



**INTERNATIONAL ATOMIC
ENERGY AGENCY**

UNITED REPUBLIC OF TANZANIA

COUNTRY

PROGRAMME FRAMEWORK

1999 - 2005

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EXECUTIVE SUMMARY

The Country Programme Framework (CPF) described in this document constitutes a flexible basis for technical co-operation between the IAEA and the United Republic of Tanzania. It arose from intensive discussions with the competent national authorities followed by a multidisciplinary team mission. In the **mutually agreed strategy** for matching nuclear technology to national priorities for sustainable development, the focus of co-operation will be on aspects of **agricultural production, human health and water resources development**.

Consistent with recommendations from the Agency's Board of Governors, the New Strategy for Technical Co-operation and the objectives of Country Programme Frameworks, the future programmes are organized into three categories, namely, (a) the near-term core programme, (b) the medium-term core programme, and (c) general support activities.

The Near-Term Core Programme will focus essentially on three sectors in the field of agriculture, the main one being *livestock development in Zanzibar* as a consequence to tsetse eradication following the successful implementation of an Agency Model TC Project, URT/5/016. It is proposed to raise the number of pure-bred and cross-bred cattle, which is only possible in a tsetse-free environment, with a view to increase meat and milk production on the island. There is strong national commitment in this area and the Government, with the support of other donors, is currently assisting small-holder farmers in Zanzibar to increase the number and improve the quality of their livestock. The three-pronged approach envisaged under the technical co-operation project involves the use of nuclear and nuclear-related techniques to optimise the efficiency of the artificial insemination programme, to develop supplementary feeding strategies, and to control animal diseases.

Another clear future opportunity is in *improving the productivity* and other important characteristics of *rice through mutation breeding*. Rice production in Tanzania has increased from 140,000 tons in 1974 to 732,000 tons in 1995, indicating that this cereal is becoming the preferred staple food in the country. Moreover, improving its yields is a top priority of the National Research Master Plan.

Following the eradication of the tsetse fly from Unguja Island, Zanzibar, the Government has identified two other sites in Tanzania where similar projects could have an equally good chance of success. The first one is an area of about 45,000 km² in northeastern Tanzania, where there appears to be only one tsetse species and which is also well isolated from reinvasion. The second site is Mafia Island, with a land area of 692 km², 40 km from the eastern coast, where only one tsetse species seems to exist. The Agency's contribution is to *integrate the sterile insect technique (SIT) into the national tsetse and trypanosomiasis programmes* with the ultimate aim of eradicating the tsetse fly from these two regions.

Assistance of the Agency in the three areas in the agricultural sector identified for technical co-operation in the near-term is expected to extend over a few more years to overlap with the **Medium-Term Core Programme**. The latter should include additionally areas of co-operation in the sectors of human health and water resources development.

More particularly, *nuclear imaging diagnostic capabilities as well as the radiotherapy services will have to be further consolidated* to meet the present and future demand. Further to the provision of equipment and related training to strengthen the nuclear medicine unit, it

would be useful to establish an in-house radiopharmacy facility to prepare kits for *in-vivo* diagnostic studies. Such a facility would not only improve the standard of nuclear medicine services but also result in savings on the cost of imported kits. In the field of radiotherapy it is necessary to change the cobalt-60 source of the only teletherapy unit in the country and overhaul the machine. In order to improve the quality of treatment the provision of a simulator to ensure accurate localization of tumours prior to irradiation is necessary.

The use of nuclear techniques could play a significant role in providing relevant data and information to plan the exploitation of *groundwater resources* in the country. In this regard, the Agency's assistance is expected to be integrated with national and other donor-supported programmes. More particularly, isotope techniques would be used to determine the water origin and recharge mechanisms of the Ruvu Basin, which is the major groundwater resource for Dar es Salaam domestic water supply and industrial use. These activities are expected to complement an on-going World Bank programme aimed at monitoring water quality in the same basin. Similar studies are envisaged for the Kizumbi Basin, which serves as the main source of domestic water supply for about 100,000 inhabitants in north-west Tanzania, and the Kilombero Valley, Morogoro, where a few wells are exploited for irrigation of sugar cane plantations and additional boreholes are planned to be drilled. Finally sedimentation monitoring studies would be carried out on two reservoirs, Mtera and Nyumba ya Mungu, which are used mainly of hydroelectric power generation.

Further to the core programme, the assistance of the Agency is at times essential for the continuation of on-going activities, including those initiated through previous TC projects, which might otherwise lapse or fail. The bulk of the required **support activities** could be undertaken within the framework of the AFRA programme and other regional projects.

A. INTRODUCTION

A Country Programme Framework (CPF) is intended to stimulate and facilitate communication between the AIEA and a given Member State with regard to the development and implementation of the medium-term Technical Co-operation Programme covering a period of 4-6 years. The objective is to reach agreement on a few high priority areas of development upon which the IAEA's Technical Co-operation Programme should focus.

However, the CPF is not a rigid document and may be renegotiated if it no longer serves mutual needs (1,2).

The CPF document for the United Republic of Tanzania emanates from lengthy consultations between the national authorities and the IAEA, which culminated in an Agency's multidisciplinary team mission from 13 to 17 October 1997.

