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INTERNATIONAL ATOMIC ENERGY AGENCY

COUNTRY PROGRAMME REVIEW

INT/0/053

E T H I O P I A

Division of Technical Co-operation Programmes
DEPARTMENT OF TECHNICAL CO-OPERATION

CONTENT

INTRODUCTION

Experience has shown that, in many cases, Member States have difficulty in identifying their priority programmes in the light of their development plans and within the financial constraints of technical co-operation programmes. As a result, a large number of requests are received by the Agency without proper screening by the Member States. The IAEA's Technical Co-operation Programme approved by its Board Governors for the biennium 1991-1992 includes an interregional project, INT/0/053, specifically designed to undertake in-depth reviews of past and present technical co-operation programmes in recipient countries. The reviews include a mechanism for identifying and prioritizing future technical co-operation with reference to past and present projects and to the countries' national development plans. It is expected that this activity will lead to the establishment, in Member States, of medium-term plans for the utilization of nuclear technology which are consonant with overall national development objectives, and to the definition of a useful frame of reference for the future preparation, application, assessment and eventual approval of individual technical co-operation projects.

The Division of Technical Co-operation Programmes of the Department of Technical Co-operation of the International Atomic Energy Agency selected Ethiopia as the first country in which a Country Programme Review was to be undertaken. The choice was based on the request submitted in 1990 by the Ethiopian Government through the Ethiopian Science and Technology Commission (ESTC). From 8-12 April 1991, a five-expert mission, headed by the Director of the Division, was organized for this purpose and this document reflects the findings and recommendations of the team. Intensive contacts with various sectors in the country were co-ordinated by the Ethiopian Science and Technology Commission. The ESTC also requested the mission to review the following:

1. The sectoral priority programmes as proposed in the national science and technology policy.

2. The PUNE (Peaceful Uses of Nuclear Energy) activities carried out so far, with particular emphasis on their impact on national capability building in nuclear science and technology.

3. The current organizational arrangement of the Natural Resources Department of the ESTC in relation to its role as national liaison office for IAEA technical co-operation programmes with the following options:

    a. Remains as it is with only a little adjustment and strengthening;

    b. Plans for the establishment of an independent national body with appropriate premises, personnel and budget to co-ordinate and control research and development on PUNE; or

c. Plans for the establishment of a nuclear research centre with central irradiation facilities (such as a high intensity gamma source, a research reactor, radioactive waste depository, nuclear instrumentation and maintenance facility and others) as deemed necessary.

For this purpose, the mission among other things had to:

1. Organize a one day seminar on PUNE with participation of all current and potential users of nuclear energy.

2. Visit institutions where PUNE projects have been under way with the objective of identifying their organizational setbacks, and needs for and nature of any reorganization.

3. Visit institutions where PUNE activities are planned.

4. Prepare a detailed short- and long-term programme with alternative outlines for the organizational set-up.

1. COUNTRY PROFILE

Ethiopia has a surface area of 1 230 000 km^2 and a population of about 50 million. The country is located in east Africa, with a coast line of about 1000 km on the Red Sea; it includes vast areas of mountainous terrain, with altitudes ranging from 116 m below sea level to about 4600 m above sea level.

Though a country with a substantial land and mineral resource potential, it remains today one of the least developed countries of the world, with a per capita GDP of just US$120. Although it made great strides in the late 1970s and 1980s in terms of domestic resource mobilization, raising the ratio of aggregate investment/GDP, expanding its infrastructural base, establishing a comprehensive system to improve adult literacy and basic health care, and creating an institutional framework for farmers' participation in decision-making, economic development in Ethiopia has been beset with continuing problems of drought, internal conflicts, and falling international prices for its major export - coffee. However, much has been learnt from the development efforts of the 1980s, and a series of policy measures designed to raise productivity in both the private and public sectors are being put in place. Ethiopia, therefore, has good reasons to enter the 1990s with hope of accelerated growth with social justice.

Despite an upsurge in economic growth during 1988/89, the current economic situation is characterized by: a severe foreign exchange crisis, resulting from the dramatic fall in the international price of coffee, which accounts for over 60% of Ethiopia's exports; a delay in the approval of a number of externally-funded projects due to conditions attached to the funding; and the regionally variable performance of agriculture in recent years. In addition, internal conflicts have intensified, with the result that grain movement to the drought affected northern part of the country is facing threats of disruption. The inevitable result is a decline in utilization of industrial capacity, and a postponement of the Five-Year Plan, originally intended to cover the period 1990/91-1993/94, in favour of a one-year interim plan. Meanwhile, the country's population has continued to grow rapidly and now stands at 50.1 million - the second largest in Sub-Saharan Africa.

2. NATIONAL DEVELOPMENT PLANS IN THE 1990s

Development Prospects and Priorities

In the "Advisory Note on the Fifth Country Programme of Technical Co-operation with Ethiopia (1992-1996)" of March 1991, prepared by United Nations Development Programme, a full chapter is devoted to the above title. It seems appropriate to reproduce this below, at least partially.

"Current economic trends and development issues

"Growth in Ethiopia faces a number of entrenched, long-term constraints: poor infrastructure, a low level of technological development and know-how, growing population pressure on available land, degradation of land and water resources. Moreover, in recent years, the Government's capacity to respond has been limited by a number of other factors: deteriorating terms of trade, internal conflict, recurrent drought, and the influx of refugees from neighbouring countries.

"The balance-of-payments situation is critical, and foreign currency reserves have dropped to precarious levels. Production, development programmes and maintenance of infrastructure are all choked by the resulting shortages of essential goods, raw materials for industry, spare parts and fuel.

"At US$20.5 per capita in 1988, Official Development Assistance to Ethiopia was amongst the lowest in Sub-Sahara Africa, while the flow of private capital is virtually non-existent. However, Government's record in meeting commitments has been exemplary.

"Drought, other climatic factors, and pests contribute to the poor performance in agriculture and livestock. The increasing loss of top soil through erosion and of forests to fuel wood and tillage subject the country to serious environmental and ecological danger.

"A predominantly agricultural and pastoral economy, Ethiopia has become dependent on relief food imports to supplement the meagre national output. With current population growth rates, an increase of 3 per cent annually in food production is needed just to maintain the deficit at its current level.

"Steady efforts have been made in human development, particularly education and health. Nevertheless, the basic necessities of life are still out of the reach of large numbers of people. Despite strong political commitment to the welfare of the people, and rather good public financial management, the Government's ability to maintain, extend and improve these

services, at least in the classical manner as a charge on the central budget, is endangered by the economic situation described above.

"Despite enormous efforts since 1975, there are still serious urban-rural gaps. For instance, only 9 per cent of the rural population has access to clean water, compared with 69 per cent of the urban population.

"Such disparities affect the pace of development; the absence of basic infrastructure and services in rural areas militates against increased agricultural production and encourages rural-urban migration.

"Growth in the urban population is likely to accelerate from recent relatively moderate rates; such a shift is inevitable if Ethiopia is to make the transition from dependence on rain-fed subsistance agriculture to a more diversified economy and society. It will entail measures to stimulate other sectors of the economy, develop backward and forward linkages with agriculture, provide off-farm jobs, meet increasing demand for basic services and housing in urban areas, and moreover reverse the present concentration of urban growth on only one or two poles, with secondary centres growing only slowly.

"Manufacturing has been mainly on capital-intensive import substitution industries which contribute little to employment, add little to the value of agricultural or livestock based export commodities, produce few of the inputs needed by agriculture, and far from being a source of foreign exchange are a drain on the balance of payments for raw materials and spare parts. The contribution of important mineral and hydrocarbon resources has so far been minimal, but exploration and development in these potential major earners of foreign exchange have been intensified; small-scale mining is potentially important.

"Ethiopia is well-located to develop exports. However, poor internal infrastructure, particularly roads, is a major constraint on the development of agriculture and industry, both for internal consumption and for export, and on access to basic economic and social services by an essentially rural population spread over a large and topographically broken territory.

"National Priority Programmes and Development Strategy

"In March 1990, a major policy decision was taken to move in the direction of a mixed economy, with greater private sector participation in agriculture, building, and trade, as well as security of land-tenure and tree-ownership in peasant agriculture, the right to hire farm labour and the lifting of controls on agricultural prices and marketing.

"The new economic policy is now being translated into practical measures, and discussions with development finance institutions have begun. A Special Decree on Investment was approved in May, 1990; new measures governing investment in mining are under preparation, and efforts to stimulate interest in the petroleum sector have been successful in generating bids for

prospection concessions. According to FAO, the new policy measures have already helped in raising the production of private farmers by five per cent during the first agricultural season.

"The new economic policy and related measures already announced provide a viable programme framework."

