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FOOD PROBLEMS

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The state of technology for food and agriculture in Africa

Report of the Secretary-General

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I. INTRODUCTION

1. In its resolution 37/245 of 21 December 1982, the General Assembly, inter alia, expressed grave concern about the drastic deterioration of the situation regarding food and agriculture in Africa. It further requested the Secretary-General to provide, within existing resources, the Economic Commission for Africa with the necessary resources to undertake, in consultation with relevant organizations, such as the Food and Agriculture Organization of the United Nations (FAO) and other organizations dealing with food and agriculture and intergovernmental institutions based in Africa, a survey of existing food and agriculture technology in Africa, taking into account the existing and ongoing studies thereon, and to make an assessment of the gap, detailing what exists and what is required to enable the countries in the region to begin to make an effective impact on the resolution of the food and agriculture problem and to submit a report, through the Economic and Social Council at its second regular session of 1983, to the General Assembly at its thirty-eighth session.

2. Pursuant to the above, the Economic Commission for Africa (ECA) undertook the preparation of the requested survey. However, in view of the time constraint, it was not possible to survey such a broad topic for the whole region. Relevant United Nations organizations and other international organizations (29 in all) were requested to make contributions relating to their field of specialization so as to provide a general overview of the state of technology in Africa. In addition, a questionnaire was sent to most countries in the region and a limited number of field visits were made. Unfortunately, responses to the questionnaire have not as yet been sufficient to provide an adequate basis for analysis.

3. Accordingly, the report which follows is based primarily on the Interagency Consultation on Food and Agriculture Technology in Africa and the International Year for the Mobilization of the Required Financial and Technical Resources, held in Addis Ababa from 23 to 27 May 1983. A lead paper was prepared by ECA and other papers submitted by the International Labour Organisation (ILO), FAO, ILCA, ICIPE and ILRAD, the Organization of African Unity (OAU), the International Livestock Centre for Africa (ILCA), the International Centre for Insect Physiology Ecology (ICIPE) and the International Laboratory for Research on Animal Diseases (ILRAD). FAO in particular made a very substantial contribution and the papers and the statements of the participating organizations provide the essential inputs for this report. The aim is not to have an exhaustive stock-taking of existing technology but to provide a broad overview which emphasizes the most salient aspects.

II. SUMMARY AND CONCLUSIONS

4. Food and agricultural production in Africa has continued to lag behind population growth. For the whole decade of the 1970s, when African population was expanding at an average annual rate of about 2.8 per cent, total food production in the region rose by about 1.5 per cent only. On a per capita basis, the picture is more disappointing and alarming with an average annual growth rate of -0.4 per cent in 1980-1981 and -1.2 per cent during 1970-1980. Between 1970 and 1980 the agricultural sector in Africa grew by 1.3 per cent only against a 2.2 per cent for

the least developed countries. Food self-sufficiency ratio in Africa has dropped from 98 per cent in the 1960s to about 86 per cent in 1980, meaning a decline of about 12 per cent in the home grown food per person.

5. While Africa has continued to witness a worsening food situation, other regions of the world succeeded in achieving some notable progress particularly in increasing the production of a number of major crops. Africa still has the lowest average yield for almost all major crops. For example, the average world output of cereals is estimated at 2,000 kilograms per hectare, compared to 1,090 kg/ha in Africa. For roots and tubers, the world output is over 11 tons against 7 tons/ha in Africa. As regards fertilizer inputs, Africa consumes 3 kg/ha of agricultural land compared to 8 kg for Latin America and 26 kg for Asia.

6. Food losses and waste are remarkably high particularly post-harvest losses which are estimated on average to be 10 per cent for cereals, 20 to 30 per cent for roots and tubers and much higher proportion for fruits, vegetables, fish and livestock products and other perishables.

7. The precarious food situation in Africa continues to be the cause of concern particularly in view of its nefarious effects on the economies of the region and the welfare of its population. While Africa's food production declined during the last 10 years, the food demand kept rising with population and income increases. The widening food gap has not only eroded the long cherished objective of the region for self-reliance and self-sufficiency in food, but also has caused suffering and hardship by subjecting millions of people of the region to malnutrition and outright hunger. Moreover, it has halted development efforts of many African countries by forcing them to resort to imports to cover the deficit, hence draining their badly needed foreign exchange for development. The continuity of this situation is severely undermining the very social fabric and political independence of the countries of the region.

8. In spite of different levels and rates achieved by African countries in their economic development, the most obvious common characteristic of most African economies, is their heavy dependence on agriculture where the majority of farmers are still producing at subsistence level. In 1981, agriculture in Africa made up to 24 per cent of the GDP (at factor cost) and provided occupation to 67.7 per cent of the active population. The importance of agriculture to the economies of African countries remains paramount, particularly in many non-oil producing countries where the contribution of agriculture to GDP and employment remains exceptionally high. Subsistence farming predominates in agriculture. It is marked by intensive human labour, inefficient hand tools, poor management and lack of application of suitable technological innovations.

9. After many years of neglect of the agricultural sector, many African leaders have publicly acknowledged that the greatest challenge now facing African countries is that of rural development. This was in recognition of the fact that increased agricultural productivity is an essential prelude to industrial growth, and that the development of agriculture and industry is complementary in the long run. The attainment of industrialization depends, to a significant extent, on a high rate of growth of agriculture. The two most direct linkages are manufacture of

agricultural inputs and implements and the processing of agricultural output. Hence, long-term objectives of growth, alleviation of poverty and the structural transformation of African economies will depend on increasing the production of their rural economies with appropriate policies and resources directed toward small-holder agriculture. Presently, rural areas have low productivity in terms of yields and agricultural labour output and therefore are generating little surplus for further investment. The disappointing performance in agriculture and food production must be judged against the fact that Africa has, as a whole, a very favourable man/land ratio of production increase. Africa's potential arable land is estimated at about 1.7 hectares for each person while only about 0.55 hectares per person is being utilized. The factors responsible for the slow growth of agricultural sector in Africa are several and cumulative. Some of the major causes of the food and agricultural crisis can be attributed in addition to the exogenous problems of droughts and desertification to low productivity rates per unit of land, inadequate investments, poor incentives to farmers through distorted pricing systems, fragmentation and sub-division of holdings as in the case of some countries, inadequate land tenure systems, limited agricultural research, rural-urban migration and institutional constraints.

10. Inadequate capital and agricultural finance facilities together with lack of technical skills and know-how complete the vicious circle for the poor state of agricultural performance. It is generally recognized that increase in labour productivity in agriculture is a necessary condition for economic development and that application and adoption of suitable technology is crucial for increase in labour output.

11. The importance of suitable and appropriate technology for the development of agriculture is very well recognized by African Governments. This awareness has been reflected in the Lagos Plan of Action for the Implementation of the Monrovia Strategy for the Economic Development of Africa (A/S-11/14, annex I), which stressed the fact that inappropriate research and lack of improvement of available techniques including inadequate spread of improved technology is one of the major cause of the alarming deterioration of productivity in the food and agricultural sector. To this end, African Governments have embarked upon development programmes which aim at giving priority to the food and agricultural sector particularly food crops, through promotion of investment, research and other infrastructural facilities.

12. It is however clear that the success of African countries in injecting and promoting appropriate and suitable technology in rural areas will depend upon their success in developing adequate infrastructure facilities such as transportation, storage, handling and processing and distribution systems etc., which are necessary software components of technology.

13. Africa still lags far behind other regions of the world in the adoption and development of suitable technology for agriculture. The consequences have been that African countries have not been able to fully make use of and benefit from the vast natural resources to increase productivity of the agricultural sector which is expected to serve as a base for industrialization. So far, little attention has been given by planners and policy makers to the role science and technology should

play in the development of agriculture in Africa. Even in the few cases in which the promotion of science and technology did figure in the development objectives of African countries, excessive reliance was placed by policy makers and planners on external sources for modern factors of inputs implementation, management and development. This was so mainly because most African countries have yet to formulate adequate and consistent policies and programmes for the development and utilization of technology including transfer of technology.

14. The hardware aspect of technology such as machinery, fertilizers, seeds etc., must be supported, for its effectiveness on production, by the software components in which massive investments will be required. Equally important in the development and application of suitable technology in Africa is the creation of conducive environment that encourages rural people to effectively use their resources, skills and inventiveness and increase their technological competence in order to enable them to fully participate in and contribute to the process of change. This implies that any transfer of technology must be made with an eye not only to its suitability and appropriateness in bringing rapid progress but also, its catalytic impact on the development of domestic technological skills and capacity. It requires African Governments to adopt consistent and well-conceived plans and policies and appropriate institutions, chief among which is research and development (R&D). Other factors including social, political and economic climate must also be taken into consideration. As far as the application of suitable and appropriate technology in food and agriculture is concerned, all African countries face almost similar sets of factors and constraints regardless of differences in their respective national policies and development ideology.

15. It is clear that there is still very substantial scope for the wider application of existing technology in Africa, both improved technologies and some elements of traditional technologies, provided a number of non-technological constraints can be dealt with. Unfortunately, the available information provides only a qualitative picture of the extent to which the existing technologies are already applied, although there is no doubt that this is extremely small in most cases.

16. The diffusion of existing technologies could also be accelerated by more active technological transfer between African countries. This includes the sharing not only of research results but also of information on traditional farming systems and post-harvest technologies. Close co-operation between countries is also essential for the use of modern technology for the control of plant and animal diseases.

17. International community and donor agencies should also adopt appropriate policies with regard to the above concern and adequately shift attention from mere importation of mechanical technology and instead support the development of R&D capacity in Africa and assist in the design and adaptation of technology appropriate for Africa's factor endowment (factor-supply conditions) and for various ecological zones.

18. Efforts to increase knowledge on how to acquire and utilize technology should aim at setting up appropriate national institutional arrangements for science and technology policy, planning and development which by their nature should be

multidisciplinary, dealing with all economic, sociological and technological problems and other aspects of development, adaptation, production and utilization of technology at the national level. Such institutions should also advise on the formulation of policies, strategies and their implementation; co-ordinate imported and indigenous technology involving the development of local capability to unpackage imported technology and ultimately help to build scientific and technological community in each African country.

19. Agricultural co-operative organizations can often facilitate the use of improved technologies. Apart from marketing and input supply, they make possible the joint use of farm machinery and post-harvest equipment for such purposes as threshing, drying and milling. In most African countries, however, the development of co-operatives has been very weak so far.

20. The major challenge in the development and promotion of science and technology for agriculture in Africa, is to evolve and propagate more efficient technologies that are fully adapted to the socio-cultural, economic and ecological environment in which African farmers and fishermen operate. The tasks entailed have to do especially with research, collection and dissemination of information, experimentation, training, extension services and infrastructural development.

21. The choice is either that of technology transfer or technology development at home or a combination of both, which appears more practical. Whichever choice is made, actions are required between technology and social and economic development. Imported technology should as far as possible be restricted to areas of greatest need and should be the basis for improvement of local technology, and should not inhibit local initiative capability and development effort. It must endeavour to employ local manpower and should be cost-effective by using efficient factor proportions and technical factor substitutability with respect to scarce foreign exchange resources.

22. Higher government priority for food and agriculture, in particular in public investment programmes, is one of the most important general requirements for the faster application of technological improvements. Larger public investment is required in many different fields, especially the various aspects of infrastructure and government services for farmers discussed below. A more specific area where large capital investments are needed to utilize the available technology is the control of human sleeping sickness and animal trypanosomiasis, and the development of the cleared areas for settlement and intensive agriculture. Another, which could bring quite quick results, is the rehabilitation and improvement of existing irrigation and drainage schemes, so that their technological potential (as well as the heavy investment already made in them) could be more fully realized.

23. Closely allied to higher government authority is the question of adequate incentives, which are indispensable if farmers (and particularly small farmers) are to undertake the extra costs and risks involved in using modern purchased inputs and carrying out other improvements they have not tried before. There is a difficult dilemma between higher prices for farmers and prices that are low enough for poor consumers, but the gap has to be bridged in some way or another, for instance through food for work and food distribution and supplementary feeding

schemes for vulnerable groups. The incentives for using improved technology to increase the production of local food crops like maize, millet and sorghum, and roots and tubers would be enhanced if less encouragement were given to the consumption of imported wheat, the production of which is unlikely ever to be economic in most of tropical Africa.