The country covers an area of about 945,000 km² on the South-eastern coast of Africa and comprises the mainland and two islands, Unguja and Pemba. The population is estimated to be about 30 million growing at a rate of 2.8% per annum. The basic country data are summarised in Annex 1 and described in some detail in several publications (3,4, 5).

B. RELEVANT NATIONAL DEVELOPMENT PRIORITIES AND ACTIVITIES

B.1 General

After recognizing that the public sector by itself was not capable of spearheading the development of the economy, the Tanzanian Government shifted the focus to boarder based economic development policies, with a renewed emphasis on the role of the private sector. Thus, a Rolling Plan and Forward Budget (6) (RPFb) was adopted as a continuation of the economic and institutional reform programmes which started in the mid-1980's with the Economic Recovery Programme (ERP). The RPFb aims to optimise the use of resources under new management and/or ownership, with the Government retaining a small manageable parastatal sector and most of the productive and commercial activities transferred to the private sector or run under joint venture agreements. As a result of this reform, measures were taken to reduce the size of the civil service and 128 parastatals were earmarked for privatization or liquidation.

B.2 Agricultural Development on the Mainland

Tanzania's economy is largely dominated by agriculture which contributes nearly 60% of the GDP, employs about 84% of the work force and generates more than 60% of the export earnings.

Food crops (maize, cassava, sorghum, millet, beans, potatoes, rice and wheat) account for 55% of the agricultural GDP, livestock for 30%, and traditional export crops (coffee, cotton, cashew nuts, sugar, pyrethrum, tea, tobacco and sisal) for 8%.

The objectives of the Government with regard to the agricultural sector are to a) achieve national self-sufficiency in food, b) raise the income of all Tanzanians, especially the rural poor, and alleviate poverty, c) promote sustainable production and environmental protection, d) increase foreign exchange earning, and e) produce and supply raw materials for the industrial sector.

In an attempt to achieve these objectives, the Tanzanian Government embarked on a process of "zonalisation" in an effort to refine and rationalise the prioritization of agricultural research within the framework of the National Agricultural and Livestock Research Masterplan (NALRM), as a consequence of which drastic reductions of government funds and delayed disbursements were inflicted upon several research institutions. However, attempts to mobilise domestic non-government funds have not met with the anticipated degree of success so far.

In the livestock sector, the Government is aiming to control the major diseases which are presently threatening the 15.6 million cattle in the country, in order to increase productivity. In particular, the Government is currently collaborating with FAO in conducting vaccinations against Contagious Bovine Pleuropneumonia (CBPP) in affected regions. The Animal Disease Research Institute (ADRI) has been selected as the regional laboratory for Tanzania, Malawi and Zambia. In fact, a Tanzanian Agricultural Research Support Project - Phase 2 (TARP II), funded by the World Bank and the African Development Bank is supporting ADRI with infrastructure rehabilitation, vehicles, operational funds and some major laboratory equipment.

The Tsetse and Trypanosomiasis Research Institute, (TTRI), Tanga, has the world's largest mass-rearing tsetse facilities, established under the IAEA's Technical Co-operation (TC) Project URT/5/016 (Eradication of Tsetse on Zanzibar). It is currently implementing a World Bank funded project which aims at data collection on a tsetse species prevalent in the North-Eastern part of Tanzania, the *Glossina Swynnertoni*. A European Union project, aimed at tsetse control is also scheduled to start soon.

With regard to crops, the institutes which could be of interest to the work of the Agency are the Selian Agricultural Research Institute (SARI), Arusha, which benefited from the assistance of the Agency in the fields of mutation breeding and biological nitrogen fixation (BNF), the Sokoine University of Agriculture (SUA), Morogoro, which is presently implementing an IAEA-supported regional TC project on food security, Kilombero Agricultural Training and Research Institute (KATRIN), Morogoro, which is the main station for research on rice, ARI Mikocheni, which is the leading institute for research on coconut palm, and ARI Milingano, which implemented an Agency TC project on BNF in the early 1980's.

B.3. Agricultural Development on Zanzibar

Zanzibar, which is made up of the islands of Unguja (1,530 km²) and Pemba (920 km²), has a total population of 800,000 growing at 2.7% per annum. The economy is largely dominated by agriculture, which accounts for about 55% of the GDP and provides over 90% of export earnings. Cloves represent 98% of the export value in the agricultural sector.

Rice and cassava are the main staple diets. However, Zanzibar produces only 10-15% of the rice demand of about 85,000 tons annually on an area of 9,000 ha, out of which just over 100

ha are irrigated. Rice production is low because of diseases, low inputs and the varieties used. Other important food crops are banana, sweet potato, legumes and grains.

Livestock production is predominantly in the hands of smallholders. According to a recent census, there are only about 132,000 heads of cattle on Zanzibar, with more than half of them (59%) in Pemba, where there has never been trypanosomiasis. 97% are Zanzibar shorthorn Zebus and only about 3% are pure-bred jerseys or cross-bred cattle. Pemba is relatively self-sufficient in meat and milk. However, for Unguja, between 6,000 and 10,000 heads of cattle are imported for slaughter per year from the mainland.

