PN-AAY-684

AGRICULTURE AND FOOD PRODUCTION IN TROPICAL AFRICA

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Paper presented at the USAID/ADC Seminar on "Improving the Developmental Effectiveness of Food Aid in Africa", 23rd - 26th August, 1981; at Abidjan Ivory Coast.

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INTRODUCTION

Africa has an area of 30 million km^2 and extends from about latitude 37.5° north to 40° south of the equator. As a result of the major differences in farming systems and level of agricultural development in the subtropical or Mediterranean region in the extreme north and south of the continent this paper is limited to Tropical Africa. Tropical Africa lies between two imaginary lines corresponding to latitudes 20° north and up to 26° south at its widest point. The northern line runs from Cape Blanc on the Atlantic coast of Mauritania to the northern tip of Ethiopia on the Red Sea coast. The southern boundary runs from Mocamedes on the Atlantic coast of Angola southeastwards to the southermost tip of Mozambique on the east coast of Africa including the island of Madagascar. This is a land mass 5,150 km long from north to south and 7,400 km wide from east to west with an area of 22 x $10^6 km^2$ (Kimble, 1962). In area tropical Africa amounts to about 18.3% of the world's surface equivalent to twice the area of the United States. It exhibits great diversity in relief, climate, vegetation, peoples and cultural historical features a review of which constitutes a suitable background to the agricultural systems and food production on the continent.

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Environmental Setting

Physically, tropical Africa consists of a massive plateaux surrounded by a coastal plain of varying width a major proportion of which is undulating lowland ranging in altitude from zero to 600m. To the north and west and rising above 600m are the Guinean highlands, Ahaggar (2918m) and Tibesti (3415m) mountains, Cameroun (4070m) and Adamawa highlands. To the northeast are the Ethiopian highlands (4520m) south of which is the high plateaux of east Africa with its highest points at Mount Kenya (5202m) and Mount Kilmanjaro (5363m), and extending to the Angola plateau to the southwest. Three main river systems which dissect the plateau consist of those flowing into the Atlantic ocean including the Congo (4,700km long) and Niger (4200km), those flowing into the Indian ocean the longest of which is the Zambezi (2700m) and the Nile (6,500km) flowing into the Mediterranean sea. Many of these run down the edge of the plateaux through falls and cataracts thus obstructing navigation. A striking feature of Africa is the Rift valley, a deep trench the eastern arm of which cuts across the Kenya highlands extending to the Ethiopian highlands and the western arm extending from the Luangwa valley through Lake Edwards to the Upper Nile valley. Within the Rift valley are some of the world's largest and deepest lakes (Lake Victoria (83,00km^2) Lake Tanganyika 1,434m deep).

In the tropics, temperatures are uniformly high all the year round and with the exception of highland areas, mean temperatures during the coldest months usually exceed 18°C. Mean annual temperatures range from 20 - 30°C and annual temperatures of above 30°C occur in the desert areas such as the southern parts of the Sahara desert. Annual temperature ranges are low and are often exceeded by the duirnal ranges. Solar radiation varies from about 330 cal/cm^2/day in the rain forest region near the coast to over 580 cal/cm^2/day inland at the desert margins. High relative humidities in excess of 80% occur throughout the

year close to the equator especially in the Congo basin and west coast of Africa. Inland and at higher latitudes the relative humidity varies with the season and may be below 30% during the dry months. Rainfall varies from up to 4000mm in some areas close to the equator to below 100mm in the semi-desert and desert areas of the Sahara and southwestern Angola close to the Namibian desert (Figure 1). On the basis of a comprise among classifications of climate by Trewartha (1968), Hare (1973), Troll (1966), etc. the climates of tropical Africa consist of (i) Tropical rainy climates of the Af tropical wet or perhumid type with almost no dry month and total annual rainfall in excess of 2000mm, (ii) Am humid tropical wet climate with rainfall of 1500 - 2000mm width bimodal rainfall and 9-11+ humid months; (iii) Aw tropical wet moderately humid to subhumid tropical climate and rainfall of 1100 - 1500 mm in 7-9months, (iv) Bsh Dry tropical climate consisting of a subhumid/semi-humid tropical climate with 750-1100mm rainfall in 4½ - 7months and semi-arid climate with rainfall of 500 - 750 mm in 2-4½ months and (v) Bw arid and desert climate with rainfall below 500 mm in less than 2 months of the year. Vegetation zones parallel the climatic zones especially in relation to amount and duration of rainfall as follows:

Climate	Rainfall Duration	Vegetation
1) Rainy climates	9.5 - 12 months	Equatorial or tropical rainforest mostly evergreen dense forest.
2) Humid Seasonal (wet and dry) Humid - subhumid tropics	7-9.5 months	Mixture of evergreen and deciduous forest northern margin derived savanna.
3) Moderately Humid/Semi-Humid Climate	4½ - 7months	Tropical savanna and deciduous trees. Tall grasses Miombo forest and Brachystegia woodland.
4) Dry semi-arid climate	2-4½ months	Thorny shrub; Acacias and short grasses.
5) Arid and Desert	0-2 months	Grass steppe; Thorny scrub and desert with short lived annuals.

Along coastal areas there may be coastal swamp and mangrove vegetation. Highland areas of over 900m altitude have montane vegetation corresponding to vegetation zones encountered progressively at higher latitudes. From the savannah woodland of the plateau through forest and bamboo thickets, lobellias and then grasses below the snow line. It must be noted that there are local variations such as the coastal savanna along the coastal areas of Togo and Ghana, some savanna vegetation within rainforest areas due to some physiographic features and the disturbance of climax vegetation by man through burning, grazing, clearing, farming, etc. resulting in most of the forest areas being converted to secondary bush and derived savanna.

Soils of tropical Africa are in general highly weathered and of low inherent fertility except for young volcanic soils and alluvial soils in river flood plains and valley bottoms. The main soil groups consist of Alfisols, Ultisols, Oxisols, Vertisols, Entisols, Inceptisols, Aridisols and Mollisols (Figure 2). Brief remarks about these are presented in Appendix 1.

Socio-economically speaking countries of tropical Africa exhibit marked similarity in that they (i) gained their independence during the last 25 years, (ii) belong to some of the least developed countries of the world, (iii) have rapidly (2-3% annually) growing populations with over 40% between 0-15 years of age, (iv) suffer from acute shortage of trained manpower at various levels and disciplines, (v) have over 60% of the population engaged in agriculture, (vi) exhibit marked country or regional specialization in agricultural commodities with most of them depending on just one or two commodities and/or minerals for foreign exchange, (vii) have in the past given higher priority to cash or export crop production, improvement, extension and marketing with the neglect of food crops, (vii) are increasingly relying on food imports to satisfy rapidly increasing demand due to

population 'explosion', urbanization, etc.

Despite these similarities the diverse peoples of these countries exhibit marked differences in colonial background and related socio-economic institutions such as religion and economic development, degree of commercialization of agriculture, political institutions, stability and development strategies. The interaction of the various peoples with environment, materials and technology has mainifested itself in diverse agricultural systems reviewed below.

DEVELOPMENT OF AGRICULTURE IN TROPICAL AFRICA

The evidences about the origins of African agriculture in relation to the time, process, materials and resource base are lost in the sands of time as elsewhere. Ideas that now prevail are based on few archaeological, botanical, historical and other evidences for details of which reference should be made to Murdock (1959), Porteres (1962) Clark (1970), Wrigley (1970), Shaw (1972, 1976, and 1977), Purseglove (1976), Harris (1976), Coursey (1967 and 1976) and Okigbo (1978), etc. In piecing together the available evidences of origins of African agriculture, there has been a long standing controversy between proponents of diffusion such as Clark (1970) and Oliver and Fagg (1970) and those of independent origin such as Murdock (1959) and Porteres (1962). It is now, however, generally accepted that African agriculture is the result of several centuries or even thousand of years (at least 4000 years) of evolution by trial and error involving independent ennoblement of several species of African crop plants with some diffusion of ideas and transfer of materials and practices from elsewhere and interactions thereof (Okigbo, 1978). One important idea widely accepted was that advanced by Porteres (1962) who held that Africa developed two agricultural complexes - a <u>seed agricultural complexes</u> characteristic of the savanna and

Involving the cultivation of grains and seed bearing crops in open field systems and a vegecultural complex peculiar to the forest regions and involving the growing of roots, tubers, and cuttings in gardens rather than in fields. Harlan (1971) put forward a theory of centers and noncenters in which he indicated that associated with the middle east or southwestern Asian center of domestication are African centers of plant domestication around Ethiopia and west Africa. According to Harlan, et al (1976) and based on several sources of evidence, 'traditional African agriculture is a mosaic of crops, traditions and techniques which does not reveal a center, a nuclear area or single point of origin'. Thus after thousands of years of hunting and gathering, aspects of which are still practiced today, and about 4000 years ago were domesticated African yams (e.g. Dioscorea rotundata, - white Guinea yam) as the major staple food crop on the forest margins east of the Bandama river in Ivory Coast (Coursey, 1969) and to the west of it, the red rice (Oryza glaberrima) starting from the middle Niger Delta (Porteres, 1962) which is perhaps one of the earliest flood water farming or decrue agriculture in Africa. Notable African domesticates include the following:*