24. Most of the limited technological progress has been concentrated on export crops, although even for these crops yields are usually less than elsewhere. There are as yet few viable technological packages for Africa's basic food crops that are ready for farm level application, especially in the areas of less favourable climate.

25. In the export sector, the incentives to use improved technologies for both production and processing depend heavily on international commodity agreements and other developments in world trade arrangements that would bring higher and more stable export prices and larger markets, as well as less discrimination against products processed in developing countries. At the same time, however, price policies of the monopoly export marketing boards and also export taxation policies require revision in many countries to provide better incentives for producers.

26. Especially for small producers, access to improved technology is as important as the price incentives required for them to use it. While many improved crop varieties have been developed, they are used to only a limited extent, partly because seed is not available in the right quantity and quality. Co-ordinated seed programmes, covering the production, collection, processing and distribution of good quality seed, are essential. Efficient, low-cost services are required for the supply of other inputs such as fertilizers. Subsidies may initially be necessary to encourage the use of such inputs. Credit facilities have to be made much more widely available, particularly for small farmers.

27. Expanded and more effective extension services, closely involved with applied research and demonstration plots on farmers' fields, are a key element. They would make more impact if they specifically included women in their target groups, in view of their great importance in food production as well as processing in most African farming systems. Extension services will increasingly have to adopt innovative methods of research. Indeed the shortage of trained personnel for extension and other services is one of the greatest barriers to the faster spread of improved technologies in Africa. Massive programmes of practically-oriented middle-level training are urgently required. Plant protection, machinery repair and maintenance (including fishing boat engines), the operation of modern storage and processing facilities (such as grain mills, slaughterhouses, sawmills), and forestry work with local communities are only a few examples of the many areas where the lack of trained personnel is a major obstacle.

28. The list of other services that require improvement is almost endless, and only a few can be mentioned here. Marketing has a crucial role in keeping producers in touch with production possibilities that are in line with consumer demand, and also in easing, by greater efficiency and lower costs, the dilemma between remunerative farm prices and low consumer prices. Improvements in transport, particularly farm access roads, are essential for farmers in remote

areas (of which there are many in Africa) to have the opportunity to produce for the market and thus profitably use improved technologies. Better veterinary and animal husbandry services are required, not only for the control of major diseases but also for the difficult task of introducing an animal component (for draught power as well as meat, milk and manure) into farming systems where it is not traditional.

29. Farming systems research involves the integration and concentration of all scientific disciplines on the common constraining problem sets of farmers. The removal of these constraints should enhance the farmer's abilities to substantially raise agricultural productivity and improve the maintenance and fertility of land resources over time. As the term implies, farming systems research should assess the impact of any innovations or changes in the development system - on the various sizes and types of holdings under the research command areas, regardless of the type of change, i.e., technical institutional or policy. Farming systems research is therefore much broader than traditional farm management, cropping or livestock systems research.

30. Plant breeding must remain a major part of the overall research thrust towards new and more appropriate technologies. Many more improved varieties are required that will give higher, and above all more stable yields in the very diverse and often difficult crop production environments of Africa, and that do not require heavy expenditures on other purchased inputs by small farmers. They have to be adapted to poor soils (including a number of specific micronutrient deficiencies and soil toxicities), uncertain water régimes, mixed cropping, a formidable array of pests and diseases, and (for the time being at least) low levels of management. Breeding of durable resistance to pests and diseases is of particular importance. Much more plant breeding work is required on such important African crops as millet and sorghum, the various types of rainfed rice, food legumes, roots and tubers, and leaf vegetables, which have tended to be neglected until recently. Profiles are already available of the desirable characteristics to be sought in most cases. In the longer run, the current research on the transfer of nitrogen-fixing properties to staple cereals, roots and tubers could prove particularly beneficial in Africa.

31. Land tenure systems are in general less of an obstacle to technological improvement in Africa than in the rest of the developing world. There are problems in some areas, however, including nomadic grazing rights, insecure tenure that limits both the possibility of obtaining credit and the incentive to carry out improvement. The division and fragmentation of holdings on inheritance, and the frequently small, scattered and irregular plots inhibit the use of almost any mechanical equipment. Group ownership combined with individual use rights have certain advantages, but they also create disincentives to the application of improved technologies.

32. The role of the rural household as both production and consumption unit (and thus the importance of production to assure subsistence needs), the entire pattern of labour use for both farming and non-farming purposes, and interactions with the off-farm sector, including non-agricultural employment opportunities should be taken into consideration in recommending farming systems and appropriate technology. The search must be for small-scale but highly productive permanent

farming systems based on the close integration of crop, livestock and forestry production, and in some cases fish production as well. An essential starting-point is the much more thorough study of the traditional farming systems that have tended to be dismissed in the past as requiring to be replaced almost completely. The weed and pest and diseases control components require particularly careful study as part of the basis for modern methods of integrated control.

33. A basic aim must be the better use of soil and water resources, both to increase production in the shorter run and to conserve these resources for future generations. Much more needs to be known about the behaviour of tropical soils after the removal of their protective forest cover. Efficient systems are required for the recycling of organic wastes and their use to maintain soil fertility in combination with chemical fertilizers. Further detailed work is required on micronutrient deficiencies and soil toxicities. Applied research on Azolla and blue-green algae, making use of Asian experience, could greatly increase the productivity of African rice production. Water management systems suitable for small farmers still require development, as well as multiple cropping systems for irrigated areas.

34. The traditional approach to mechanization is usually to attempt to replace manual technology by a complete package of animal draught or tractor mechanization. It has recently been suggested that it could better be approached in Africa by looking at individual tasks to determine whether they could best be performed by hand, animal draught or tractor. With the high cost of tractor fuel, draught animal power is likely to prove increasingly attractive, and substantial work will be required on the breeding, training and maintenance of draught animals as well as on appropriate harnessing and implements. Other aspects of agricultural engineering where further research would be useful include the use of small tractors in African conditions, reduced tillage, and farm buildings. Work is urgently needed on rural energy systems, and particularly on the development of alternative renewable sources of energy, such as biogas and solar and wind energy for use in rural households, village communities and small industries.

35. More work is required on fodder crops and on techniques for preserving them as hay or silage as well as on the utilization by livestock of some specific crop residues and agro-industrial by-products. Work should be expanded on the improvement of African breeds of livestock, including trypano-tolerance and its inheritance. The development of immunization techniques against trypanosomiasis, as well as some other major livestock diseases, would represent a significant break-through. Further investigation would be useful in such areas as group livestock ranching, stratification systems, and game cropping and ranching.

36. In livestock priority should be given to eradication of diseases and improvement of animal feed. Special emphasis should be given to the control of tse-tse fly through the use of available technology introduction of trypanosomiasis cattle and development of areas cleared of tse-tse flies.

37. In fisheries the main priority is the better estimation of fish stocks (including the use of remote sensing), and the utilization of this information to devise technologies for their exploitation and management on a sustained basis. Further research is required on aquaculture, and on the possible development of

cross-bred varieties of fish for this purpose. Artisan fishery development require major emphasis with consideration to improvement of gears, equipment and supporting services of storage processing, transport and marketing.

38. Further improvement of post-harvest food technologies depends greatly on the development of the alternative renewable sources of energy referred to above. Cheaper equipment is still required for various aspects of food processing and preservation at the farm and village level. The design of a sufficiently inexpensive improved cooking stove that could be manufactured locally in vast numbers would be a major breakthrough, both in making more efficient use of the limited fuelwood supplies and in raising the living levels of poor rural households.

39. It is urgently necessary to start the regular monitoring of land use and forest cover on a continent-wide basis, using remote sensing to keep watch on the changing situation and focus attention on priority areas and issues related to the conservation, management and development of land and forest resources. Wood technology research is required to increase the number of species from mixed tropical forests that can be marketed. In view of the importance of wood as a source of energy, it is necessary to devise technologies of genetic improvement and tree culture based on the concepts of biomass production and use, and also specialized harvesting and processing methods.

40. The long list of requirements for improvements in the available food and agricultural technology indicates an enormous task for Africa's research system. It is clear that the research system must have a very precise set of priorities, aiming at the rapid solution of the most pressing problems. For the speedier transfer of research results to farmers, much greater emphasis on on-farm research is essential. While the international agricultural research centres will continue to play a key role and require substantial further expansion, the most immediate need is for the strengthening of national research organizations, in part so that they can take fuller and quicker advantage of the results obtained internationally. Co-ordination between international research institutions is highly called for. Co-ordination and co-operation among national African research institutions should be given top priority. It is particularly necessary to provide greater incentives for African agricultural scientists to stay on in their own countries and play their part in the eradication of hunger and malnutrition.

41. Manufacture of machinery, equipment and implements in Africa should be encouraged. Trade policies in many countries favour importation of implements at the expense of the development of local manufacturing industries. There is a need for revision of tax policies and trade regulations to suit development of new agricultural machinery industries. Substantial savings in human and other resources could be achieved through proper selection and standardization of equipment and specific raw materials to be used, adapted or manufactured in African countries or brought from outside. The proper selection of equipment to be imported or domestically produced would greatly reduce the need for subsequent adaptation. The need for integrated national programmes linking agriculture and industry is greatly felt in most African countries. Programmes to encourage artisan manufacturing of agricultural implements should figure prominently in plans for development of indigenous industries.

42. The role of government and private research organizations should be clearly determined. The creation and strengthening of local technological consultancy agencies and firms to service local industries should receive added impetus.

43. Self-reliance in the field of agricultural technology should be strongly established at the national level and complemented by co-operation among African countries in particular and LDCs in general: for example by importation and evaluation of better and improved implements developed in other African countries as well as from LDCs elsewhere; and in the context of TCDC, especially in the generation and transfer of suitable technologies, enlargement of intra-Third World trade in agricultural manufactures, creation of joint institutions exchange of information and building up of African controlled and funded channels for financial resources flows and movement towards an African monetary system. The building up of effective African technological capacity calls strongly for co-operation among African countries in all fields.

44. The above account suggests that there are formidable obstacles even to the further application of existing food and agricultural technology in Africa. The reduction of such obstacles is an integral part of the proposals of such studies as AFPLAN and Agriculture: Toward 2000, 1/ but massive efforts are clearly required if they are to be realized, and it must be accepted that they may prove to be too optimistic. Unless the obstacles can be quickly reduced, they will also hold up the application of the new and more appropriate technology that still has to be developed.

III. SURVEY OF EXISTING TECHNOLOGY

A. Overview

45. Variations exist among African countries in terms of climate, topography and levels of economic development. Nevertheless, the countries of the African region have many characteristics in common, particularly pertaining to the state of technology and are therefore facing similar problems in the development of agriculture. These problems vary in intensity and magnitude from one country to the other, but since they apply equally to all countries, they are discussed here in a general manner.

46. Technology within the agricultural context may be viewed as the systematic application of scientific and organized knowledge to practical tasks through a combination of assimilable and proven scientific skills, processes and practices, applied within the context of a certain culture which, when managed in co-ordinated and consistent manner, leads to increased and improved physical productivity of food and services. Two aspects of technology are distinguished here, hardware and the software. Hardware technology refers to agricultural machinery, tools, equipment, seeds, fertilizers and new products, while software indicates economic, social, political, cultural, institutional and administrative factors which are essential for the application and adoption of hardware technology. The state of technology is therefore discussed within this overall perspective.

47. The pattern emerging from the African countries shows the predominance of small-scale farming using traditional methods. Manual labour is the dominant energy source in all major agricultural activities, including production of food and non-food crops, livestock, forestry and fisheries. With the exception of utilization of improved seed varieties and animal breeds in certain areas and countries, use of modern inputs is in general limited to a small number of farmers and large-scale modern public and private enterprise. Animal power is used by a small percentage of farmers for specific operations, in particular for transportation and ploughing. However animal power is not commonly used by the majority of farmers for various reasons, chief among which are, cultural barriers, unsuitable climate, terrain disease infestations, presence of flies (particularly tse-tse), lack of knowledge, financial constraints, non-availability of animals and equipment at economic prices, and lack of incentives. However, in countries like Egypt where there has been a long tradition of animal traction, usage is more pronounced.

