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NOTE BY THE INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA) ON APPLICATIONS OF ATOMIC ENERGY IN AFRICA

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APPLICATIONS OF ATOMIC ENERGY IN AFRICA

Note by the International Atomic Energy Agency (IAEA)

The International Atomic Energy Agency is the organisation of the United Nations system responsible under its Statute for encouraging the utilisation of atomic energy for peaceful purposes in its Member States and for performing any operation or service useful in research on atomic energy. This includes providing materials, services, equipment and facilities. It is also responsible for fostering the exchange of scientific and technical information on the peaceful uses of atomic energy and encouraging the exchange and training of scientists and experts in this field.

The following African countries are Members of the International Atomic Energy Agency :-

Algeria	Mali
Cameroun	Morocco
Congo (Kinshasa)	Niger
Ethiopia	Nigeria
Gabon	Senegal
Ghana	Sierra Leone
Ivory Coast	South Africa
Kenya	Sudan
Liberia	Tunisia
Libya	Uganda
Madagascar	United Arab Republic
	Zambia

The IAEA has concluded an agreement with the Organisation of African Unity and expects to collaborate with that organisation and its appropriate commissions in matters of mutual interest; this includes a proposed sysmposium on the uses of atomic energy in Africa to be held in Kinshasa in the summer of 1969.

Aid is given under a Regular Programme of Technical Assistance which is available to any Member State of the Agency; all Member States of the ECA can receive aid from the Agency under the United Nations Development Programme. Signature of the Treaty on the Non-Proliferation of Nuclear Weapons is not a pre-requisite to receiving assistance.

In practical terms applied to Africa, the IAEA's assistance, rendered only in agreement with the governments concerned, is related to the implementation of national economic and social development plans and designed in part to ensure that the potential of the peaceful uses of atomic energy is taken into account in the preparation of future or rolling plans. Generally speaking, the peaceful applications of atomic energy have no role in isolation in economic development, but it does have an important ancillary place in development of food and agriculture, natural and mineral resources exploration and development, in medical diagnoses and therapy and in various industrial processes. Its potential in power production is acknowledged by economic planners even where abundant supplies of water power or oil exist.

The IAEA between 1960 and 1962, in order to ascertain the status of development of atomic energy programmes in Africa, dispatched missions to the following countries :-

1960	1961	1962
Sudan	Liberia	Togo
Morocco	Ghana	Cameroun
Tunisia	Nigeria	Congo (Kinshasa)
Senegal	Ivory Coast	Madagascar
Malia		Tanzania
		Uganda
		Kenya

Reports were made available to the governments. These have been followed up by similar missions, approximately every two years after.

This note (which is illustrative and not necessarilly comprehensive of all atomic energy activities in Africa) briefly describes the present

position of development of certain applications of nuclear techniques of concern to African conditions and endeavours to suggest certain areas in specific countries in which its benefit could be of practical benefit in economic and social development.

I. Nuclear Raw Materials

In 1967 Africa produced about 19 percent of the world's uranium output, mainly from South Africa and Gabon, and totalling about 4000 tons U_3O_8. In response to the quickening demand for nuclear generated power, uranium productionand plans for new capacity are now increasing. In South Africa alone, uranium production in 1968 is expected to exceed 4000 tons U_3O_8. This figure is still well below South Africa's short-term production capability which is estimated to be about 6000 tons U_3O_8, and it is expected that production at this level will be reached before 1975. In addition, it is expected that production capacity, in Gabon, Niger, and possibly the Central African Republic, will amount to about 3000 tons U_3O_8 per year by about 1974-75.

Prices being paid for present production are still principally based on earlier long-term contracts but there is likely to be increasing freedom for the negotiations of new contracts and these are likely to lie in the price range of US$ 5 - US$ 8 per pound of contained uranium oxide in concentrates. While presently negotiated contracts may mainly be in the middle of this range, it is expected that the upper part of the price range will be operable in the early and mid-1970's.