Government's efforts are now directed towards the small-scale farmers to help them improve the production and supply of food. The inception of "FOOD FOR ALL" policy aims at attaining self-sufficiency in rice, meat and milk by the year 2000. To attain these objectives several developmental projects dealing with rice irrigation and seed development have been launched. In particular, various seeds from the International Rice Research Institute (IRRI) have been tested and ten varieties have been approved for use at various irrigation sites.

Control of East Coast Fever by Immunization and the virtual elimination of trypanosomiasis through tsetse eradication are already having a positive impact in the livestock sector on Unguja Island. However, there is a potential for a considerable further increase in the cattle population and milk yields through better feeding practices and the introduction of a larger number of upgraded animals. Some assistance to the smallholders through the utilization of an IFAD loan as well as the promotion of more effective livestock management practices are also expected to benefit this sector.

B.4 Water Resources Development

In the water resources management sector, the Government, is guided by the National Water Policy, launched in 1991. The main objectives are to provide the population with clean and safe water within a distance of 400 metres by the year 2002, to identify and develop new water resources, to improve the efficiency in the development and management of water supplies, and to ensure that the development of the sector is environmentally, socially and financially sustainable.

About 30% of the total water supplied for domestic use in Tanzania is groundwater, the other 70% being from surface water sources. Most groundwater in the country is potable.

Notable water quality problems are salinity, which is prevalent in coastal areas and in internal drainage basins where surface drainage is poor, and high fluoride content in volcanic and Rift Valley areas. Pollution of surface water coupled with very high costs of water treatment has prompted the Tanzanian Government to implement a programme to prevent depletion of water resources, especially as vast areas in the central part of the country are semi-arid. Thus, the River Basin Management and Smallholder Irrigation Improvement Project (RBMSII) funded by the World Bank aims to strengthen the Government capacity to manage its water resources in an integrated and comprehensive manner at the national level (7).

With regard to more specific activities the following could be of direct relevance to the activities of the Agency:

- a) A World Bank Programme to monitor water quality in the Ruvu basin in the Shinyanga region is in progress.
- b) The Ministry of Water is proposing to drill about 50 boreholes in the Kizumbi Basin in the Shinyanga region.
- c) The major sugar cane plantations in Tanzania are in the Kilombero Valley, Morogoro. They are managed by parastatal bodies which are currently planning to drill several boreholes in this region for domestic and irrigation purposes.
- d) The Mtera Reservoir, Iringa, and the Nyumba ya Mangu Reservoir, Kilimanjaro, are used as hydro-electric power generation sources. The Government, which is presently planning to increase the capacity of these reservoirs, wants to take measures to minimise the sedimentation problem.

Further to the above, it is important to note that the newly formed Water Sector Unit in the Southern Africa Development Community (SADC) is promoting joint water studies in the sub-region, incorporating surface and groundwater flows as well as environmental and other water-related issues. It is intended to include isotope hydrology techniques in these studies.

B.5 Human Health

The health care structure in Tanzania is in a pyramidal form, with the base consisting of dispensaries spread out in every village and the apex formed by the national referral Muhimbili hospital in Dar es Salaam. In between are health centres, district hospitals, regional hospitals and zonal referral hospitals. There is also a private health delivery system which is found almost exclusively in Dar es Salaam and a few other major towns.

The broad objective of the Government is to ensure health care for all Tanzanians by the year 2000. In order to provide quality health service on a sustainable basis the strategy of the Government is to improve the efficiency of the health sector, make those who can afford it pay for the services, continue to subsidize the health sector to ensure that the poor get access to the services, and educate the population on improved nutrition and sanitation as well as on disease prevention.

The utilisation of ionising radiation in the health sector started as far back as 1972 when a Jenus telecobalt machine was installed at the Muhimbili Medical Centre (MMC) through the efforts of Professor Ulrich Henschke, a US citizen. Again at the initiative of Professor Henschke a gamma camera for in-vivo nuclear medicine imaging was provided by Germany in 1981 through a bilateral agreement. Both these items subsequently became faulty beyond repair.

Due to congestion at the MMC, radiotherapy services were moved to the Ocean Road Hospital, now known as the Ocean Road Cancer Institute (ORCI), in 1982.

In 1987, through a bilateral agreement with the Tumorhilfe of Heidelberg, Germany, a single-channel Buschler intracavitary unit was provided, installed and used for the treatment of cervical cancer. In 1997, a three-channel Buchler intracavitary unit was provided.

ORCI is also operating a Co-60 teletherapy machine and gamma camera (see Section C.2).

C. SUMMARY OF RELEVANT PAST TECHNICAL CO-OPERATION ACTIVITIES

The United Republic of Tanzania became a Member State of the Agency in 1978. An overall programming mission to Tanzania carried out by the Agency in 1978, laid the foundation for the utilization of nuclear techniques in the country. The objective of the mission was to identify areas in which nuclear technology could benefit the country's development programme in nuclear medicine, agriculture and raw materials research.

The National Radiation Commission (NRC), which operates under the aegis of the Ministry of Science, Technology and Higher Education (MSTHE) is responsible for the co-ordination of the Agency technical co-operation programme in the country.

