin America and the Caribbean (RSP)*. This was approved at an extraordinary meeting of the Board of ARCAL Representatives (BAR) held on 14 June 2007.

ARCAL representatives at all levels (BAR, ARCAL Technical Co-ordination Board (ATCB) and BAR Working Group) participated in the various stages of the preparation and approval process. The Department of Technical Cooperation and technical departments took part on behalf of the International Atomic Energy Agency (IAEA). Support was also provided by national experts from the region and from Spain and France.

In preparing the RSP, account was taken of such documents as the 2004 Regional Cooperation Plan (RCP) and the guidelines from the report of the Standing Advisory Group on Technical Assistance and Cooperation (SAGTAC) on regional programming of the IAEA technical cooperation programme presented in February 2007.

The work was subdivided into the following sectors, taking into account the priorities and needs of the Latin America and Caribbean region, including a study of trends and possible scenarios:

1. Food safety (mutation induction and genetic improvement of plants; integrated management of soils, water, plants and fertilizers; integrated pest management; animal production and health; nutrition and environmental protection);
2. Human health (nuclear medicine, radiotherapy, medical physics, radiopharmacy, nutrition, radiation protection of patients, nuclear molecular biology – infectious diseases);
3. Environment (atmosphere, water resources, terrestrial environment, marine environment);
4. Energy and industry (nuclear power, experimental reactors, applications in industry);
5. Radiation safety (regulatory infrastructure, occupational radiation protection, regulatory aspects of exposure in medical practices, radiation protection of the public, radiological emergency preparedness and response, education and training).

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Objective

The RSP establishes, based on the technical cooperation implemented by ARCAL in its four phases and the situation of the member countries, a descriptive analytical profile of the region's most pressing needs and the priority with which they can be addressed using available nuclear technology, with the support of the IAEA or other international sources of cooperation.

Thus, the RSP will serve as a basis for the preparation of regional programmes to be carried out using nuclear technology, but it will serve fundamentally as an aid in the process of project submission and selection under ARCAL, in accordance with its specific procedures.

Work methodology

First, terms of reference were established for the preparation of the RSP, and a survey was designed and sent to countries participating in ARCAL to assist in the initial identification of regional needs in each sector. Next, national experts carried out SWOT (strengths, weaknesses, opportunities and threats) analyses, allowing the region's most pressing problems/needs to be identified.

The experts, for reasons of prioritization, assigned specific attributes to these problems/needs related to their seriousness, time, extent, relevance and level of complexity. The resulting values allowed for quantitative comparison among them in their corresponding sectors, taking into account the different levels of development of each country in the sectors in question.

In addition, representatives of the United Nations Environment Programme (UNEP), the Pan American Health Organization (PAHO) and the Food and Agriculture Organization of the United Nations (FAO) presented both the priorities and the guidelines for technical cooperation with those implementing their programmes in Latin America and the Caribbean.

Needs/problems identified

The SWOT analyses allowed problems/needs to be identified, and use of the chosen prioritization methodology helped to fix the levels of the corresponding attributes for each sector.

The problems/needs identified are presented below in order of priority.

Food safety

- Inadequate sustainability in the application of nuclear techniques in agriculture.
- Restricted access to markets owing to the presence, in foodstuffs of animal and plant origin, of chemical residues that pose a risk to human health.
- Deficient agricultural soil management practices and inadequate use of fertilizers, water and biological nitrogen fixation.
- Presence of areas with a high prevalence of fruit flies.
- Loss of agricultural areas through soil degradation caused by extensive agricultural activity.
- Incidence of exotic transboundary diseases in animals.
- Low productivity, and susceptibility to biotic and abiotic stress, of traditional basic food crops.
- Presence of areas infested with New World screwworm.
- Vulnerability of livestock species at risk of extinction.
- Low productivity of native plants with nutritional and/or medicinal potential in areas of biodiversity.
- Limited development of aquaculture owing to health and genetic factors.
- Presence of areas with a high prevalence of codling moths.

Human health

- Regional deficit in trained human resources in terms of both quality and quantity (medical physicists, technicians, oncological radiotherapists, nuclear medicine specialists, molecular biologists, radiopharmacists and specialists in nuclear applications in nutrition).
- Lack of protocols (mainly clinical) and procedural manuals that have been evaluated, adapted and adopted by the region for the application of nuclear techniques in human health.
- The processes for the technological management of the infrastructure for application of nuclear techniques in human health in the region, including planning, incorporation and sustained operation of new technologies, are generally not implemented in accordance with international requirements.
- Lack or non-adoption of quality management systems in many centres in the region.
- Insufficient awareness among national and international decision makers and in the scientific community about the usefulness and safety of nuclear techniques in preventing and resolving public nutrition problems.
- Lack of institutionalization of the position and functions of the medical physicist in radiotherapy and imaging services (nuclear medicine and radiology), and to a lesser degree of other professionals associated with medical practices, by health ministries in many countries in the region.
- Limited application of molecular isotopic techniques in the region for the diagnosis of emerging infectious and contagious diseases such as SARS (severe acute respiratory syndrome) and avian influenza, and re-emerging ones such as dengue, malaria and tuberculosis, and lack of a regional laboratory network.
- Unequal access in the region to radionuclides, radiopharmaceuticals, reagent kits and stable isotopes for diagnostic and therapeutic procedures in nuclear medicine, nutrition and medicine.