Priority Programmes

The Ethiopian "Country Presentation" for the Second UN Conference on the Least Developed Countries (Paris, 3 to 14 September 1990), on the basis of overall development efforts anticipated in the 1990s, sets out the national priority programmes as follows:

"(a) National food self-sufficiency and food security by ensuring domestic production and distribution adequate to supply 2100 kcal of energy per person per day;

"(b) Reversing the growing balance-of-payments deficit by initiating an integrated export development programme composed of an expansion of existing export value, and diversification into new agricultural and industrial exports;

"(c) Diversification of the overall production base by promoting labour-intensive, small and household industry;

"(d) Continuation of previous efforts to extend the availability of education and basic health care to a larger proportion of the population; and

"(e) Initiating specially focused programmes to stem the decline in the natural resource base including, inter alia, a National Population Policy and a National Conservation Strategy."

The major economic objectives of the 1990s are to raise the productive capacity of the economy by promoting all forms of productive enterprise; to attain food self-sufficiency in production and supply; to improve the flow of basic consumer goods and services; to reduce unemployment; to raise the country's net foreign exchange earnings; to conserve and develop forest, soil and water resources; and to promote the economic and social integration of the country. Within this general set of objectives, emphasis is to be given to peasant agriculture; small-scale industry and handicrafts; diversification of wood-fuel sources; water resource development; and the expansion of the construction industry.

The targeted rate of GDP growth over the Five Year Plan period is 5% per annum. To achieve a real GDP growth of 5% over the 10-year period, the Government has planned that agriculture has to achieve a growth of 4.3%; industry of 6.0%; and services of 5.3% in real terms. Given the low industrial base, the growth target for industry has to be achievable. In agriculture, the 4.3% target implies both a significant rise in productivity as well as its stabilization over time.

The ten-year public investment programme by sector shows the following distributions (see Annex I for details):

1.	Agriculture and Natural Resources	29.2%
2.	Transport and Communications	13.4%
3.	Industry	13.0%
4.	Energy	10.3%
5.	Mining	10.1%
6.	Construction	7.4%
7.	Urban Development and Housing	5.0%
8.	Education	3.3%
9.	Trade and Tourism	2.6%
10.	Health	2.2%
11.	Others	2.7%

Development Strategies

The same document ("Country Presentation"), as part of the concluding remarks, states that the aims of the development strategies for Ethiopia in the 1990s are "to use all forms of productive enterprise - public, private and co-operative - to push investment ratios to GDP to a point where growth can become self-sustaining. This threshold is commonly acknowledged to be at least 25 per cent of GDP for a 5 per cent GDP growth. Moreover, existing investments must be made more effective by reducing public sector losses, by more careful selection of future projects, and by paying greater attention to choice of technology.

This major investment effort is dependent on two pre-conditions. First, that external concessional finance in the form of grants and debt cancellations should be forthcoming to complement the expected steady increase in savings - itself an important outcome of the development process. Second, that persistent structural constraints imposed by rapid population growth, accelerating soil erosion, and the absence of agronomically suitable agricultural technology be removed. Only then can the overwhelmingly fundamental questions of food security and regional integration be effectively tackled.

No one familiar with the Ethiopian economic terrain can fail to be impressed by the depth and comprehensiveness of the policy initiatives under way since the ninth Plenum in 1988. The ground has been laid for an accelerated tempo of development in the 1990s. As with other least developed countries, Ethiopia needs the sustained support of the international donor community to realize its significant development potential."

3. REVIEW OF PAST AND PRESENT IAEA TECHNICAL CO-OPERATION ACTIVITIES IN ETHIOPIA

Applications of ionizing radiation in Ethiopia began in 1970 when the Institute of Pathobiology (IPB) of the Addis Ababa University acquired the first and only cobalt-60 radiation source together with other basic equipment. Since then around fifteen pathobiological and related research projects that employ ionizing radiation have been conducted.

A nuclear medicine service was started in 1978 in the Tikur Ambessa (Black Lion) Hospital of Addis Ababa University. The Nuclear Medicine Unit (NMU) of this hospital is the only one of its kind in the country and serves as a referral centre for patients from all over Ethiopia. It also serves as a teaching unit and undertakes research in nuclear medicine.

The other major national institutions where nuclear energy has been put into use are the Faculty of Veterinary Medicine, Debre Zeit, and the Institute of Agricultural Research (IAR). In co-operation with other institutions, the Faculty of Veterinary Medicine has been using isotopes to improve animal productivity, health and reproduction; IAR applies nuclear techniques to study the efficiency of nitrogen fertilizer use by certain crops and the ability of legumes to fix biologically-bound nitrogen. Though the activities of the Institute in this area are yet at their infant stage, the scope of the intended applications is wide.

In addition, the Ethiopian Airlines and the Ethiopian Petroleum Corporation use ionizing radiation sources for non-destructive testing (NDT) and the Biology Department of the Addis Ababa University uses nuclear techniques for biological research.

Over the last two decades the IAEA has been assisting projects in IPB, NMU and IAR. During this time, although skilled manpower and resource inputs have remained limited, a number of projects have been carried out and remarkable results have been achieved. Nevertheless, important application areas such as hydrological, hydrogeological, mineral exploration, and geophysical studies have not been considered.

Over the period 1970-1990, assistance for a total value of US$2 158 400 has been provided to Ethiopia, out of which US$604 100 were for experts and consultants, US$1 031 700 for equipment, and US$522 600 fellowships. Part of the total amount, US$437 500, was contributed by the UNDP, US$5400 were extrabudgetary contributions, US$132 500 in-kind contributions, and the remaining US$1 583 000 were financed by the Agency's Technical Assistance and Co-operation Fund (TACF).

Details of the IAEA assistance provided to Ethiopia during the last ten years, by year and by field of activity, are presented in the table attached as Annex II.

The Agency's technical co-operation programme in Ethiopia has focused mainly on research into the health and productivity of various breeds of cattle and on the establishment of a nuclear medicine unit in the country's primary teaching hospital, Tikur Ambessa. Concomitant with the development of these activities has been the growing

awareness of the need for an effective radiation protection service. In 1983, the Agency was requested to assist in strengthening the personnel monitoring service created by the Institute of Pathobiology. In addition, since 1985, isotopes have been used in the agricultural sector to study the uptake by certain crops of nitrogen from nitrogenous fertilizers and the effect of different rhizobia on symbotic nitrogen fixation by leguminous crops.

The approach to improving the health and productivity of indigenous cattle and cross breeds on one of the State experimental farms is through research on reproduction and nutrition. Ovarian function is monitored by radioimmunoassay of the hormone progesterone to determine the cause of reproductive failure. This is a simple yet highly specific technique that can be used under traditional management systems. The assay kits are prepared and distributed by the Agency. In parallel with these studies, the nutritive value of different local cattle feeds is being determined to assess whether nutritional factors affect the onset of puberty, milk yield and calving interval. The results of these experiments are to be passed on to small farmers to enable them to increase milk production and improve the quality of meat.

In connection with the project on animal production, a regional FAO/IAEA training course on the diagnosis of rinderpest was organized with Agency assistance at the National Veterinary Institute, Debre Zeit, in 1988. Emphasis was placed on the use of enzyme-linked immunosorbent assay techniques in sero-monitoring rinderpest. Nineteen veterinary scientists from 17 African countries participated in the course.

The Department of Internal Medicine in Tikur Ambessa Hospital has established a Nuclear Medicine Unit with the infrastructure and manpower to perform most of the in-vivo and in-vitro nuclear procedures needed for clinical diagnosis, and to produce locally the necessary radiopharmaceutical "cold-kits" for instant labelling with technetium-99m. With the steady increase in the number of patients referred for treatment, the Unit is now planning to expand its services. With the assistance of Agency consultants, a plan has been drawn up for establishing the country's first radiation oncology department at the hospital.

The scope of the radiation protection service at the Institute of Pathobiology on the Southern Campus of the University of Addis Ababa has expanded from the initial monitoring of staff who were developing radiation-attenuated vaccines to radiation protection country-wide. Some 88 institutions are now being served with TLD badges. However, the service is restricted in its power to enforce international regulations and codes of practice because the Government draft proclamation on radiation protection has not yet been finalized.

An underlying feature of all the projects has been the gradual build up of trained manpower through Agency fellowships. However, a major constraint in manpower has been the shortage of engineers and technicians trained in the maintenance and repair of electronic equipment.

Agency-supported projects have been in line with the national development plan and have benefitted from governmental support through, for example, the Ministry of State Farms and the Ministry of Health. The commitment of the Government to the projects is reflected in their steady growth over the years.

