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SOME POSSIBLE CONTRIBUTIONS OF NUCLEAR SCIENCE IN MEETING THE BASIC NEEDS OF EMERGENT AFRICA

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SOME POSSIBLE CONTRIBUTIONS OF NUCLEAR SCIENCE IN MEETING THE BASIC NEEDS OF EMERGENT AFRICA

by

J.R. STEBBING

A B S T R A C T

It is forecast that, in spite of present plans, need in emergent countries will not significantly decrease during the next 20 years. Nuclear science could make a contribution to this problem. For instance, much valuable work has been done recently by the International Atomic Energy Agency (IAEA), and other international bodies, in improving rice production in Asia and the Far East; the Agency has sponsored a full scale pioneering plant, in Turkey, for the disinfestation of grain by irradiation; desalination is being widely studied in the United Kingdom and the USA, in association with nuclear power; earth moving by peaceful detonations forms part of the US Atomic Energy Commission's programme; and ground water tracing has been studied by the IAEA and in the United Kingdom. All of this work is briefly reviewed in relation to the basic needs of emergent Africa. Finally, a number of proposals are outlined which employ the known resources of nuclear science.

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C O N T E N T S

1. INTRODUCTION

Need is assuming grave new proportions in emergent countries. The United Nations Food and Agricultural Organisation (FAO) 1967 Indicative* World Plan for Agricultural Development has forecast a sharply widening gap between the gross domestic products of the developed and the developing countries. Assuming that present plans for economic advance in the emergent countries are completely successful, they will raise the per capita gross domestic product from $133 in 1965 to $255 in 1985 while the expected increase in the rich countries will be from $1300 to $3000. If the most optimistic advance is so manifestly insufficient there can be no doubt about the role of a relatively new branch of science which has scarcely yet been brought to bear in the underdeveloped countries and has been particularly lacking in Africa. In terms of ultimate benefit, nuclear science may have no greater contribution to make than other branches of science and technology but practically the whole of its resources have yet to be deployed; these include sources of immense power on the one hand, and applications of extraordinary subtlety on the other.

It follows also from the F.A.O. forecasts that new criteria will have to be considered for development finance in aid of emerging countries. In the past it has been the practice to provide mainly capital aid and to expect the recipient to meet recurrent charges, either immediately, or after a defined period. This attitude may well have to change; longer range obligations should be acceptable by donor countries in order to speed up development. The vast increase in the prosperity of the richer countries should create a readiness to do this and to explore some of the more costly (and, in immediate terms, uneconomic) possibilities offered by nuclear science.

Basic needs are food, adequate in quantity and variety; and water. The area to be considered lies south of the Sahara and north of the Republic of South Africa; it is inhabited by over 200 million people, who are increasing at a rate of more than 4 millions each year, who are living in 33 separate countries, the great majority of which are newly independent.

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* 'Indicative' because the F.A.O. cannot back its strategy with legislation. Times, Oct. 19th, 1966.

The principal fields which will be considered are:-

(i) Seed improvement, the improved use of fertilisers, the control of pests;

(ii) The disinfestation of grain, for storage;

(iii) Desalination, with the possible use of nuclear power;

(iv) Major earth-moving projects by peaceful detonations, particularly for surface and underground water storage;

(v) Ground water tracing.

It will not be suggested that nuclear science can provide a distinct and separate approach to the development of emergent countries. Rather the reverse: the purpose of this study is to identify some of the grafting points, in the general framework of development, where these new techniques might most profitably be added. It happens, however, that nuclear science has an impressive contribution to make towards improving tropical subsistence farming and water supplies.

Africa has been chosen partly because it has lagged behind Asia and the Far East in benefiting from nuclear science and partly because the writer had direct administrative experience in the West, South and East of the continent: as a District Officer in Nigeria; for ten years responsible for development planning in Swaziland; and finally having more general responsibilities in the Somaliland Protectorate.

2. SEED IMPROVEMENT

Seed improvement of rice and barley has been achieved by radiation induced mutations. Particularly valuable work has been done with rice in seven countries of South East Asia[1]. This has been co-ordinated by a joint F.A.O./IAEA organisation which has a programme for the production and use of induced mutations in rice breeding. The International Rice Research Institute in the Phillipines also operates a co-ordinated Rice Mutations Programme; this encourages

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[1] Ceylon, China, India, Japan, Pakistan, the Phillipines and Thailand.

the conduct of uniform regional trials, and arranges for the exchange of information. During 1966, scientists concerned with both of these programmes met in Manila to co-ordinate their efforts.

Work in Japan resulted in mutant lines of rice reaching maturity up to 50 days earlier than the mother variety, so that an extra crop becomes possible each year[1]. China has reported the results of four mutant lines with improved yields over local varieties of 3 to 8%, and with superior straw strength[2]. Work in India resulted in improved grain, higher yield and disease resistance. Steps were taken to organise trials in all seven participating countries to compare the mutants with local and internationally known varieties.

This immensely important work on rice mutants could affect the lives of nearly a third of mankind in the course of the next generation.

3. IMPROVED USE OF FERTILISERS

The efficient use of fertilisers has been studied with an entirely new degree of precision by the use of radioactive tracers: these are transportable; able to be chemically associated with their stable counterparts such as the phosphorus or nitrogen in a fertiliser and at the same time to demonstrate to a geiger-counter their precise movements, whether in the soil or inside living plants. This unique property has made it possible to study differing methods of fertiliser applications and variations in the timing of applications with a speed and precision that has never before been possible. Recent experiments in Asia and the Far East have shown that 'the same application performed simultaneously in a number of countries with widely differing soils and climates has given the same results'[3]. It has for instance been established that broadcasting fertilisers on the surface is practically as effective as the far more costly process of working them into the soil and that late application of fertilisers can be effective; indeed, fertiliser can with great benefit be broadcast over growing rice and thus vagaries of supply in remote areas need not jeopardise crop yields, as they have done in the past. By conducting identical and simultaneous experiments, at widely separated points, work has been done in one year which might have taken at least five

years to accomplish by older traditional methods. Conclusive results have been achieved 'which could be immediately applied in practice'[4].