The most up-to-date information on future supply and demand of uranium indicates that in the cost category of under US$ 10 per pound U_3O_8 some 700,000 tons U_3O_8 of "reasonably assured reserves" are available in the Western countriesA further 126,000 tons U_3O_8in this cost and reserve category may be available as a by-produce of the exploitation of other minerals. Larger amounts of uranium are expected in the higher cost ranges.

It is estimated that world nuclear capacity, which is presently approximately 18,000 MW(e), will grow to 235,000 - 330,000 MW(e) by 1980. This rapid increase of nuclear capacity would result in a correspondingly rapid rise in demand for uranium. Estimates indicate that uranium consumption will rise during the 1970's from some 13,000 tons in 1970 to 34,000 - 46,000 per annum in 1975 and reach 65,000 - 86,000 tons per annum by 1980.

On the basis of these figures and projections beyond 1980 it is estimated that there is an urgent requirement for the discovery and development of new low-cost uranium deposits. Since the interval between discovery of a new reserve and its exploitation into production may take at least five years and more often nearer ten years, it is important that new uranium exploration and prospecting programmes are undertaken as soon as possible.

Deposits of uranium already known and developed in Africa represent the results of limited search and there seems little doubt that more intensive prospecting, particularly in areas not as yet surveyed, will result in new deposits of uranium ores. Investigations of such areas are currently being carried out, or are planned in Central African Republic, Congo (K), Ethiopia, Gabon, Kenya, Morocco, Niger, Nigeria, Senegal, Somalia, South Africa, United Arab Republic, Upper Volta, etc. In addition, the possibility of economic recovery of uranium as a by-product in fertilizer production from phosphate rock is being studied in Senegal and Tunisia and has previously received some attention in Algeria, Morocco and the U.A.R. Although the cost of production from this source is not attractive on current prices of uranium, this situation might change with alterations in the supply and demand position or through improved extractive technology giving rise to lower costs.

The above facts are important for Africa either because of the possible development of nuclear power within the continent in the latter part of the century or through the development and exploitation of uranium ore deposits to take advantage of the anticipated new commercial demand which could be an important source of foreign exchange.

In regard to thorium, which is also a potential fuel for the generation of nuclear energy, considerable research is being conducted in various countries towards its utilisation for power purposes but its general economic employment still appears to be in the more distant future. Thorium is not in short supply in the world and the possibility of a commercial outlet from new deposits at the present time appears to be small. Nevertheless, any thorium deposits found in a nuclear raw materials exploration programme should be evaluated and recorded.

II. Nuclear Power

The vast water power resources of Africa are reflected in the number of large-scale hydro-electric schemes already installed, being installed, or envisaged - nearly 40 million KW in only eight stations. In addition, there are substantial quantities of oil and natural gas in arid zones, as well as adjacent to hydro potential. These large facilities have output in excess of present domestic need. Inter-country connections are only just being introduced and the potential of these is very great. While capital construction costs of hydro plants and costs of transmission lines continue to rise, it is to be noted that recent advances in applied nuclear energy are bringing it nearer to break-even point with conventional energy, at least in the developed world. This break-even point has been achieved, however, by large stations of 500,000 to 1,000,000 KW, operating at high-load factors. Construction costs in this range vary between $140, and $200 per KW, but these unit costs would be substantially higher in lower capacities of 300,000 KW and below. The demand in Africa is for pockets of relatively small loads and even if energy intensive industries are established, the existing and planned hydro and thermal installations should be able to meet energy requirements for the foreseeable future.

There are instances where nuclear power may be appropriate to meet specific needs. The U.A.R. has embarked on a nuclear power project calling for a nuclear power station of 150 MW(e), which would be integrated into the grid system. South Africa has concluded in a recent report that nuclear power would be economically competitive in that

country during the first years, if a station with an output of between 200 and 350 MW were to be put into service in the Western Cape between 1978 and 1980. No other projects for the installation of nuclear power for the electric grid in Africa are known to be under consideration.