At present there are six operational projects, fully funded by the Agency's Technical Co-operation Fund, with the following financial provisions, in US dollars:

	1991	1992	1993	1994	1995
NUCLEAR INSTRUMENTATION (started in 1988)	18 400				
ESTABLISHMENT OF A NUCLEAR INSTRUMENTATION UNIT (new)	67 700	53 400			
ANIMAL SCIENCE (second phase)	42 700	33 600	24 500	25 400	26 600
RADIATION THERAPY (new)	303 100	160 100			
RADIOISOTOPES IN MEDICINE (second phase)	45 700	92 500			
RADIATION PROTECTION (started 1988)	68 700	185 200			

In addition, a three-year project for Teaching Applied Nuclear Physics in the Addis Ababa University, Department of Physics, has been approved without financing and is awaiting donor countries to provide support through extrabudgetary contributions. Furthermore, Ethiopia is participating in certain of the regional projects such as that on biological nitrogen fixation or on combatting rinderpest.

4. SECTORAL PROGRAMMES AND INSTITUTIONAL REVIEW

The following sectoral-programme and institutional review is based on the "Country Presentation", visits to the various institutions, and intensive contacts and discussions with sectoral authorities during the mission, as well as on written information supplied by the Ethiopian authorities.

The review covers four major areas of nuclear applications:

- Food and agriculture;
- Human health;
- Water resources;
- Industrial applications and nuclear instrumentation;

as well as important supporting areas such as radiation protection and higher education.

FOOD AND AGRICULTURE

a. Programmes.

Over the entire decade 1991-2000, primacy in sectoral programmes is given to the development of agriculture and natural resources, which take up 29.2% of total public fixed investment. The planned target for an expansion of crop production implies a growth rate of 7.6%. Much of the expansion in crop production is expected to come from an increase in productivity (6% per annum) as compared with an average expansion (1.6%). However, even with this high target, by the mid-1990s, Ethiopia will still manage to provide only 85% of its food requirements. Therefore, the food self-sufficiency target will run on into the second half of the 1990s, assuming a series of good harvests.

The overall thrust towards food self-sufficiency is accompanied by a drive to achieve food security at the household level in the medium term. The National Food and Nutrition Strategy estimates that, even taking into account livestock products, fruit, sugar and food imports, the average food availability is only 1766 kcal per person, including the 1356 kcal from crop production. The former figure is still 30% below the 2100 kcal considered to be nutritionally adequate. The projected increase in supply must be accompanied by improved distribution towards the nutritionally most vulnerable groups.

To attain food self-sufficiency and nutritional security over the medium term remains perhaps the most important objective of the agricultural sectoral programme. Given the overwhelming dominance of peasant agriculture in Ethiopia, a significant rise in crop productivity must come from developing new technologies suited to the local situation, and from providing significant incentives for the peasants to adopt the improved technologies on their own farms. At present the technological base remains weak due to the difficulties of developing suitable crop technologies across an exceptionally varied landscape. However, with the IDA financed Agricultural Research Project now in place, and the emphasis given to on-farm trials and to farming systems research under the First

Peasant Agricultural Development Project, there is a significant possiblility of easing the research bottle-neck of the past. Moreover, a series of Minimum Package Projects as well as regional components of the First Peasant Agricultural Development Project have created an extension umbrella over much of the country using the training and visit extension system. A reasonable infrastructure for agricultural research and extension exists in Ethiopia. In the 1990s, the emphasis must be **to ensure that research is more effectively focused and to persuade farmers to change their techniques of production towards more productive seed varieties and cultural practices (ref. FAO Country Programming).**

Regarding livestock, Ethiopia possesses the largest number in Africa, amounting to some 40 million cattle, sheep and goats. However, its productivity is low. Much of the livestock is in the highlands as part of the crop farming system. The sector as a whole contributes approximately 40% of the total agricultural sector output. Measures to improve livestock productivity to date include the provision of veterinary and fodder extension services under the Fourth Livestock Development Project and a number of dairy development projects. However, other projects covering rangelands development; widening of export markets for live animals and processed meat; and cattle fattening schemes are under preparation. These will form important components of the coming phase of the national livestock development programme.

b. Research Institutions.

Institute of Agriculture Research, Addis Ababa

The Institute was founded in 1966 and is the main institute in Ethiopia which undertakes research and development in the field of agriculture. Currently it has 15 research centres, 7 subcentres and 13 trial sites. It maintains a link to its main user through its extension linkage. It is governed by a board consisting of the Ministers of Agriculture, State Farm Development, Coffee and Tea Development, Higher Education, Industry, and the Commissioners of Sciences and Technology and Water Resources. The Chairman of the Board is the Deputy Prime Minister and the Minister for Agriculture. The Institute has more than 3000 employees, including 132 PhD or MSc holders. Of its budget of around US$ 15-25 million, 50% derives from the Ethiopian Government, 20% from a World Bank loan and 30% from foreign aid. **The Institute is the main counterpart of FAO and should, therefore, also be the right counterpart for the Agency for chanelling the technical co-operation programme based on the utilization of nuclear techniques in agriculture to the country through its research centres.**

Institute of Agricultural Research, Holetta Research Centre, Holetta

The Holetta Research Centre is the largest centre belonging to the Institute of Agricultural Research. It is located at one hour's drive by car from Addis Ababa with somewhat difficult road conditions. The Centre was established in 1966, 45 km west of Addis, 2400 m above sea level. The average annual rainfall is 1100 mm. The Centre has four sub-centres at Sheno, Giuchi, Denebi and Adami Tulu, representing different soil and climatic conditions. At Holetta, the Centre is organized into 11 Divisions, concerned with different research areas such as: field crops; horticulture; agronomy and crop physiology; soil science and water management; crop protection; animal production;

animal nutrition; animal health; food science; agricultural economics; and research and extension services.

The Centre has a staff of 350, of whom 24 hold PhD or MSc degrees. 20 Staff members are currently on advanced training. The Centre has the mandate to study "highland crops", which are barley, faba bean, field pea and several oilcrops (rape, niger, linseed). Horticultural crops include potato and fruit trees (apple, plum, peach). Livestock includes mainly dairy cows, but also draught animals, sheep and goats to a smaller extent.

The Holetta Centre co-operates intensively with international agricultural research centres such as CIMMYT, ICARDA, CIP and with international organizations such as UNDP and FAO. Until 1981, there was a major UNDP investment in Holetta. Other donors are IDRC (Canada) and SAREC (Sweden); FAO is at present involved in a fruit crop research and development project at Holetta.

Soil and water conservation is being given highest priority, followed by improvement of irrigation efficiency and control of soil salinity. Ethiopia is said to loose 1.6 billion tons of soil every year. Many soils have acidity problems. Fertilizer use efficiency would be another topic of interest where nuclear techniques could make a contribution.

The Institute is also interested in improving nitrogen fixation of grain legumes and was assisted in this task by an IAEA project providing expert services and equipment (an emission spectrometer for nitrogen-15 analysis); it also collaborates in a regional FAO/IAEA project on this topic. There would be interest, too, in using nuclear techniques for genetic improvement of crop plants, especially oilseed crops.

The other areas of co-operation with IAEA are animal reproduction, animal nutrition and animal health under TC projects and research contracts.

Institute of Pathobiology (IPB), Addis Ababa

The Institute now belongs to the Addis Ababa University and was the counterpart for the first IAEA project in Ethiopia, starting in 1970. Vaccine production against sheep lungworm was a major topic. This has now been handed over to the Ministry of Agriculture. Another major responsibility is radiation protection. In 1974, a cobalt-60 gamma source was provided by IAEA (selfshielding Gamma Chamber 900, made by BARC, Bombay, India). At present there are serious functional problems because of poor maintenance: the electric device for moving samples to the source does not function; mechanical (manual) movement is possible but is too slow for accurate dosage.

The Institute works on Phytolacca dodecandra, a saponin containing plant from which a molluscicide, a contraceptive and a detergent can be manufactured. The neurotoxin contained in Lathyrus sativus is another topic of research: the Institute supports related work of the Ministry of Health by carrying out tests with mice, sheep and goats. The work is internationally co-ordinated through the "Third World Medical Research Foundation".

Agricultural Research Centre of the Alemaya University of Agriculture, Debre Zeit

The University of Agriculture at Alemaya, ca. 400 km east of Addis Ababa, is the main institution for agricultural education in the country. One of its research centres is located at Debre Zeit, some 70 km southeast of Addis Ababa. The road is good, but has heavy traffic.

The Centre works on improving the use of locally available natural feeds. Work includes chemical analysis, determination of antinutritional factors and farm trials. The Centre also has strong plant breeding programmes for durum wheat, tef, chickpea and lentil. There is likewise work on horticulture, forestry, soils, plant nutrition and plant protection, where the use of nuclear techniques could be envisaged.

The Centre's tef programme has been using induced mutations, obtained from irradiating seeds at the IAEA Laboratory. There are several high yielding mutant lines derived from a local variety.