While comparatively little work of this kind has been done in Africa, one interesting experiment has been conducted in the Congo in which the results of broadcast fertiliser in an oil palm plantation were compared with the results from the traditional methods of mixing fertiliser into the soil. The actual uptake was measured; the results compared with the Asian experience: a saving of 10-20% was made in the amount of fertiliser used and costs of applications in the oil palm plantation were reduced by 75%[5]. Fertiliser trials with maize have been started in Argentina, Brazil, Columbia, Mexico and Peru[6].

4. CONTROL OF PESTS

Pest control investigations in the Far East and Asia have formed a part of the measures to improve rice production[7]. The stem borer, the principal threat to rice crops at every stage of growth, and throughout the whole area, can be controlled by insecticides but these are costly, in some degree indiscriminate, need applying more than once and can involve the handling of hazardous chemicals. Investigations are now proceeding with the aim of using the sterile male technique. These will involve mass rearing, the determination of the optimum radiation dose, which has to be sufficient to ensure a reasonable percentage of sterile flies, without too high a mortality rate, and the dispersal of sterile male insects throughout the rice producing area. This is a vast task with obvious difficulties but there is the possibility of very significant and lasting improvements in food production.

5. DISINFESTATION OF GRAIN

A solution of the problem of grain disinfestation would be of particular value to Africa where losses are frequently as high as 25% and percentages of double this figure are not unknown. Storage in many areas has not changed from the primitive tribal methods which provide very little protection against vermin and less against termites. Storage is traditionally a short term matter because production is barely sufficient and margins are precarious; indeed, in some areas,

the storage of surplus grain could do no more than expose problems of communications which are insufficient, and lack the flexibility needed to distribute supplies normally, or as relief when it is urgently needed.

Advances in grain irradiation have recently reached a stage in which a pioneer large scale plant will shortly be in operation in Turkey. This plant, the first of its kind in the world, will continuously irradiate grain at a rate of 30 tons per hour to a level which sterilises insect pests and reduces grain losses to an insignificant degree, provided re-infestation does not occur[8]. The contract to build this plant was awarded to Nuclear Chemical Plant Ltd. of Ealing, London, by the IAEA on behalf of the United Nations Development Programme[9].

The makers of this large plant have also developed a small Mobile Grain Irradiator (costing £13,000, about one tenth of the large plant): this can be moved by a 10-ton lorry and can handle up to one ton of grain per hour. It is based on a well tried research irradiation unit of robust design and suitable for transportation[10].

6. DESALINATION

This has been a need for many centuries. It is also a field in which the United Kingdom has long and varied experience. British plants account for over half of the large scale land based desalination capacity now in operation[11]. Until recent years the economics of plants have confined their use to particular situations, such as exist in Kuwait with its great wealth, its abundance of local fuel and its extreme scarcity of potable water. But the increasing needs of power and water in the highly centralised industrial societies, combined with improved methods of desalination and the improving economy of atomic power have opened up new possibilities. The United States and Mexico are engaged in a joint study (with the IAEA) of the possibilities for large dual purpose nuclear schemes to provide power and water to serve neighbouring areas in both countries: similar plants are envisaged to provide water for Arizona, Florida, California, and Sonora in Mexico. President Johnson has announced his government's intention to construct a wide variety of plants producing from

1 million gallons per day by 1970. A joint United States-Israel team has completed a study of a dual purpose plant for Israel to yield 100 million U.S. gallons per day and 200 megawatts of electric power.

In Britain, the U.K.A.E.A. has recently assumed responsibility for the Government Committee working in this field. The Authority is also responsible on behalf of the government for desalination research and development. Its programme includes the improvement of the technical and economic efficiency of the multi-stage flash distillation of sea water in collaboration with Weir Westgarth Ltd; the design of dual purpose nuclear plant for the production of electricity and heat for desalination; and the study of the process of electrodialysis for the conversion of brackish water. Considerable effort is also being made to identify and develop alternative new processes.

Multi-flash distillation removes the water from sea water by boiling, in successive stages, in conditions of declining pressure and, therefore, temperature. A combined plant, in prospect, can produce 72 million U.S. gallons per day and 400 megawatts of electricity. For brackish water (containing 0.6% or less of salt as opposed to the 3.5% in sea water) electrodialysis is a cheaper process. In this method, developed in the early 1950's, the brackish water is introduced into specially designed membrane cells, which with the passage of an electric current, separate the constituent parts of the salt from the water. It does not seem probable that, in the next few years, any new process will displace either method. Nor is it likely that it will be possible to produce water at an economic cost for irrigation (10d per 1000 Imperial gallons) before the late 1980's and then only with very large schemes. But it could well take as long to discover the best means of using irrigation water in arid regions where the people are often nomadic and have not had the chance to develop agriculture. Pilot projects which would be small scale and sub-economic would enable these highly important social and agricultural problems to be tackled concurrently with the evolution of more economic desalination methods.

Nuclear power has not until recently been a practical power source for smaller desalination plants, but this situation could well change

in the light of American successes with small package power reactors. Five of these have given highly reliable service in remote temperate regions, as well as the Arctic and Antarctic, providing base power and heat. In these conditions they are far more economical than fossil fuel plants: the existing installations are in the 1 to 1.5 megawatts range, they weigh about 400 tons and have been transported by air in 30 packages. They could be most valuable in providing power for desalination projects in inaccessible coastal and inland areas where the conversion of sea or brackish water could be the only available source.

7. PEACEFUL DETONATIONS

The explosion of the first U.S. thermonuclear bomb in 1952 very soon opened up the possibility of peaceful nuclear detonations, capable of massive constructive benefits and without the dangers of radioactive fall-out of the earlier fission explosives. The deflection of water courses and earth moving became possible on a geographical scale: the U.S. Atomic Energy Commission has now revealed the possibilities of 'digging sea level canals between oceans, stripping overburdens from deep mineral deposits, cutting highway and railway passes through mountains, creating harbours and lakes where none existed before'(12).

Research carried out by the U.S. Atomic Energy Commission at the Lawrence Radiation Laboratory in California has led to an understanding of the possibilities of predictable crater and canal excavations which are now feasible in conditions of safety.

At the 17-Nation Disarmament Conference the United States proposed in 1966 that the nuclear powers should provide a worldwide earth moving service at reasonable cost, so that other powers should not be able to develop nuclear weapons under the guise of doing this research for peaceful purposes. In February 1967 President Johnson repeated the U.S. offer to make available to all signatories of the Non-Proliferation Treaty 'nuclear explosive services for peaceful purposes'.