There are possibilities, however, of achieving an improved load factor in areas where fresh water requirements will have to be met by plants for the joint production of desalinated water and electricity. Studies on the feasibility of dual-purpose power and fresh water producing nuclear plants have been carried out by the United States, Israel and Mexico with IAEA participation. The possible use of nuclear power for the desalination of sea water was studied in South Africa, but it was concluded that there was no region where fresh water produced in this way could compete in price with natural water for many years. In the U.A.R., a project for sea water desalination and a pilot agricultural farm representing the first stage of a project aiming at the construction of a large agro-industrial centre with a 500 WM reactor is under consideration.

Reports of African power meetings held under the auspices of ECA and ECE have pointed out the desirability for planning authorities in member countries to keep abreast of technical changes in the nuclear power field. The IAEA will provide information on nuclear power costs to the second African Energy meeting to be held under the auspices of ECA in 1970 and is prepared to undertkae studies in specific areas, but there is no doubt that power demand will grow, and a developing country planning a new power programme should bear in mind the relative costs, both actual and projected, of all energy sources including nuclear.

III. Uses of nuclear techniques in agricultural development plans

Agriculture occupies a dominant position in the overall economy of Africa and agricultural production is not keeping pace with population growth and food production is falling short of the demand for higher consumption domestically and better nutrition standards. The majority of agricultural sectoral plans in African development plans concentrate on increasing yields for both domestic consumption and export and on the

modernisation of agriculture practices, including the possibilities of processing agricultural products. The success of these programmes is vital, both at the national and continental level. The projects forming the programmes usually consist of several sub-projects and it is in these that atomic energy in the form of radioisotopes and radiation plays an important part. This is particularly the case in investigations essential to crop and animal production and protection, preservation and conservation of foodstuffs. Recent IBRD and OECD reports have drawn attention to the need of improving research programmes benefiting developing countries and the need to evolve a system which would relate research in developed countries to that being carried out in institutes of developing countries. The required fundamental research using atomic energy which could affect African agricultural problems is being carried out mainly in institutes in developed countries, but bearing in mind the nature of specific tropical agricultural problems, the necessary applied research has to be carried out in situ. This means in most cases the addition of appropriate facilities, such as small radioisotope units, to existing agricultural research institutes or, where none exist, in the faculties of agriculture at national universities. It is not intended that these units should be continuously in use, but should be available if and when the need arises to solve particular problems. The cost of equipping such units is small - some $8,000 to $10,000. They exist already in Tunisia, Senegal, Cameroun, Ivory Coast, Ghana, Madagascar, Kenya, Uganda, U.A.R. and South Africa and, with IAEA assistance, are being installed in Sudan, Morocco, Nigeria and Zambia.

The current large-scale fertilizer campaigns are assisted by studies into the efficient use of the fertilizer, i.e. appropriate placement, timing of application and the suitable chemical form. Radioactive fertilizers have been applied for example in IAEA programmes designed to improve efficiency of fertilizer uptake by perennial tree crops. Studies are undertaken for cocoa (Ghana), oil-palm (Ivory Coast), sorghum and groundnuts (Senegal), coffee (Kenya), olives (Tunisia). Further trials could usefully be carried out on groundnuts and maize, particularly in Ghana and Congo (K) and should be extended, particularly in the oil-palm culture. This should be carried out in conjunction with the current programme expanding this production in Ivory Coast, Cameroun, Congo (K)

under FEDOM auspices. It is hoped later to include tea in the programme in Kenya and Uganda. The use of portable instruments (neutron moisture probes) for soil moisture determination is invaluable and relatively simple. These methods are now commonplace in Africa, but could be extended as part of an existing IAEA programme to other areas where reforestation and reclamation projects are in operation, e.g. Nigeria, Ghana and Malawi.

Durum wheat strains developed through radiation have recently been shown in trials in Tunisia, Libya and the U.A.R. to be superior to local and common strains by as much as 44%. These strains were developed in Italy. These successful strains are now being tested also in Algeria, Ethiopia, Kenya, Morocco and Sudan.