Faculty of Veterinary Medicine of the Addis Ababa University and National Veterinary Institute, Debre Zeit

The institutions are recipients of assistance under IAEA TC projects. At the Faculty, there is interest in a diagnostic X-ray machine and perhaps a gamma source to produce vaccines. There are also plans to extend hormonal assays beyond progesterone and to widen isotope applications for disease diagnostics. The staff of the Faculty would deserve training in the application of nuclear techniques.

Food Research and Development Centre of the Ethiopian Food Corporation, Addis Ababa

The Centre is concerned with baby food made from soybean. The imported defatted soybean is being replaced by the local product. Bread using mixtures of wheat with other cereals is being developed. Quality tests are being carried out to support the production of spices (ginger and turmeric) in Ethiopia. Other work concerns the use of mustard cakes (Brassica nigra), which contain too high an amount of glucosinolates to be used as such for animal feed. Wheat responds with higher yields to the application of mustard residues as fertilizer. With chilli peppers, an attempt is being made to select strains with less pungency so that the seed oil can be used in cooking as well as a spice instead of the powder. There is interest in using irradiation for grain desinfestation. Other areas of promise for the application of nuclear techniques may be identified in the future.

National Plant Genetic Resources Centre

The Centre preserves now about 50 000 samples belonging to some 100 different plant species. It also practices an "on-farm preservation and enhancement programme", where genes can be introduced (also from mutants) to be intercrossed and become subject to "natural" selection pressure. The Centre co-operates with several international germplasm and genetics networks, e.g. DNA-Network (Dr. Bailer, Texas) and IBPGR. There

is co-operation with the Ministry of Health on medicinal plants. Studies are undertaken to identify local lines of crops with more efficient absorption of nutrients and water under low-input agriculture. Vernonia sp. is being investigated as a source of oil for paint.

The Centre itself is unlikely to be using radiation or tracer techniques in the near future as it has a particular, already very demanding mandate. However, there are plans for mutagenesis and genetic engineering to be added to the tools of plant breeders in Ethiopia, when suitable problems are identified.

HUMAN HEALTH

a. Programme.

In the health sector, the basic objectives of giving priority to primary health care, especially immunization programmes, remains unchanged for the 1990s. The target of the Five-Year Programme is to raise the proportion of the population with access to modern health care to 50%. Projects under the programme include construction of clinics and health centres, and the training of medical personnel.

b. Hospital.

Tikur Ambessa (Black Lion) Hospital

Tikur Ambessa Hospital is the most important medical care centre in Ethiopia, serving a population of approximately 2 million. The medical staff belongs to Addis Ababa University. This hospital plays a leading role in medical teaching at both undergraduate and graduate levels and in clinical research. The capacity has recently been increased to 800 beds, with an average occupancy rate higher than 95%.

The hospital has four Departments: Internal Medicine, Surgery, Radiology, and Clinical Laboratories. Internal Medicine includes nuclear medicine and radiotherapy. There are plans for their integration in the Radiology Department, which is well equipped for conventional diagnostic X-ray procedures but has no facilities for either tomographic or angiographic studies. Diagnostic ultrasound techniques are available in the hospital.

The prevalent pathologies in the hospital are mainly related to communicable diseases, malnutrition, endemic goitre and certain types of cancer, especially hepatoma and lymphoma.

The Nuclear Medicine Unit was established in 1978 and was assisted by the IAEA through its technical co-operation programme, during the early stages providing the training necessary for manpower development through fellowships and scientific visits in Canada and organizing the acquisition and installation of the required instruments. Experts assisted with the establishment of the Nuclear Medicine Unit and the radioimmunoassay laboratory, and with gamma camera quality control.

The in-vivo section has a rectilinear scanner and a twin-probe renographic system; they are not in working condition owing to lack of spare parts. At present, the unit is working with a dose calibrator and a refurbished gamma camera. The daily and periodic procedures for quality control included in the gamma camera's log show an

excellent performance of the instrument. The Radiopharmaceutical Section is very well equipped for routine production of the conventional radiotracers. It includes a refrigerator, calibration equipment, autoclave sterilizer, laminar flow hood, centrifuge and a freeze drying unit, all in good operating condition. The Radioimmunoassay Section is also very well equipped, with four gamma counters in excellent operating condition. All the above mentioned equipment has been provided by the IAEA within technical co-operation projects.

The Nuclear Medicine Unit operates with commercial radiopharmaceutical kits, technetium generators and bulk reagents for radioimmunoassay, also provided by the IAEA. Since a technetium generator is delivered every two weeks, the Unit only performs clinical studies for two weeks per month. Radiopharmaceutical kits for DTPA, DMSA and sulphur colloid are also being provided. The Unit is well staffed and equipped and will soon receive another technician in radiopharmacy and an additional nuclear physician, as well as a dedicated computer for the gamma camera. This will increase the potential for both medical care and teaching.

There is a serious under-utilization of the facilities with a severe effect on the advancement of nuclear medicine at the Tikur Ambessa Hospital. There is a good proportionality between equipment and number of staff members, but there is a great imbalance between equipment and staff on the one side, and number of tests undertaken on the other. More important than that is the small spectrum of in-vivo clinical studies, which are limited to static imaging of thyroid, liver, brain and kidney.

The limiting factor seems to be related to the radiopharmaceutical field, since the Nuclear Medicine Unit depends entirely on the provision of consumables by the IAEA, while the Radiopharmaceutical Section remains idle by using commercial kits.

Physicians of the Radiotherapy Unit are receiving training abroad. A building to house the unit is under construction. A teletherapy unit will be provided by the IAEA.

WATER RESOURCES

a. Programmes.

The national priorities in the water sector are the development of water resources for hydro-electric power generation and water supply schemes for domestic and irrigation purposes. Water resource development has so far mainly been based on the use of available surface waters, while the water supply for rural small communities relies heavily on the local springs and/or shallow hand-dug wells.

For hydropower development, the technically feasible potential in the country is given in the following table.

Hydropower potential in Ethiopia by basin

River Basin	Annual mean runoff ($10^9 m^3$)	Hydroelectric potential (MW(e))
Northern River Basin	11.6	150
Awash River Basin	2.7	300
Blue Nile River Basin	54.0	9 100
Baro Akobo River Basin	13.1	2 240
Omo River Basin	16.4	1 310
Genale Dawa River Basin	4.0	670
Wabeshebele River Basin	2.5	1 610
Rift Valley River Basin	1.1	-
Totals	105.4	15 380

Source: WRDA, 1985

The presently installed capacity in the country for hydro-power production is 372 MW(e), out of the presently installed total of 455 MW(e). Another hydro-power scheme with an installed capacity of 306 MW(e) is under construction. The country has substantial hydro-power development potential and only a small percentage of this potential is presently developed.

The potential irrigable and presently irrigated areas are given in the next table. Only 168 205 ha out of the gross irrigable total of 2 694 600 ha are provided with irrigation water at the present. Another 45 000 ha are under irrigation through traditional small-scale irrigation systems.

Domestic water supply and sewage systems are presently available for about 200 towns, and the 10 year development plan aims to develop water resources so that 85% of the urban population receive potable water.

Potential irrigable and irrigated areas by basin

River Basin	Gross irrigable (ha)	Net irrigated (ha)
Northern River Basin	200 000	10 336
Blue Nile River Basin	760 000	21 011
Baro Akobo River Basin	600 000	346
Omo (Give) River Basin	248 000	27 310
Rift Valley River Basin	47 600	12 273
Genale Dawa River Basin	300 000	82
Awash River Basin	184 000	75 504
Wabeshebele River Basin	355 000	21 343
Totals	2 694 600	168 205

Source: WRDA, 1985.

The persistent drought conditions observed in the region during the last two decades make the groundwater resources more attractive as a reliable source of water. The occurrence and conditions of groundwater resources are very diverse and detailed mapping and studies of aquifers on a national scale have not yet been made. The most suitable formations as a source of groundwater are the loose quaternary sediments often found in the flood plains and valley fills. The volcanic rocks occupying susbstantial parts of the country have diversified hydrogeological features, and the groundwaters in these formations are usually associated with poor water quality and high fluoride concentrations.

The presently implemented 10 year development plan includes 96 feasibility studies, 42 design and 50 construction works for urban water supply purposes. For rural water supply, the targets of the 10 year plan include construction of an additional 10 400 hand-dug wells and 1657 boreholes for rural water supply development, so that a total rural population of 11.5 million will be served.

In the case of development activities for irrigation water supply within the ongoing 10 year development plan, feasibility studies for 70 projects and completion of the construction of 50 medium-scale irrigation projects are envisaged. For large-scale

irrigation development, substantial activities are planned, which include:

- preparation of master-plan for the Baro-Akobo basin (1 million hectares);
- feasibility studies for development of 74 000 hectares;
- pre-feasibility studies covering 263 000 hectares in different regions;
- development of irrigation water supply schemes for 113 000 hectares in seven river basins.