48. Mechanical power is gaining ground, though still being used by a small percentage of farmers for selected agricultural operations. It is overwhelmingly conspicuous in the large-scale public schemes such as Gezira in the Sudan. Mechanical power in use, as well as other improved inputs and techniques, tend to favour non-food crops, especially those destined for export. It could be safely generalized that the state of technology for the majority of farmers in Africa is poor. Manual labour prevails, and traditional methods which have been in use for centuries with little improvement, are still dominant. Scientific and accumulated knowledge has been applied systematically only to specific activities by a small, but growing, number of farmers. Selected aspects of existing technology on food and agriculture are discussed below in a general manner, with the understanding that minor variations exist among countries. Hardware technology is discussed first, followed by software.

B. Hardware technology

Human power

49. Human labour still provides a much larger share (84 per cent) of total farm power in Africa than in the rest of the developing world. Mechanical inputs in common use are largely confined to locally produced hand tools, such as the cutlass and axe for land clearing, hoes for tillage, dibbling sticks for planting, and sickles for harvesting. Hand tools for improved design and quality are manufactured in Africa, but have not yet been widely adopoted by small farmers. The same is true of hand operated implements and equipment for tillage, seeding, weeding, and the application of crop protection chemicals.

50. The requirement for efficient agriculture is not less than 0.5 horsepower per hectare. Human power could provide on the average around 0.1 hp, but in Africa human power averages only about 0.05 hp compared to 0.2 for Asia and 0.27 for Latin America. (The accuracy of these specified figures can be questioned; however they are given here as an indication of magnitudes.) The main reasons for this are: debilitating diseases, poor nutrition, lack of required farming knowledge, migration of most of the able and enterprising youth to cities and inadequate incentives to

agriculture. Raising the human power to 0.1 hp/ha is of crucial importance to Africa because of its favourable land/man ratio, with 639 million hectares of arable land potential, of which 35 per cent is in good rainfall areas, 10 per cent in low rainfall areas, 7 per cent naturally flooded and 45 per cent in problem areas, where rain falls for 270 growing days but the land is only marginally suitable. About 115 million hectares are suitable for irrigation. Since this region does not face a problem of the most basic resource in agriculture, that is land availability, power, particularly human, would be of crucial importance to the development of agriculture in Africa.

Animal power

51. Animal power is a recently introduced form of mechanization in a large part of Africa, it is not widespread due to its late introduction in many African countries, the existence of the tse-tse fly, and the lack of horizontal integration of the two main enterprises (livestock and crop production) among producers. With the main exceptions of North Africa, Southern Africa and Ethiopia, there is little tradition for the use of draught animals. Trypanosomiasis inhibits its use in many of the more humid parts of the continent. In the drier areas animals are traditionally used for transport, meat and milk, but rarely for agricultural draught power. There have been many attempts to promote animal traction since the early years of the century, but they have often dwindled as a result of problems with the supply, care and handling of animals, periods of drought, changes in government policies, and inadequate veterinary and other support services. Such use as is made of animal draught power in non-traditional areas in mainly limited to cash crops such as cotton and ground-nuts.

52. The use of animal draught equipment is generally confined to the "ard" plough, the spike-tooth harrow (which often doubles as a land leveller), and the two-wheel cart. Many improved ploughs, seeders, cultivators and other animal draught implements have been developed and are being manufactured in Africa, but their use by small farmers is limited by reluctance to break with tradition as well as by costs.

53. Given the present condition of African agriculture, adoptive technology and its equipment must be simple to make and repair; cheap for the rural people; and superior to hand methods. An improved ox-plough falls into this category. Local R&D to support this innovation is essential in order to avoid occurrence of failure as in previous schemes involving animal-powered equipment. Improvement can be made on the harness or yoke, as well as by developing a multi-purpose toolframe/tow-bar for ex-drawn equipment with attachments for tillage, weeding, seeding, cultivating, ridging and transporting of implements. The integration of draught animal power into farming systems and the development and propagation of a wide range of farm tools and implements to handle the various tasks and chores at the farm, will require sustained and improved breeding programmes and feeding standards to improve integration of livestock and crop production.

54. Animal power is used in Egypt and the Sudan only for selected farming operations, while in Kenya, Senegal, and the United Republic of Cameroon, they are sparingly used; in Burundi, Gabon, and Rwanda, they are rarely used. Efforts are being made by national and international organizations to improve the state of

technology for animal power and to permit its widespread use in areas suitable for it. The control of tse-tse fly and animal trypanosomiasis which covers between 5-10 million square kilometres in Africa and the introduction of trypano-tolerant breeds would offer a great potential for livestock and crop development through animal power technology. Animal power as an intermediate technology offers great prospects for utilizing the vast areas of Africa if properly introduced through an integrated programme of livestock, crop and industry. The fact that with the hand hoe only about 0.5 ha can be prepared, coupled with the escalating costs of machinery and fuel, underscores the importance of animal power in the development of agriculture in the region.

Mechanical power

55. In most parts of the continent power mechanization is mainly confined to export crops, to primary tillage operations, and to tractors with only a small range of implements (usually a mouldboard or disc plough and a disc harrow and trailer). There is a long history of failure in over-ambitious power mechanization schemes, particularly because of low rates of use and inadequate repair and maintenance of the tractors and other equipment. In addition many government tractor-hire schemes have been unsuccessful, in spite of subsidies, because of the high cost of operating in scattered, small and irregularly shaped plots. The increases in fuel prices since the early 1970s have slowed the pace of tractor mechanization. The use of small tractors is still only in the testing stage in Africa.

56. Mechanical power is the most recently chosen path of economic development in Africa, that is, industrialization; and as far as agriculture is concerned it is believed to be the symbol of rapid agricultural development. Changes in crop and animal husbandry, rotation of crops, farming systems, and investment in appropriate agricultural technology are probably the most important factors in the improvement of rural production. However, the tendency has always been to put more emphasis on mechanical reapers, combine harvesters and others, but the tractor tends to receive the greatest attention. They all tend to be labour-displacing, land-using, biased to economies of scale and call for large amounts of capital investment, and are therefore accessible only to large farmers, or government run or supported farms. Furthermore, ill-designed mechanization disturbs established systems of social justice by accentuating socio-economic inequalities.

57. Tractor mechanization has mostly been connected with large-scale government farming schemes in many African countries e.g., State farms, land settlements and others. These large-scale mechanized public agricultural schemes have met with many failures and have been a drain on government budget through subsidization. Examples of disappointing results could be found, among others, in such undertakings as the Sierra Leone government plantations, Ghana's state farms, farm settlements in Southern Nigeria, the Mokewa scheme in Nigeria, the settlements of the United Republic of Tanzania during the first years of independence; and present parastatal farms. The unsatisfactory performance was due to poor planning and management, inadequate maintenance of the tractors and equipment, resulting in reduced life, the inappropriateness of conditions (soil and ecology) and improper use which sometimes destroys soil structures and exposes them to erosion. These schemes relied heavily on outlays of foreign exchange, while the employment creation result was minimal. They frequently resulted in overcapitalization, in addition to poor maintenance and repair facilities and inefficient use.

58. In the Sudan, for instance, while heavy clay soils necessitate mechanical power, the introduction of tractors has been instrumental in expanding rainfed and irrigated agriculture. Negative aspects were nevertheless reported in the form of deterioration of land fertility in areas where due attention was not paid to the ecology and soil fertility; including the required crop rotation and soil management. In the absence of co-operative schemes, the high cost of acquiring, running, and maintaining a tractor precluded many small farmers and concentrated mechanization in few hands, thus accentuating income disparities. Introduction of mechanical power was not accompanied by improved skills in running and maintaining machines, which resulted in escalating costs of mechanical power at all levels.

59. Introduction of mechanical power that is cheap enough to be afforded by the majority of farmers is yet to be made, although small tractors are being introduced in some parts of Africa. More efforts are required to make them more economical and suitable to the varied requirements of farming. It has to be borne in mind that agricultural mechanization (tractor and other machinery) requires large capital investments not within the reach of the majority of farmers. The introduction of tractors into the farming system can be beneficial in extensive farm lands when accompanied with the use of yield-increaaing innovations. It can also take into account the small-holders, where tractor use can be made possible combined with small-holder farming through hire or contract system. Small farms can hire modern equipment which they cannot afford to purchase, and in this way they will be able to mechanize certain areas of their farming operations (selective mechanization), particularly the most arduous operations.

Water Control

60. Many parts of Africa have highly erratic rainfall, and are subject to extremes of drought, flooding or extreme intensity of precipitation. Better water control, through the rehabilitation and improved management of watersheds, as well as irrigation and drainage, are thus essential technological applications.

61. Contour and strip cultivation and in some instances the introduction of man-made structures, such as terraces and dams, are often required to control the volume and velocity of water flows. There is also a biological component in watershed rehabilitation and management, including reforestation, forest management, agro-forestry, range management and pasture improvement, which has so far been applied to only a limited extent.

62. Irrigation is much less significant in Africa than in most of the rest of the developing world. Accurate data are not available, partly because of problems of definition, but FAO statistics indicate that only about 4 per cent of the cultivated area is irrigated. More than 60 per cent of the continent's irrigated area is in Egypt (where all of the cultivated area is irrigated) and the Sudan, and with the addition of Madagascar and Morocco four countries account for three quarters of the total. It is noteworthy that in each of these countries where large-scale, modern irrigation projects are important, irrigation was already a major part of traditional farming systems.

63. Elsewhere there are many small areas with traditional irrigation systems, particularly in swamps or based on mountain streams. In the inland swamps, for example, four stages of water control for rice production may be identified. At the first stage small bunds are constructed with little land levelling; at the second stage there is more bunding and levelling, as well as the digging of a drainage canal; the third stage involves still more levelling and also terracing and lateral canals, at the fourth stage, which represents the transition to fully irrigated production, small dams or storage reservoirs are constructed. In continental Africa most of the inland swamps are at the first or second stages, while in Madagascar large areas have been developed to the second and third stages by traditional methods.

64. In addition to the four countries singled out above, large-scale, modern irrigation projects are also of some importance in parts of Algeria, Ethiopia, the Libyan Arab Jamahiriya, Mali, Mozambique, Senegal, Somalia, Swaziland, Tunisia and Zimbabwe. As a result of the recent droughts in the Sahel and elsewhere, there has been a marked increase in interest in irrigation.

65. Soil degradation from salinization can be avoided by using water of the right quality and appropriate irrigation techniques. A number of irrigation schemes have failed because of salinity and waterlogging caused by inadequate drainage. More attention is now being paid to the rehabilitation and improvement of existing irrigation and drainage schemes, which is much quicker and cheaper than the construction of new ones. In many cases these schemes have neglected the necessary downstream works on farmers' fields, as well as the need for maintenance.

66. The development and demonstration of water harvesting techniques, both biological and mechanical, to increase moisture availability, to check run-off, to recharge the water table and, therefore, develop appropriate conditions for plant growth are essential, particularly for the Sahelian and other semi-arid areas of Africa. Catchment rehabilitation techniques which make the best use of manpower availability and cost-efficient local materials should be refined particularly in those countries which have large rehabilitation schemes in the highland and upland areas: Ethiopia, Guinea, Kenya, Madagascar, Nigeria and United Republic of Tanzania. Research in forest hydrology needs expansion to other ecosystems, since the research conducted by the East African Freshwater Fisheries Research Organization (EAFFRO) in Kenya for the last 20 years has been confined to the hydrological behaviour and the various types of conversions (pasture, shamba shifting cultivation, pine plantations) of the bamboo forest in the mountain vegetation life zone.