Trials of these and other varieties in research stations outside of Africa have focused attention on the high returns possible through expanded research. Use of nuclear techniques in other crops such as corn, grasses, legumes and oil seeds should be stimulated in the existing network of research institutes in Africa.

Nuclear techniques applied to entomology include the use of radiation to induce sterility (sterile male technique) and the use of radioisotopes as tracers(tagging of flies). The former has been used with success against screw worm fly in South East United States and fairly intensive research is being undertaken in the Central African Republic and countries in the East Africa Community on tsetse; this is a long-term programme designed to eradicate rather than control. Investigations using radiation on the Mediterranean Fruit Fly are being assisted bilaterally in Tunisia and similar programmes could be extended to the sunn pest in Morocco. Tracer studies on mealybugs in cocoa are being carried out by the IAEA in Ghana. Insecticides labelled with one or more radioisotopes are frequently used to study insect resistance to insecticide and the normal physiology of insects and the extent of pesticide residues on plant and animal food. Studies are about to be introduced by the IAEA in Uganda and could usefully be started in Central and West Africa.

Nuclear techniques are used intensively in animal production and

disease control. Long-term programmes in this field designed to produce vaccines are being started in Senegal where it is proposed to establish an animal biochemistry laboratory with radioisotope facilities in an existing veterinary institute. In 1969, a regional programme in East Africa based in Kenya will establish a radiation facility to investigate the potential of vaccines produced by irradiation for use against such diseases as East Coast fever and Trypansosmiasis. In connection with the control and eradication of disease in the human and animal population in East Africa, using both conventional and nuclear techniques, there is a need for technical personnel involved in all aspects, i.e. medically qualified staff, entomologists, veterinarians, etc., to discuss together the whole problem of tsetse control and eradication.

IV. Food Preservation

Prevention of losses of food, particularly in tropical countries is a major objective of government policy. It has been estimated, for example, that enoughtgrain is lost annually in Africa to feed 55 million persons. Intensive research and planning efforts to prevent these losses is being carried out in both the developed and developing countries. One method is the use of ionising radiation which has been found to have little effect on the quality of raw foods such as fruits, vegetables and meat. The control of insects in grain and other seed products can be accomplished by flowing these in bulk through a radiation treatment unit. This treatment is at its optimum when employed with products that can be handled in large volume and operated over a great part of the year; it is not a process that can be used to treat small lots of products on a seasonal basis. Thus for example, it can be considered in grain at 30 tons of wheat per hour and for meat one million tons per annum would be required to be economic. The cost of initial installation is high and it might be desirable to concentrate installations in a few centres working on behalf of several countries which have the same products. As with other food processing methods, it is not always possible to apply the treatment to all products. For example, it has only limited application with dairy products, but the prevention of sprouting of potatoes, onions and garlic and control of the ripening of bananas, mangoes and papayas can be achieved.

Grain, fruit and vegetables: Whilst research is taking place in developed countries where facilities, resources and trained personnel are available, experts have recently advised that some of the work should be carried out in countries where the raw materials are produced and where the processes would be applied eventually, even if such countries now have no adequate facilities for such work. The IAEA is assisting in laboratory-scale radiation trials in Tunisia for inhibition of sprouting in potatoes, in Madagascar for lengthening of shelf-life of lychees and other fruit, and in groundnut disease control in Nigeria. It is hoped eventually to carry out more intensive research on a larger scale at the Ford Foundation Institute for Research into Tropical Foodstuffs Other than Rice, now being constructed in Ibadan, Nigeria.

Fish: Considerable research into the losses of both fresh and salt water fish due to insect spoilage has been undertaken utilising conventional means in Mali, Niger and other countries. The possibility of the prevention of these losses by radiation is being actively investigated. A major problem is one of packaging to prevent re-infestation and unless an inexpensive insect-proof package can be found, the application of radiation is not wothwhile. Under the European Development Fund pilot studies combining irradiation and refrigeration are being carried out in Europe designed to permit transport of fish from Abidjan to the interior of the Ivory Coast, whilst ensuring it is fit for human consumption. The second stage of the project will be carried out in Abidjan.