- Insufficient human resources in the region trained in predictive, preventive and corrective maintenance of laboratory, diagnostic and treatment equipment employing nuclear technology that is many years old.
- Regional databases on infrastructure in nuclear medicine, radiopharmacy, molecular biology, radiotherapy and radiology, which can assist with planning and investment, are not up to date or do not exist.

Environment

- Lack and/or inadequacy of systems for early warning, diagnosis and evaluation of the environmental impact of pollution with pesticides, persistent organic compounds, heavy metals and other pollutants of anthropogenic and natural origin in foodstuffs and environmental matrices at the basin level.
- Inadequate systems for management, protection and knowledge of the availability and quality of water resources.
- Lack of regional systems for early prediction and evaluation of the toxicity of harmful algal blooms via radiotoxicological tests and bioassays.
- Limited knowledge of the processes that occur in the coastal area (loss of habitat, transfer of pollutants, sedimentation, nutrient cycles, climatic changes and effects of the El Niño phenomenon), to establish regional management programmes that reduce its degradation.
- Inadequate diagnosis and evaluation of the impact on human health of atmospheric pollution with trace elements in urban and rural areas and in enclosed spaces.
- Inadequate assessment of the hydrological and hydrogeological risk in hydraulic structures and lack of systematic monitoring of sedimentation in the region's artificial and natural water bodies.

Energy and industry

Nuclear power

- Need to improve the provision to the public of objective and extensive information on nuclear energy.
- Need to expand and strengthen training of qualified personnel to manage nuclear power projects and nuclear power plants.
- Shortage of long term energy and electricity supply and demand scenarios and analyses to decide on possible inclusion of nuclear power in order to diversify efficient and sustainable energy sources and provide power to areas with no supply.
- Expediency of countries having nuclear fuel cycle policies covering everything from mining of energy resources to disposal of radioactive waste.
- Lack of statistical databases and procedures and adequate indicators for use in energy assessment and planning studies.
- Need to strengthen exchange and transfer of experience and knowledge in the nuclear power sector.
- Insufficient energy integration in the region.

Experimental reactors

- Need to exchange experience in order to enhance reactor safety, operation and maintenance.
- Need to train highly qualified personnel in the management and operation of experimental and production reactors and to replace professional staff who are retiring.
- Need to upgrade the region's reactors to improve their safety and extend their operating lifetime.
- Insufficient use of experimental and production reactors.

Applications in industry

- Need to disseminate the benefits of applications to end users, making use of existing capabilities and experience in the region.
- Need to strengthen the training of personnel who assist in the development of the required applications.
- Insufficient use of nuclear applications in industry, which affects its competitiveness.
- Restrictions on trade and transport of radioactive material among countries in the region.
- Limited indigenous technology development for transfer to industry.

Radiation safety

- Lack of regulatory control standards in potentially high risk practices (linear accelerators, interventional radiology).
- Lack of standardized training requirements for occupationally exposed workers in various practices.
- Deficiencies in control over materials to be recycled to ensure the absence of radioactive material.
- Limited coverage of the demand for postgraduate training in radiation protection.
- Difficulties with the application of the concepts of exemption, exclusion, declassification or clearance.
- Insufficient individual internal monitoring coverage.
- Insufficient knowledge of the radiological impact of NORM (naturally occurring radioactive material) industries.
- Lack of effective regional coordination to provide assistance in emergencies.

Publications related to the RSP

To facilitate review of the material generated by the RSP preparation process, it has been published in separate parts covering the following aspects:

Regional Strategic Profile for Latin America and the Caribbean (RSP) 2007–2013;

Background, Methodology and Process for the Preparation of the RSP for Latin America and the Caribbean;

Food Safety in Latin America and the Caribbean in the Light of the RSP;

Human Health in Latin America and the Caribbean in the Light of the RSP;

Environment in Latin America and the Caribbean in the Light of the RSP;

Energy and Industry in Latin America and the Caribbean in the Light of the RSP;

Radiation Safety in Latin America and the Caribbean in the Light of the RSP.

For more information

IAEA
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