Biochemical technology

67. The adoption of new and improved high-yielding seed varieties (HYVs) technology; soil management, manures and chemical fertilizers, animal and plant protection chemicals (insecticides, fungicides, weedicides, etc.), and regulated flow of irrigation water, are all complementary inputs which must be used as a package for potential increases in output to be realized. This seed/fertilizer/ irrigation technology as it is called is scale-neutral, land-augmenting and labour-using. Simple hand implements can efficiently be used in the control of

weeds and for fertilizer application. The biochemical innovations tend to be more desirable than say, tractorization and the desirability lies in the fact that they tend to be more labour-absorbing, land-saving, and scale-neutral and therefore ideal for all classes of producers, all of whom stand to benefit from its adoption.

68. The technologies based on high-yielding varieties (HYVs) of cereals that, especially in Asia, have made rapid headway in many countries since the late 1960s have, with the main exception of hybrid maize in some areas, had very little impact in Africa so far. By 1976, the latest year for which there are estimates, HYVs covered only 22 per cent of the small wheat area and 3 per cent of the rice area. Most of the limited technological progress has been concentrated on export crops (many of them grow on large-scale plantations), although even for these crops yields are usually less than elsewhere. There are as yet few viable technological packages for Africa's basic food crops that are ready for farm-level application, especially in the areas of less favourable climate.

69. The recent Asian experience has some lessons for Africa. While the technologies based on HYVs were rapidly adopted there in the early stage by large- and medium-scale farmers with adequate access to land, water and services, they were gradually used by small farmers as well. However they have brought little benefit for the millions of landless poor. Africa too has millions of small farmers, and greater progress here must depend greatly on the diffusion of existing improved technologies among them and perhaps even more so on developing new ones better suited to their needs.

70. Much could clearly be achieved by the more widespread application of the already existing improved technologies. Indeed the increases in production from higher yields called for both in the AFPLAN and in FAO's study, Agriculture: Toward 2000, 1/ are based almost entirely on this. The main requirements for filling this part of the technology gap lie in such fields as higher government priority for food and agriculture, incentive prices, better services for farmers (especially small farmers) in applied research, training extension, input supply, credit and marketing, and more active technological transfer between countries.

71. In all countries of Africa, improved high yielding seed varieties (HYVs) are being used with varying degrees of intensity between countries and crops. HYVs success has hinged on a package of other services, particularly availability of irrigation, pesticides, fertilizers, etc. Their introduction in many countries often necessitated the importation of fertilizers, machinery and other package inputs. Given the present economic problems of many African countries, the mounting imports of these technologies have compounded the serious structural problems they are facing. Moreover, small-scale farmers who are involved mainly in subsistence agriculture and who are the major producers of food are again not greatly affected by this revolution. Selected seed varieties are more common and wide-spread than hybrid varieties, mainly because hybrid varieties require efficient infrastructure and supporting services which are lacking in many countries.

72. A number of countries have initiated programmes for the production and distribution of improved seed varieties, current emphasis being given to the modern sector. HYVs do produce higher yields, but they are more demanding for other modern inputs, and in addition, in dry areas where the crops are less drought or

disease resistant than the crop they replace, the risk of crop failure is tremendously increased. With regard to food crops, new seed technologies are more advanced with rice and wheat, and to some extent maize and a few other tropical crops. Others, like roots, tubers, millet and sorghum, have not received much attention. These locally produced crops have not been given the necessary attention, particularly relating to genetic improvements required to increase resistance to unfavourable environmental conditions and to strengthen their competition with surrounding biological systems of weeds, insects, diseases etc. Research needs to be directed towards locally adaptable food varieties, which are less demanding on imported inputs such as fertilizers and pesticides. Since Africa has continued to depend on the outside world for most of its energy inputs, such as fertilizers, the development of biochemical technology ought to receive the highest priority. Although Africa has considerable animal wealth, yet the use of composite fertilizers particularly animal manure has not yet been properly utilized, as is the case in other regions, particularly Asia.

73. A basic aspect of progress in food and agricultural technology is the development of improved crop varieties by plant breeding. While their successful use demands simultaneous improvements in many agronomic practices, the development of new varieties capable of taking advantage of an economically higher level of inputs and providing bigger revenues, capable of justifying these improvements is an essential requirement.

74. Plant breeding work has a long history in Africa, but during the colonial period it was concentrated on export crops. Local food crops were not regarded as unimportant, but it was assumed, probably with some justification at the time, that subsistence production could easily be expanded in line with population growth. Nevertheless the result has been that until quite recently most of Africa's important staple food crops were largely neglected by research.

75. Research work done elsewhere, for example, on hybrid maize and on the HYVs of wheat and rice, has (for reasons discussed below) had little impact in most of Africa. Intensive research has recently got under way to develop varieties of these and other food crops suited to African conditions. A number of new varieties with at least some of the desired characteristics are already available, but their use in practice is still limited.

76. By far the most important cereals in Africa are maize, millet and sorghum. Yields of maize on small farms seldom exceeded one ton per hectare and are often much less. Most small farmers still grow traditional open-pollinated varieties, although in a few countries (Kenya, Zambia and Zimbabwe) some 40 to 50 per cent of them use high-yielding hybrids. On large private or parastatal farms, using mechanization and other modern methods, yields of 3 to 7 tons/ha are obtained in some countries. Yields of 6 to 7 tons/ha are also frequent on experimental farms, but their research is still geared mainly to the needs of large farmers. Limited attention has been paid to varieties suitable for less than optimum conditions and for mixed cropping, or to the need to introduce a satisfactory level of resistance in open-pollinated varieties to pests and diseases such as streak virus, leaf spot, rust, stalk borers and ear rot.

77. Millet and sorghum, like maize, are cross fertilized, so that the maintenance of varietal purity is difficult. Millets, which are of special importance in the Sahel, have probably benefitred less from research than any other major cereal. Yields in Africa are rarely more than 0.5 tons/ha and crop failures are common. Local tall pearl millet varieties with good management have given high yields (2.5 to 3.0 tons). Short-statured improved varieties or hybrids are still under analysis, particularly for adaptation. There is also considerable scope for improving local varieties by recurrent selection.

78. Research on sorghums has so far been more successful than that on millets. In comparison with the prevailing low yields of 0.6 to 0.9 tons/ha, 3 to 5 tons can be obtained through improved varieties and agronomic practices. Striga is a particularly serious weed, as it is parasitic on the sorghum plant; although resistant varieties are not available, it can be checked by crop rotation. Though difficult it should be possible to develop varieties resistant to the other main pests and diseases. However, the biggest menace to sorghum production is the weaver bird (Quelea, spp.) which cannot be controlled in this way.

79. The high-yielding varieties of rice were developed for irrigated areas and, like those of wheat, require large inputs of fertilizer. However, except for Egypt, most of Africa's rice is rainfed. Some varieties introduced from Asia have done well in rainfed lowland areas with good water control, but in general varieties are needed that are closely adopted to the highly diverse local conditions. Yields of upland rice are usually no more than 0.5 to 0.8 tons/ha, and although they can be at least doubled in experimental conditions this has rarely yet been possible in the actual conditions encountered on farms. Carefully adapted varieties are also required for the highly specialized sytems of inland swamp and mangrove swamp rice production. Mangrove swamp producers have for centuries selected suitable traditional varieties yielding 1.5 to 2.5 tons/ha. Normally, several different varieties are planted even in a small area because of the highly variable conditions; however some improved varieties are also now available. A serious problem with rice in Africa is that new strains of blast and other diseases have arisen as fast as varieties resistant to the preceding strains have been developed.

80. Wheat is a major crop north of the Sahara, and here the HYVs have made some headway. South of the Sahara it is mainly grown in the highlands of Ethiopia and Kenya, and in parts of Mozambique, the Sudan, the United Republic of Tanzania and Zimbabwe. Many other countries as well are trying to promote wheat production because of the rapid increase in consumption, but it appears to be uneconomic in most cases. Yields of wheat south of the Sahara are generally less than 1 ton/ha, and the chances for raising them seem small because of high temperatures, short growing seasons, and pests and diseases. Varieties bred in Kenya have more disease resistance than those introduced from outside, but it has tended to break down after two or three years, with the consequent need for their rapid replacement.

81. Roots and tubers are also very important staple food crops in Africa south of the Sahara, but have so far received even less research attention than millet and sorghum. Cassava yields vary greatly in subsistence agriculture, ranging from 3 to 15 tons of fresh tubers hectares. High-yielding varieties under good management

can produce 30 to 40 tons. Even less research has been done on sweet potatoes and yams than on cassava. Yields of the numerous traditional varieties of yams grown in West Africa are from 5 to 10 tons/ha, while the limited research has indicated potentials of 30 to 50 tons/ha from selected varieties in favourable climates.

82. Ground-nuts have attracted most research attention because of their role as an export crop. In comparison with average yields of about 0.5 tons/ha in West Africa, experimental yields with improved varieties and management have reached 3 to 5 tons. There has also been some research on cowpeas, which are the most important food legume in Africa. Average yields in subsistence agriculture are only 0.1 to 0.3 tons/ha, but 2.0 to 3.0 tons can be obtained with improved varieties and practices. Breeding programmes are directed mainly towards early-maturing varieties with high yield potential, disease and insect resistance and wide adaptability.

83. Mixed cropping, involving particularly cereals (like maize, sorghum and millets) and legumes (cowpeas, beans, ground-nuts, pigeon peas etc.) is now becoming more and more common practice in many countries with beneficial effects on soil fertility, pest control and yields.

84. For most of the main export crops, improved varieties have long been available and used on large plantations. The main obstacles to their greater use have been the high standards of management they require, together with the disincentive effects of export pricing policies in many countries. The classic example of the effects of these policies concerns oil palms in West Africa, where hybrid varieties introduced as long ago as the early 1960s outyield the local wild palms by a phenomenal 70 per cent but have been adopted only very slowly.

85. Little reliable information is available on the extent of crop losses from pests and diseases. However, it is clear that they are very large, and that the intensification of production has increased both the incidence of pests and diseases and their economic importance. Recent estimates of losses in the Sahel range from 20 to 67 per cent for millet and sorghum, 20 to 69 per cent for maize, and 25 to 75 per cent for cowpeas.

86. Traditional African farmers have developed cropping systems that embody various pest and disease control components. These include the selection of local resistant varieties, appropriate planting dates, the interplanting and rotation of different crops, burning, shifting cultivation, and the destruction of harvest residues. All of these and some other traditional practices help to reduce pest populations. However, in many instances farmers react mainly to incidental pests that cause only occasional damage, while paying little attention to those that are almost permanently present, such as annual weeds in newly sown crops.

87. Improved technologies for plant protection were for a long time based almost exclusively on the use of chemical pesticides. These have proved not only too costly for small farmers, but also environmentally harmful and ineffective. It has been found that the regular use or misuse of pesticides can create an imbalance, increasing the prevalence of certain organisms up to the status of pest, eliminating natural predators and parasites, causing the development of pesticide resistance, and requiring a constantly escalating use of pesticides.

88. More recently therefore, attention has been focused increasingly on integrated systems of pest control. These are based on a combination of resistant varieties, appropriate cultural practices, the deliberate use of natural predators and parasites, and the use of chemical pesticides when they are indispensable. The International Centre for Insect Physiology Ecology (ICIPE) is carrying out research work on pest control in relation to some target crops, mainly maize, sorghum, cowpeas and rice. The main aim is to develop environmentally safe and economically feasible integrated components of pest management which could be applied in the region for maximization of the advantage of multicropping systems. Such methods, however, are not yet at all widely used, and their widespread use requires substantial research, extension and the existence of major infrastructure.

89. Crop varieties introduced from outside Africa often face a new pattern of diseases and pests. As indicated above, the intensification may also increase pest and disease damage. For many important crops, especially relatively low value food crops (cereals, legumes) the development and the use of resistant varieties is the main line of defence. In various institutes in Africa crop cultivars with adequate resistance are developed; the durability of the resistance needs special attention to avoid future problems.

90. At the same time, many new pests and diseases have recently been introduced in Africa. Cassava is a striking example. Although pests and diseases of this crop were previously not considered important, cassava mosaic virus and bacterial blight to cassava have gained in importance but resistant materials are now available and are gradually distributed to farmers. The situation is different for the recently introduced cassava mealy bug and green cassava mite: these attack 45 per cent of Africa's cassava areas and cause average losses of nearly a third. Insecticides are used against the mealy bug but, apart from the costs, their effective widespread application is difficult. Besides breeding for resistance, biological control, mainly of the cassava mealy bug, holds great promise thanks to the introduction of natural enemies from Latin America.