Africa south of the Sahara is smooth in coastline and poor in natural harbours. Indeed Africa as a whole is the second largest continent; it has an area of 11 million square miles, but a coastline

of only 19,000 miles; this is less than Europe, which is a third of the size[13]. African rivers offer great possibilities for diversion, power generation and irrigation, and, perhaps more immediately important, its water supply problems could be eased by new methods of surface and underground water storage.

8. GROUND WATER TRACING

The remarkable performance of radioactive isotopes has already been noticed in the field of fertiliser research. These same qualities can be used in tracing the wider ranging movements of ground water. Hitherto, soluble dyes have been used, but they are readily leached away by the soil. Soluble radioactive tracers of Iodine^{131} are less easily removed and are detectable over short distances from the surface and 'instantaneous quantitative measurements are possible in situ'[14]. These soluble tracers are particularly suitable for porous strata, where water moves in open passages. Such strata exist widely throughout Africa.

It is possible also to use tritium which is an isotope of hydrogen and forms a constituent part of the water itself. Although this tracer is not leached away and can be used in the least porous soils, there are technical difficulties with it and only a limited number of samples can be assayed per day[15].

These two methods offer possibilities of water tracing, particularly in arid zones, where little is known of underground water movements and where it would be of great value to discover the routes followed by water from river spates between the points at which they go underground and their ultimate areas of storage. Although the arid zones are not highly populated, their people are often nomadic; they could not be absorbed elsewhere; and the first requirement for improving their conditions is to provide reliable water supplies.

9. THE BASIC NEEDS OF EMERGENT AFRICA

By Western standards, practically the whole vast continent of Africa is under-developed. This is particularly so throughout the area which lies between the Sahara and the Republic of South Africa, an area which includes all the most newly independent African countries

(Map I). Apart from Ethiopia and Liberia they have all achieved independence since 1957.

The rapid transfer of power in the newly independent countries encouraged speedier advances in political, than in economic, spheres: in many instances this led to disillusionment and frustration. Differing systems of law and government and the differing languages of the former metropolitan powers have made inter-territorial groupings difficult and led to the perpetuation of the unrealistic boundaries of the colonial era; many of these still cut across tribal areas. Federal systems devised by colonial powers tended to be abandoned and new amalgamations along tribal lines are exceptional. Orthodox Western democratic forms have often given way to single party governments, partly because the multi-party system was not acceptable and partly because the new emergent countries had insufficient resources in political leadership to sustain a fully effective opposition: single party regimes have, in many countries, been replaced by military regimes.

These changes have produced a varying pattern of unrest and political disintegration. The most extreme example is the Congo Republic; a very large area in the centre of the continent still, after seven years of chaos, lacking an effective government. More recently, there are the precarious conditions in Zambia and Malawi during the continuing Rhodesia crisis, the critical state of the Nigerian Federation and, finally, the increasing tensions in the Horn of Africa, the largest homogeneous area in the continent.

These and other centres of disturbance have set up tides of migration across the boundaries of the new countries: across the borders of the Southern Sudan, Ethiopia and Uganda; the Congo and Angola; Zambia, Tanzania and Mozambique. In some instances large numbers of a tribe have been forced to return to an overcrowded homeland, as with the Ibos in Nigeria: others such as the Southern Sudanese have moved into Uganda and Ethiopia for temporary refuge until conditions will allow them to return: yet others have left zones that have been shattered by extreme violence and are seeking permanent resettlement. Resettlement itself creates difficult problems of land tenure in the receiving country and often involves changes of occupation and the provision of basic services in new areas.

All of these political influences have been at work in conditions of generally increasing population pressure on the land, and over-stocking; food shortages and precarious water supplies. It is in the improvement of food and water supplies that nuclear science might make a fundamental and significant contribution.

A very recent and important development in this connection is the announcement[16] that the IAEA is negotiating an agreement with the Organisation of African Unity (O.A.U.) to collaborate in matters of mutual interest. This Organisation, which has its headquarters in Addis Ababa, has a wide membership of independent African States, it has created a community of interest among its members. Its chief objectives are to promote African unity; to co-ordinate political, economic and social policies; and to foster cultural, health, and scientific progress[17]. One of the first and most widely known aims of the Organisation has been to eliminate colonialism in Africa.

Of the 96 countries which belong to the IAEA, 21 are African and of these 14 are newly independent tropical countries which are, generally, in need of the forms of basic aid discussed. No doubt increasing collaboration between the two organisations will bring about a widening of African membership of the Agency and a steady encouragement to benefit from its resources.

But the O.A.U. is a political rather than governmental body; it has not entered into the practical field of administration; indeed, one of its objectives is 'the common defence of the independence of the member states'[18]. The Organisation might reject as neo-colonialism any concerted new efforts by western powers for scientific advancement. This provides an opportunity for the IAEA, formed under a United Nations Statute approved in 1956, since it could direct in an international manner the endeavours of all participating states, particularly western ones, to the benefit of the new countries.

The fragmented character of emergent Africa has not yet been modified by the development of inter-territorial collaboration between the new states, largely because of their differing colonial experiences, and because they have not yet achieved an economic margin for joint enterprises. There is however one notable exception to this: the East African Common Services Organisation (E.A.C.S.O.) which serves

Kenya, Uganda and Tanzania (Map II). This is an important survival from the East African High Commission which was set up by Great Britain in 1948, as the nucleus of a possible East African Federation. This Organisation is responsible for railways, roads and lake services, and ports; posts and telecommunications, civil aviation and meteorology; for the collection of income tax, customs and excise; for commercial and industrial co-ordination; for joint social and research services.

A Central Legislative Assembly of the Common Services Authority is responsible for passing legislation for the administration of the joint services. The budget in 1964/65 provided for the expenditure of £7½m[19].

There is thus a well defined area of collaboration between inter-territorial and national organisations. The EACSO administers the social, research, scientific and economic services of the region, while the separate governments remain responsible for all basic public services. The combined transport system is the most comprehensive in tropical Africa; it has 3700 miles of railway routes, 3500 miles of marine services on Lakes Victoria and Tanganyika, and 2400 miles of road services.

The two complementary systems of government cover an area of 682,000 sq. miles with a population of 26 million peoples: they provide a regional structure unique in Africa and potentially of extreme value as a means of securing the maximum benefit from large scale proposals such as the bulk disinfestation and storage of grain. The E.A.C.S.O. could well provide a convenient centre for research work in tropical Africa.