The support of the Agency to Tanzania until the end of 1998 amounted to about US\$ 11.3 million. In fact, Tanzania was the topmost beneficiary of the IAEA TC programme in 1994 (US \$2,153,300), second in 1995 (US\$ 1,936,500), third in 1996 (US\$ 1,353,900), and third again in 1997 (US\$ 993,500). This high rank is attributed mainly to the implementation of a Model Project on tsetse eradication since 1994.

More than half of the assistance during the past ten years has been provided in the form of equipment (56%), complemented by expert services (28%), and training (16%). Most of the resources were provided by the Technical Co-operation Fund (64%), the rest being made available through extrabudgetary contributions (34%) and assistance-in-kind (2%).

By far the largest sector of assistance during the past ten years has been agriculture (68%), followed by human health (11%), nuclear safety (9%), and nuclear physics (7%). Industry and hydrology accounted for less than 5% of the total assistance (8).

C.1 Food and Agriculture

C.1.1 Crop Production and Crop Improvement

In the area of crops, the assistance of the Agency has focused primarily on 3 sectors, namely:

- (i) to increase yields of main crops through efficient use of water and fertiliser;
- (ii) to determine the amount of nitrogen fixed by various nitrogen-fixing trees, such as *L. leucocephala*, to identify better sources and methods of application of mineral fertilizers, and to monitor environmental pollution as a result of nutrient movement; and
- (iii) to develop varieties of barley and wheat with improved yield, resistance to disease, and tolerance to drought and salinity, through mutation breeding.

A TC project, URT/5/004, was initiated in 1981 to set up an isotope laboratory at the Milingano Agricultural Research Institute with a view to carry out research aimed at increasing fertiliser use efficiency and crops yields. However, very little progress was made by the time the project was completed in 1985, indicating that Milingano might not have been an appropriate location for such a project.

The assistance of the Agency in this field was shifted in 1993 to the Selian Agricultural Research Institute (SARI) in Arusha, through the implementation of a TC project, URT/5/013.

Field experiments were carried out to quantify nitrogen fixation in tree species, studies were undertaken on nitrogen uptake from ammonium sulphate and the prunings of nitrogen-fixing leguminous trees, fertiliser use efficiency by barley, maize and rice was assessed, and the BNF potential of different genotypes of common beans and soy beans was evaluated. By the time the project was completed in 1996, SARI had developed the necessary capabilities in terms of manpower resources and laboratory equipment to pursue relevant activities. However, one major constraint remains the lack of an adequate local operational budget for the institute.

SARI has also benefited from Agency support in the field of mutation breeding of barley and wheat as from 1993 through a TC project URT/5/011, which was subsequently extended in 1995 under the project number URT/5/017. Barley seeds irradiated in 1993, with a view to improve straw strength and plant stature to resist lodging, as well as malting grain characteristics, were planted on SARI's experimental fields on the outskirts of Arusha. Selection for the desired characteristics was performed on the M2, M3, M4 and M5 generations, and the material is currently being evaluated in replicated trials for agronomic and malting quality characteristics. Project research has already progressed to on-farm trials, but the final testing before release of the improved advanced mutant breeding lines may take a few more years.

C.1.2 Animal Production and Animal Disease Diagnosis

The Sokoine University of Agriculture, Morogoro, has been the main recipient of the Agency's assistance in the field of livestock productivity. The TC project URT/5/008, which was implemented from 1986 to 1993, led to the establishment of appropriate laboratory facilities and the training of the necessary manpower. Under the follow-up project, URT/5/012 (1993-1996), radioimmunoassay (RIA) techniques were used to carry out studies on ways of improving the reproductive performance of local breeds of cattle. Moreover, an ELISA-based system for studying *Salmonella* infections in cattle and poultry has also been established at the Sokoine University of Agriculture.

The Agency TC project on animal disease diagnosis (URT/5/009), implemented by the Animal Diseases Research Institute (ADRI), Ministry of Agriculture and Livestock Development, Dar es Salaam, from 1989 to 1993, helped to strengthen the national capability for utilising nuclear and nuclear-related techniques to diagnose and monitor the major diseases affecting livestock, in particular, rinderpest, food-and-mouth-disease (FMD), brucellosis and trypanosomiasis. An animal disease diagnosis laboratory, using ELISA techniques, was also established at the Ministry of Agriculture, Zanzibar, mainly to monitor the prevalence of trypanosomiasis in connection with the tsetse eradication project.

C.1.3 Tsetse Eradication

The Tsetse Fly Eradication Project, which started in 1984, was upgraded to a Model Project in January 1994, with the objective of achieving full-scale tsetse eradication in Zanzibar (Unguja island). Extrabudgetary contributions for project implementation were made available by Belgium, Canada, China, Sweden, U.K., U.S.A., and the OPEC Fund. The Zanzibar authorities contributed substantially to the project through the provision of funds from an IFAD loan.

The implementation of this project led to the establishment at the Tsetse and Trypanosomiasis Research Institute (TTRI), Tanga, of the largest tsetse mass-rearing facility ever. At the peak of their operation, the insectaries contained a tsetse female colony of over 900,000 flies and were producing nearly 100,000 sterile males for release on a weekly basis.