91. As regards more specialized crops, cotton is attacked by a particularly large number of pests, mainly insects, and a considerable proportion of insecticide used in Africa is for this crop. Where insects have been successfully controlled, yields have been raised from 0.5 tons/ha to 1.0 tons in rainfed and 3.0 tons in irrigated production. The breeding of varieties resistant to bacterial blight and jassids was a major part of the historical process of the adaptation of cotton to East African conditions. However, new efforts on breeding for bacterial blight resistance are needed. A new race of bacterial blight overcomes all known resistance genes in Sudan.

92. Cocoa in West Africa encountered swollen shoot, and diseased trees have had to be eradicated at enormous cost. Black-pod disease has also caused serious losses, and although chemical control is possible it is not always economically feasible. Coffee berry disease has spread rapidly, but can be chemically controlled where the costs can be afforded. Resistance programmes are under way in Ethiopia and Kenya.

93. The small-scale farmer not using herbicides may have to spend 20 to 60 per cent of his total crop production effort on weeding. Land under shifting cultivation has often had to be abandoned because of weeds rather than declining

soil fertility. Land preparation and planting take precedence over weeding, and there is sometimes a shortage of labour, particularly for the early weeding required by improved varieties. Few draught animals are trained to the degree or precision needed for inter-row weeding.

94. In improved weed management, the planting of useful vegetation (like a vigorous legume) for ground cover can often be a useful means of weed control and reduce the need for herbicides. In fragile ecosystems, intra-row weeding should receive priority and inter-row weeds be left as long as possible. At most, herbicides should be used to assist in the orderly scheduling of weeding by controlling the first flushes of susceptible weeds rather than for the control of all weeds. Appropriate crop rotations can also help to reduce weed problems.

95. Many of the worst agricultural pests of Africa are migratory, and thus require international co-operation for their control. This has been greatly facilitated by the use of remote sensing by satellite to monitor and forecast pest outbreaks, and in particular to keep a close watch on the rainfall and vegetation conditions which affect the formation of migratory swarms of desert locusts. For many years poisoned bait was spread around, potentially damaging locust populations, but since the 1950s the application of concentrated oil-based insecticides from aircraft has been found much more effective. Thus, a long period of almot continuous plague has been replaced by one of almost continuous recession, with only one major outbreak (in 1968) since 1962. Control measures are costly, however, and the avoidance of a full-scale plague in 1977-1979 required the mobilization by FAO of international intervention amounting to $US 8.6 million. There are also some as yet unsolved problems of upsetting ecological balances.

96. Among other migratory pests, grasshopper control is usually through the use of poisoned bait, but little impact has been made so far. The most numerous and damaging of the grain-eating birds is the red-billed Quelea, which is estimated to cause over $US 60 million of damage annually in East Africa alone. Aerial spraying methods have been improved by the replacement of parathion by fenthion, thus reducing toxicity and pollution hazards. Control is now focused mainly on those bird concentrations liable to damage newly planted crops, instead of pursuing them everywhere. Infestations of army-worm spread each year from initial outbreaks in East Africa, and control has been facilitated by the development of a forecasting service.

Technology in post harvesting

97. For the staple cereals and food legumes, post-harvest technology begins with threshing. Traditional threshing methods, usually by hand or occasionally using animals, often involve big losses, and require much time and labour at a critical period. Simple, small mechanical threshers, suitable for farm or co-operative use or hire, are available and are already manufactured in several African countries. They have in general been more widely adopted than most other mechanical improvements, although their use remains small.

98. These crops are traditionally dried in the sun. The procedures and surfaces used are seldom ideal, although there are efficient traditional methods of sun drying in some areas that could be more widely used. Where artificial drying may

be required (as in the more humid areas), simple hatch driers have been developed that are suitable for joint use by co-operatives or other groups of farmers.

99. Efficient drying of grain crops is the first requirement for their successful storage. Most storage is by rural households, either in a part of the dwelling or in containers such as mud-brick silos or woven straw granaries. Many traditional farm-level storage systems are now regarded as more efficint than was formerly believed, especially where simple fumigants and insect barriers like sand and ashes are used and there is constant inspection and rotation. For more centralized storage, where losses are potentially much higher, there are well-developed modern technologies for building structures, temperature and humidity control, and the prevention or reduction of pest infestation, but skilled management is the main essential and is frequently lacking.

100. Storage losses are particularly large for roots, tubers, bananas and plantains because of their high moisture content. The highly perishable products like meat, dairy products and fish pose even more serious problems, and the post-harvest technologies for these products require separate discussion.

101. Technology in other post-harvest operations include various storage techniques, used at different levels to prevent deterioration and to preserve food value, as well as various drying and disease and pest control methods. All these will call for evolving appropriate technologies through assessment and evaluation of traditional structures and methods, and their potential for improvement using adaptive research and through appropriate national policies. Importation of appropriate storage has always been a burning issue. Improvement of local storage facilities has been undertaken by national and international institutions, but has not yet been fully developed and implemented. A breakthrough in this area would go a long way in improving income and food production.

102. Traditional farm-level processing of grain by hand pounding is extremely arduous and time consuming, but is likely to predominate in Africa for a long time to come. Small plants for mechanical hulling and grinding are available for use at the village level. A variety of more modern technologies are used in large-scale plants in urban centres, but they require a steady supply of good quality grain, and skilled workers and management. Technologies have been developed for the nutritional enrichment of flour, as well as for the production of composite flours using local roots and tubers, but their use so far is very limited. Chipping and drying of roots has well developed traditional technologies, but could be made more efficient by improved simple equipment.

103. In many parts of Africa livestock for slaughter are trekked along routes that are not equipped with water and feeding points, or are carried in unsuitable vehicles, with the result that weight loss and mortality are high.

104. Slaughter for local consumption, generally in unhygienic premises, does not assure the full use of the carcass meat and by-products, and the technology for the utilization of edible by-products is inadequate. Low standards of hygiene in distribution and marketing further reduce the quantity and quality of the meat. In a number of countries meat is preserved by drying and smoking, sometimes combined with salting, but the quality varies greatly. Many new slaughterhouses have been

constructed, but with few exceptions they do not use the improved technologies that have been developed. Only industrial abattoirs established for export operate at a level of hygiene and technology that is adequate for the full use of meat and by-products.

105. Most milk processing is carried out in primitive and unhygienic facilities at the level of the herd or flock or sometimes the village. Only a limited quantity of locally produced milk is processed in urban plants, which generally use recombined milk. Where there is no pasteurizing plant, milk is usually sold raw or boiled or fermented. Since priority is generally given to the marketing of liquid milk, there is little diversification of production. In some countries fermented milk is processed into butter and ghee, and the remaining milk is consumed with or without the addition of flour. Cheese is made in only a few countries. In general the use of improved dairy technology, such as the setting up of village milk collection and cooling centres or small cheese plants, is inhibited by the lack of rural electrification.

106. Food-processing industries and other agro-processing industries are prevalent in Africa. Rapid population growth and rising income tend to favour these industries which are usually geared to the domestic market with competition in the export market being rather keen. The structure of manufacturing in Africa is, typically, 31 per cent of the share to food, beverages and tobacco, and 21 per cent to textiles and clothing: these play the role of forerunners of industrialization, and a reliable supply of raw materials is an essential factor. Some of the more common processing activities include rice parboiling/milling, garri (cassava meal) production, maize grinding, foofoo production, fish-smoking, palm-oil processing, ground-nut oil processing, coconut oil processing, and the processing and utilization of meats, dairy products, and other livestock products such as leather. Others include the processing of perishable products (canning, freezing, etc.) such as fruits and vegetables and milk. All these activities contribute to the commercialization of agriculture, and reduce post-harvet losses while creating rural employment. A balance should therefore be maintained with respect to the competition between the local small-scale-processing industries on the one hand and imported goods on the other.

107. Chilling is the only satisfactory technology for minimizing the rapid deterioration in the quality of fish following death. However, the use of ice for refrigeration implies high capital and current costs that are often beyond the means of individuals or small communities, especially in tropical conditions. Fish is traditionally sold locally in the fresh state, and the surplus, after immediate fresh sales, is preserved through curing by drying, salting and smoking in various combinations. These are basically sound preservation methods, and improved technologies are available for them, such as salting techniques and the better construction and loading of kilns. The low quality of traditional salt production is, however, a problem in improving the product. More modern processing technologies, like freezing and canning, are little used because of the need for heavy capital investment, skilled manpower, high costs and a regular supply of good quality fresh fish.

108. Availability of supporting services such as transport, processing, storage and marketing are integral components in the development of agriculture and therefore should be developed simultaneously with production Otherwise, all efforts to

enhance production would be nullified. In general, the post-production services in the region are inadequate and have in many instances frustrated development plans. They depend on imported technology particularly for the modern and export-oriented sectors.

109. Transport has continued to be one of the major bottle-necks to development of food production in Africa. The imported technology in road, rail and river transport suffers from problems such as inadequacy of the supporting services, poor maintenance, unsatisfactory road facilities, excessive cost of fuel and spare parts, poor planning, and lack of co-ordination. The majority of farmers depend mainly on human and animal power for their transport. Modern transport, though spreading, still has to make inroads in many parts of rural Africa.

110. Local transport still depends heavily on headloading, buckets, bicycles and animals, although the latter are slowly giving way to trucks. Farm tractors towing rubber-tyred trailers are increasingly used for transport in rural areas. Many roads are impassable during the rainy season. Although rail and barge transport appear to be cheaper than road transport, few areas are served by them.

111. With locally rapid dwindling of fuel-wood supplies, interest is focusing increasingly on technologies for their more efficient use, both in agricultural processing and other rural industries and in the household for cooking. Possible means include the seasoning and pre-processing of firewood, more efficient methods of charcoal production, and simple improvements in cooking stoves, utensils and methods, combined with efforts for fuel-wood plantations.

112. Little improvement has been made on traditional and transport methods whether animal or human and even less for traditional river and lake transport. In some countries, where improvement has been introduced, as in human drawn implements, efficiency has been increased and the arduousness and drudgery of work greatly reduced. ECA has taken the lead in formulating subregional and regional plans for development of transport in Africa. However, in general, the state of technology is still poor and calls for many improvements. First and foremost, the importation of suitable and appropriate transport technology for agriculture should receive utmost priority. Efforts should be made to produce transport technology suitable in various conditions of Africa through three major ways: importation and modification, importation of parts and assembly according to requirements, and finally local production.

113. Processing of grains during harvesting, threshing, shelling, drying, milling and conservation of food often uses only simple methods, equipment and technologies. Hand or food threshing can be replaced with improved hand-operated or small-engine powered threshers. In general, processing is geared towards urban areas and the export sector, utilizing modern imported equipment. Owing to poor planning and management and inadequate training to maintain and run them, many of these facilities are uneconomical and grossly underutilized. Breakdowns, lack of spare parts and insufficient raw materials are recurrent problems. Most of them are not suitable for developing countries in view of their capital-intensive nature and high degree of sophistication. Processing at farmer and village level is still primitive and inefficient. This is a field where great improvement could be made

with tremendous forward and backward effect on agriculture. Small- and medium-size processing facilities could be developed, not only for better utilization of agricultural products but also for spreading the benefits of development.

114. Marketing of food products remains the weakest link in the process of food production in Africa. It could generally be described as inadequate and inefficient.

115. The unsatisfactory performance of the marketing system could be singled out as the major factor in the inadequate incentive of farmers to adopt and use modern techniques and inputs necessary for increased food and agricultural production. With increasing urbanization population pressure has worsened the situation, causing great strain on the already fragile marketing facilities and methods. Wholesale and retail markets in both rural and urban areas are ill equipped and unsanitary. Marketing services such as standardization, grading, packaging, storage etc., are still rudimentary. The state of technology is poor in this field with the exception of export crops. This is a field where existing knowledge from developed and other developing countries could be gainfully applied. This requires proper planning, training of manpower and financial commitment on the part of Governments.