Meat and meat products: Radiation decontamination of meat, bone and blood meals would substantially increase the markets for such products in Europe and elsewhere. Some laboratory tests (similar to the fish studies) in respect of meat preservation are being undertaken in Europe as the first phase of a pilot irradiation scheme in Chad designed for the export of meat to neighbouring countries.

Food irradiation is a complextsubject and radiation treatment cannot be considered a panacea for all food problems or even as a substitute in all cases for the use of conventional methods presently practised.

Certain economic problems must be taken into consideration, as also must the use of mechanical handling equipment. Such applications as have been described must be tested through research studies under the particular conditions under which the process is to be used. With increased yields following fertilizer campaigns and as disease control improves, requirements for storage will increase. The need for applied research into food preservation is increasing in importance.

V. Applications of Radioisotopes in Industry

Radioisotopes are commonly used by industry in many African countries in analysis or quality control where radioisotope guages allow rapid measurements not previously possible, with resulting produce improvement and raw materials savings, e.g. in cigarette manufacturing, brewery processing and food packaging. In developing mineral resources, nuclear techniques are now used for both prospection and field analysis. The Radiation processing of wood plastic composites has led to trials which are in an advanced stage for hardening of tropical soft woods by radiation with a view to their utilisation in housing and other building constructions. It is hoped that this will ultimately be of value, particularly in the mangrove swamps in West Africa. Radiation processing of textiles and a wide range of chemical products is a rapidly expanding field for the application of nuclear technology. It is standard practice to utilise nuclear techniques in the copper industry in Congo (K) and Zambia; in the glass industry and fertilizer plants in the U.A.R.; trials for thickness measurements and non-destructive testing of various substances have been carried out in Kenya and Tunisia. With the proposed steel industries there will be a marked increase in the utilisation of radioisotope techniques, since many of these are common practice in this industry. Tracer applications in moisture measurements in construction of highroads have been utilised in, for example, Kenya, Tunisia and UAR. Consideration of use of these techniques in industrial development schemes now being planned or undertaken in Africa should be given by planners, as well as industrialists and contractors.

VI. Use of Nuclear Techniques in the Development of Water Resources

Recent studies have proved that data of great economic significance with regard to the availability of ground water in arid zones and in the investigation of water resources can be obtained with comparatively small effort and at a lower cost through the use of isotope techniques. These techniques may be used to locate the source of recharge and to determine the direction and velocity of ground water movement as an additional tool in the effective utilisation of available water resources The wider range and use of these techniques is evidenced by the work being undertaken by the IAEA (in conjunction with WHO, UNESCO and FAO) in projects designed to locate underground water resources in the Hodna region of Algeria and shortly to commence in the Northern Sahara on the borders of Algeria and Tunisia. The evaluation of exploitable water resources for irrigation, animal production and other development is being actively studied in the Chad and Senegal River Basin projects. In arid and semi-arid zones groundwater must be developed to maintain viable pastoral and nomadic economics. In Uganda and in the Dallol Maouri Valley project in Niger, isotope techniques are used in evaluation of long-term potential for sustained groundwater production.

Radioisotopes in the measurement of suspended sediment and of 'bedload' are important in Africa; reservoirs for dry season storage are a critical factor in development and sediment transport shortens the life of reservoirs to an unpredictable extent. Stream gauging and river flow measurements are carried out in Kenya and South Africa. Their use is being studied in the gauging of the Mubuku in Uganda and the Kafue River and Lake in Zambia; it is also hoped to undertake studies to determine the feasibility of radioisotope applications in swamps in the Lake Bangweulu area in Zambia.