A. VEGECULTURAL ZONE

Root Crops

Dioscorea rotundata	White Guinea yam
D. cayenensis	Yellow Guinea yam
D. praehensillis	Bush or forest yam
D. dumetorum	Butter or cluster yam
D. bulbifera	Aerial yam
Plectranthus esculentus	Hausa or Kafir potato
Solenostemom rotundifolias	Piasa
Sphenostylis stenocarpa	African yambean

Tree Crops

Elaeis guineensis	oil palm
Cola nitida	Gbanja cola
Cola acuminata	Abata cola
Cola lepidota	Ochicha cola
Treculia africana	African breadfruit
Dacryodes edulis	African pear
Irvingia gabonensis	Nature mango

Vegetables, Nuts and Seeds

Abelmoschus esculentus	Okra
Telfairia occidentalis	Fluted pumpkin
Vernonia amygdalina	Bitter leaf
Solanum macrocarpum	African egg plant
Sphenostylis stenocarpa	African yambean
Celosia argentia	Shoko yokoto
Cucumeropsis edulis	White melon
Colocynthes vulgaris	Egusi melon
Ricinus communis	Castor bean
Lagenaria siceraria	Bottle gourd

B. RICE ZONE

Oriza glaberrima	African or red rice
Aframomum melegueta	Molegueta pepper

C. SORGHUM - MILLET ZONE

Cereals

Sorghum bicolor	Guinea corn or sorghum
Digitaria exilis	Fonio or Hungary rice
D. iburua	Black fonio
Pennisetum typhoides	Pearl (candle) millet
Eleusine coracana	Finger millet
Eragrostis teff	Teff

Grain Legumes

Vigna ungiuculata	cowpea
Voandzeia subterranea	Bambara groundnuts
Kerstingiella geocarpa	Kerstings groundnuts
Cajanus cajan	Pigeon pea

Tree Crops

Butyrospermum paradoxum	Shea butter
Parkia fillicoides	Locust bean
P. clappertomiana	" "
Tamarindus indica	Tamarind
Adansonia digitata	Baobab

Vegetables and Miscellaneous Crops

Polygala butyracea	Black benniseed
Sesamum indicum	Sesame
Citrullus vulgaris	Watermelon
Hibiscus subdariffa	Roselle
Ensete ventricosa	Ensete
Cucumis melo	Melon
Catha edulis	Kath

The production of these crops was based on an early slash and burn shifting cultivation system. About the first millenium A.D. came Asian crops with several of them coming through Madagascar island. These included:

Cereals

Triticum spp.	Wheat
Hordeum vulgare	Barley
Oryza sativa	Rice

Root Crops

Colocasia esculent	Dashean, Taro
Dioscorea alata	Water yam
Zingiber officinal	Ginger

Legumes

Pisum sativum	Pea
Cicer arietinum	Chick pea
Lens esculenta	Lentil
Glycine max	Soybean

*Adapted from Harris (1976).

Tree Crops

Citrus spp	Oranges, grapefruits, etc.
Camelia sinensis	Tea
Musa spp.	Banana, plantain
Mangifera indica	Mango
Cocos nucifera	Coconut

Vegetables and Miscellaneous Crops

Solanum melongena	Egg plant
Alluim cepa	Onion
Saccharum officinarum	Sugar cane

Following the discovery of America in 1492, these were introduced later at various times several American crops including:

Cereals

Zea mays	Maize

Legumes

Arachis hypogaea	Groundnut, pea
Phaseolus vulgaris	Common bean
P. lunatus	Lima bean

Root Crops

Manihot esculenta	Cassava
Ipomoea batatas	Sweet potato
Xanthosoma sagittifolium	Tannia
Solanum taberosum	Potato

Tree Crops

Theobroma cacao	Cocoa
Persea americana	Avocado
Anacardium occidentale	Cashew
Carica Papaya	Paw paw, papaya
Psidium guajava	guava

Vegetables and Miscellaneous Crops

Capsicium annum	Chillies
C. frutescens	Sweet pepper
Curcubita spp.	Pumpkins, squash
Ananas comosus	Pine apples
Lycopersicum esculentum	Tomato
Gossypium hirsutum	Upland cotton
G. barbadense	Sea island cotton
Agave sisalana	Sisal.

Many of these exotic (Asian and American) crops were not only cultivated as the related indigenous African crops but were grafted into the existing farming systems. Moreover, it would appear that several of them (Asian yams, cocoyams, plantains) were easily processed and prepared for eating as the indigenous yams and each became adapted to similar ecological zones as in their original homes.

Most of the livestock were domesticated elsewhere or were introduced from north Africa and south-western Asia. These included goats, sheep, chickens, pigs and ducks. Some livestock became adapted to different ecological zones. For example, the humped cattle (*Bos indicus*) of India were mainly adapted to the African savanna and tsetse free areas and European type cattle (*Bos taurus*) was also kept originally in north Africa and now in subtropical and highland areas of the tropics. Only the Ndama and Muturu (African shorthorn) trypano-tolerant cattle were adapted to the forest zones of west Africa. These were poor milk yielders and it is for this reason that livestock rearing and milking was not part of the culture of African peoples in the forest of tropical Africa. Only the Guinea foul is strictly indigenous to tropical Africa.

Changes in Agricultural Systems

The agricultural systems in tropical Africa have not remained strictly traditional and unchanged. Various factors and developments have brought about changes in the agricultural systems of tropical Africa. According to Okigbo and Greenland (1976) these changes arose from:

1) Introduction of Asian crops listed above during the first three centuries A.D. and later introduction of American crops after 1500 A.D. These various crops changed the resource base of the African farmer and no doubt contributed significantly to capabilities for supporting population increases at various times. Associated with these are production, processing and other techniques. There is also no doubt that introduction of exotic crops relegated some indigenous crops to the background and led to our current inability to realise their full potentials because they initially lacked some of the characteristics that have made some introductions more attractive.

2) Population explosion initially resulting from introductions of exotic crops but later more due to advances in science, medicine, sanitation and public health which has resulted in increasing pressures on the land. This has drastically shortened the fallow periods necessary for maintenance of soil fertility and productivity in the shifting cultivation system, and resulted in bush and grass fallow systems and intensive more or less permanent production systems currently in vogue in many areas.

3) European colonization of Africa started with commercialization of wild forest products such as the Guinea pepper and rubber and later oil palms, groundnuts, cotton, etc. The differences in the policies of the various metropolitan and industrial countries of Europe have had far reaching effects on African Agriculture. British colonial policies in East Africa more especially in the Kenya White Highlands and the Rhodesias where there was early interest in establishment of English settlements resulted in a different land acquisition and tenure system that led to development of largescale European type farms producing subtropical or temperate crops mainly for sale. At the same time the natives were either made labourers on the large scale European farms or farmed as peasants in the traditional

farming systems. On the otherhand, in west Africa where the lowland malaria infested areas did not favour European settlement, British policy encouraged smallholder tree and cash crop production rather than plantations. Commercialization of cocoa, oil palms, rubber and groundnuts production did take place based on government support in research and extension and the farmers' initiative in response to the returns from the cash crops which were susceptible to fluctuating world prices. This policy which did not encourage plantations then appeared good, humane, and somehow more 'democratic' but now constitutes a major stumbling block in efforts to increase production since smallholder tree crop plantations are unable to absorb certain inputs that large-scale farms can take full advantage of. For this and other reasons a different policy that encouraged plantations in Malaya has resulted in continuing ability of Malaysia to maintain its place in the world oil palm and rubber production.

French policy of encouraging plantations and cash crop production in west Africa more or less on a 'partnership' basis while to some extent discouraging until recently development of local capabilities in research, managerial and technical competence of Africans has also resulted in continuously increasing production of many cash crops in Ivory Coast and Cameroun. In the latter this policy reinforced an earlier German plantation policy. It should also be borne in mind that it is a policy that has not always been successful where major political changes have taken place such as in Zaire, Angola and Republic of Guinea where the exodus of expatriate technical staff and managers on the eve of independence, limited local management and technical capabilities. Moreover, to some extent, political instability and changes in strategy or ideology has led to disappointing performance of the agricultural sector. There are, however, situations

where African take over of largescale farms, for example in Kenya, has not resulted in similar disappointing consequences.

The general high priority given to cash or export crop production by the colonial powers often to the neglect or disadvantage of the food crop sector is largely responsible for the current food problems that will be considered in more detail later. European colonization generally did result in commercialization of farming and development of an export economy and limited local markets and supporting infrastructure. European colonization did also result in the accelerated growth of urban centers and some commercial production of food crops and horticultural crops in market gardens initially for satisfying demands of European settlements but later for satisfying general demands of high rate of urbanization in Africa which is double is double the world average (Mabogunje, 1976).

4) Development of railways and road systems associated with building of settlements, markets and farms along them has had a lot of influence on farming systems. It has resulted in movement of materials (crops, equipments, techniques) rapidly from one part of Africa or a country to another. It gave strong impetus to the commercialization of agriculture and facilitated movement agricultural and industrial products to and from local and foreign markets and consumers.