10. THE IMPROVEMENT OF FOOD PRODUCTION IN TROPICAL AFRICA

Africa south of the Sahara is a farming and ranching country. Recent political progress has taken place in the towns and expenditure tends to be centralised. But for generations African prosperity must be founded on its own agricultural production.

By far the most important food crops in Africa are maize and millet. Maize is grown where a mean annual rainfall of 800 mm

(Map III) is reasonably assured and warm temperatures can be relied upon. Where rainfall is less certain, the more hardy, indigenous millets are grown. One or other of these two staple foods is to be found throughout the savanna country and the wide grass and parkland areas in the interior of the continent; from the southern limits of the Sahara to the Transvaal and beyond. Most of this production is by subsistence peasant farming. Often crops are barely sufficient to last from one season to the next and the failure of rains can rapidly lead to serious shortage (Map IV). Some larger scale production is beginning in Kenya, Malawi and Rhodesia; and in the Republic of South Africa a European maize growing industry produces 4 million tons yearly.

Valuable new work could probably be done at every stage of this food grain production: the evolution of mutant lines which can stand up to erratic and inadequate rains; new strains which will produce increased yields; varieties which are disease resistant; the discovery of improved methods of fertiliser application. There is reason to hope that the results achieved with rice in Asia and the Far East could be repeated with maize and millet in tropical Africa. The introduction of improved seed requires field staff if it is to be a rapid process but, in this, African farmers are perhaps not as conservative as others. More propaganda might be needed to apply the results of research on fertilisers and pest control. The urgency of all this work can scarcely be overstated.

Finally, wherever substantial surpluses can be created, there are possibilities of the disinfestation of grain by irradiation. Carefully sited, one or two large plants could begin to provide food reserves in emergent African countries which could, for the first time, begin to remove the constant threats of widespread food shortage. Such large plants would need to be served by carefully developed transport systems; generally roads, but, where they are available, railways, river and lake transport. Large plants would need to be operated by Co-operatives, or, preferably, Marketing Boards. The following criteria for such installations were recently proposed in the Bulletin of the I.A.E.A.:

'Unfortunately the economics, as with all kinds of foodstuffs, are against irradiation methods in those parts of the world where they are most desperately needed. Grain irradiation plants are large, expensive installations and can only be operated economically if backed by a well-developed transport system, allowing a throughput of large quantities. In addition, a truly economical use of such a plant could probably only be achieved if more than one commodity were involved, assuming a continuous utilisation over most of the year'[20].

These strictly economic considerations need revision in the light of the F.A.O. forecasts of the increasing prosperity of the rich countries in comparison with the poor; they ignore the social and economic value of the removal of constant threats of food shortage. In areas which are only marginally sufficient in food grown on a subsistence farming basis a disproportionate effort is spent in finding supplementary supplies; too often the new crops are eaten green or immature and seed is not selected or kept. Thus, a bad season tends to influence the succeeding year which may have a good rainfall. Instability of this kind is enervating. If production, pest control and storage can remove these anxieties and create reserves, much energy could be released for the wider production of export commodities with an assured future demand, such as cocoa, coffee and ground nuts; some of these products would eventually help to exploit disinfestation plants. But it would be unrealistic to withold disinfestation facilities until full utilisation is possible.

Smaller, mobile, grain disinfestation plants should be brought into use to encourage individual and community grain storage schemes. Scientific storage of food grains on a local, and regional, basis could alone increase food supplies by over 30%. After an initial sub-economic period, the whole system could become self-supporting. Mobile disinfestation plants should be accompanied by the development of smaller scale storage suitable for use by farmers' societies and cooperatives: this could include the new inflatable type plastic buildings as well as orthodox concrete or corrugated iron containers. Investigations should also cover the possible development of bagged storage of grain using modern materials which prevent re-infestation by termites, after irradiation.

In parallel, there are the social problems of planning the operation of mobile plants so that good geographical coverage and reasonable economic utilisation are achieved.

Rural schemes of this kind would be feasible throughout the whole of the maize and millet producing areas: from Mali to Nigeria; from the Congo Republic to Kenya and Ethiopia; in Malawi, Zambia, Botswana and Swaziland.

Food crops which belong to the forest areas, cassava, yams, sweet potatoes and plantains could very probably benefit by fertiliser trials and the production of mutants. A later field of enquiry could cover the most promising cash crops.

Altogether, these measures could help to raise the precarious subsistence farming of the region to a system of balanced agriculture yielding exportable surpluses of food and other crops. But this could not be achieved without a readiness to take sensible risks. These results would be further improved by inter-territorial co-operation; this possibility will be discussed later.

The problems of meat production are different. Cattle, sheep and goats are widely available throughout Africa but meat is regarded as a rare luxury. Cattle, and to some extent sheep and goats, are kept as symbols of prosperity and status: protein needs are partially met from vegetable sources. The most optimistic U.N. forecast is that 'there could well be no reduction in protein malnutrition over the next 20 years'. As income levels rise, meat will replace the cheap vegetable proteins, which will be neglected[21]. Perhaps the greatest single benefit to livestock production would be the provision of reliable water supplies.

Possibly, in addition, the sterile male technique could steadily eliminate the tse-tse fly and release new areas for grazing. These possibilities are now being explored in Uganda: they are needed throughout the very large tse-tse areas stretching from Nigeria to Southern Tanzania (Map V). For many years tse-tse control has been confined to selective clearing and the treatment of infection. This has disadvantages; clearing can cause erosion and is not lasting, and changes in settlement and cultivation can renew contacts between infested bush areas and the local people. The use of the sterile

male techniques, combined with clearing, might make it possible to eliminate the fly from the whole areas and so change their ecology. This possibility has been known for ten years but it has not yet been considered in relation to the very wide areas affected by the fly, perhaps largely because this time has been dominated by political change.

11. IMPROVEMENT OF WATER SUPPLIES

Throughout most of tropical Africa there are water problems. The most acute are in the arid countries of Somalia and Botswana where there are large areas without permanent water and where rainfall is irregular and liable to be concentrated into heavy storms; these collect into spates in the dry river beds and are rapidly lost underground. In these areas, with less than 250 mm of rain in the average year, there are three significant possibilities: desalination, the tracing of underground water, and earth moving to construct irrigation dams and canals.