Another innovation linked to this project was the aerial release of sterile tsetse flies on an operational scale.

As a result of the project activities, no wild tsetse fly has been caught on the island since September 1996, indicating the complete eradication of this vector. Animal disease monitoring on Zanzibar also points to the complete absence of cyclical transmission of trypanosomiasis on the island.

This project served not only to eradicate tsetse on the island of Zanzibar as a step towards an increase in livestock and crop production, but also provided valuable technical and managerial information for the implementation of large-scale projects on tsetse eradication on the African continent.

C.2 Human Health

C.2.1 Nuclear Medicine

The Muhimbili Medical Centre of the Faculty of Medicine, Dar es Salaam, has a capacity of 2,000 beds and handles more than 1.5 million patients per year. It is the most important hospital and medical training centre in the country. The implementation of TC projects URT/6/004 (1984-1991) and URT/6/006 (1991-1995) enabled a radioimmunoassay (RIA) laboratory to be established at this medical centre for the assay of thyroid-related and other hormones.

However, since the Muhimbili Medical Centre is very congested, the assistance of the Agency in the field of in-vivo nuclear medicine was directed to the Ocean Road Hospital, also in Dar es Salaam. An Agency-supported TC project, URT/6/008 (1993-1996), enabled the delivery of a gamma camera to that Hospital, which recently changed its name to Ocean Road Cancer Institute (ORCI). The gamma camera, which was subsequently upgraded through another TC project, URT/6/009, initiated in 1995, to perform dynamic imaging, is in constant use and is the only such facility in the whole country.

C.2.2. Radiotherapy

ORCI has also benefited from the assistance of the Agency in the field of radiotherapy. In 1985-86, the Agency assisted the national counterparts in testing, checking, transporting and installing a Theratron-780 radiotherapy machine, donated by the Harvard Medical School, U.S.A. Through the implementation of a TC project, URT/6/007, initiated in 1993, this equipment was overhauled, the Co-60 source was changed, and a treatment planning system, dosimetry equipment and an orthovoltage X-ray machine were provided. A new project, URT/6/017, which started in 1998, enabled brachytherapy facilities to be provided to ORCI.

C.3. Water Resources Development

The use of isotopes in hydrogeological studies was first introduced in Tanzania in 1979 through an IAEA-supported TC project, URT/8/003. The studies were concerned with the use of environmental isotope methodologies in the assessment of the origin and replenishment characteristics of the Makutupora and other basins in Central Tanzania. In 1986, the Ministry of Water, with the assistance of the Agency under the TC project URT/8/005, installed a nuclear sediment gauge on Mkonda River in the Dodoma region for the automatic recording of suspended sediment content. This information on sediment transport was meant to be used in the design of future dams and reclamation projects in the area.

A subsequent TC project, URT/8/006 (1988-1993), focused primarily on isotope studies of the replenishment dynamics of groundwater at the Makutupora Basin, which is the main source for domestic water supply to the capital city of Dodoma.

All these TC projects have been implemented by the Water Research Department of the Ministry of Water and its various regional laboratories. The laboratory in Dar-es-Salaam has recently been upgraded under a TC project, URT/8/008, through the provision of a liquid scintillation counter, a tritium enrichment unit and other equipment.

C.4 Industrial Applications and Instrumentation

C.4.1 NDT Techniques

In 1985, well before any co-operation with the Agency in this field was envisaged, the Tanzania Industrial Research and Development Organisation (TIRDO) procured a limited number of equipment for industrial radiographic studies, including two industrial X-ray units and an X-ray film developing set. The staff received some on-the-job training and TIRDO started to launch radiographic inspections on a semi-commercial scale.

At the request of the Tanzanian Government, a TC project, URT/8/007, was initiated in 1993, with a view to consolidate and expand the NDT facilities at TIRDO. As a result of the implementation of this project, the various NDT techniques, including X-ray, gammagraphy and ultrasonics, have been fully established and the skills of the personnel considerably improved. TIRDO is carrying out non-destructive inspection for public and private enterprises. In particular, the non-destructive inspection of the TAZAMA oil pipeline, which runs from Tanzania to Zambia and cast-iron rollers for the sugar industry deserves special mention.

C.4.2 Instrumentation Maintenance and Repair

It was brought to the attention of the Agency's Country Programming and Review Mission of December 1991 that, out of the 180 or so X-ray machines in the country, about 60 were out of order, 40 were not installed and the rest were in use with various defects and without quality assurance certificates. Moreover, numerous nuclear instruments, most of which supplied by the Agency, were out of order.

As a result of these findings, a TC project, URT/4/002, was initiated in 1993 with a view to assist the National Radiation Commission in Arusha to strengthen the national service and

maintenance programme for nuclear and nuclear-related equipment, with special emphasis on X-ray machines. These objectives have been achieved through the provision of appropriate equipment and training of the local staff through fellowships and national training courses. However, the repair and maintenance of medical equipment is a huge task, which now requires substantial national investment in terms of financial and manpower resources.