5) The expansion of cassava production due to the crop's adaptation to shortening periods of fallow which result in fall in soil fertility in addition to the demand for cheaper staple foods in urban centers (Morgan 1959). Moreover, in areas where dry season ranges from 1 to 4 months cassava is one of the few food crops that can thrive without irrigation. Consequently, cassava has brought about changes in crop combinations and sequences in addition to land use.

6) There are major changes in farming systems being brought about by mechanization, growing of fruits and vegetables for local processing, canning and packaging both to satisfying local requirements and for export. There are commercial farms for production of tomatoes and other vegetables and flowers for export in such countries as Senegal, Ivory Coast, Kenya, Upper Volta, etc.

Finally, recent developments in industry, for example, production of plastics and results of increased pace in agricultural research in both food and non-food crops have resulted in improved crop and animal varieties, new and better techniques and equipment which are bringing about remarkable changes in farming or agricultural systems in different parts of Africa.

REVIEW OF AGRICULTURE AND AGRICULTURAL PRODUCTION SYSTEMS IN TROPICAL AFRICA

A simplistic model of a traditional farm in tropical Africa consists of a pattern of fields at different distances and in different directions from the compound and/or homestead garden (Figure 3). On each of the fields and the homestead garden is practiced different methods of soil management and fertility maintenance usually with fallows, clearance systems, production systems for varying numbers of species of crops and/or livestock according to prevailing practices, customs and needs of the farmer. Thus each traditional farm is a complex of units or subsystems differentiated from others in terms of physico-chemical (soils, water, climate and nutrients), biological (crops, animals, pests), socio-economic (labour, markets, preferences, religion, customs), technological (tools, machines, practices) and managerial (knowledge, decision making process, courage) elements of the production process aimed at satisfying certain objectives of the farmer.

The farm may be an enterprise and means of livelihood of one or more individuals, usually a family unit with only some or all members participating for part or most of the time in farm work. The general features of traditional tropical African farming or agricultural production systems based on Okigbo (1975, 1980 and 1981) and Okigbo and Greenland (1976) are listed below:

1) Farm sizes are small with over 60% of them ranging in size from 0.10 to 3 ha. There are few but increasing numbers of large scale farms in Zambia, Kenya and many other countries in addition to tree crop plantations in countries such as Ivory Coast and Cameroun.

2) Farming is predominantly for subsistence but with increasing and varying degrees of commercialization with the percentage of produce sold for cash, according to Cleave (1974), ranging from 3% for maize in Chiweshe (Rhodesia) to 95% for cocoa in Abeokuta (Ogun State of Nigeria) and percentage of farms under cash crops ranging from 8-85%.

3) Widespread reliance on simple tools and human labour for most of the farm work; minimal mechanization and limited use of animal power in large areas where tsetse flies and trypanosomiasis are endemic.

4) There is widespread use of slash and burn clearance systems of which local variations of this and preplanting cultivations exist.

5) Reliance on fallowing and nutrient cycling by plants for restoration of soil fertility lost after each cropping phase is a common practice. This is an ecologically sound low input practice for extensive agriculture but with increasing population and pressure on the land, the fallow period has become drastically shortened in some areas and is unable to restore soil fertility without fertilizers.

6) With the exception of some cash or export crops, there is very limited use of costly inputs such as fertilizers and pesticides. This is because many of the farmers lack credit or capital for the purchase of inputs and payment

for services.

7) Most farms in tropical Africa suffer from shortage of labor especially during peak periods of clearing, land preparation, planting, weeding and harvesting. Shortage of labor is the result of division of labor among the sexes, most of the children in school unable to assist in farming, low returns to agricultural labor and drudgery in farming encouraging rural/urban migration, sometimes competition with industry in the labor market and change in standards that has resulted in detestation of manual work. The overall result of this is that farming is increasingly left to old men and women.

8) Most farming activities, cropping patterns and systems and some aspects of livestock production are dependent on the prevailing rainfall regime and amount. Irrigated agriculture of traditional or modern types have made limited impact especially in the Sahel where periods of drought spell havoc to man and stock.

9) There is a diversity of farming systems ranging from true shifting cultivation and nomadic herding where settlement is often moved to permanent cultivation and intensive livestock production such as modern poultry production and dairying. True shifting cultivation is now rare but was reported to be restricted to parts of Rhodesia (Zambia and Zimbabwe), Allan (1965), the Ivory Coast and Cameroun or Cameroun/Nigeria border (Morgan, 1969, Grigg, 1974). Nomadic herding is widespread in the semi-arid, Sahel and Sudan savanna areas and adjacent dry regions in west and east Africa. It should be noted that true shifting cultivation where homesteads are moved with farms has probably been replaced by systems involving permanent homesteads and temporary huts on or close to distant farms. It is more correct to say that shorter bush and grass fallows of varying but longer periods of cultivation and different shortened periods of fallow

now exist in tropical Africa.

10) Permanent cultivation occurs in (i) compound farms, kitchen or homestead gardens, (ii) some soils of high fertility, (iii) confined sites on uplands, islands, etc (e.g. steep slopes of Maku in Anambra State of Nigeria where terrace farming is practiced and on islands such as Ukara island in Lake Victoria, (iv) plantation agriculture of the forest zone or irrigated farms as in the Gezira and (v) overcrowded areas of high population densities such as the Ibo and Ibibio areas of Anambra, Cross River and Imo States of Nigeria, the eastern rice growing slopes of Malagasy Republic, Kano close settled zone of northern Nigeria (Morgan 1969) and on desert oases.

11) The compound farm system is the most widespread permanent agricultural system and forms the center from which paths lead to other field systems and other production units and various activities revolve around it. The largest number of crops in mixtures are found in the compound farm. These crops are not only grown for food but also for oils and fats, condiments and spices, drugs, fibers, structural materials, beverages, animal feed, damarcation of boundaries, masticants and stimulants, fuelwood, shade, protection and privacy of the homestead, religious and social functions, ornamentals and various other uses (Table 1). Its development as a regular feature of the traditional farming systems in most areas of Africa and more especially in the non-highly urbanized areas of humid and subhumid zone is related to three phenomena:

(i) Division of labour between the sexes in which the women are responsible for cooking and provision of soups and sauces or supplementary food preparations with which the main starchy staples often produced by men are eaten and for which all year-round availability of fresh vegetables, condiments and spices at close range is necessary and convenient, (ii) the fact

that with frequent clearing of forests and bushes, useful trees often harvested from the wild or protected in fallows are rapidly disappearing and their cultivation in the compound farms ensures that their products are readily available and they do not become extinct or very scarce, and (iii) the use of the compound garden as an experimental area for trying out interesting plants collected from neighboring compounds or during trips further afield (Vermeer, 1977). Soil fertility in the compound garden and on certain systems of permanent cultivation is maintained with household and kitchen refuse, ashes, farm residues, animal pen manure, human waste, compost etc. Annual staples, vegetables and other food plants are grown with perennial trees and shrubs which may each be planted in characteristic locations, patches and complex intercropping patterns of mixtures often in the rainforest area producing a multistorled structure approaching a tropical forest ecosystem.

12) Very often next to the compound garden and periferal to it are 1-2 year short term fallow permanent rotations in which tree crops are cultivated or protected in mixtures with annual staples and other crop plants constituting a less complex agroecosystem than the compound garden.

13) Semi-permenent long or short natural bush, planted bush or grass fallow rotations exist in other field systems with length of fallows depending on population pressure and characterized by (i) length of fallow decreasing with population pressure (ii) number of species of treescrops and vegetables decreasing with staple food crop being more dominant the greater the distance from the compound garden, (iii) heavy pruning of trees and shrubs may be practiced to reduce shade but stumps of varying heights may be used as supports for climbers such as cucurbits and cowpeas, facilitating early regeneration of fallow, reserve fuelwood, etc.

14) Preplanting cultivations may be minimal and planting may be on the flat or involve making of mounds, beds, ridges and holes of various sizes to aid water table and drainage control, concentration of surface soil or organic residues, harvesting, etc.

15) Intercropping of various kinds (row, mixed, patch or relay intercropping) and their sequences is more or less the usual practice in all field systems. Growing of crops in rows is more often associated with animal or tractor cultivation. Growing of crops in pure culture is more often practiced with cash or plantation crops or crops grown in special environments such as rice. Classical rotational sequences of pure crops is not very common except in areas practicing European improved agricultural production systems growing crops in pure culture.

16) In a given location, the most important staples, cash crops, or nitrophiles adapted to rich soils such as maize and yams are usually grown during the first year of the cropping phase after clearing of forest, bush or grassland fallow. The number of crop species usually also decreases with the increase in number of years of cropping before fallow. Crops less sensitive to soil fertility such as cassava are last in the sequence before bush fallow.

17) Traditional African agricultural systems especially in relation to crop production take full advantage of local topographic features, microrelief and related perculiarities such as old home sites, termite mounds, hydromorphic soils and valley bottoms. However, it must be stressed that although sugarcane, fruits and vegetables may be grown in valley bottoms and locations subject to high water table in the savanna and in most areas close to urban centers, a major characteristic of African agriculture is its restriction to upland production systems with the limited use of highly fertile hydromorphic soils as in the rice culture of Asia. Although this

may be due to presence of health hazards such as schistomiasis and simulids, cultural factors are also partly involved.