In Dakar, Kampala and several other capital cities, studies for water supply, sewage and drainage are being undertaken in conjunction with WHO. The use of isotopes is two-fold; firstly to identify the technical and economic potential of water resources for the water supply of the city and in the investigation of conditions determining the best

method of the disposal of sewage into the sea or the lake. The same techniques will be applied in Morocco in a nation-wide survey of drinking water supply and, in particular, of the plan for the disposal and insured purification of contaminated water and household refuse in the coastal region. These applications of isotopes are carried out on a sub-contractual basis and their extended use in many other projects in Africa, both in agricultural development and in urban reconstruction is anticipated.

VII. Medical and Biological Applications of Radioisotopes

Improvements in health services and facilities have been assisted in recent years by advances in nuclear medicine and laboratories and clinics for medical radioisotope work have been established in many medical centres in Africa, especially in those associated with university medical schools, e.g. Uganda, Senegal, South Africa, Sudan and Nigeria. The availability of radiotherapy facilities is increasing and these are now operational in U.A.R. Morocco, Sudan, Algeria, South Africa, Congo (K) and Nigeria. Plans exist for their installation in Uganda, Tunisia, Ghana and the Ivory Coast. Medical research utilising radioisotopes in the cases of tropical disease, such as liver cancer, sickle cell anaemia and various types of malnutrition is being undertaken in all countries with the necessary facilities.

This work requires trained personnel and specialised equipment and adequate health and safety measures have to be observed. The IAEA has assisted in the introduction of appr priate measures including the drafting of legislation in Tunisia, Ghana, Algeria, U.A.R., Sudan and Uganda. The use of the biological effect of ionising radiation is employed in plant breeding, entomology, food preservation, radio-sterilisation and bio-medical products and in micro-biology. In 1970, together with interested governments, the IAEA hopes to study the role of radiobiology in specific African environments, but this subject, as well as the increased availability of radioisotope facilities throughout Africa, must allow time for the training of personnel and the creation of the appropriate infrastructure.

VIII. Manpower - Research Reactors and Training

The need of trained personnel to implement a programme of applied nuclear techniques is evident. For example, about 100 engineers and skilled technicians are needed to maintain a nuclear power station of 500 MW. A research reactor will absorb the services of a considerable number of qualified scientists, as well as the trained supporting staff of technicians and other operatives. The engineers and scientists will need advanced training founded on the basic sciences. The move throughout Africa is to make basic scientific training available within the country and as much advanced training as is possible. In this context, nuclear sciences figure in the curriculum of the national universities in

Algeria	Senegal
Congo (Kinshasa)	Sierra Leone
Ethiopia	South Africa
Ghana	Sudan
Kenya	Tunisia
Madagascar	Uganda
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Plans exist for their introduction in the Ivory Coast and elsewhere. Visiting lecturers and equipment have been provided by the IAEA for example to the universities in Sudan, Tunisia and Uganda, and will be provided to the University of Zambia in 1969. With the increasing trend for the provision of full training facilities at the national level, the need to include nuclear techniques, both in applied technology and as a research tool, will have to be met.

In 1968, there were three research reactors operating in Congo (K), South Africa and the U.A.R. These facilities provide the scientific tools in a national environment for scientists and apart from providing radioisotopes and a source of irradiation, help to sustain the scientist in his own country. Research reactors, excluding the building, cost over $500,000. It is however important to integrate this facility into the educational and scientific programme of the country, otherwise its thirst for scientific manpower can tend to divert scientists from higher priority work.

In respect of advanced and highly specialised training, this can be provided by IAEA to all candidates or personnel from the level of technicians to middle-grade scientific personnel, to highly specialised scientists and engineers in the various branches of nuclear sciences and technology. Nuclear engineering is now being taught, not only in South Africa and the U.A.R, but in the University College of Nairobi, Kenya. To date, 330 Africans have received training under the IAEA Fellowships Programme, which provides study overseas. In addition, grants to cover scientific visits for qualified personnel to study special aspects of atomic energy are also available. Nationals from many countries, including Ethiopia, Senegal, Sudan and Tunisia, have benefited from this latter programme.

Vienna, December 1968