Livestock, forestry and fisheries

116. It is more informative to consider the state of technology and requirements in regard to livestock, forestry and fisheries under each subsector rather than under the various technological components as in the case of crops. However, abundant similarities exist between the problems encountered in technological applications, even though there are variations in depth and urgency.

(a) Livestock

117. The livestock subsector occupies a position of importance in the region and plays a significant socio-economic role. Africa is endowed with considerable animal wealth, amounting to 14 per cent of the world's cattle, 16 per cent of sheep, 33 per cent of goats and more than 50 per cent of camels. It has also favourable livestock/population/land ratios. Nevertheless, the contribution of the livestock subsector is not commensurate with the number of animals or the extent of land resources used. The subsector is still dominated by traditional patterns of production where livestock activity is carried out under sedentary, nomadic, semi-nomadic and transhumane systems. The three last-mentioned systems are predominant. Modern production systems are being progressively developed, particularly in the field of dairy and poultry farming and have so far received more attention that the dominant, traditional sector. Nevertheless, their impact is not yet significant, with the exception of poultry farming. In many countries unsatisfactory performance is reported in large-scale beef and dairy enterprises.

118. Generally, the quality of livestock in Africa is poor; productivity and reproductivity levels are far below international standards. This is due to a number of factors such as insufficient animal feed, environmental conditions, inadequate health control measures, poor genetic characteristics of animals, cultural factors impeding development, inadequate institutional and infrastructural

support. Animal husbandry techniques used for livestock are unsatisfactory. Livestock producers are conservative in adopting an innovation unless it suits their requirements and harsh environment. Crops and livestock in many areas are carried out as separate activities. Diseases are still a major constraint, though considerable progress has been achieved in controlling many of the killer diseases. Research on animal production aspects in arid areas lags behind crops. National and international institutions such as FAO and ILCA are addressing themselves to these problems and encouraging research on livestock production. The institutional support is weak, with wasteful and inefficient marketing systems, severe shortage of trained manpower, and inadequacy of related institutional links. Appreciable efforts are made by the Governments of the region to improve the livestock subsector, and yet the degree of development remains in many countries alarmingly low.

119. Almost all of the feed supply of Africa's livestock comes from unimproved pastures and rangelands, fallows, and crop residues. Concentrate feeds are hardly used except for poultry production, and a small number of large-scale pig production units. Partly because of high internal transport costs, agro-industrial by-products useful for livestock feeding are often exported.

120. Modern methods of range and pasture management, requiring fencing, strictly controlled stocking levels, firebreaks and regular water supplies, are practically unknown in the traditional sector, where overgrazing is rife. Irrigated pastures and intensive fodder production exists only in North Africa. There is no tradition of preserving grass or other fodder as hay or silage. In the semi-arid areas where most of the ruminant livestock are concentrated, the dry season lasts for six to nine months, and keeping the animals alive during this period is the main goal of the often nomadic or semi-nomadic pastoralists. Herd and flock movements are governed more by the availability of water than of grazing.

121. The indigenous breeds of livestock have been developed by natural selection. Improvement schemes based on modern genetics are few, and have had very little impact on the traditional sector.

122. While there are some native trypano-tolerant breeds, rational selection for trypano-tolerance has hardly started. Exotic breeds and their cross-breed offspring are a very small proportion of the African population of cattle, sheep and goats. The main exceptions are North Africa and a few highland locations in the tropics, where they are used for intensive milk production. Few of the indigenous cattle breeds appear to offer the minimum genetic potential for commercial milk production. In contrast, the beef performance of most of the indigenous breeds is satisfactory provided they are fed correctly. The same is true of sheep some of which are excellent mutton producers. There is no improved indigenous goat breed in Africa.

123. Commercial pig and poultry production is based entirely on imported breeds and hybrids. Traditional production relies on nondescript local stock, which has low genetic potential but is able to survive in difficult conditions.

124. Artificial insemination has been successfully introduced in some tropical as well as North African countries. However, its application is limited by the low levels of management and feeding achieved by most breeders.

125. Parasitic and infectious diseases of livestock are a major problem in Africa. Trypancsomiases, carried by the tse-tse fly, affects all livestock except chickens in seven million square kilometres of potentially productive land in 37 countries. A variety of methods of vector control have proved successful either singly or in combination. These include insecticide application from the ground or from aircraft traps with or without attractants, screens impregnated with insecticides, sterile male techniques, bush clearing, biological control, game control and drag control. ICIPE is carrying out adaptable research in all these activities for the implementation of those proven to be technically and economically feasible. The International Laboratory for Research on Animal Diseases (ILRAD) in Nairobi, is mandated to develop vaccines for trypanosomiasis and tick-borne diseases. Research is in progress but a breakthrough has not been made. Since there is still no effective immunization technique, the control of the disease itself is mainly through chemotherapy and the use of trypano-tolerant breeds. Tick-borne diseases, especially east coast fever, cause heavy losses in both indigenous and exotic breeds. The main control measures remain dipping and spraying but rising resistnce to acericides is causing concern.

126. Among the major infectious diseases, there has been a significant reduction in rinderpest, mainly because of an internationally co-ordinated vaccination campaign. However, it was still enzootic in some countries, and has recently recurred in West, Central and Eastern Africa in the absence of follow-up vaccination campaigns. The control of foot-and-mouth disease has proved difficult, especially because of the lack of virus typing facilities and difficulties in securing supplies of vaccines. Contagious bovine pleuropneumonia is still a major problem in some countries, despite the availability of good diagnostic methods and vaccines in most of them. African swine fever is enzootic in many parts of the continent. Poultry diseases are becoming more widespread with the growth of commercial production.

127. Standards of livestock husbandry and management still vary considerably. Whereas the traditional pasturalists usually have an intimate knowledge of their animals' needs and give them excellent care, the settled farmers are often ignorant of these needs, and this causes problems in the introduction of an animal component into traditional crop-based farming systems. Such modern livestock production systems as ranching and stratification have been tried in some areas, but usually without much success so far.

128. There are two levels of existing wildlife management technology in Africa for the production of food. By far the most important are the traditional systems that exist in most parts of the continent. These cover harvesting strategies and techniques, the processing and preservation of products and, in some communities, conservation measures. Animal protein derived under such systems can make a significant contribution to the diet of many subsistence farming economies, especially those in humid forested areas or trypanosomiasis zones where possibilities for domestic stock production are limited.

129. At a different level the cropping of wild mammal populations and wildlife ranching have formed the subject of pilot projects and schemes in various parts of the continent. These have often been conceived as government-implemented programmes or operations carried out in the context of large-scale ranching.

130. There is a certain scope for the transfer and adaptation of existing technologies between countries in the region. However, the primary requirement is to evaluate existing traditional systems in biological and ecological terms, with a view to developing approaches which are sustainable and possibly more productive. At the same time, systems that are compatible with other land-use practices need to be evolved.

131. Game farming as such has progressed little beyond the experimental stage in many parts of Africa. An intensification of research effort with the accent on arid zone and trypano-tolerant species is necessary, not only on biology, ecology and economics, but also on husbandry and sociological implications.

(b) Forestry

132. The forestry subsector plays an important socio-economic role in the region by providing the needed fuel and wood, generating employment, producing food and ensuring the environmental stability necessary for continued food production. Africa's forest area was estimated at 605 million ha in 1975, out of which 205 million ha was closed forest and 400 million ha other woodland. Total removal was estimated at 293 million cubic meters, out of which 261 million cubic metres was for fuel-wood and 32 million cubic metres industrial wood. Fuel-wood consumption in the region was estimated roughly at 373 million cubic metres on the basis of an average per capita consumption of 0.7 cubic metres. Industrial wood consumption for the same period was estimated as follows: 4 million cubic metres sawnwood, one million cubic metres wood-based panels and one million tons of paper. The region still exports sawlogs, veneer and sawnwood though not at the same levels as five years ago. Projections at 2000 by FAO indicate that the region will be able to satisfy its requirement of wood with some quantities remaining for export. However, the recent escalating costs of fuel have prompted increases in fuel-wood as an alternative source of energy. With the increase in consumption, wood removal in a planned manner could hardly be adequate for current and future needs without expansion in forests. The phenomenal increase in the prices of fuel-wood and charcoal in most countries of the region is a reflection of this trend.

133. Logging operations in forestry have increasingly been mechanized in recent years. In some countries, however, manual logging operations still exist side by side with highly mechanized ones. Especially in tropical high forests, the chainsaw has almost completely replaced the axe and handsaw. There has been a tendency to use more and specialized logging machinery to suit different forest and ground conditions. Thus, for instance, articulated wheeled skidders have been introduced in tropical forests in addition to crawler tractors. At the same time, however, with rising capital and fuel costs, improvements in productivity have been sought by re-organizing logging operations rather than using higher-powered machinery. Particularly in plantation forests with small-sized trees, agricultural tractors (and sometimes draught animals) with forestry attachments have been introduced. As regards transport, a large proportion of the logs is still floated, but trucks are used wherever possible.

134. Primitive sawmills and small-scale pit sawing are common in Africa. The use of improved sawmilling technologies and equipment has been held back by the need for better mill layout, improved handling, automation where appropriate, better

knowledge of species through wood technology research and the protection of timber from decay and insect attack. There is also a lack of skilled men-managers and workers. Industries producing wood-based panels (veneers, plywood, particle board, fibre board, wood cement board and block board) are often capital intensive and require economies of scale. However, in some cases they have been successfully established in conjunction with sawmilling, thus ensuring integrated utilization of the raw materials.

135. In spite of the abundant supply of mixed tropical hardwoods for pulping in Africa, this raw material is very little used for this purpose at prsent. There is only one mill in the United Republic of Cameroon which produces pulp from mixed tropical hardwoods, mainly for export, although a number of other countries are contemplating projects of this kind. The chemical pulping process is used for wood in Angola, Kenya, Morocco, Nigeria, Swaziland and the United Republic of Cameroon, and mechanical or semi-mechanical processes in Madagascar and Zimbabwe. Non-wood fibres such as straw, bagasse and esparto grass are used for pulping in Algeria, Egypt and Tunisia. A number of African countries also have unintegrated paper mills using imported pulp or waste paper.

136. The technologies for the management of natural forests are based on a detailed knowledge of the characteristics and requirements of the individual species of tree and shrub that make up the varied forest formations. Such knowledge is as yet rarely available in Africa, which has led to incorrect silvicultural treatment and the degradation of the resource. It is increasingly being realized that it is necessary in many cases to give preference to protecting and managing viable natural forests with multiple-use characteristics (including fuel-wood supply) and environmental protective capacity, rather than replacing them with expensive planations of species with relatively narrow end-use abilities.

137. The establishment of plantations (man-made forests) requires specific technologies for particular types of site and soil. The related technologies for seed source selection, seed collection and storage, nursery propagation and the handling of seedlings are as important as those for the establishment phase, but they are as yet little applied in Africa because of the shortage of trained personnel. Technologies are also viable for weed management, the prevention and control of attacks by diseases, insects and animals, and of damage or destruction by fire, but those too are still little used in Africa.

138. Technologies for the culture, establishment and management of multiple-use tree species (for food, animal fodder, medicinal products, timber, and above all fuel-wood) are readily applicable at the village level. The appropriate choice of tree species and planting techniques makes it possible to grow trees simultaneously for all these purposes, often in close integration with agriculture. In addition to small plantations where there is sufficient land, such trees can be planted in available spaces along roads and as farm shelterbelts or windbreaks. Fuel-wood production can be increased by simple technologies of pruning, pollarding and coppicing. Forestry for local community development is still a new activity, but projects are already under way in a number of African countries, particularly in the Sahel. A main constraint is the lack of qualified forestry staff for the necessary nursery and extension work on a large enough scale and in close contact with the local communities.

(c) Fisheries

139. The basic technology of fish capture in Africa has changed remarkably little for centuries. The hook and line, the stabbing tool or spear, and the barrier or enclosure (including movable traps as well as fixed gear) have been traditionally used. The design of some of the traps and lifting gear on the Niger River, for example, is extremely sophisticated. Seasonal bonanzas, when bodies of water dry out and fish can be picked up by hand, also occur frequently. These techniques have usually sufficed to meet the needs for food fish of communities situated close to bodies of water. Hollowed out logs have been used to extend the range of the fisherman from the shore into deeper water, and larger and somewhat safer craft have been made from places of wood fastened together.