18) In almost all traditional farming systems varying numbers of small livestock are involved (especially poultry, goats, sheep and pigs) in compound farms and adjacent areas where they may be in free range or restricted during the cropping season. Small livestock may be kept as (i) sources of meat, (ii) thrifty scavengers converting farm, compound and kitchen refuse into meat, (iii) sources of manure for maintainance of soil fertility and suitable levels of soil organic matter, (iv) savings in yielding cash in times of emergency with livestock tenancy as means of spreading risks among relatives (Uchendu 1965). Large animals such as cattle are only kept in large numbers in tse-tse free savanna and semi-arid areas in which nomadic herdsmen such as the Fulani in West Africa and the Mesai in East Africa are found. Settlement of such nomadic herdsmen constitutes a problem in agricultural development. Modern intensive livestock production involving cattle is restricted to favorable locations such as the White Highlands of Kenya and other areas with cooler climate such as Zambia and Zimbabwe. Intensive poultry production close to urban centers is on the increase. But a widespread phenomenon in traditional livestock production is that of keeping of livestock more or less as a status symbol rather than mainly for commercial purposes.

19) In general, it may be concluded that traditional African agriculture is very complex with each farmer often growing many crops and rearing many kinds of livestock, in addition to engaging in several non-farm activities (Figures 4, 5, and 6). Specialization in production is only just beginning and the objective of farming appears to be the production of reasonable levels of a range of products on a sustained basis (i.e. from year to year) at

minimum risk to satisfy subsistence and commercial requirements. The intension of most farmers is not to maximize production of one particular product except where it is grown purposely for cash.

Agricultural Systems in Africa and their Classification

There is at present no generally accepted typology for classification of farming systems of tropical Africa. But, for convenience, an attempt is made here to present a conceptual framework for description and classification of the traditional and transitional farming systems of Africa based on Allan (1965) Miracle (1967), Morgan and Pugh (1969), Morgan (1959 and 1969), Floyd (1969), Boserup (1970), White (1971), Ruthenberg (1971) Benneh (1972), Greenland (1974), Grigg (1974), Okigbo and Greenland (1976) and McDowell and Hildebrand (1980). The classification of farming systems in tropical Africa is presented in Table 2. An enumeration of the main crops and livestock associated with the prevailing farming systems is presented in Table 3.

As a result of lack of adoption of improved technologies for one reason or another or absence of research and lack of progress in solution of problems in some aspects of agricultural production, productivity of traditional farming systems remains low and usually only a small fraction of the potentials observed on the experiment station. This is most pronounced in food crops especially in legumes such as cowpeas.

FOOD PRODUCTION AND NUTRITION IN TROPICAL AFRICA

The farming or agricultural systems in which various food crops in tropical Africa are produced have been reviewed. Of relevance to the topic of our discussion here is the fact that food production in tropical Africa is the preoccupation of millions of small farmers over 90% of who farm less than 5 hectares.

It is also reasonable to estimate that over 90% of the food produced in tropical Africa come from small farmers. This should be borne in mind in considering the performance of the food sector of agriculture and in planning and developing effective programs aimed at finding solutions to African food production problems.

All available figures for the past 20 years indicate that food production has steadily increased but at a very slow pace in almost all African countries. However, the per capita food production appears to be declining in many instances. Consequently, in many countries of tropical Africa, there has been a steady rise in food imports at a time when these countries are confronted with rising energy bills due to unprecedented high cost of petroleum. This situation, in addition to the current world wide inflation, does not augur well for the economic, nutritional and general wellbeing of the peoples and countries of tropical Africa. As newly independent countries, they are pre-occupied with maintenance of peace and stability and building of strong and prosperous nations capable of maintaining their territorial integrity and sovereign status among nations. But with rising food and petroleum import bills, it is impossible for most of these countries to finance educational and manpower development, industrialization, health and general economic development programs. The food situation in Africa at present and in the next two decades is of major concern not only to Africans themselves but also to even the developed countries in this increasingly interdependent world of ours. The situation is brought out more clearly by observations and studies reviewed below.

The FAO in 1980 reported that at least 20 countries mostly African are suffering from acute food shortages. In the same year, 26 African States facing serious food problems requested food aid to supplement their meagre food resources caused by drought, earthquakes, typhoons and war which have during the past decade or so made them dependent on the World Food Programs. Stacey (1981) observed that Africa is the only region of the world where per capita food production has

declined during the last 20 years. He noted that demand for food imports have soared at a time when foreign exchange and heavy debts are severely limiting commercial import possibilities for most African nations. Even an OPEC country such as Nigeria has been suffering the heavy burden of rising food imports. In response to this Nigeria has during the last 10 years launched the National Accelerated Production Program (NAFPP), the Operation Feed the Nation (OFN) and now the Green Revolution program all aimed at making the country self-sufficient in food production and regaining her leading position in production of cocoa, oil palm produce, groundnuts, etc. Similar programs have been launched by Ghana, Liberia and several other countries. Yet there is no indication that effective solution to the problem is in the offing.

Status of Food Production in Sub-Saharan Africa

A recent IFPRI study of the food situation in 40 Sub-Saharan African countries has highlighted various aspects of the problem based on analysis of production and consumption figures from the 1961-1965 to the 1973-1977 periods with projections to 1985 and 2000. World production of major staple foodcrops in 1977 was about 1,700 million tons in addition to about 600 million tons of livestock and poultry products (Table 4). The 1,700 million tons of dood crops consisted of cereals 1,476 million tons and noncereal staples 210 million tons while the 600 million tons of animal products was made up of meat 128 million tons, milk 449 million tons and eggs 25 million tons (Table 4). In 1977 developing countries of the world with about 75% of the world's population produced only 48% cereals and 72% noncereals. The same countries accounted for 35% of the world's meat, production, 22% of milk, and 33% of eggs. Among developing countries, Sub-Saharan Africa with 7% of the world's population produced 3% of the cereals, 15% of the noncereals, 2% each of the meat and eggs and 1% of the milk.

Details of Sub-Saharan Africa's food production and consumption in 1977 are presented in Table 5. Of the major staples in Sub-Saharan Africa, cereals accounted for 53%, root crops 31%, grain legumes 6%, groundnuts 5.2% and 5% for bananas and plantains. Of the cereals, sorghum and millets most of which are presently produced in the Sahel which is subject to periodic droughts accounted for about 23% and maize 20% with rice 5.2%, wheat 1.6% and others 3.7%. Wheat and rice constituted major items in the food import bill of most countries of the region. Consumption figures indicate that the region had serious shortfalls in the cereal component of staple foods amounting to 72% for wheat and 29% for rice, of the total domestic requirements. Deficits in other cereals ranged from 5 to 7% of consumption with the overall cereal production amounting to 6.1 million tons or about 14% of the domestic cereal needs in 1977. Small deficits were observed in root and tuber crops and grain legumes but the region was more or less self-sufficient in the noncereal crops as a result of small surpluses of bananas, plantains and groundnuts. On the basis of the total domestic food utilization, total consumption amounted to 58% cereals, and 42% noncereals with maize, millet, sorghum and root crops amounting to 70% of the requirements. Thus Africa depends on several starchy staples other than rice which is the main staple in most of Asia.

Of the meat consumed, beef amounted to 65%, sheep and goats accounted for 21%, poultry 15.4% and pigs 8.4%. There was a balance between meat and eggs produced with those consumed while there was a deficit of milk in which 5.8 million tons was produced and 7.4 million tons consumed. Milk was mainly from cows (81.7%) and goats (19.4%) and eggs came mainly from chickens (98.6%). The source of milk produced varied in different countries. Thus in Nigeria, Malagasy, Uganda and Zimbabwe cow's milk was the bulk of the milk while in Somalia goat milk amounted to 35-40% and camel milk 30% of the total milk production.

The rate of increase in the production of major staples was 1.6% in 1961 - 1977, about 1% lower than population growth. A detailed analysis of the data indicated that only kenya with 3.6% population growth rate and 5% annual food growth rate and Zaire with food increase rate of 2.7 and population growth rate of 2.3% recorded annual growth rates in food production higher than the population growth rate. Output of food crops in 1961-1977 in the Sahel amounted to a very slow growth rate of 0.1% which was attributed to overall effect of slight increase in noncereal component output in offsetting the declining trend in cereal production. About 80% in the growth of production of food crops resulted from expansion of area under cultivation both for cereals and noncereals. This regional pattern was reflected in varying degrees by individual countries. Extreme weather variations occurred during the period caused marked fluctuations which magnified food problems in the region since most of the commodities are produced under rainfed conditions and are dependent on the weather. Most serious fluctuations were observed in the Sahel, Malagasy Republic, Tanzania and Zaire.

Total consumption of major staple food crops in Sub-Saharan Africa between 1961/65 and 1973/77 increased at an annual rate of 2.3% (Table 6). This was 0.4% lower than the estimated population growth rate in the region indicating a decline in domestic use of these commodities. While consumption of food crops increased faster than population growth in Ghana, Malagasy, and Zaire, and just kept ahead of population growth in Uganda and Tanzania, it lagged behind in Ethiopia, Kenya, Nigeria and the Sahelian countries by 1%. In general, average rate of growth of cereal consumption was high in such countries as Zaire (5.3%) and Ghana (4.9%). Growth in consumption of noncereals was sustained where domestic use of food crops fell below population growth except in Kenya. The amount of major food crops utilized for direct human consumption increased by 2.6%, animal feed by 2.9% and for other uses by 1.1%. Growth in the utilization of

food crops for animal feed was related to the rate of growth in poultry development. Meat consumption increased annually by 2.1% as compared to 2% for milk and e.5% for eggs. Thus meat and milk consumption lagged behind population growth while that of eggs increased faster than population. Pork and poultry consumption outpaced the rate of population growth. Cow milk consumption increased fastest or was highest in Nigeria with 13% as the highest in the region.