C.5 Nuclear Physics

With the support of the Agency since 1977, through TC projects URT/1/002 (1977-1979), URT/1/003 (1980-1991) and URT/1/005 (1991-1994), a Nuclear Physics Unit has been established in the Physics Department of the University of Dar es Salaam. Mössbauer spectroscopy and X-ray Fluorescence (XRF) techniques have been introduced and several students trained at post-graduate level. XRF studies have been carried out in the assessment of heavy metal pollution in water discharged by industries and in the determination of trace elements in blood with a view to correlate malnourishment in children with deficiencies in the essential trace elements. Mössbauer spectroscopy has been used in the analysis of soils, ores and mineralogical samples and in the study of atmospheric corrosion of steel. Both the Mössbauer spectroscopy and XRF facilities have been upgraded through a recent TC project, URT/2/002, in order to use these techniques to study the correlation between the occurrence of gold and certain iron sulphides and to assess environmental pollution levels. In this regard, the Agency is working in close collaboration with IPPS, Uppsala University, Sweden.

C.6 Nuclear Safety

The Agency has provided assistance, under TC projects URT/9/002 (1984-1993) and URT/9/003 (1993-1997), for the development of a national radiation protection service in Tanzania. This service operates under the National Radiation Commission (NRC) which was established by an Act of Parliament "The Protection from Radiation Act, 1983". The NRC, which is a government body responsible for all atomic energy matters in the country, is located in Arusha and has laboratories for:

- TLD personnel monitoring;
- food contamination monitoring;
- radon monitoring;
- quality control of medical equipment; and
- calibration of radiation monitoring equipment

At present, over 500 radiation workers in about 170 institutions are benefiting from personnel monitoring services. Country-wide radiation safety inspections are also currently undertaken by the NRC.

The NRC has a computerised gamma spectrometer system using a sodium iodide scintillation detector, which is used for routine radiation monitoring of samples of imported food.

A National Standard Dosimetry Calibration Laboratory, established in 1991, has recently been upgraded.

C.7 Participation in Regional Projects

Tanzania is a member of the AFRA Agreement that came into force in 1990. As such, it is benefiting from assistance under the regional agreement in the fields of:

- Maintenance of Medical and Scientific Instruments (RAF/0/014)
- Strengthening Waste Management Infrastructure (RAF/4/015)
- Animal Feed Supplementation Packages (RAF/5/041)
- Development of Improved Crop Varieties (RAF/5/042)
- Improvement of Clinical Radiotherapy (RAF/6/014)
- Consolidated RIA Capability for Tumour Markers (RAF/6/018)
- Radiation Processing of Food & Industrial Products (RAF/8/024)
- Non-Destructive Testing Industry (RAF/8/025)
- Harmonization of Radiation Protection Practices (RAF/9/022)

Moreover, Tanzania is also participation in the following non-AFRA regional projects:

- Institutional Support for Least Developed Countries (RAF/0/012)
- Increasing Food Security in Sub-Saharan Africa (RAF/5/036)
- Isotopes for Control of Human Communicable Diseases (RAF/6/017)

D. PROJECTED PROGRAMME OUTLINE

Consistent with recommendations from the Agency's Board of Governors (1), the New Strategy for Technical Co-operation (2) and the objectives of Country Programme Frameworks, future programme planning discussed in this section is organised into three categories.

The first category, referred to as the Near-Term Core Programme, includes the highest priority activities which have Model Project potential and for which the bulk of the country's programme budget will be devoted.

The second category includes those activities which are projected to become the next set of core projects. Support for these activities will be concentrated primarily on building those components of infrastructure and technical capacity, including human resources development, that are expected to be required for the next set of core activities and which require a significant lead time.

The third category identifies the support that is essential for the continuation of on-going activities, including those initiated through previous TC projects, which might otherwise lapse or fail.

The programming plans outlined here emanate from numerous consultations between the national authorities and staff members of the Agency, followed by a multidisciplinary team mission to Tanzania.

D.1. The Near-Term Core Programme

The near-term core programme is expected to be constituted essentially of three projects in the field of agriculture, namely, (a) livestock development in Zanzibar after tsetse eradication, (b) improving the productivity of basic food crops, especially rice, and (c) control and eradication of tsetse.

D.1.1 Livestock Development on Zanzibar After Tsetse Eradication

For several decades, livestock production on Unguja Island, the larger of the two islands constituting Zanzibar, has been seriously constrained by the prevalence of animal diseases, especially trypanosomiasis and East Coast Fever (ECF). Thus, at present Zanzibar produces only 30% of its beef and 7% of its milk requirement.

Out of the 46,000 head of cattle on Unguja Island, only 2,600 are cross-bred dairy animals, the rest being indigenous zebus. Although the average milk production of the cross-bred dairy cow is considerably higher than that of the Zebu dairy cow, the farmers faced difficulties in the past to raise cross-bred animals, which are much more prone to animal diseases.

Trypanosomiasis is transmitted by tsetse fly. However, the implementation of an Agency Model TC project, URT/5/016, has led to the eradication of this vector, as testified by the fact that no tsetse fly has been detected on the island since September 1996. As a result, trypanosomiasis has been virtually eliminated. Also, ECF is now being controlled by immunization of cross-bred cows.