It is evident that substantial efforts will be needed in the future for development of water resources to meet the needs of the country for various uses of water.

b. Institutional Framework

The establishment of national institutions responsible for water resource assessment and development was started in 1950 and the institutional framework for water activities has been subjected to revisions since then.

In 1981, the National Water Resources Commission was created, which has now the overall responsibility for the development of both surface and groundwater resources for various purposes in the country. The Commission has four separate subsidiary organizations, which are autonomous bodies, each headed by a General Manager. These are:

- Water Resources Development Authority;
- Water Supply and Sewerage Authority;
- Ethiopian Water Works Construction Authority;
- Ethiopian Meteorological Service Agency.

The Water Resources Development Authority is in charge of the overall planning of the national water resource development activities, design of the water structures and distribution systems, and supervision of their construction. The Water Supply and Sewerage Authority is responsible only for the design and operation of domestic water supply systems and sewage systems for large urban settlements. The construction of the water systems planned and designed by the above two institutions is entrusted to the Ethiopian Water Works Construction Authority. The Ethiopian Meteorological Service Agency is in charge of the collection of basic meteorological data all over the country.

In addition to the National Water Resources Commission, the following four bodies also deal with specific aspects of water resource assessment and development:

- The Ministry of Mines and Energy, which carries out hydrogeological and geothermic studies and research, also studies related to mineral exploration;

- The Ethiopian Electric Light and Power Authority, responsible for production and distribution of hydroelectric power;

- The Ethiopian Institute of Geological Survey, an autonomous body in charge of geological and hydrogeological mapping all over the country, and of exploratory investigations for geothermal and mineral prospecting;

- The Addis Ababa Water and Sewerage Authority, responsible for the municipal water supply and sewage system in the capital.

The institutions among the above cited bodies that have a direct responsibility in conducting field work either for exploratory purposes or for developmental and operational purposes are the Ethiopian Institute of Geological Survey and the Water Supply and Sewerage Authority. These institutions are the ones most likely to benefit from the application of appropriate nuclear techniques in field investigations. Their basic infrastructure in terms of the staffing and the laboratory facilities for conventional methods are adequate and the routine field work being undertaken in water resource assessment and development could benefit from the introduction of isotope and nuclear techniques.

INDUSTRIAL APPLICATIONS AND INSTRUMENTATION

a. Industrial Applications.

Although the industrial sector has been allocated 13.0% of the public fixed-investment programme during 1991-2000, it is nevertheless rather premature at the present time to apply nuclear techniques in the sector as the structure of Ethiopian industry is dominated by domestic resource-based consumer industries, especially the food and beverage, textile and leather industries. Moreover the diversification of the industrial base, which constitutes a major development proirity in the 1990s, lays as much emphasis on the fuller utilization and rehabilitation of existing industries as on the establishment of new ones.

Besides basic consumer goods, industry will be encouraged to focus on the supply of farm implements and construction materials, expanding the supply of exportable products and import substitutes - especially leather and shoes, textiles, chemicals, paints and non-ferrous mineral products. Preference will be given to labour-intensive technology as part of the overall employment generation programme.

Although nuclear techniques at present have no potential customer in Ethiopian industry, there are two institutions which use nuclear techniques for quality control inspections, Ethiopian Airlines and the Ethiopian Petroleum Corporation. The latter institution was not visited.

Ethiopian Airlines

Ethiopian Airlines flies a great number of routes within the African Continent, where it has a prominent position as the most advanced in the business. As is to be expected, the company pays great attention to maintenance, and has well equipped non-destructive testing facilities with cobalt-60 and iridium-192 sources for radiographic testing of important mechanical parts, as well as ultrasonic, magnetic particle, and eddy-current equipment. The staff has been trained in the United Kingdom at Level II in the respective techniques. Film badges are used for control of radiation levels; films are sent to the United Kingdom for dosimetry.

b. Instrumentation.

Considering the problems associated with instrumentation in general, the Ethiopian Science and Technology Commission took the initiative in establishing a National Scientific Equipment Centre described below.

National Scientific Equipment Centre

The centre is part of the Ethiopian Science and Technology Commission. Plans for its establishment were initiated in 1985, a feasibility study financed with the assistance of the Swedish Government was completed and approved in 1987, and construction started in 1988; only finishing and painting of the building is now pending, and it is expected that it will start operation before the end of 1991. Scientific and and technical equipment will be provided through a UNDP project, and training of the staff will be implemented with the assistance of the Swedish Government through SAREC.

The objectives of the Centre, as defined in the original project document, are:

- To maintain, service and repair scientific equipment used by the research institutions and universities;
- To build up the capacity to design and produce scientific and technical equipment;
- To train the manpower needed for maintenance and repair of equipment in other institutions;
- To provide consultancy services to Ministries, research institutions and universities for the procurement, installation, commissioning and testing of scientific equipment.

In the future, it is expected that most of the other institutions using scientific equipment will be able to undertake their own maintenance, servicing and repair, and the Centre will concentrate on training, design, development and consulting.

Electronic, electro-mechanical, optical and glass blowing workshops are being equipped with the UNDP contribution of US$700 000. The staff of 50 includes nine professionals with advanced degrees, and 25 well trained technicians.

The IAEA is supporting, through a technical co-operation project, the establishment of a nuclear instrumentation workshop for the maintenance, repair and construction of nuclear instruments and for training in these skills. The Centre has dedicated 108 square metres to the nuclear workshop. Equipment will be installed soon, training is foreseen for 1992, and expert services for training in the day-to-day running of the workshop will start as soon as equipment is installed.

RADIATION PROTECTION

A National Radiation Protection Service was first established on a small scale in 1976 at the Institute of Pathobiology of the Addis Ababa University. It is now responsible for radiation protection in all sectors in the country. Assistance has been provided by the IAEA for a number of years for equipping the facilities and training the staff. A

technical co-operation project is still operational for the upgrading of existing services and to establish a national calibration laboratory. At present, premises have been made available for thermoluminescence dosimetry, environmental monitoring, calibration, and servicing nuclear instrumentation. Some 500 radiation workers in 90 centres throughout the country are monitored regularly on a voluntary basis. The absence of a radiation law and appropriate regulations is hindering enforcement and the expansion of the radiation protection services. A draft proclamation is awaiting enactment by the Council of Ministers. Base-line data on environmental radioactivity are being collected in Addis Ababa and small amounts of imported foods are checked for radionuclide contamination. Efforts are now being made to establish a national calibration laboratory and a centralized waste-disposal facility for the increasing number of unsealed radioactive sources being used in medical institutions. Shielding for the calibration laboratory is expected to be completed in 1991. The Radiation Protection Unit is staffed with four physicists, a medical doctor and two technicians.

A gamma irradiator and safety equipment have been requested from the Agency for 1991 and a superficial X-ray machine with accessories for 1992. As soon as the proclamation has become law, advice will be given on preparing and putting into force radiation protection regulations and codes of practice. Expert services are also neeaed for measuring radon levels in the mines. Fellowship training is foreseen in calibration techniques. At the end of 1992, an assessment is to be made of project achievements.

The aim is to create a national radiation protection service with full authority to ensure the safe use of all forms of ionizing radiation and the health of both radiation workers and the general public.

HIGHER EDUCATION

Addis Ababa University, Department of Physics.

The Department graduates an average of 100 students every year with a first degree; there are at present 15 students undergoing MSc studies, while the PhD programme has just started with the assistance of the Swedish Government. The staff of 27 full-time professors includes 11 with PhD degrees (6 foreigners and 5 Ethiopians) while 15 hold MSc degrees. Additionally, 12 are presently abroad following studies towards a PhD degree. Subjects such as nuclear physics are offered for 2nd year level students only as chapters within a course; formal nuclear physics courses are included in the curriculum at the 4th year for undergraduates; some practical laboratory experiments are done as part of this course. More specialised training in subjects like X-ray diffraction are part of the training at the graduate level. Assistance has been provided by the IAEA International Centre of Theoretical Physics in the form of books, journals and some equipment.

A technical co-operation project on introduction of nuclear physics into the undergraduate and graduate curricula was approved for the 1991-92 biennium, subject to its receiving extrabudgetary contributions from donor countries.

Adequate space is available in the Department of Physics for experimental equipment and for a liquid nitrogen plant. There are two local lecturers in nuclear physics and a Department head who is anxious to introduce the new programme. The Department library is stocked with relevant journals, some also provided by the American

Institute of Physics, and an electronic workshop is at hand for the maintenance and repair of electronic equipment for teaching.

Addis Ababa University, Department of Chemistry.