140. Among traditional techniques, the "acadjas" or fish holes that are used for intensive fish culture and capture in some parts of West Africa are of particular interest. This ancient method, which actively increases the productivity of the system, is not widely practised elsewhere, and has no modern equivalent except for intensive aquaculture in ponds. The latter is still only a very small activity in Africa, and has so far been developed mainly in Nigeria.

141. The main improvements in fish-capture technology for the small-scale fishermen have been through the introduction of better materials. The most important are better iron and steel hooks, natural and synthetic fibres for lines, twine and rope, and manufactured webbing for nets. A striking example of adaptive capacity is the hand braiding of nets by the fishermen of northern Lake Malawi, who have systematically stripped the nylon threads from old truck tyres and knotted them together for netting. Two examples of improvements in fishing gear which have greatly accelerated the development of small-scale fisheries are the introduction of the ring-net in Ghana and of small purse seines in many West African fisheries.

142. In multi-species fisheries as diverse as those of the African inland waters and coastal lagoons, a corresponding diversity of gear is desirable. Traditional gear is usually aimed at exploiting all sizes of fish and all habitats. More recently it has tended to be replaced by synthetic netting, generally in the form of gillnets. While this simplifies the fishery in one way, it probably results in an unbalanced and ultimately inefficient exploitation pattern.

143. Mechanized propulsion has permitted the construction and use of large vessels, with the capacity to tow heavier gear and perform an active rather than passive fishing role. Even in the smaller size ranges, the mechanized craft have been able to adopt more active fishing methods. Mechanization has, however, been held back by inadequate skills and maintenance facilities, as well as the rising cost of fuel.

C. Software (non-material) technology

144. Development of indigenous technological capability requires, among other things, the existence of conducive and favourable social, economical and psychological climate for innovations and sustained betterment. Technology is not merely a mode of production and therefore not neutral, it carries within it a code of economic and social and cultural structure which is also cognitive. It is an

embodiment of the accumulated knowledge and culture of the people who are producing it. Technology which is harmonious with the dominant social structure is acceptable, otherwise it will not take root and would at best be marginal and for a peripheral group, at worst it will be completely rejected. Experience of countries who have recently succeeded give support to this. These facts underscore the importance of software as an important means of creating the necessary climate in Africa which is technology dependent.

145. For efficient and timely transmission of the hardware an appropriate and efficient software system should be given equally serious emphasis and treatment. But unlike hardware, which can more easily be transferred from one human environment to another, software has to be developed on site. The technological change will then involve changes in the whole matrix, encompassing manufacturing, social phenomena and human behaviour patterns, politics of the society, physical infrastructure and institutional and administrative systems necessary for desired innovations. Discussion of the present situation below, and in the next chapter, reveal that the necessary climate for development of effective technological capability has yet to be created. Lack of space dictates selectiveness of major aspects of software. More details are given in papers presented by two other specialized international agencies.

Institutional, organizational and administrative efficiency

146. Agricultural development is not a mechanical or solely technological undertaking; hence, the factors that impede the assimilation of new technology are lack of knowledge and appreciation of that fact, as well as inadequate institutional and organizational structures. Organizational defects exist either because the form of organization has been imported without modification or created without due consideration of available resources, especially trained manpower and capital.

Education and training

147. The under-utilized agricultural resources of land, unskilled labour, capital and potential capital formation can be exploited only by improved and trained manpower. Skilled manpower is also a key input in the development and operation of institutions for land reform, research, input supply, marketing and credit facilities. In Africa, the severe shortage of trained and experienced manpower may be singled out as the major impediment to the development of agriculture. The present education system has been cited as inadequate and unbalanced. Generally, there is a similarity in the education systems of the countries visited. The present system resembles a pyramid. At the base there is wide and expanding primary education, to be followed by a narrower stratum of middle school education of predominantly academic variety, and finally the narrowest stratum which includes universities that are mainly modelled upon European universities.

148. The tendency in the region is to put more emphasis on academic education at the expense of scientific and vocational education. Humanities dominate in the universities. In the Sudan, the total number of graduates at the higher education level for the period 1977-1981 were 20,399, out of which 16,032 belonged to universities (10,954 humanities and 5,078 science faculties) and 4,637 to technical

colleges. The General Conference on Education in Africa, in 1964, recommended that the ratio of students at technical colleges to universities should be three to one. At present in Sudan the situation has deteriorated further, and the rate is five students in the university to two in technical colleges. Within universities the ratio is four students for humanities to one student in the science faculties. The same is more or less true in other African universities. Technical education particularly relating to agriculture, at all levels, is also neglected. In the Sudan it is reported that only less than 5 per cent of all students enrolled in formal education were receiving vocational, technical or agricultural training. The main reasons for dominance of academic training over the country's requirements for this type of education could be related to poor planning which does not co-ordinate education with economic development and its manpower requirement and to the fact that the financial rewards and employment opportunities for technology trained persons are not commensurate with those in humanities, particularly in administrative jobs. The education system itself has been criticized for being modelled on European education patterns which might not be suitable to Africa, for its regimentation and for the rigidity of its curricula, with orientation towards memorization instead of training students to be independent thinkers, imaginative and creative: those factors are necessary for developing the spirit of scientific inquiry. Owing to unplanned expansion of education, standards have been dropped in many countries as reported by many observers.

Land use, land tenure and farming systems

149. Recent changes in overall land use in Africa have mainly been characterized by the widespread destruction of the tropical forests, and a declining share of forest and grazing land in relation to cultivated land.

150. Since so little is known about the behaviour of tropical soils after their natural forest cover has been removed, the application of modern land use planning technologies is urgently necessary. Cultivation and grazing are being extended to more and more marginal areas, where fragile soils, often on steep slopes, are rapidly being eroded. Crops like maize and upland rice are grown in many dry areas where millet and sorghum would be more appropriate and productive.

151. Shifting cultivation is the most widespread traditional system of land use in tropical Africa, especially in the more humid areas of West Africa. The land is generally cropped for 2 or 3 years, and then left under forest fallow for 8 to 12 years in tropical rain forest, and 15 or more years in drier areas. When practised correctly, shifting cultivation is a soil-conserving system, although a low-yielding one, with limited possibility of raising the productivity of land or labour but one which can be improved without major socio-economic changes. As a result of population growth, the fallow period has been shortened to three to five years in many of the most densely populated areas. Productivity normally declines during the cropping period, and the decrease in yields becomes more pronounced as the fallow period is reduced.

152. Sustained development in agriculture requires substantial changes in the institutional structure, particularly land tenure. Communal ownership of land predominates in rural Africa. Shifting cultivation is still the traditional technique in many parts of the region. It is agreed that though it is wasteful to

keep three quarters of land without cultivation, nevertheless, it is a rational and ecological way of farming abundant and infertile soil. This system is breaking down due to population pressures. Settled agriculture is expanding, and private ownership is emerging in many countries. The population pressure, compounded by alienation of communal lands to large-scale public and private schemes, resulted in changing the land-use cycle to shorter periods of fallow and longer periods of cultivation. This has led not only to lowering yields and soil fertility but also to excessive removal of forests, and excessive grazing, all of which resulted in irrevocable damages to the soil and desertification. The state of technology should have changed in the region with the changes in land use and tenure to maintain productivity of land and the welfare of the people. It is an accepted fact that communal ownership is inimical to introduction of modern technology and agriculture. Nevertheless the emergence and growing private property ownership in Africa would not necessarily lead to adoption of technology, particularly if it has resulted in fragmentation of land with uneconomical units or to renting of land under unfavourable and unfair conditions to the tenant, such as insecurity of land tenure.

153. Mixed cropping (or intercropping) is a main feature of shifting cultivation and of most other traditional African farming systems. It was long regarded as irrational, requiring replacement by single cropping and planting in rows, but more recently its virtues have begun to be recognized again. Its potential technical advantages include nitrogen fixation by legume intercrops, reduction of weeds by intercrops that cover the entire ground surface, the higher densities at which mixtures can be grown, fewer insect and disease problems, and the differences in the heights and ages of mixed crops at maturity, which make possible the exploitation of a limited area of high quality soil with reduced competition between crops. In addition, mixed cropping provides a hedge against crop failure and widens the variety of diets for families with access to little land. To enhance their food security, many African farmers not only plant several different crops in a single plot but also different varieties of the same crop. At the same time, it has certain drawbacks such as low labour productivity, and limited opportunities to use manufactured inputs to raise yields.

154. As population continues to increase, it will become more and more difficult to include a fallow period in the farming system, and wherever possible shifting cultivation will gradually have to be replaced by permanent systems. Many such systems already exist in traditional African agriculture. Although they are mostly highly specialized and location specific, many of them embody technological elements that could be applied in other areas as well.

155. Improved technologies exist for the establishment of permanent farming systems in suitable areas. They are likely to be more successful, however, if they are carefully grafted onto the best elements of the traditional systems, rather than used to replace them completely. The aim of the improved technologies is productive, stable farming systems that not only take advantage of such modern inputs as better varieties, chemical fertilizers, and mechanical equipment to break labour bottle-necks, but also make full use of crop residues for animal feeding, and of crop and animal residue and nitrogen-fixing crops for the maintenance of soil fertility. In some cases, such as swamp rice production, these improved farming systems can also be combined with fish farming.

156. The existing improved technologies also make possible a much closer integration of forestry with crop and livestock production. The Taungya system, already in use in many parts of Africa, offers only a temporary solution, since farming is discontinued after the re-establishment of the forest. Modern agrisilviculture involves the integrated management of land for the production of field crops, livestock and tree crops. The use of fast-growing leguminous tree species is particularly important, not only for the stabilization of shifting cultivation but also for the supply of fuel-wood.

157. In many parts of tropical Africa, perennial export crops, such as cocoa, coffee, oil palm, rubber, sisal and sugarcane, are grown on large-scale plantations. These generally use the most modern technologies available for both production and processing, but in many cases standards (especially of pest and disease control) have fallen in recent years, because of the lack of skilled staff, lack of imported inputs, as well as low export prices. In some countries attempts have been made to use plantations as centres for the diffusion of improved technologies to neighbouring small-scale producers, but little success has been achieved. In other organized smallholds tea and coffee has been successful, including the use of high-level technologies. Large-scale, generally highly mechanized schemes for the production of staple foods or annual export crops like ground-nuts have also often proved failures.

Planning

158. Comprehensive planning which includes technology as an integral part is essential for the adoption of appropriate technologies and the generation of effective indigenous technologies in an economical and organized manner. Few countries in Africa have formulated specific plans for technology. Economic policies should be designed in a manner conducive to technological advancement, and this has been rarely the case in the region. Linkages between and within sectors are not established in a manner conducive to development of appropriate technologies and co-ordination between and within sectors leaves much to be desired. Although in some countries specialized institutions are created to deal with technology, as in the Sudan, with an envisaged transfer of technology unit within the National Research Council, they are yet to be given the authority to co-ordinate and influence decisions at the highest planning level. Since technology shades almost imperceptibly into all economic activities, it is better to locate institutions or departments dealing with technology either with the ministry of planning or the president's or the prime minister's office.

159. In planning for technology, full note should be taken of the importance of incentives. For technological innovations to be accepted and adopted, incentives have to be adequate and appropriately oriented to cope with new situations. Risk and uncertainty should be minimized (or insurance increased) for the farmer-innovator. There must also be a conducive prices/subsidies structure, national tax structure and policy, credit systems and land and agrarian reforms.