In order to make optimal use of the new conditions on the island, the Ministry of Agriculture, Livestock and Natural Resources of Zanzibar has elaborated a "Five Year National Programme" which aims at a substantial increase in meat and milk production(9). The strategy is not only to double the cattle population over a five-year period, but, more especially, to increase the number of improved dairy cattle by a factor of twenty. Farmers are already eagerly participating in the national programme and are convinced that the set objectives are achievable.

The Agency's contribution to the national efforts through the use of nuclear and nuclear-related techniques will be concentrated on three major areas, namely,

- a) the improvement of veterinary services at the farm level to increase the efficiency of artificial insemination and to assist smallholders in improving the reproductive performance of dairy cattle through, notably, early diagnosis of non-pregnancy;
- b) the promotion of appropriate feeding practices and feed supplementation strategies based on the use of locally available feed resources under sustainable crop-livestock integrated small-holder systems, and
- c) the control of animal diseases, with the focus on monitoring the absence of trypanosomiasis and the efficiency of the vaccination campaign against ECF.

According to the National Programme, by the year 2005 the cross-bred cattle population is expected to increase from 2,600 to 49,000, milk production from 7,400,000 litres to 41,360,000 litres, and beef production from 413 tonnes to 921 tonnes. The average annual

income of livestock farmers is projected to increase more than eightfold, from the present US\$ 97 to US\$ 884, and 26,000 livestock farmers are expected to be gainfully employed.

D.1.2 Improving the Productivity of Rice

Rice is becoming a very important staple food both on the mainland and in Zanzibar, as reflected by the increase in per capita consumption from 15 kg/year in the 1970's to 35 kg/year at present. In view of the importance of this crop, rice research has become the top priority of the National Research Master Plan (Annex 2).

Rice is grown in all parts of Tanzania Mainland and in Zanzibar under several different ecosystems. In 1995, an estimated 730,000 tons of rice were harvested from about 480,000 ha. These figures show that the rice area more than tripled since 1974-75, and the production more than quintupled, due also to higher yields (1.5 tons/ha instead of 1.0 tons/ha.), as shown in Annex 3.

Varietal improvement of rice was initiated in Tanzania in 1965. The national rice research programme is co-ordinated by the Kilombero Agricultural Training and Research Institute (KATRIN) of the Ministry of Agriculture, Morogoro Region. Rice breeding activities are carried out at KATRIN, Sokoine University of Agriculture (SUA), and the Dekawa Agricultural Research Centre. Several improved and introduced varieties have been released to farmers and other promising lines are under various stages of testing.

The objective of an Agency-supported TC project would be to assist national efforts to use induced mutations to produce short-statured and early-maturing rice mutant varieties with improved grain quality and resistance to diseases especially blast and rice yellow mottle virus. Subsequently, the development of new mutant lines could be speeded up through the use of in-vitro culture techniques. Appropriate institutions for the implementation of such a project are the Sokoine University of Agriculture (Morogoro), KATRIN, and the Ministry of Agriculture, Livestock and Natural Resources, Zanzibar.

D.1.3 Control and Eradication of Tsetse

The implementation of the Model Project URT/5/016 and previous tsetse eradication projects has enabled a national capacity to be established for tsetse control and eradication and the staff of the Tsetse and Trypanosomiasis Research Institute (TTRI) to acquire considerable experience in the mass-rearing of tsetse flies.

Following the eradication of the tsetse fly from Unguja Island, Zanzibar, the Government has identified two other sites in Tanzania where similar projects could have an equally good chance of success. The first one is an area of 45,000 km² in northeastern Tanzania, where the *G. swynnertoni* is a major vector of trypanosomiasis in livestock and sleeping sickness in humans. It appears that the *G. swynnertoni* is the only tsetse species in this region, which is also apparently well isolated from reinvasion. This part of Tanzania is economically important because it has the highest concentration of cattle, large farms for cash crops, and fast developing tourism. A World Bank loan amounting to US\$ 250,000 has been secured mainly to establish baseline data with regard to tsetse population density and prevalence of trypanosomiasis in this region.

The second site is Mafia Island, with a land area of 692 km², 40 km off the eastern coast. Farmers have mixed crop and livestock systems and small scale intensive dairy units with improved breeds. There are about 15,500 cattle, including 3,000 improved and exotic breeds, and 1,900 goats and sheep on the island. However, the prevalence of the tsetse fly *G. brevipalpis* is a major constraint to livestock development. There is no indication that other tsetse species exist on the island, which is well protected from tsetse reinvasion because of its geographical location.

The Agency's contribution is to integrate the Sterile Insect Technique (SIT) into national tsetse and trypanosomiasis management programmes with special reference to the two regions mentioned above. The ultimate aim is to eradicate the tsetse fly from the specified region in northeastern Tanzania and Mafia Island with a view to eliminate trypanosomiasis, thus paving the way to more productive mixed farming and a subsequent increase in meat, milk and crop production.

D.2 The Medium Term Core Programme

The three areas in the field of agriculture identified for technical co-operation in the near-term are likely to extend over a period of a few more years. Moreover, the Medium-Term Core Programme is expected to include additionally other areas of co-operation in the fields of human health and water resources development.