The Chemistry Department of the University offers both undergraduate and post-graduate (MSc and PhD) level education. At present, there are 400 undergraduate and 20 post-graduate level students enrolled in the Department. The full time teaching staff of the Department is 27 (most of them with PhD degrees).

Nuclear chemistry forms part of the curriculum and is offered as an elective course, depending on the availability of teaching staff. The Department has a full analytical chemistry laboratory, but no analytical capability is available yet for nuclear chemistry. The Department would be very interested in having some Agency assistance in training of their staff, so that nuclear chemistry could be fully incorporated as a regular course at the Department. Furthermore, provision of some minor items of laboratory equipment for basic teaching in nuclear chemistry would be most desirable.

Addis Ababa University, Department of Biology.

The Department is one of the largest in the University, certainly the largest in the Faculty of Science. The staff includes 15 with PhD and 20 with MSc degrees, 12 of whom are working on their PhD thesis. The PhD programme is carried out in co-operation with foreign universities, e.g. in Denmark or Sweden, or with institutions like the International Centre for Insect Physiology and Ecology in Nairobi (Kenya). The research work of the Department is very diversified and is concerned with topics like fresh water fishery, bioconversion, applied and basic plant genetics, indigenous tropical forests, traditional medicinal plants, flora of Ethiopia, plant ecology, and immunoassay of disease and pathogen vectors (tsetse, ticks).

There has not been much use of nuclear techniques in the Department. But after appropriate training and establishment of facilities, nuclear techniques could certainly contribute very much to increase the research effectiveness of the Department.

Agricultural University, Alemaya

This university is the principal institution for agricultural education in the country; through its research stations, such as that at Debre Zeit, it is also actively involved in agricultural research and development. Its location, 400 km from Addis Ababa, near Dire Dawa, may have deprived it of much of the attention of international and other donors and therefore of opportunities for receiving financial and scientific assistance. Future requests for support should be favourably considered by IAEA and FAO.

PROGRAMMING, CO-ORDINATION AND DEVELOPMENT

Ethiopian Science and Technology Commission.

The Ethiopian Science and Technology Commission is a governmental agency, headed by a Commissioner with the rank of Minister. With a staff of 250, out of which about 150 professionals hold Bachelors or Masters degrees, it has an important role in the programming, planning, promoting and implementing of scientific and technical activities in all national institutions. During the years of its existence, it has built up strong links with several United Nations agencies as well as with donor countries. The ESTC is involved in all stages of negotiations for assistance for all sectors in the country.

In September 1978, the ESTC was assigned to represent the country at the International Atomic Energy Agency, of which Ethiopia has been a member from its inception. As part of the responsibilities deriving from this assignment, the Commission was in charge of the national technical co-operation programme with IAEA, which was relatively modest at that time. In March 1987, the ESTC organized a seminar to assess the possible peaceful uses of nuclear energy in Ethiopia, as a consequence of which a National Co-ordinating Committee on the Peaceful Uses of Nuclear Energy was formed, with representatives of various Governmental institutions where the subject was of some interest. This Committee undertook a detailed study of the existing applications of nuclear techniques in Ethiopia and prepared a very detailed report which can still be used as an excellent work of reference in the programming and planning of the IAEA technical co-operation programme with Ethiopia.

The ESTC is organized into several specialized departments: Food and Agriculture, Health, Natural Resources, Industry and Transport, Social Science, Science and Technology Policy and Plan, Construction and Housing, Foreign Relations, Administration and Finance, Patents and Legal, Organization and Management, Information Centre, Computer Centre, and the National Scientific Equipment Centre.

The Department of Foreign Relations, in close collaboration with the Department of Natural Resources, is in charge of the processing of documents related to the IAEA technical co-operation projects in Ethiopia. Since it is also the liaison office for assistance from UNDP, WHO and other UN organizations, as well as for developmental assistance from donor countries, it has accumulated valuable experience in such dealings that should be preserved. In particular, it is important to note that ESTC has also played an important role in the incorporation of nuclear applications into national development programmes.

5. PEACEFUL USES OF NUCLEAR TECHNOLOGY IN ETHIOPIA AND POSSIBLE FUTURE TECHNICAL CO-OPERATION ACTIVITIES

Nuclear techniques often provide only one of several routes to the solution of a particular problem. Most of these applications are well established and their use can be very relevant in developing countries. However, it should be borne in mind that development of any specialized science and technology and its applications, such as nuclear science and technology, should not be carried out in isolation from the framework of the overall national development plan of the country. Taking into account the infrastructure of the various institutions in Ethiopia that are presently using or are potential users of nuclear techniques, and, in particular, of the human resources available, a reasonable pattern for the future development of nuclear science and technology and its peaceful applications in various fields can be foreseen. Careful consideration has been given to selecting nuclear techniques that, because of their special nature, can contribute best where other techniques have limitations or are not available. Good integration of nuclear activities within the overall country development programme has also been given high priority in the elaboration of the recommendations that follow in some detail for the different fields. It is expected that IAEA technical co-operation projects will contribute to the development of applications identified as possible activities within the above framework and will thereby contribute to the overall development of the country.

FOOD AND AGRICULTURE

There are many possibilities for useful applications of nuclear techniques in agricultural research in Ethiopia, for regional co-operation and for the use of products of such research in other countries. There is scope for technical assistance, research contracts and training, and a need for information. Researchers are motivated to do research, eager to learn and to accept new technologies.

In more specific terms the following is foreseen:

(a) To continue the support for ongoing projects in animal research and development (animal nutrition, animal health, animal reproduction), which are very much in line with the country's national development plan. More consideration, however, should be given to "sustainability" in the sense of avoiding further increases in the number of livestock, while increasing efficiency of production without the risk of contributing to environmental degradation and soil erosion. Several institutes want to have the benefit of applying nuclear techniques also for research on smaller animals and for expanded veterinary applications to more diseases. It would seem appropriate to consider this for ongoing and future IAEA technical co-operation projects.

(b) In the area of soils and agronomy, the Holetta Centre will probably continue research work on nitrogen fixation and fertilizer application using nitrogen-15, but higher priority should be attached to soil and water conservation, more efficient irrigation and to forestry. Agency technical assistance in these extremely important tasks will be required for training, expert services and equipment to ensure the proper application of nuclear technology.

(c) In the area of plant breeding, application of nuclear techniques does not have a high priority. The plant breeding programmes in the country seem to depend to a very large extent upon co-operation with international institutes like CIMMYT, ICARDA, ICRISAT and CIP. It is assumed that the use of improved cultivars already available is still rather limited and that a considerable increase in crop production can be achieved by introducing such cultivars and appropriate technology to farmers. Ethiopia also has a very good national plant germplasm collection, so that there should be no shortage of genetic resources to be used by plant breeders. However, there are exceptions with indigenous crop plants like tef, niger and enset which are well adapted to local environmental conditions through a long evolution. Their further production in Ethiopia, however, will depend upon genetic improvements when no genetic variability is available. If no such improvements can be achieved, the farmers will gradually switch to other, potentially more profitable crops. To create the necessary genetic variation through mutagenesis and other advanced genetic techniques, more national inputs in terms of land and trained labour should be provided. IAEA can then assist with training in mutation breeding, provide for seed irradiation by the IAEA Seibersdorf Laboratory, and advise on the use of in-vitro culture techniques when appropriate. Co-operation of Ethiopian genetecists and breaders in international programmes co-ordinated by FAO and IAEA with facilitate up-to-date technology transfer.

(d) In the area of post harvest crop losses and food preservation, some interest in using irradiation exists. Although immediate application is not possible, it would seem recommendable to supply current information about developments and prospects in this area to the Ethiopian Food Corporation's Food Research and Development Centre.

(e) There seems to be little awareness about the potential use of radioisotopes in environmental protection, for example avoidance of contamination by agrochemicals, studies of the ecology of rivers and lakes, or bioconversion of agricultural residues for feed or energy. Participation in the Agency's training courses in the subjects mentioned is recommendable.

(f) Ethiopian scientists are, however, already aware of the potential of nuclear techniques to control plant and animal parasites and insect vectors of dangerous human and animal diseases. Projects involving the sterile-insect technique require an appropriate infrastructure, which currently does not exist. When national authorities give such projects high priority, they should be given effective support by the IAEA and FAO.

HUMAN HEALTH

Nuclear Medicine in Ethiopia will be more effective and would advance more rapidly if all facilities were used on a full-time basis, increasing the variety of procedures in order to enhance clinical versatility and value. Imported commercial radiopharmaceutical and radioimmuno-analytical kits should be replaced as soon as possible by imported bulk reagents for local kit production to reduce costs. Facilities and staffing would need to be established for this. The setting up of procedures should follow the priorities given by the prevalence of diseases in the population. Quality control of instruments, reagents, radiopharmaceuticals and procedures is essential for safety and effectiveness, as well as for cost saving, and any faults should be followed by appropriate correction.