The desalination of sea water is possible along Somalia's 1800 miles of coastline where there are areas with a suitable depth and quality of soil. As already noticed, desalination is a well established process and there could be no doubt about the possibility of securing fresh water supplies for use in coastal areas in Somalia. Salt water could be extracted and treated by the use of orthodox power sources; it would possibly be more economical, in remoter parts of the country, to use nuclear power. For the first time in history the transformation of desert into productive land is within the grasp of man: the Somali regions in East Africa have a strong claim to a pilot scheme to study this possibility, including the social problems involved in introducing an element of productive settlement into the nomadic life of the region. There are great difficulties in such an experiment: at the same time, the exceptional pressure on grazing and the meagre natural resources of Somalia make it worthy of trial.

Seldom are water problems absent in the wide savanna and parkland areas in the interior of the continent. In these regions, as in the arid zones, the first need is to provide permanent drinking water supplies. It is possible in the more remote areas to make use of the

powers of nuclear detonations to provide surface or underground water storage. Underground storage has particular attractions as it disposes of the problem of evaporation. The Project Gnome detonation organised by the U.S. Atomic Energy Commission in 1961 produced an underground cavity with an estimated capacity of 960,000 cu.ft. This was in effect a standing hemispherical reservoir capable of storing over 6 million gallons of storm water: the internal dimensions were 75 ft in height and up to 196 ft across[22], achieved by a relatively small explosion of 3.1 kilotons.

Besides the possible creation of underground reservoirs, nuclear detonations could be used to connect river spates with existing, or potential, underground water resources[23] so that this water is not lost. There is also a case for the study of ground water movements in arid zones, using radioactive tracing methods.

Finally, there are the possibilities of canal excavation and dam building, partly or wholly by nuclear detonations. A particularly promising scheme has been surveyed in Botswana. Here, in the extreme north west of the territory, the Okavango river enters from Angola with a steady flow of water of 8,600 cu.ft per sec. After 90 miles it divides to form an inland swamp of about 10,000 square miles which is covered with papyrus and infested with tse-tse fly[24]. This area is unproductive and these very considerable water resources are wasted, in a region which is one of the most arid in the continent.

The proposed scheme is to divert the Okavango river into two dams and a 140 mile canal which would circumvent the swamp area, to the south. This would enable at least part of the swamp to be drained and the water used to irrigate suitable land elsewhere alongside the canal; and, perhaps at a later stage, parts of the original swamp could be brought under productive irrigation. The Mission concluded that the scheme would involve further surveys, soil classification and hydrological studies and seemed to be a very suitable subject for assistance from the U.N. Special Fund[25].

This very imaginative scheme could possibly benefit from two contributions provided by nuclear science: some at least of the earth moving might be done by nuclear detonations, using the experience gained in the Plowshare project: also the tse-tse fly might be

eliminated from a compact, heavily infested, area by the sterile male technique. Although the project is in a very lightly populated area it could nevertheless be effectively developed to the benefit of one of the most impoverished countries in the continent. The Economic Mission recorded in 1960 that 18,400[26] adult African males (24.5% of the total adult male population) were recruited each year to work in the mines in the Republic of South Africa. It would be very beneficial, economically and socially, if productive rural employment could be found within the territory.

12. A PROGRAMME FOR THE APPLICATION OF SOME OF THE KNOWN RESOURCES OF NUCLEAR SCIENCE IN TROPICAL AFRICA

Suggestions for the introduction of the benefits of nuclear science into tropical Africa must be hypothetical. They are summarised here, sometimes in specific terms, to illustrate the very considerable, and mainly new, practical benefits which are becoming available to emergent tropical countries as the result of nuclear research. They are divided into three parts.

I FOOD PRODUCTION

(i) Seed improvement of maize, and, later millets

A survey is needed of food grain producing areas in West, East and Central Africa so that co-ordinated trials can be arranged of radiation induced mutants of improved African and South American maize strains in comparison with known local varieties. There is a need for the collection of data for similar work with millet.

(ii) The improved use of fertilisers to increase food grain production

Co-ordinated investigations are needed of fertiliser use, employing isotope-labelled materials, applied by varying methods and timing. Parallel investigations with both maize and millet should be possible.

(iii) The improved production of tuber, root and tree crops

In the longer term, seed improvement and fertiliser trials are needed to improve other basic food crops such as cassava, yams and plantains.

(iv) The elimination of the tse-tse fly in selected areas by the sterile male technique

Pilot schemes are needed in areas selected in relation to the local conditions and the local fly species. These should be planned to expand into programmes for the elimination of the fly, on an inter-territorial basis.

II. FOOD PRESERVATION

(i) Regional schemes

Studies should be undertaken of the problems of large scale disinfestation by irradiation methods where surplus maize production is beginning to be available and where communication systems are reasonably developed; the development of large scale (2000 tons and larger) pest-free storage, protected from re-infestation e.g. in Kenya, Nigeria and Malawi.

(ii) Rural schemes

A study should be made of smaller scale grain disinfestation by the use of mobile irradiation plants, with throughputs of about 1 ton per hour. The associated development of smaller scale storage methods, for widespread application, is also very important.

III. WATER SUPPLIES

(i) Desalination

A survey should be made of the possibilities of desalination in Somalia using well tried designs of plant, and possibly, in this remote area, using nuclear power. An initial small scale pilot project could establish the possibilities of intensive production by modern irrigation methods, and of inducing a traditionally nomadic people to adopt a degree of settlement necessary to benefit from it.

(ii) Water conservation and storage

Ground water tracing techniques need to be widely used to extend hydrographic knowledge, in particular about the underground movements which are the sequel of river spates; an examination should be undertaken of the possible use of nuclear detonations

for the creation of underground reservoirs for connection with known water resources, or with artificially impounded water from surface spates.

(iii) Canal and dam construction for irrigation

Entirely new methods should be developed for earth moving by nuclear detonations, supplemented by orthodox explosives so that large scale schemes such as that outlined, in Botswana, could be effectively and economically developed.

13. CONCLUSION

Tropical Africa could benefit greatly from the recent developments of nuclear science. For instance, national plans could immediately include large and small scale projects for food grain disinfestation by irradiation: the design work of a large installation has been completed. The greater part of the work on a prototype small mobile irradiation unit has been done and promising new systems of storage are now being tested under tropical conditions; orthodox well tried ones already exist.