Food Trade

During 1961-1965 and 1973-1977, the Sub-Saharan region changed from the status of a minor exporter of food crops to that of a major importer (Table 7). Exports of food crops consisting mainly of groundnuts decreased by 56% and imports consisting mainly of cereals increased by 122%. Average yearly net imports of the region in 1973-77 amounted to 3.5 million metric tons equivalent to about 5% of the average yearly consumption in the period. Only Ethiopia and Kenya retained their trade positions among major food crop producers and exporters in the region which also included Nigeria and Malagasy Republic. The situation in Nigeria involved the most drastic change from a largely agricultural country to one depending mainly on petroleum exports. During 1961-1965 Nigeria was the largest exporter of various food commodities (groundnuts, oil palm product, cocoa), but in 1973-1977 Nigeria's position was reversed to that of the largest importer (Table 8). This is the result of slow growth in domestic food production and rapid growth in incomes. The self-sufficiency ratios indicate decline in 1973/77 as compared to 1961/65 - this being most pronounced in milk as compared to meat and eggs, the appropriate balance of which was maintained. Meat exports rose 14% between 1961/65 and 1973/77 but imports rose by about half as much. Meat exports exceeded imports by 3% of production with exports from Ethiopia, Kenya, Malagasy, Zimbabwe and the Sahel countries. Nigeria was the largest meat importer.

Sub-Saharan milk exports between 1961/65 and 1973/77 rose about 60% while imports increased by more than 150 percent. Total Sub-Saharan net milk imports rose by 9% of the milk consumption in the early 1960's to about 18% by the mid 1970s. Most Sub-Saharan countries are net milk importers with the largest amount going to Nigeria. Milk imports dropped in Kenya, Malagasy and Zimbabwe between 1961/65 and 1973/77 but Kenya remained the only net milk exporter of some importance. Eggs are not much traded across wide distances without refrigeration but most Sub-Saharan countries exhibited defacto self-sufficiency.

Nutritional Implications of Decline in Food Production in Tropical Africa

All available data so far indicate that rate of increase in food production in Tropical Africa is too slow to meet the demand for food resulting from rapid population growth. Per caput food supplies is actually on the decline. The situation is really more serious because of the fact that for the amount of food produced to satisfy all demands, it is not just enough to produce more for the increasing population but also for meeting the demands due to rising incomes, animal feed requirements, trade and industrial requirements, etc. Nigeria, for example, was the world's leading exporter of palm oil which is used as cooking oil by a large segment of the population of 80 million people. There is no evidence that the total amount of palm oil produced annually has actually declined but Nigeria is now a net importer due probably to its inability to produce enough palm oil to satisfy the cooking oil requirements of over 50 million people, satisfy the industrial and other demands including the manufacture of soaps, candles, margarine and tin smelting. Even the average national food requirement figures used to determine how far available food supplies can ensure that the population of a country is well fed and make projections about future requirements fail to give us a good idea about the nutritional status of the population in

addition to not taking into account all demands to be satisfied. Most of the evaluation of national food self-sufficiency and projections on future food requirements are based on estimates of average per caput food supplies in relation to national average requirements. These values in addition to food balance sheets also based on global figures do not always reflect the extent of malnutrition that exists in the population. This is necessary if meaningful projections on future food requirements and the magnitude of the food production problem can be realised. Malnutrition results when (a) one does not get enough food in which case he is undernourished, (b) the diet lacks one essential nutrient or more causing deficiency diseases, (c) one has a condition or illness of genetic or environmental origin preventing him from digesting or properly absorbing some constituents, and (d) one takes too many calories or consumes an excess of one component or more and suffers from overnutrition (Mayer, 1976).
Mazumdar (1980) observed that available data provide strong evidence that some degree of undernutrition exists even when average available per caput food supplies are in excess of calculated national average requirements. Usually, variations in income levels coupled with inadequate distribution and storage facilities result in inequalities in the amount of dood taken by different segments of the population of a given country. Thus while a significant proportion of a country's population are rich enough to purchase and consume food that makes them suffer from overnutrition, there is also a large segment that is unable to obtain enough of the food that is available and as a result suffers from under-nutrition.

FAO's approach to the problem of arriving at a good estimate of future food requirements in its Fourth World Food Survey (Mazumdar, 1980) and also arriving at reasonable estimates of the extent of undernutrition involves (i) establishment of a critical per caput daily food intake and (ii) establishment of a relationship between proportion of food requirement available and the extend of undernutrition.

Firstly, the critical food intake is taken to be 1.2 times the basic metabolic rate (BMR). Food intake below 1.2 BMR is regarded as insufficient for a normal healthy life and such underfed individuals will manifest various types of malnutrition related to certain deficiencies in the diet depending on age, sex, activities and environment. When this approach was applied to 46 African states, it was found that the average available per caput daily food supplies amounted only to 2110 calories or 90% of the required 2336 calories equivalent calculated on basis of the critical 1.2 BMR. By analysis of data from 25 States of the African region where reasonable amount of relevant statistics were availabe, it was found that the proportion of underfed ranged from 8% in Ivory Coast and Morocco to 50% or more for such countries as Mali, Chad, and Mauritania. Secondly, based on an almost linear relationship that was established between food availability as percentage of requirement and the proportion of the underfed in the population (Figure 7). It was found that for each 3% increase in the proportion of available food supplies as percentage of requirement, there was a 4% decrease in the proportion of the underfed. The linear relationship was found to hold true until the point is reached where food availability is equal to requirement. Above this point the ratio of availability to requirement has to increase more per unit of decrease in proposition of underfed. But study of data from Ivory Coast and Latin America (Mazumdar, 1980) indicate that a small proportion of the population remains underfed even when average food availability is considerably in excess of requirements. Using Figure 7 to arrive at estimates of underfed people in 21 countries that lack relevant data, it was estimated that for the base year 1972 - 74, about 100 million or 32% of the population of the African region was underfed.

Projections of Future Food Requirements and Need for a Regional Food Policy

With information on the proportion of underfed population in each African country, it was possible to quantify the food deficit of a country for a given period of time. With such data for all African countries, it is possible to arrive at a regional policy framework and then within it individual national frameworks can be established. Mazumdar (1980) used the FAO food survey data to establish an African regional policy framework which holds that 'in no African country shall the proportion of underfed population exceed 25% by the year 1985. With the 1972-74 data, it was found that there were 23 countries out of the 46 countries in the Africa region where proportion of underfed population exceeded 25% and that these countries accounted for about 75% of the regions population. Also it was observed that these 23 countries had 87% of the regions underfed population with average per caput daily food supplies as compared to 2392 calories for the reamining countries. The proportion of underfed in the same 23 countries was estimated at 37% as compared to less than 16% for the other countries. Moreover, the estimated average per caput food availability for the 23 countries amounted to only 85% of the requirements as compared to 3% above requirement for the other countries.

A meaningful regional policy similar to that stated above may be aimed at reducing the proportion of the underfed population in the 23 nutritionally worse off countries from 32% in 1972 - 74 to less than 22% in 1985 with the remaining countries continuing to improve their food situation.
Reference to Figure 7 shows that the reduction of a country's underfed population to 25% would result in increasing the per caput availability to over 95% of requirements. If the regional framework is specifically 'to ensure that 1985 In no African country shall the per caput national food availability be less than 95% of its requirements, it would be possible to arrive at projections of future food requirements for each country. Calculations reported by Mazumdar (1980)

indicate that food increases projected under this policy will on the basis of the 1972-74 figures vary from 5% or less for Kenya, Rwanda, Sao Tome and Principe to over 25% for Chad, Mali and Upper Volta. It is, therefore, necessary for any such regional policies to take into account the varying populations and prevailing socio-economic conditions on the different countries. Above all there must be political will for closer economic integration and for United action for the common good as exists today between ECOWAS countries. With the greater interdependence among countries and the recognition that no 'single country can prosper alone unless the basic needs of the populations of all other countries in the region are met' the above regional policy may be able to work.