The actual infrastructure and manpower strength of the Nuclear Medicine Unit at the Black Lion Hospital are appropriate to initiate a national programme for the development of nuclear medicine in Ethiopia. With the support of the Government and IAEA's technical co-operation, the Nuclear Medicine Unit offers good conditions for it to be
transformed in a relatively short time into a centre of excellence for training in nuclear medicine and related fields, for the production of radiopharmaceuticals and radioimmunoassay reagents, and for medical research.

Agency technical co-operation should be extended to strengthen the Radiopharmaceutical Section. The supply of technetium-99m generators should be increased to a weekly basis after the receipt of the computer for the gamma camera. Local inputs should be gradually increased, replacing the IAEA input. The Radiopharmaceutical Section should start to replace the commercial kits supplied by the IAEA with locally produced kits. The in-vivo studies section should respond: by increasing the variety of procedures, including qualitative dynamic studies such as renal sequential imaging and brain and hepatic angiography, which do not need computer processing; and by increasing the number of patients studied every day. The Agency should supply disposable aerosol systems and provide technical advice on their recycling. With these provisions, the unit could increase in a short time its throughput from about 700 to more than 3000 in-vivo studies per year, at very low cost.

The Radioimmunoassay Section should start gradual replacement of the bulk reagents supplied by the IAEA with bulk reagents obtained directly; a similar gradual scheme as that for the generators could be devised. It should start the experimental work for the local production of reagents, mainly for T_4 and T_3 RIA.

Preventive maintenance of equipment is an essential component of any nuclear medicine programme. A medical physicist should be trained on preventive maintenance for the gamma-camera and computer system; the technicians of the in-vivo section should be trained in the use of the gamma camera computer system; in the future, it would be advisable to train a second nuclear physicist.

A second thought should be given to the plan of integrating the Nuclear Medicine and Radiotherapy Units in the Radiology Department, since these units merit <u>independent</u> organization. Although each uses ionizing radiations, the three specialties use different principles, instruments, techniques and philosophies and, above all, have different objectives. Radiotherapy is part of oncology, and nuclear medicine is a clinical specialty pertaining to internal medicine.

WATER AND GEOTHERMAL RESOURCES

Isotope and tracer techniques have not yet been introduced in the domain of water resource assessment, development and management activities carried out in Ethiopia. There has been no technical co-operation project of the Agency in the water sector, and only two professional staff from water organizations in Ethiopia have attended short regional seminars on the use of isotope techniques in hydrology organized by the Agency.

Consequently, the professional staff of various national institutions involved in water resources development activities are not fully aware of the capabilities of nuclear applications to solve various hydrological problems encountered in water resource studies on both surface waters and groundwater.

(The exception to the above were the isotope analyses that were performed on a few occasions in the exploratory investigations undertaken by the Ethiopian Institute of Geological Survey concerning geothermal waters. These isotope analyses were limited to studies conducted within the scope of a UNDP project implemented during the 1970s and recent studies completed in few geothermal areas through bilateral assistance provided by Italy. The samples collected in the course of these projects were analysed outside the country, as there is no local analytical facility in Ethiopia for this purpose. Recently, the Ethiopian Institute of Geological Survey has procured nuclear logging equipment to be used as a part of the geophysical prospecting applications; it is the only nuclear equipment available for geological investigations.)

In view of the substantial activities needed and planned for water resource assessment and development in Ethiopia, the use of appropriate isotope and nuclear techniques should be introduced. The basic infrastructure in this sector already exists to accomodate these techniques. Specific areas where isotope techniques are likely to be particularly effective are:

- Geothermal studies being conducted at different sites;
- Use of environmental isotope studies in hydrogeological activities being undertaken for groundwater assessment and mapping;
- Introduction of artificial tracer techniques, particularly for studies related to leakage investigations from hydraulic structures;
- Use of environmental isotopes in studying the erosion processes, and siltation studies of natural and man-made lakes;
- Use of isotopes to study groundwater dynamics in heavily irrigated areas and heavily exploited coastal aquifers.

Specific requirements and details of the activities to be undertaken in each of the above areas would need to be assessed so as to enable an appropriate plan of action to be established, in accordance with the national development plan.

To prepare the ground for future action, it would be necessary to create an awareness among local staff involved in water resource development regarding the capabilities and methodologies of isotope and tracer applications. This could be initiated by organizing a national seminar for senior staff of the various water related institutions. This should be followed, in the medium-term, by in-depth training of several staff members from institutions directly involved in the water resources sector, to create a body of staff fully capable of designing and planning isotope applications.

Studies and exploratory work are already being undertaken in the geothermal areas. Several important geothermal fields are still under investigation, and the map shows their location. The use of isotope techniques would substantially improve the understanding of the geothermal systems, particularly with respect to age of geothermal reservoirs, the generic relationship of thermal waters and their recharge, determination of underground temperatures and interference between productive wells. Studies of the very hot (high-enthalpy) fields in Tendaho and Corbetti could benefit significantly from immediate application of isotope techniques.

Isotopic analyses of water samples for any isotope study to be initiated immediately and in the medium-term would need to be undertaken at an isotope hydrology laboratory abroad. The number of isotope analyses to be undertaken for studies likely to be initiated in the near future, would not warrant establishment of such a national capability in the medium-term.

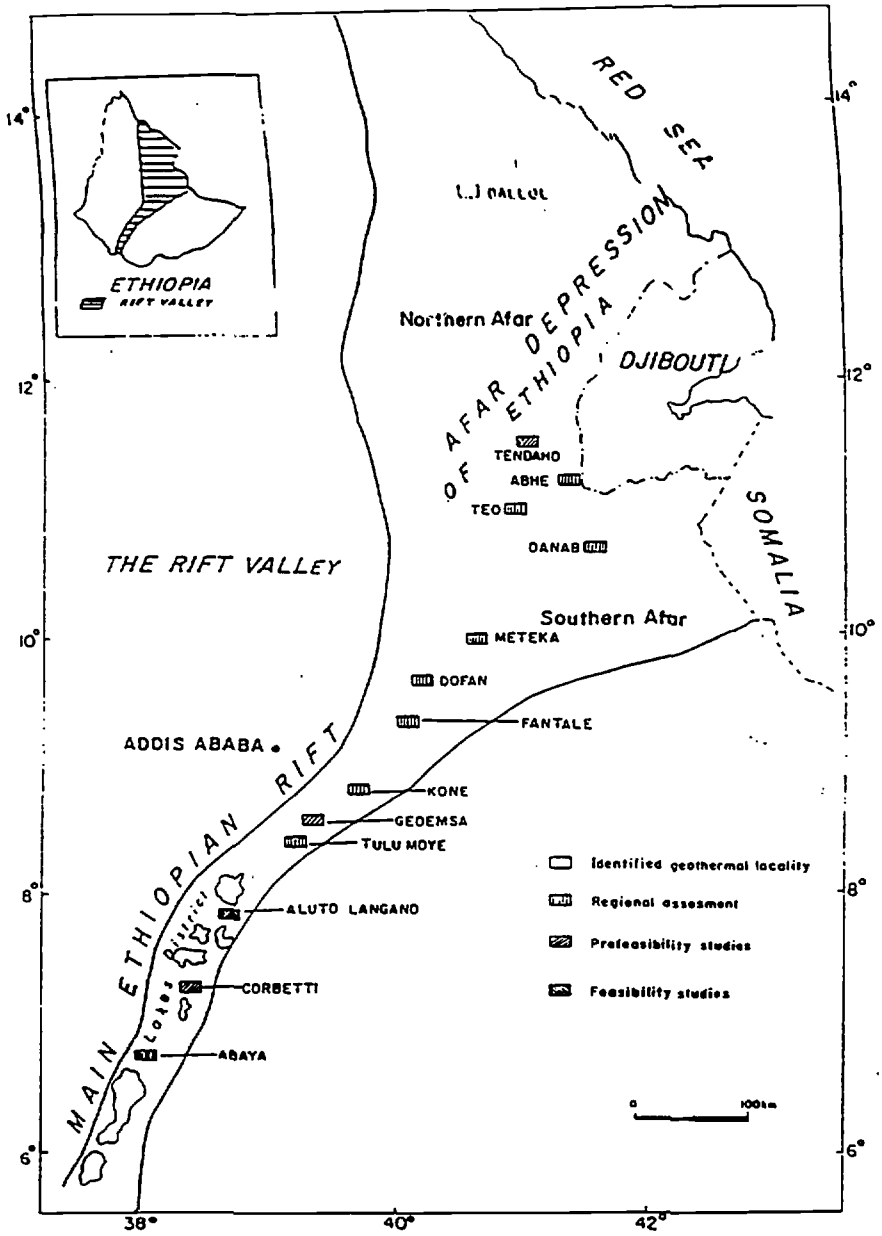
Immediate in-depth training of the staff of the Geological Survey in nuclear well-logging methods is essential, so that the nuclear logging equipment can be effectively used.