Research and extension

160. Research is the most important factor in adapting and adopting transferred technology and for developing effective indigenous technological capability. In Africa, most of the countries have established and strengthened research

institutions, and some of them have reached advanced levels. However, research still suffers from a number of constraints, such as shortage of trained manpower, insufficient equipment and facilities, poor working conditions, lack of incentive to research workers, and lack of co-ordination between research institutions and with policy and planning institutions. Moreover, lack of adequate financial resources is a major contributing factor inhibiting the effective development of research. Research efforts have been concentrated on export and urban consumed crops. Little has been done on traditional crops. However, some international institutions are providing useful assistance and encouragement in research for traditional crops particularly for dry farming areas. The inadequacy of extension services and the prevalence of illiteracy among farmers, coupled with lack of co-ordination and follow-up of research results, have reduced the possibility of development problem-solving research directly related to the farmers' specific needs and requirements.

161. Therefore, it is essential that there be an institutionalized link between research, extension services and farmer requirements, in order to constantly tailor research effort to farming realities and thereby to improve the adoption process by minimizing alienation between research and extension.

IV. THE TECHNOLOGY GAP

162. In an attempt to assess the technology gap, it is useful to consider it as consisting of two parts: the first part of the gap is the extent to which the currently available technology (and sometimes traditional technology as well) is not fully applied; and the second, the extent of the non-introduction or non-use of new and improved or advanced technology. In the main, the former will entail the removal or reduction of the constraints that have so far prevented its more widespread use, while the latter will depend on the capacity and ability of the countries to acquire and absorb the new technology.

163. It is clear that there is still substantial scope for the wider application of existing technology in Africa, both improved technologies and some elements of traditional technologies, provided a number of non-technological constraints can be dealt with. Unfortunately the available information provides only a qualitative picture of the extent to which the existing technologies are already applied, although there is no doubt that this is extremely small in most cases.

164. There is of course no absolute distinction between existing improved technology and the further technological advances required for the future. Apart from exceptional breakthroughs, both are part of the same research continuum, with the latter building on the former. Often what is most required is a new technological package, bringing together a number of existing improvements, or the simplification of such improvements to put them within the reach of poor small farmers.

165. As regards food and agriculture, Africa also trails far behind the developed countries in technological capacity. In Africa, there also exists an enormous gap between available knowledge of improved agricultural technology and actual practice and performance of African agriculture. Agriculture in African countries is

characterized by inadequate use of modern techniques and low productivity of land and labour. This gap in technology is reflected in the differences in yields per hectare between peasant farms and experimental stations. In Burundi, Egypt, Rwanda, Senegal, Sudan, and the United Republic of Cameroon, to name a few, yields obtained on peasant farms average between 30-80 per cent of yields obtained for most crops on agricultural research stations in these countries. This gap is even wider when productivity in Africa is compared to that in the developed countries. As the data below indicate in the case of cereals, the 0.8 ton/ha for Africa is too low compared to the 3.5 ton/ha obtained in Western Europe and North America.

Region	Yields in tons per hectare
Western Europe and North America	3.5
Eastern Europe	3.1
China	2.1
USSR	1.6
Oceania (LDCs), Latin America	1.4-1.7
Africa	0.8

166. Africa's technological backwardness is one of the major explanations of low standards of material living, ill health and inability to control or modify environment factors such as droughts and floods. Traditional technology in use in most African countries generally makes little use of scientific and technological advances, hence it is often less efficient. The capacity to generate home-grown technology is very low, partly because of the inability or unwillingness of many African countries to give it the emphasis needed i.e., formulate appropriate national development policies, including a technology policy which leads to technological self-reliance.

167. In addition to lack of meaningful policies, the African countries' failure to develop indigenous technological ability is also to be explained by the non-existence of effective national institutions to implement and monitor the established policies.

168. One important effect of the technological gap between Africa and the developed countries, where most of the search for new technology takes place is the dependence that has developed. Economically and technologically, Africa has come to depend on the developed countries which not only generate capital and technology but also regulate their flow. This is a subject of the new international economic order which has implications on the rapid rate of industrial growth envisaged by the Lagos Plan of Action 1/ and the Lima Declaration and Plan of Action on Industrial Development and Co-operation (see A/10112, chap. IV). Technological dependence is aggravated by the lack of ability in African countries to select,

acquire, adapt and modify technologies. And in the absence of an indigenous technological capability, the transfer of technology will be ineffective and sometimes harmful.

169. Technology is not static but changes all the time, particularly in the developed countries, and this trend is likely to continue. The technological changes in the developed countries are characterized by the increasing importance of economics of scale, more use of capital in relation to labour at given factor prices and the declining flexibility in the substitution of factors of production e.g., labour for capital. Most technological developments especially in the developed countries are therefore likely to become increasingly inappropriate for the needs of poor countries.

170. Technological dependence involves not only the techniques which have to be transferred from developed countries to least developed countries, but also the capacity to utilize the available knowledge in investment and production. The price a country has to pay for technological dependence includes among others the following:

(a) Cost of importing technology: direct costs (payment of patent rights, licenses, trademarks, technical services etc.);

(b) Loss of control over decisions;

(c) Technology received may be unsuitable - cannot be easily turned or adapted to local requirements;

(d) Contribution to lack of an effective local scientific and technical and innovative capacity.

171. The transfer of technology has however permitted some least developed countries to effectively use this technology without having to go through the process of inventing or developing it, thus somehow enabling them to bridge the technology gap between them and developed countries. However, the advantage which some late-comers have enjoyed in the transfer of technology has not been shared by African countries where the transfer of technology of foreign manufacturing and processing firms has not taken place.

V. REMEDIAL POLICIES, PROGRAMMES AND RECOMMENDATIONS ON MEASURES TO BRIDGE THE TECHNOLOGY GAP

172. An attempt has been made to identify the technological gaps and advance reasons for their existence. It is believed that the following set of recommendations will go a long way in assisting the region and its various countries in alleviating the deteriorating situation in food and agriculture. Each individual country is of course free to determine its priorities and rank these recommendations accordingly. In the implementation of these recommendations it is

felt that special attention should be paid to the formulation of specific projects for the provision of solutions of the pressing problems highlighted in the text in the fields of crop, livestock, fisheries and forestry.

A. At the national level

173. A prime task of African Governments should be to formulate adequate and effective national plans, programmes and policy instruments for the development of science and technology in general and the promotion of their application to the development of food and agriculture, with special emphasis given to monitoring and evaluating. In addition, programmes should be launched for the creation of a satisfactory incentive system, which would stimulate farmers to adapt new improved technology and encourage local production of the necessary agricultural inputs through the establishment of remunerative pricing structure, storage, credit, marketing and transportation facilities.

174. Given the primary importance of agriculture in the economies of African countries, it is imperative that agriculture should be accorded the highest priority and efforts should be made to increase substantially the allocation of national resources to the rural sector in particular and to agriculture in general, in order to generate and disseminate suitable agricultural technology for increasing agricultural production. Fiscal and monetary policies as well as the tax system should be revised in a manner conducive to the development of agriculture. Financial institutions catering for agriculture should be established and/or strengthened.

175. Top priority should also be given to the strengthening and consolidation of existing agricultural research institutions and to the creation and/or strengthening of a mechanism for the effective co-ordination of their activities. Because of the existence, in some cases, of different ecological farming zones within national boundaries, African Governments that have not done so are urged to establish research institutions to address the problems of these zones. In order to minimize or reduce the rate of non-application of available research results, research priorities and programmes oriented to the development of appropriate technology for the use of relevant target groups, in particular women, should not only be determined within the framework of the requirements of the national development plan, but also should take due cognizance of socio-economic conditions, available local inputs and ecology. The primary and productive role of technology recipients should be recognized and extraordinary steps taken to involve him in the design of the technology package.

176. In order to make a significant breakthrough in the development of effective technological capability for agriculture, African Governments should make every effort to devote at least 1 per cent of their gross national product to the development and promotion of science and technology in food and agriculture.

177. Another crucial factor hindering agricultural development in Africa, especially the creation of adequate technological capability, is the severe shortage of trained and experienced manpower at all levels. Measures should

therefore be taken to develop the required skills. In this endeavour, special attention should be paid to first restructuring the education system to produce skilled manpower according to pressing requirements. Emphasis should be given to agricultural training at all levels and to achieving the right balance between academic and technical education.

178. For the collection and dissemination of reliable information on technologies and research results, African Governments are urged to create an adequate mechanism for this purpose and seek help, if necessary, from relevnt international organizations, particular the FAO/CARIS (Current Agricultural Research Information System) assistance programme.

179. Plans and programmes for manufacturing agricultural machinery, tools, and implements should be formulated and implemented. In this endeavour, efforts should be made to link this activity to agriculture, so as to provide required inputs. Special emphasis should be given to the role of the artisan informal sector, which should be up-graded through training and the provision of adequate financial and technical support. In addition, each African Government is strongly urged to give full support to the recommendations of the First Regional Consultation Meeting on the Agricultural Machinery Industry which was held at Addis Ababa from 5 to 9 April 1982 (ID/285).

180. An autonomous unit should be established within government departments of agriculture or any other relevant departments, with the sole objective of co-ordinating and harmonizing policies and programmes on research and technology in agriculture, including transfer of technology and its impact on the development of local technological capabilities, patent system and any other matter pertaining to the application and promotion of appropriate technology in agriculture.

B. At the subregional level

181. In view of the fact that development of technology and related industrialization necessitates economies of scale, and access to assured and large markets currently beyond the capability of individual African countries, co-operation and pooling of efforts are imperative. ECA and OAU should take the lead in strengthening their endeavours to promote subregional co-operation among member countries in all activities relating to agriculture as a logical first step towards regional economic integration. Full support should be given by the international community as well as African national Governments to the ECA MULPOCs and subregional intergovernmental organizations and institutions.

182. Detailed plans/programmes should be prepared by each subregion on areas for co-operation and joint ventures on all fields of agriculture, such as the production and propagation of agricultural inputs, improved seed varieties, machinery, farming implements and equipment, fertilizers, pesticides, irrigation, livestock, fisheries and agro-industries. Financial resources for the approved programmes and projects from internal and external sources should be sought.

183. A network of subregional institutions to co-ordinate activities relating to food and agriculture technology among countries of the subregion should be established. It should take into consideration the varied ecological and climatic conditions of the region. The general objective of the network would be to serve as a resource centre and promote activities relating to development of suitable technology for the subregion, including the formulation of joint projects, collection and dissemination of information, training, research and giving support to national institutions. It should be related to the existing intergovernmental organizations and, if possible, located with a suitable existing intergovernmental body to speed action and save costs.

184. Through the subregional network of institutions, assistance should be provided in dividing research work among national institutions, by assigning to each national research institution a specific area for in-depth investigation in order to increase the effectiveness of research through specialization in order to optimize the use of resources.

C. At the regional level

185. OAU, ECA and FAO should constantly monitor the implementation of the food and agriculture chapter of the Lagos Plan of Action. They should at all times work closely with national governments for this purpose.

186. The African Regional Centre for Technology in Dakar and the Engineering Design and Manufacturing Centre in Ibadan should be strengthened and expanded, with major emphasis given in the work programmes on agriculture and directly related activities. Both should co-ordinate, through periodic meetings and constant exchange of information and experiences, their activities with the recommended subregional centres.

187. A detailed survey should be undertaken on existing agricultural technology, to be followed by the formulation of specific programmes and projects on improvement and development of technology for food and agriculture, and funds for their implementation should be sought.

188. Efforts and activities at the national, subregional, and regional levels should recveive strong support and assistance from the international organizations such as UNDP, UNIDO and FAO in the transfer of technological know-how and the development of indigenous technology for food and agriculture. The International Community (bilateral and multilateral) should be requested to give assistance to all food and agriculture research and related organizations in the region at subregional and regional levels.

189. Relevant United Nations agencies should strengthen co-ordination of their activities relating to technology in agriculture and create mechanisms to ensure continuity and effectiveness of this co-ordination.

190. The United Nations Financing System for Science and Technology for Development should be strengthened with a view to expanding its activities relating to agriculture.

191. Developed countries should increase aid to agriculture and adopt trade policies favourable to agricultural development and the generation of indigenous technologies in Africa and foster techniques suitable to developing countries in general and Africa in particular. Furthermore, the region as a whole, should promote South-North co-operation for strengthening its indigenous technological and autonomous financial capacity.

Notes

1/ Food and Agriculture Organization of the United Nations, Agriculture: Toward 2000 (Rome, FAO, 1981).