D.2.1 Consolidation of Nuclear Medicine and Radiotherapy Services

The refurbished gamma camera provided by the Agency in 1994 under a previous TC project, URT/6/008, is still the only one in the country. However, the number of patients benefitting from this facility have greatly increased from about 50 in 1994 to over 500 in 1998. In fact, the demand is much higher than indicated by these figures. The lack of tomographic (SPECT) capabilities is also a serious limitation. A second gamma camera with SPECT facilities is now necessary for the Ocean Road Cancer Institute (ORCI) to enable it to cope with the present and future demand at least for the next 5-10 years. Moreover, the Nuclear Medicine Unit should be further strengthened by establishing an in-house radiopharmacy facility to prepare kits for in-vivo diagnostic studies. Such a facility would not only improve the standard of nuclear medicine services but would also result in savings on the cost of imported kits.

With the assistance of the Agency, the cobalt-60 source of the Theratron-780 teletherapy unit at ORCI was changed and the machine overhauled in 1993. This machine is currently being used for the treatment of 70-80 cancer patients per day. However, the quality of treatment could only be improved through the provision of a simulator to ensure accurate localization of tumours prior to irradiation. The assistance of the Agency in the field of radiotherapy within the next five years or so is expected to focus essentially on the change of the cobalt-60 source and overhaul of the machine as well as on the provision of a simulator, coupled with related training and expert services.

In view of the limited number of local qualified personnel in the fields of radiotherapy and nuclear medicine, it would be appropriate to establish telemedicine links between ORCI and appropriate institutions abroad in order to allow for rapid communication and referral of patient images for advice and consultation. Internet facilities are being installed at ORCI, as

part of the University of Dar es Salaam network, and the additional inputs required for the telemedicine links should not exceed US\$ 25,000.

D.2.2 Water Resources Development

The medium-term TC programme in water resources development should be correlated with the national priorities and activities in this sector as described in Section B.4.

Thus, isotope techniques could be used to determine the water origin and recharge mechanism of the Ruvu Basin, which is the major groundwater resource for Dar es Salaam domestic water supply and industrial use. Meteorological and geophysical data as well as gauge records of the Ruvu river run off are already available. Additional data, which could be obtained through the use of nuclear techniques, are necessary for the judicious exploitation of the Ruvu Basin. The support of the Agency is expected to complement an on-going World Bank Programme to monitor water quality in the Ruvu Basin as well as a project to be launched by the UN Agency, HABITAT, which has secured funds from the Turner Foundation for activities related to water supply in selected African cities, including Dar es Salaam.

Similar studies could be envisaged for the Kizumbi Basin, which serves as the domestic water supply for about 100,000 inhabitants in the Shinyanga region in north-west Tanzania. The Ministry of Water is proposing to drill about 50 boreholes in this region and isotopic data would be useful to monitor the exploitation of the groundwater resources.

Two reservoirs, Mtera in Iringa and Nyumba ya Mungu in Kilimanjaro, are used mainly for hydro-electric power generation and also for irrigation and domestic water supply. The Government, which is presently planning to increase the capacity of these reservoirs, wants to take measures to minimise the sedimentation problem. Isotopes techniques are well suited for sedimentation monitoring and to provide data for modelling of surface water run off and reservoir water seepage.

In the Kilombero Valley, Morogoro, where a few wells are exploited for irrigation of sugar cane plantations and additional boreholes are planned to be drilled, it is important to establish the water balance and the age and origin of the water. Isotope techniques are quite appropriate for these studies.

The Ministry of Water and its various regional laboratories are suitable counterpart institutions for the implementation of the projects outlined above.

D.3. General Support Activities

Support for on-going co-operative endeavours in several areas, and a few new areas, is projected primarily through a variety of regional projects.

D.3.1 Radiation Safety

The radiation safety facilities in Tanzania are being further consolidated through participation in an AFRA project "Harmonization of Radiation Protection Practices" (RAF/9/022). However, additional support would be needed to address some specific radiation safety issues. Participation in the regional model project entitled "Upgrading Radiation Protection

Infrastructure” RAF/9/024 or even the establishment of a national project with modest funding and limited duration could be envisaged for that purpose.

D.3.2 Improved Diagnostic Techniques for Animal Diseases

Tanzania is currently improving the production potential of its largely indigenous cattle population (currently 15.6 million) by introducing exotic animals and crossbreeding programmes. Since the improved cattle are more susceptible to diseases, more sensitive diagnostic techniques are required for efficient disease control programmes. ELISA kits are now in routine use for the diagnosis of rinderpest and have been introduced for Contagious Bovine Pleuropneumonia (CBPP) with the assistance of the Agency. The extension of the use of ELISA techniques to cover other animal diseases, such as Brucellosis, Heartwater and East Coast Fever, could be envisaged. The Animal Diseases Research Institute (ADRI), in Temeke, Dar es Salaam, is an appropriate institute to implement such a project, especially as it has been selected as a regional laboratory for Tanzania, Malawi and Zambia. Moreover, a Tanzanian Agricultural Research Project, funded by the World Bank and the African Development Bank, is supporting ADRI with infrastructure rehabilitation, vehicles, operational funds and laboratory equipment.

D.3.3 Other Activities

It is anticipated that Tanzania will continue to be an active participant in the AFRA programme and various other regional projects, as specified in Section C.7.

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