Again, with the 1972-74 data, it is not only possible to calculate the additional food availability for each country between 1972-74 and 1985 but also the contributions of each commodity or group of commodities such as cereals and roots and tubers (Table 9). Also with the available information on food imports for the same period, it is possible to calculate the contributions to the per caput daily food availability of domestic production andimports (Table 10). Assuming that within the short period from 1974 to 1985 very little changes in consumption of cereals relative to root crops will occur, calculations of extra amounts of calories from the various commodities can be calculated taking into account the population growth rates of each country. The annual production growth rates and cummulative import figures required to meet the targets set by the above policy can then be calculated on the basis of calorie equivalents. It would also be necessary to determine the contributions that are likely to be made not only from cereals and roots and tubers alone but also from fruits, nuts, vegetables, oils, fats, etc. relative to the anticipated growth rates. Shortfalls in one should be duely made up from production or supplies from others. Allowance should also be made for the relative roles of imports as determined by policy, likely stock changes, animal feed and seed requirements, manufacturing industry

requirements, wastes, etc. (Mazumdar 1980). With respect to imports it is necessary for each country to determine what the relative contributions of domestic production and imports should be. This should be based realistically on existing socio-economic conditions. An agricultural country in the tropics which produces mainly roots and tubers but imports most of its calorie requirements as wheat would be foolish to plan to be self-sufficient through producing both wheat (which may be uneconomical) and roots and tubers. It should plan how to obtain foreign exchange to buy wheat and may be also how to reduce wheat imports by utilizing easily produced starchy cereals and root crops to replace wheat in the preparation of fortified bread. This satisfies the objective for importing wheat to be used for bread. Mazumdar (1980) projected required growth rates for selected African countries based on the following alternatives.

i) Both domestic production and imports grow at the same annual rate in terms of energy value of food. In 1985 the relative proportions of the energy value of average food supply derived from domestic production and from imports remain the same as during base period 1972-74.

ii) Per caput daily energy value derived from imported foods in 1985 remains the same as during the base period 1972-74, i.e. food imports in terms of energy value grow at the same rate as populations and the remainder of food requirement is met through higher domestic production.

iii) Energy value derived from domestically produced food in 1985 on a per caput basis remains the same as during base period 1972-74, i.e. per caput food production in 1985 remains equal to that of 1972-74, the remainder of food requirements being met through greater imports.

iv) Half of the energy value of incremental food requirement in 1985 is met through domestic production and half through imports.

v) In 1985 there is no food import and the entire amount of food requirements is met through domestic production alone.

Projections based on alternatives, i, ii and v are shown in Table 11 It was observed that in 1972-74 only 69% of the root and tuber crops produced in Nigeria were consumed. Consequently, irrespective of what happened to the remaining 31% the amount of root and tubers that is targeted to be produced by Nigeria in 1985 must give due allowance to this by ensuring that higher production figures are needed than the target and this should at least be 31% higher than the target figure. It should be noted that the annual growth rates called for in the three alternative policy frameworks are very high in relation to current annual growth rates of 1-2% and especially for alternative v. Nigeria's current Green Revolution program calls for self-sufficiency in major food crops and livestock products by 1985. This amounts to an annual production growth rates of about 6% for food crops and 11% for livestock. This calls for unprecedented efforts in production, management and financial investments in agriculture.

Factors of Practical Relevance in Determining Production Targets Based on Nutritional Considerations

In setting production targets for the African region, there are various factors that should be taken into account in addition to manufacturing industry and seed requirements, animal feed, etc. which have already been mentioned. Firstly, the very high rate of urbanization in tropical Africa which is about twice the world average, the increased mobility in both rural and urban areas and the changing roles and status of women has resulted in the unprecendented demand for convenience foods. Added to these factors is the high cost of fuel for cooking in urban areas at a time when fuelwood is not only inconvenient but also increasing in scarcity. It is, therefore, very likely that the 69% of roots and tubers consumed in Nigeria is related to the low elasticity of demand for these crops with rising incomes. Moreover, these are commodities which are not convenient to transport and require a lot of preparation before consumption. Consequently,

increased production of root and tuber crops and in fact many indigenous food crops must be associated with increased processing capabilities if their demand is to be enhanced. It is also falacious to assume that fast change in tastes and food preferences is not taking place in Africa. The high imports of rice and wheat is very closely related to demand for convenience foods.

It should also be borne in mind that the most effective way of solving the problem of malnutrition is to produce enough foodstuffs on a continuing basis or where this capacity is lacking earning enough money to eliminate poverty and buy enough food (Alschul, 1969). In addition to level of production and income, other factors which affect nutritional status include farming systems, local preferences and taboos, religious beliefs, education and ignorance about nutrition, ecological conditions (soils, climate, vegetation, and socio-economic factors including level of food technology, food industry, economic progress, urbanization, local customs, transportation, roads, level of affluence, biological factors such as in-born errors of metabolism, parasites, etc. (Okigbo, 1978). A consideration of these factors is important not only in predicting possible future changes in food requirements but in the selection of priorities and strategies for funding effective solutions to the food problem in Africa.

PROBLEMS AND POTENTIALS FOR INCREASING FOOD PRODUCTION IN AFRICA

There are several options for increasing food production. These include (i) expansion of area under cultivation, (ii) increasing the quantity and quality of what is produced per unit area, (iii) mechanization and/or appropriate technology, (iv) improved post harvest handling, transportation, storage and processing, (v) more food from livestock or farm animals, (iv) more food from ponds, rivers, streams, lakes, seas and oceans; (vii) more food from forests, (viii) non-conventional sources of food (Okigbo, 1978).

Expansion of area under Cultivation

This is currently the main approach for increasing food production in Africa. It has been observed earlier that over 80% of the increased food production in Africa is achieved through this method. Cultivated land in Africa is just 0.48ha per capita as compared to potential 1.71 ha per capita. Comparable figures for Australia and New Zealand are 1 ha and 3.57 ha; Asia 0.21 and 0.28; South America 0.43 ha and 1.79 ha, North America 0.75 and 1.31 ha. There is still a high potential for increasing area under cultivation in Africa but there is also acute shortage of labour for clearing. This and interest in the introduction of highly mechanized largescale farming systems of the temperate countries into the tropics calls for increased mechanization of clearing and land development of highly fragile soils. More research is required in this area since large-scale mechanized farms have been very disappointing the tropics. Research is also needed in post clearance management systems including measures to control erosion such as zero tillage and residue management. Of high potential in this regard is the development of fertile hydromorphic valley bottom soils amounting to about 1 million ha in tropical Africa, provided that the high cost of development and attendant disease (e.g. schistomiasis) problems are effectively tackled. Irrigation could be used in increasing area under cultivation especially in semi-arid areas. But potentials for this are higher in Africa than in Asia where although land area suitable for irrigation is larger more of the Asian potential has been utilized (Table 12).

Increasing quantity and quality of Production per Unit Area

This calls for use of improved crop varieties, improved soil management and conservation practices, use of fertilizers and soil conditioners, more efficient use of water, timely use of cultural practices, multiple cropping and more intensive cropping systems, reduction of losses by weeds, pests and diseases.

For small farmers who lack credit, plant improvement which results in higher yield, disease and pest resistant varieties adapted to environmental stresses are required to minimize cost of fertilizers and pesticides. More efficient use of fertilizers and increased reliance on biological nitrogen fixation and biological nutrient cycling processes hold some promise. The development of continuous production systems with sustained yields remains more or less intractable in the humid and subhumid tropics where fallows tie up land and could be released if cultivation can be safely made more continuous by shortening fallows. For small farmers, multiple cropping and various aspects of intercropping once regarded primitive are imperative. Specialization in agriculture may also be used to increase production per unit area by growing crops only where they are best adapted. In this regard, African agricultural production is not yet as intensified as that of Asia (see Table 12).

Mechanization and/or Appropriate Technology

This has high potential in increasing yields especially since shortage of labor and the rural urban migration among the youth make it imperative to reduce drudgery in farming. Potentials of this method are not yet being realized because mechanization of tropical food crops is still in its infancy. Development of appropriate technologies that are within the means of small farmers to own, hire, use and repair and relevant to their needs while socially acceptable holds much promise at this transition stage when tractorization even where possible may not be economically biable. With respect to mechanization and use of intensive labor devices, Asia is far ahead of Africa (see Table 13 in Appendix II). At present only partial mechanization is possible in the production of most food crops in Africa with the most likely operations to be mechanized being limited to clearing and tillage.

Improved Postharvest Handling, Transportation, Storage and Processing

Post harvest losses range from 1-60% for cereals, and 1-100% for perishables. Consequently, minimization of these losses could considerably reduce overall losses and increase available food supplies. Moreover, as indicated above, processing can enhance the utilization of some foodstuffs by urban masses if it renders them into convenience forms. Processing and storage minimize the inequalities in seasonal availability of many foodstuffs which are usually seasonal. Processing also enhances distribution, transportation and marketing. Asia is ahead of Africa in this regard.

More Food from Livestock

This can be achieved through genetic improvement, improved nutrition, improvement of forage and pasture plants and their management, increased production of feed at reduced cost, improved range management, control of parasites and diseases, improved housing and improved processing of animal products.

More Food from Ponds, Rivers, Seas, Oceans

This has hardly been explored except by primitive fishing methods. At present, many countries such as Japan and USSR harvest most of the fish from oceans and seas around Africa. Control of pollution and improved processing hold much promise. Much research is still required in this area to enhance realization of potentials of fisheries and aquaculture in Africa.

More Food from Forests

Hunting and gathering is still used to augument cultivated food crop and livestock products. But potentials are limited by rapid population growth and rapid deforestation. With good management game ranching in some areas of East Africa hold some promise. Otherwise good wild life management in countries such as Kenya, constitutes a good source of foreign exchange to support some food

imports. Many African useful and edible plants are still wild or protected. These need to be brought into cultivation. Efforts should be made in agroforestry research to minimize competition between agriculture and forestry. Improved agroforestry systems can enhance availability of fuelwood, the shortage of which may constitute a major future crisis since 85% or more of the timber harvested in most African countries are still used for fuelwood.