Desalination cannot yet provide irrigation water at economic rates, but sub-economic pilot schemes are justified in the interval to tackle the very complex social and agricultural problems involved: small nuclear reactors might be used in remote areas. Ground water tracing techniques could be more widely used and experience gained from underground detonations in the United States could be put to use in Africa.

Other possibilities need coordinated, widespread and mainly new investigations, particularly those connected with seed improvement, the improved use of fertilisers, pest control and the elimination of the tse-tse fly. This is research work which should normally be undertaken by local institutions, university departments and government research centres. But a comprehensive programme on a scale which compares with the rice programme in Asia would almost certainly exceed local resources. These are hard, exacting tasks which require international cooperation.

These varied applications are not likely to be adopted in any systematic or widespread manner in an area so divided and poor as

tropical Africa. They could best be promoted by an international body, such as the IAEA, which could set up a research centre for tropical Africa similar to the Middle Eastern Regional Centre for Arab Countries, in Cairo. Such a centre might be most suitably sited near to the headquarters of the East African Common Services Authority: its establishment in Eastern Africa would make possible the most rapid advances in the fields of basic need. Later, a research centre would doubtless promote valuable medical and industrial applications which are beyond the scope of this paper.

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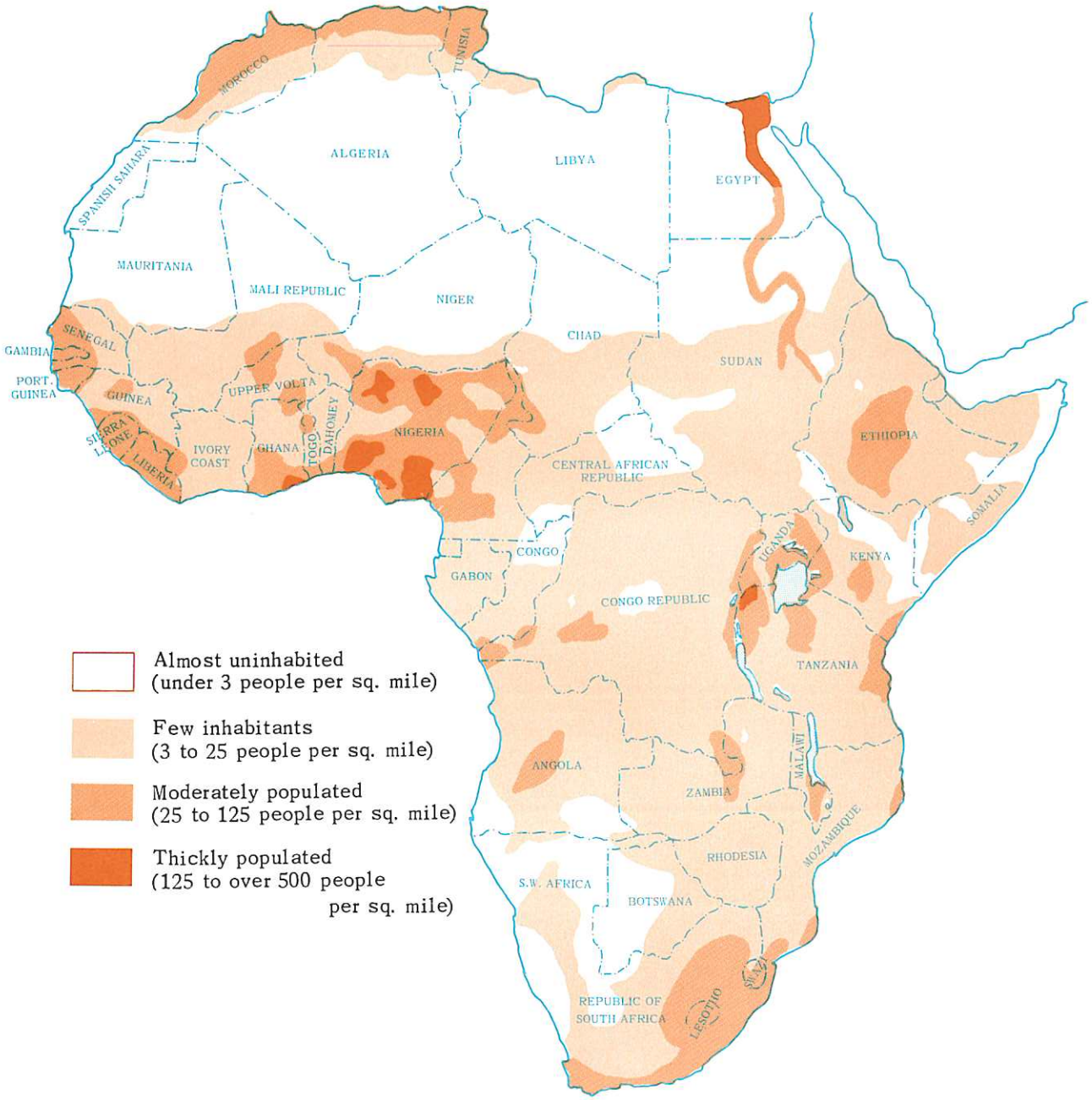
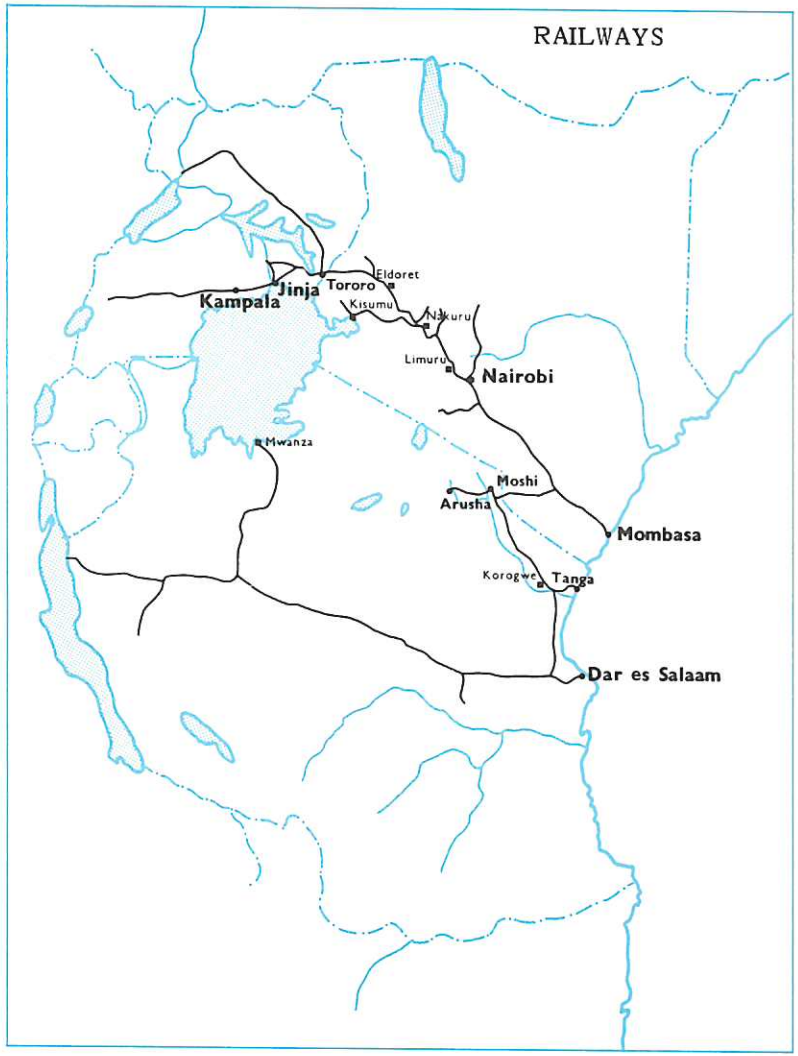
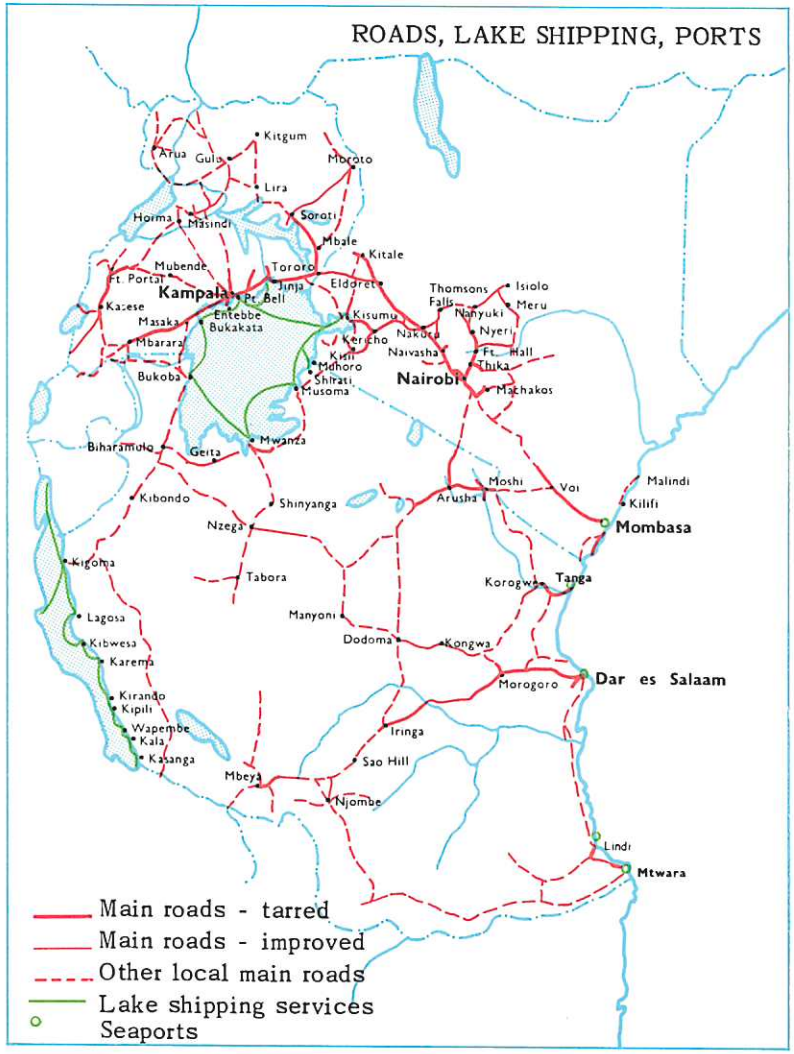
The maps are based on the "Oxford Regional Economic Atlas for Africa" and the "Oxford Atlas for East Africa".