INDUSTRIAL APPLICATIONS AND INSTRUMENTATION

The National Scientific Equipment Centre of ESTC will soon start operation and it is expected that, with the resources made available by the Government and financial assistance from the UN agencies and donors, its contribution to the repair, maintenance, design and construction of scientific equipment will improve the efficiency of many scientific institutions and will contribute to training national staff. For the nuclear sector, the IAEA has approved a technical co-operation project to assist the Centre and steps have been taken to provide basic equipment; experts will provide on-the-job training once the equipment is installed in the facilities under construction. It is recommended that Agency support should concentrate in the future on consolidating local capabilities in the nuclear instrumentation workshop.

The Ethiopian Airlines and the petroleum industry are at present the only sectors using, in highly specialized applications and with their own standards, non-destructive testing techniques. It can be expected that, as the economy of the country develops and becomes more industrialized, the need for broader use of the techniques will arise. This will require adoption of national standards, training and qualification of personnel, and licensing procedures.

Since there are already plans to start a regional co-operative programme to establish non-destructive testing capabilities in the African countries, with a view to improving quality control and safety through standardized and regionally harmonized certification schemes, it is recommended that Ethiopia associates itself with the activity at an early stage to derive maximum benefit.



Location map of known geothermal prospect areas in Ethiopia

RADIATION PROTECTION

Ethiopian institutions in the health sector, the Ethiopian Science and Technology Commission, institutions presently employing radioactive sources, and certain national authorities have been aware for sometime of the urgent need to have radiation protection legislation. A law has been drafted. It is of the utmost importance that the law is approved as soon as possible and that full Governmental support be given to ESTC, which is responsible for enforcement, to ensure effective application of the necessary controls.

HIGHER EDUCATION

As the general situation in the country improves, there will be a need for manpower trained to apply nuclear techniques in the various fields. The various scientific departments in the universities should continue their efforts to expand gradually the subjects and courses relating to basic knowledge and practical uses of nuclear techniques, with careful consideration of the real needs of the country and the priorities in the national development plans. The Departments of Physics and Chemistry of the Addis Ababa University have well qualified staff who could undertake such teaching, but expert advice would be needed to introduce certain specific techniques. The Department of Biology of the same university and the Alemaya University of Agriculture should consider sending staff to take part in Agency training courses or recommending them for Agency fellowships.

The Water Technology Institute of the National Water Resources Commission, located at Arba Minch, provides undergraduate level education in the fields of hydraulic, sanitary and irrigation engineering in order to train local staff of the water institutions. Introducing training in nuclear techniques into the regular curricula of the Institute would be most desirable. This could be achieved by providing in-depth training through the Agency's Fellowship Programme to one of the senior staff.

PROGRAMMING, CO-ORDINATION AND DEVELOPMENT

The Ethiopian Science and Technology Commission has accumulated valuable experience in programming activities concerning the application of nuclear techniques, as well as in dealing with the IAEA technical co-operation projects. A member of its staff attended the regional seminar on Design, Management and Evaluation Techniques of IAEA Technical Co-operation Projects for African Countries (April 1991, Accra, Ghana). The seminar was designed specifically to provide national liaison officers with an overview of the procedures necessary to design and implement a technical co-operation programme with the Agency.

The ESTC should continue to play a co-ordinating role in matters relating to the application of nuclear techniques in all national sectors, thus making good use of the experience gained over several years. In order to better fulfil this task, it would be desirable to strengthen the links with all national institutions presently using nuclear techniques, as well as with those that may be interested in applying them in the near future. Improvement of the channels of communication as well as expeditious processing of documents in relation to technical assistance requested of or provided by the Agency is also advisable.

It is anticipated that further on-the-job training of the liaison officer may be of value. Such training could be offered by the Agency through a two or three month fellowship in Vienna. This would enable the officer to get acquainted with the day-to-day handling of different aspects of technical co-operation programmes.

Considering present utilization of nuclear technology in Ethiopia and its possible expansion in the coming five years, the mission is of the opinion that the present organizational framework within the Ethiopian Science and Technology Commission should be not only be kept, but strengthened to the greatest extent possible, in particular its co-ordinating and programming role.

Although there are a lot of highly qualified scientists and engineers in Ethiopia, given the present economic situation and the programme in nuclear science and technology, the mission is of the opinion that establishment of an atomic energy commission or a research centre with a major nuclear facility would not at this time be in the best interests of the country. The experience of many countries has shown that, without proper long-term planning and a matching infrastructure, a commission or a nuclear centre can easily become an unnecessary burden on the country. The idea should not be abandoned; rather it should be re-examined within the next five or six years, when the utilization of radiation and radioisotope in Ethiopia has become more extensive and broader based.

ANNEX I

TEN-YEAR PUBLIC FIXED INVESTMENT PROGRAMME BY SECTOR

in million birr

	Actual	Provisional actual	Preliminary estimate	TEN-YEAR PROJECTION										Total	Share in percent
	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/2000	1991-2000	1991-2000
1. Agriculture & Natural Resources				515.2	737.0	794.8	856.9	923.7	944.3	1014.8	1090.2	1170.9	1257.2	9305.2	29.2
-Agriculture				283.0	404.9	436.6	470.8	507.5	518.8	557.5	599.0	643.3	690.7	5112.1	16.0
-Natural Resources				232.2	332.1	358.1	386.2	416.2	425.5	457.3	491.3	527.7	566.5	4193.1	13.1
2. Transport & Communicatio				236.4	338.2	364.7	393.2	423.8	433.3	465.6	500.3	537.3	576.9	4269.7	13.4
3. Industry				229.7	328.6	354.3	382.0	411.8	421.0	452.4	486.0	522.0	560.5	4148.4	13.0
4. Energy				181.5	259.6	279.9	301.8	325.3	332.6	357.4	384.0	412.4	442.8	3277.2	10.3
5. Mining				179.2	256.3	276.4	298.0	321.2	328.4	352.9	379.1	407.2	437.2	3235.7	10.1
6. Construction				130.7	187.0	201.7	217.5	234.4	239.6	257.5	276.7	297.2	319.0	2361.4	7.4
7. Urban Development & Housing				87.6	125.4	135.2	145.8	157.1	160.6	172.6	185.4	199.2	213.8	1582.8	5.0
8. Education				74.2	80.9	87.2	94.0	101.4	103.6	111.4	119.6	128.5	138.0	1038.8	3.3
9. Trade & Tourism				45.4	65.0	70.0	75.5	81.4	83.2	89.4	96.1	103.2	110.8	820.1	2.6
10. Health				39.9	57.1	61.6	66.4	71.6	73.2	78.7	84.5	90.8	97.4	721.2	2.3
11. Others				47.0	67.2	72.5	78.2	84.3	86.1	92.6	99.5	106.8	114.7	848.8	2.7
Public Sector				1766.8	2527.4	2725.5	2938.8	3167.7	3238.5	3480.2	3738.8	4015.6	4311.4	31910.7	100.0
Private Sector				311.8	463.1	518.8	581.1	650.9	691.7	772.8	863.5	964.7	1077.9	6896.3	
Total Fixed Investment	1804.8	1782.8	1426.2	2078.6	2990.5	3244.3	3519.9	3818.6	3930.2	4253.0	4602.3	4980.3	5389.3	38807.0	

ANNEX II

IAEA ASSISTANCE PROVIDED TO ETHIOPIA
BY FIELDS OF ACTIVITY
FROM 1981 TO 1990
IN US DOLLARS

FIELD	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
NUCLEAR CHEMISTRY								885	1 212	
PROSPECTING, MINING AND PROCESSING OF NUCLEAR MATERIALS									15 850	
NUCLEAR ENGINEERING AND TECHNOLOGY			102	10 104					5 413	16 268
APPLICATION OF ISOTOPES AND RADIATION IN AGRICULTURE	137 868	42 779	791	7 047	77 797	96 705	55 337	73 332	46 676	75 920
APPLICATION OF ISOTOPES AND RADIATION IN MEDICINE	24 047	23 782	61 047	35 144	67 429	70 202	44 209	111 235	45 206	141 478
SAFETY IN NUCLEAR ENERGY	164		2 199	58 214	51 971	24 318	10 116	42 650	6 581	76 202
TOTAL BY YEAR	162 079	66 561	64 166	110 509	197 197	191 225	109 662	228 102	120 938	309 868

TOTAL 10 YEARS = 1 560 307