Nonconventional Sources

Most of these non-conventional sources of food such as synthetic foods do not at present appear economically viable. Research on single cell protein is still a long way off for economic utilization in developing countries. Leaf protein and other non-conventional products are only useful in times of war or other disasters and even then in a very limited way.

Constraints to increased Agricultural Production in Africa

Several physical (climatic and soil), biological and socio-economic constraints bedevil agricultural production by traditional farmers in Africa. Details of these are presented in Appendix III. The only way to minimize these or bring them where possible under increasing control especially in relation to the physical and biological ones is through research on food crop production which in the tropics has received relatively lower priority as compared to cash or export crops.

Research to improve cropping systems in tropical Africa needs to be farming systems oriented if it is to be more relevant to the needs and situations of small farmers than has hitherto been the case. There is also need for ensuring that attention is given to some aspects of largescale agricultural production in which many African governments are interested despite the location specificity of

agricultural production and ineffectiness of horizontal transfer of most technologies developed in temperate countries. Afterall both largescale and small scale food production systems are complementary and one should not replace the other.

The farming systems research approach requires team work and interdisciplinary interaction. This is because, firstly, it usually calls for upstream research in which the farmers environment, existing farming systems, input/output relations, and constraints to improved productivity are studied as a basis for determining priorities in research and establishing strategies for development of improved technology. Secondly, it calls for on station research by which alternative production systems are developed forimproved crops and livestock based on understanding of existing systems and its constraints in addition to possible future trends. A few relevant production systems and their components are tested and evaluated first at the main research station and then at stations in selected ecological or benchmark zones. Thirdly, through the downstream research component, proven technologies are then tested and evaluated at the farm level under farmer's control. By monitoring the adoption process and changes taking place in existing farming systems, effective feedback is enhanced in on station research in designing, modifying and development of new technology. This approach facilitates development of packages of new technology rather than individual disjointed and sometimes irrelevant components.

The major problem to adoption of this approach in many developing countries in Africa include of (1) shortage of manpower at all levels in research and in most disciplines (2) interdisciplinary research team work by staff who are disciplinarily trained, and (3) vital role of socio-economic research input which In the past was neglected or not regarded as necessary. There is also need for more basic research support for farming systems research than was recognised

in the past. This could be accomplished by cooperation with universities to an extent more than is the norm in many African countries. The existence of many IARC's such as IITA and IRRI where training in farming systems research and production can be given has somehow improved the chances of strengthening national capabilities in cropping systems research.

Apart from the above constraints to increased food crops and agricultural production in tropical Africa, there are still some issues that need more attention in solving the food problem. One important aspect is that of current research not effectively identifying relevant components of existing farming systems as targets for special research effort. The compound farm system, if considered a target for research, highlights the need for greater integration of crop production and livestock (small animals in humid areas and large ones in tse-tse free drier areas) in research on mixed farming with its potential for maintaining soil fertility while producing several commodities. Sometimes it also involves the use of animals for work. For more information about this reference should be made to McDowell and Hildebrand (1980). There is also need in the humid tropics for more reasonable balance to be struck between tree crops and cash crops on the one hand and food crops on the other. High priority needs to be given to the current energy crisis and the concern about environment in the development of new technologies for sustained yields in the tropics. The greater erosion hazard that tropical soils are subjected to under continuous cultivation also calls for greater interest in integrated watershed development in the integration of technologies for rural development projects. All these not only call for changes in research policy and strategy but also for reorientation of directors of research institutes and research program leaders in developing countries of Africa.

Finally, there is also the need to recognise the importance of political commitment in agricultural research and development to achieve which there is need for greater and more effective communication between research scientists and political policy makers. It should also be realized that rapid agricultural development can be achieved if what Mosher (1970) designated as essential factors and accelerators of agricultural development are given due consideration in the agricultural and rural development programs. The five essential factors consist of (i) effective marketing system for agricultural produce, (ii) continuous and systematic research effective in generating new agricultural technology, (iii) presence of adequate incentives for farmers to increase their output or for operators of agricultural services to perform their tasks efficiently, (iv) presence, maintenance and operation of an effective transportation and communication system, that reaches most farms, and (v) local availability through manufacturing or importation of equipment and farm inputs required by farmers at reasonable prices.

The effectiveness of the above essential factors are accelerated by (i) presence of adequate educational and training facilities for the production of agricultural technicians and exports for all supporting services, (ii) availability of production inputs, (iii) organization to enhance group action by farmers through cooperatives, social organization, etc. or in the African situation assists in giving farmers more 'political voice', and freedom from clutches of middemen (iv) means for improving and expanding agricultural land (i.e. suitable land tenure system), (v) mechanism for planning and directing agricultural development programs as integral component of overall economic development. This section is incomplete without emphasizing that unless bilateral and multilateral foreign assistance programs give the highest priority to assisting African countries develop cababilities for rapid achievement of meaningful economically sound and culturally acceptable self-sufficiency in food and agricultural production, chances of solving the current food problems are minimal.

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APPENDIX I

MAIN SOIL GROUPS FOUND IN AFRICA

i) Alfisols formed in well drained upland situations, with coarse or medium textured surface layer and base saturation of over 50% - found mainly in savanna and forest/savanna transition zones of west Africa and East and Central African highlands on which large scale mechanized farms are located.

ii) Ultisols which are morphologically similar to Alfisols but with bare saturation of the B horizon below 50% hence more acid and leached than Alfisols - dominant soils in Liberia, Sierra Leone, Eastern Cameroun, Central Angola, southeastern Nigeria and Ivory Coast.

iii) Oxisols which are strongly weathered soils without much variation with depth. Oxisols with basaltic rocks constitute soils of major agricultural importance in East and Central African highlands and in a few scattered areas in west Africa.

iv) Vertisols the so called black cotton soils, consist of dark coloured cracking clay soils rich in swelling clays and difficult to work when wet- occurs in alluvial plains in the Lake Chad area, Accra plains, savanna areas of East Africa.

v) Entisols and Inceptisols are young soils alluvial and colluvial origin in valley bottom situations.

vi) Aridisols formed in arid areas with horizon differentiation and accumulation of calcium carbonate, gypsum or salt, and deep dark soils of high base status; and

vii) Mollisols which are very rich in organic matter (Figure 2).

APPENDIX II

COMMENTS ON STATEMENTS ON AGRICULTURAL DEVELOPMENT IN ASIA AND AFRICA

(Some Differences that Affect Food Aid and Food Policy)

1) Statement essentially correct. Agricultural development in many parts of Asia is more advanced than in Africa generally although, there are such areas as parts of New Guinea, among the Tasaday (stone age tribe of 28) in rain forest area of Mundanao Island and parts of Thailand under shifting cultivation where agriculture is as traditional and outmoded or more so than in many parts of tropical Africa. Asia has utilized more of its land and agricultural potentials more than Africa. The Asian wet-rice production system is one of the most efficient production systems of continous (permanent) agriculture in the world. It is of widespread use in Asia and it is of limited use in Africa. Africa specializes in upland agricultural production systems but as yet, with the exception of a limited extent on the homestead garden system, no widespread system of permanent agriculture for sustained yields has been developed in Africa.

The intensification of agricultural production has been more accomplished in Asia than in Africa (see Table 12). Irrigation is more important in Asia which has utilized not only more land under irrigated crops but also higher proportion of the potential irrigable land than Africa. With the very high population density already attained in Asia and associated socio-economic pressures, labor intensive technology is more widely used and is more culturally acceptable than in Africa as shown below:

Table 13. Sources of Energy for Agriculture Billions Manday Equivalents

Energy Source	Africa	Asia	Latin America	Near East
Human Labor	12.8	38.6	6.6	5.1
Draught Animals	2.5	20.5	2.9	2.0
Mechanical	0.5	1.5	2.2	1.0
Totals	15.8	60.6	11.7	8.1

More knowledge is definitely required to improve African agriculture. This calls for high priority in manpower development and research to develop technologies that minimize drudgery and are culturally acceptable in Africa which lags behind Asia where already surplus manpower is being exported and there are several strong national agricultural research institutions servicing some 'green revolution' countries that are still to develop in Africa.

2. The time required to increase food production in Africa if it is to be effective is considerably shorter than in Asia since Africa has started late. Yet the task of achieving a reasonable measure of self-sufficiency in Africa is made more formidable by the fact that Africa is now experiencing faster population growth than in Asia. While in Asia population growth is levelling off and population pressure has gingered Asians into more intensive food production the millions of hectares of empty lands and currently lower population pressures in Africa has resulted in much greater complacency in not only failing to give high priority to agricultural development but also failing to integrate it with measures to curb high rate of population growth. Food aid has a potential of both accelerating and bringing about disincentives in agricultural production depending on how it is managed and response of

policy makers in recipient countries to the various factors that resulted in the situation where that made food aid a necessity.