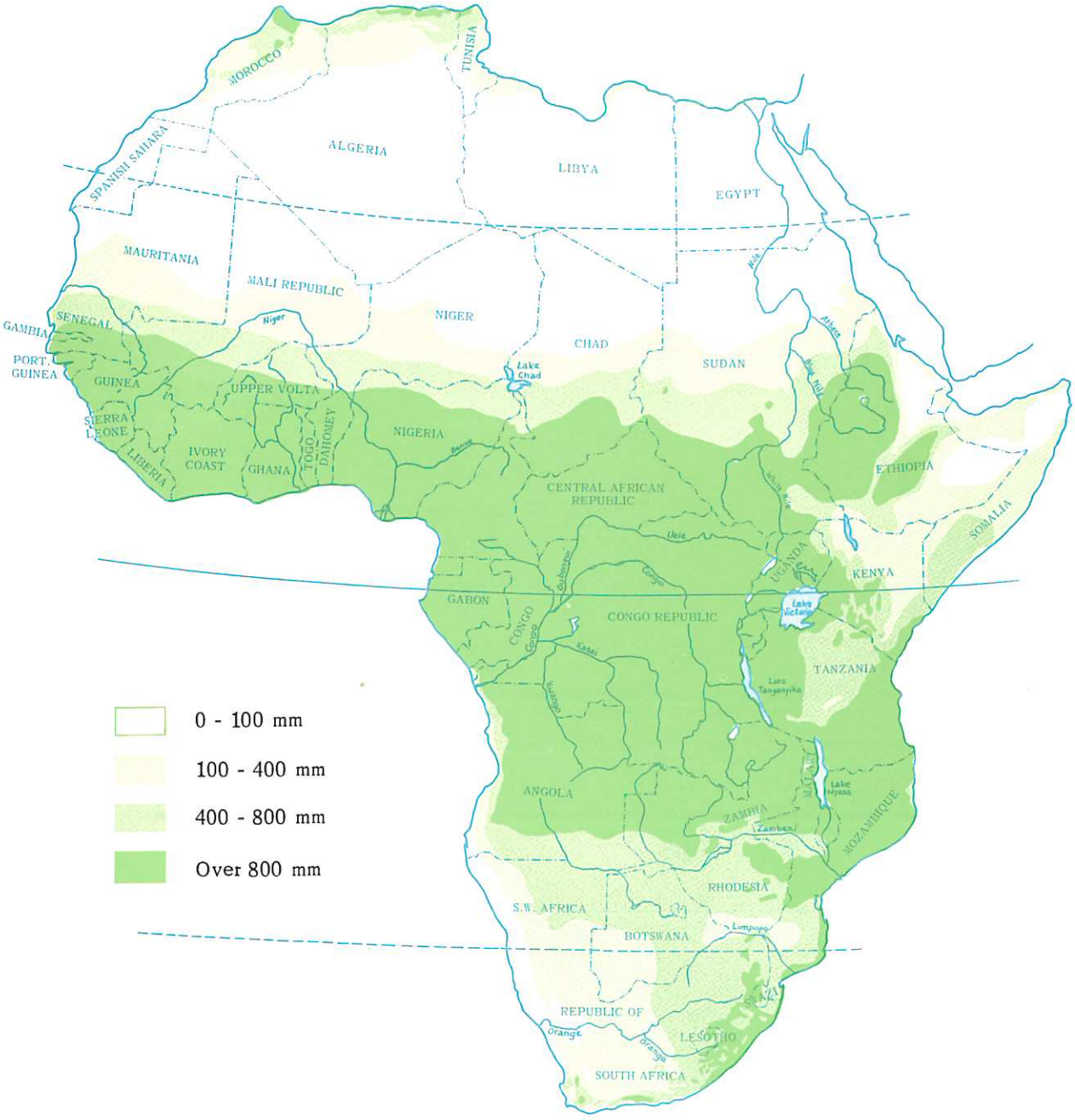


Map I Population

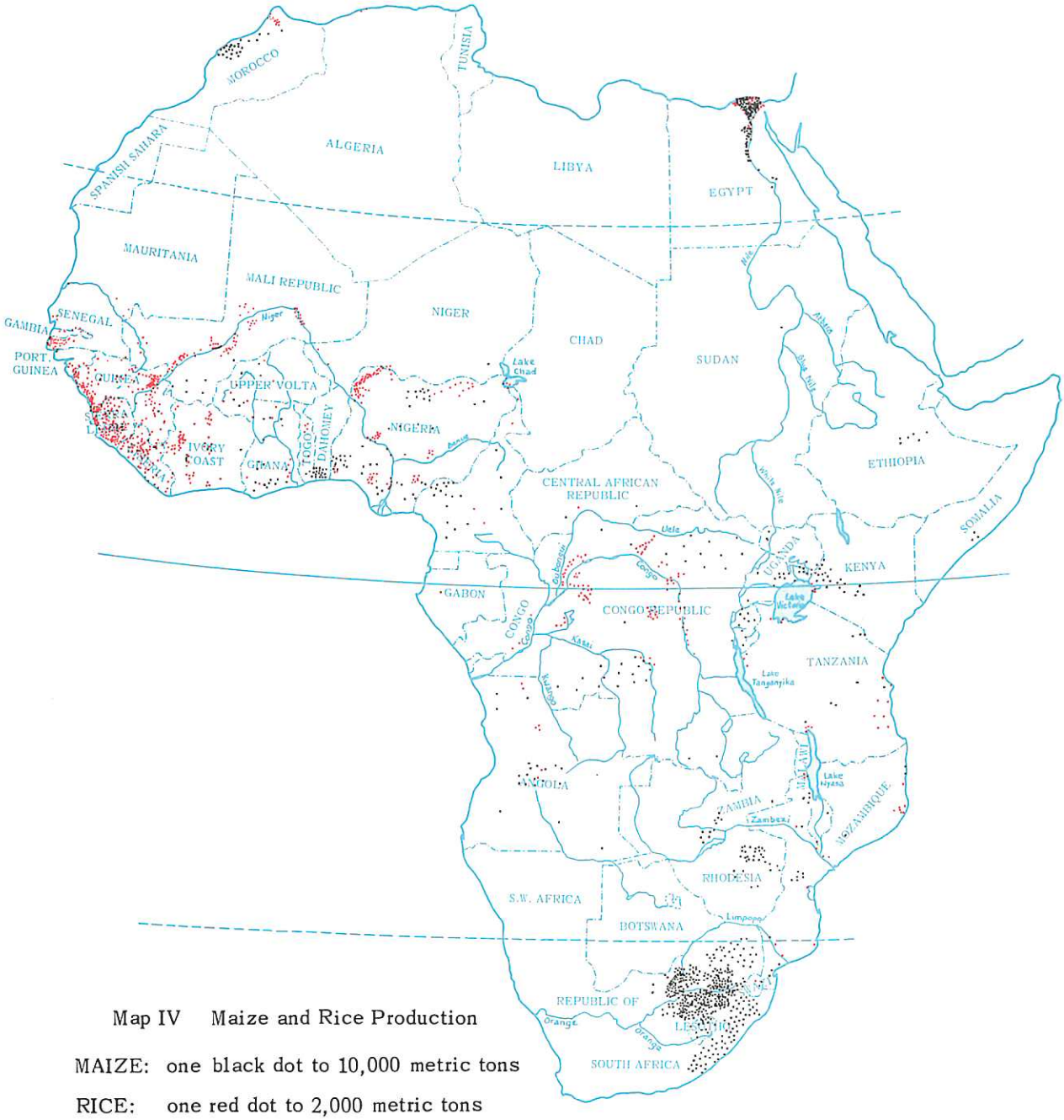




Map II East African Communications



Map III Mean Annual Rainfall



Map IV Maize and Rice Production

MAIZE: one black dot to 10,000 metric tons

RICE: one red dot to 2,000 metric tons

Note: Very large quantities of maize are grown as a subsistence crop and not included in any statistics; similarly millets are grown for family and local consumption in areas where rainfall is insufficient for maize, exportable surpluses are very rare and statistics are lacking. Both of these crops are of wider significance than rice.

Map V Tsetse Fly Areas