3) Food aid is often nothing more than an unavoidable or necessary pallative in time of disaster - earthquakes, typhoons, drought, war, etc. It never constitutes a lasting solution to the problem. Consequently, when food aid is given in time of diaster, with what foodstuffs that are available, one does not have much choice as to whether the commodities involved will result in changing food tastes or not. Since food is not produced in Africa, it may not be given in forms suited to African traditionally prefered foods. Due to very high rates of urbanization, increased mobility, long periods of training of many African intellectuals in Europe or north America many urban and well-to-do Africans have already developed new tastes for convenience or fast foods. Can food aid be given in such a way as to channel the 'exotic' foods to those whose tastes have already changed while more traditional foods and preparations are directed to the rural masses? Is it possible to sell food aid items to countries or segments that already consume large amounts of them and use the proceeds for purchase of traditional foods and for institutional support? To what extent is this possible? These are important questions to be addressed in the formulation of guidelines for food aid. Culturally speaking, there are many religious and socio-economic factors which have polarized Asian food habits towards items and preparations which are not only closer to what is given in food aid but will not render recipients as easily changeable in tastes as in Africa.

In whatever way food aid is given priority should be given to foreign assistance, major components of which in addition to food aid have direct and indirect effects that significantly contribute to the recipient countries developing capabilities to feed themselves and offering sufficient incentives

associated with infrastructural development to ensure increased food production on a sustained basis. Capability for increased agricultural production that renders the country capable of importing food with its own foreign exchange will have a similar effect.

It is also necessary to consider to what extent food aid involves dumping of surplus food items on developing countries with no concerted effort in providing food aid to minimize the adverse effects it may have on tastes and food production.

4) Africa seems more drought prone than Asia. Also in Africa area of land that has been exposed to varying degrees of desertification is higher, amounting to 16,600km^2 as compared to 15,230km^2 for Asia. Africa has made much less progress in developing and realizing its irrigation potential as compared to Asia which has slightly higher potential irrigable land and has already developed (Table 12).

Food reserve system is necessary especially for the Sahel and semi-arid areas of Africa. But this can be done as a long-term measure involving use of commodities that are bought from the African region at least for part of the reserve than by using 100% exotic food items. Countries of concern in this regard could be assisted to produce surpluses during favorable periods to be stockpiled in improved storage structures. These could then be utilized in times of disaster or unfavorable climate for food production.

5) Intra-regional trade exists in Africa but it is true that it constitutes more of a problem in some cases since it is often easier for some African countries to trade in some food commodities with the developed countries than among themselves or other regions in Africa. Food aid could be managed to enhance inter-regional or inter-country trade.

Appendix II cont'd.

The problem of smuggling exists and is real. But there is already more smuggling of cash and export crops going on for example, between Nigeria and Benin or Ghana and Ivory Coast due to the existing economic conditions in individual countries and trade barriers erected by these countries. If each country develops its full potential or is assisted to do so in terms of those commodities for which it has definite economic advantage to produce, then formal trading can be developed across national frontiers while minimizing smuggling. In some cases smuggling is secretly fueled by influential people in high places and it is difficult to stop. The government functionaries involved in food aid in recipient countries have the responsibility for taking necessary action to minimize smuggling but aid agencies should avoid getting involved in anti-smuggling control activities that may cost them more than the food aid that they are giving to a specific country. Items involved in smuggling are usually black market items that are scarce in some countries. They can most effectively be stopped by making them available more uniformly throughout all countries in the region rather than by trying to minimize exchange of items that command premium prices in some countries because of real or artificial scarcity, created by existing policies.

6) It is true that there is a multiplicity of donors in Africa and sometimes donors give food aid that is beyond the capacity of recipient countries to handle (store or distribute) efficiently. Stevens* (1980) cites a situation in which in the 1972/3 drought, Britain offered Lesotho 6,000 tons of wheat as against 1,000 tons it indicated it could absorb and Belgium offered 1,000 tons of wheat flower instead of 662 tons Lesotho originally requested.

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*Stevens, Christopher (1980). Food Aid and the Developing World. From African Case Studies. New Delhi, Vikas Publishing Houste PUT. Std.

Donors need to have a clearing house preferably both outside and inside the recipient countries as far as it could be conveniently arranged so as to coordinate activities and avoid taking counter-productive measures or causing more problems than they are effectively solving.

7) There is a definite difference between urban and rural demands in Africa. But this is more marked with respect to convenience foods. Sometimes there may be more ignorance in sanitation among rural masses but the recent Nestle experience may actually result in not assuming too much about this difference. It may be much better now to encourage feeding of mothers in both urban and rural areas so that they can more effectively breat-milk feed their children than supply tinned milk more to the urbanities on the assumption that they are more likely to bottle-feed.

There is some interdependence between urban and rural people. If Food Aid consisting of convenience foods are directed to urban masses it may minimize transfer of food to the cities from rural areas and minimize production even though it may also create a slump in the rural markets, food aid assistance which enhances production in rural areas indirectly benefits urban populations. What is called for are policies which may benefit both parties such that food must be made available to both segments when necessary and it is difficult for one who has nothing to pick and choose. At the same time there should be built-in components of the aid which encourages rural people to produce food and may be encourage urbanities to work on infra-structural developments of agricultural relevance (roads, disqribution and supply of farm inputs, etc.)

General Comment

Food aid will continue to be given as long as there are natural and other disasters in the world. There is need however, for putting in enough

effort into collecting adequate statistics on various aspects of food aid so that studies carried out on them are of sufficient scope and provide enough information for developing more effective policy guidelines and strategies.

What is most important about food aid is to recognise that it is a paliative. The real aid of lasting value is that which embodies supply of food to the hungry when disaster strikes and at the same time measures are taken to assist recipient countries develop capabilities to achieve meaningful self-sufficiency on a sustained basis. Above all, food aid should be given in such a way as not to have lasting adverse effects on agricultural and especially food production. Food aid should also not adversely affect policies in recipient countries that are aimed at increased agricultural and food production.

APPENDIX III

CONSTRAINTS TO AGRICULTURAL PRODUCTION

1. Physical Constraints

a) Climatic:

i) unreliability of rainfall in onset, duration and intensity;

ii) unpredictable periods of drought, floods and environmental stresses;

iii) reduced effective rainfall in sandy soils and steep slopes;

iv) high soil temperature for some crops and biological processes (N fixation);

v) high rates of decomposition and low OM level;

vi) cloudiness and reduced photosynthetic efficiency.

b) Soil: Most soils of the humid and subhumid tropics are intensely:

i) weathered - sandy low in clay;

ii) of low CEC, hence colloidal complex less active;

iii) of low inherent fertility except on hydromorphic and young volcanic soils;

iv) high soil acidity and sometimes high soil surface temperatures;

v) subject to multiple nutrient deficiencies and toxicities under continuous cultivation;

vi) high P-fixation

vii) leached with high erosion hazard under prevailing rainstorms;

viii) soil salinity problems under poor irrigation management.

2. Biologic. : Constraints

a) Unimproved crops and livestock;

b) low yields - low potential;

c) susceptibility to disease and pests;

d) high incidence of diseases, pests weeds due to favourable environment.

e) Drastic environmental changes resulting from human activities with adverse effects on ecological equilibrium or balance in nature.

3. Socio-Economic Constraints

a) Small farm size more drastically reduced by population pressure;

b) land tenure;

c) shortage of labor;

d) lack of credit, low income;

e) poor marketing facilities and pricing structure;

f) unavailability and high cost of inputs;

g) poor extension services;

h) illiteracy and superstitution sometimes hampering adoption process;

i) poor transportation;

j) inappropriateness of inputs;

k) lack of package approach to technology, development and use.

Table 1. Food crops and other useful plants found in crop mixtures in compound and outlying farms in parts of southeastern Nigeria

Crop plant group	Area of sample										
	A* 0.003-0.45 Ha		B* 0.04 Ha		C* 0.04-0.4 Ha		D* 0.04-0.5 Ha		E* 0.04-0.5 Ha		Mean percentage frequency
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	
1. Roots & tubers	1-12	5	4-6	5	5-8	7	1-8	4	7-9	8	47
2. Cereals & other starcy staples	0-3	1	1-2	1	2-3	2	0-4	2	2-3	2	38
3. Leaf vegetables...	3-7	4	0-4	2	4-8	6	10-11	6	2-8	5	27
4. Fruit vegetables	4-6	4	1-3	2	5-6	5	0-6	2	3	3	44
5. Legumes	1-5	3	0-4	2	2-4	2	0-3	1	0-3	2	33
6. Fruits, nuts & oil plants	1-14	5	0-1	1	10-11	10	2-15	7	5-12	9	20
7. Spices & beverages ...	0-3	1	0-1	1	2-6	4	0-9	4	1-7	4	18
8. Miscellaneous useful plants	0-7	2	0-1	0	10-14	13	1-29	11	4-18	12	11
Range in total number of species or cultivars...	0-65		4-19		40-48		6-62		25-52		

*A = Derived Savanna; B = Transition Zone - Derived Savanna-Oil Palm Bush; C = Oil Palm Bush - High Population Density; D = Oil Palm Bush - Medium-High Population Density: E = Oil Palm Bush - High Population Density.

Source: Okigbo and Greenland, 1977.

Table 2. Traditional and Transitional Systems.

1. Nomadic herding:
   shifting cultivation (Phase I), $L > 10$[2]

2. Bush fallowing or land rotation:
   shifting cultivation (Phase II), $L = 5-10$

3. Rudimentary sedentary agriculture:
   shifting cultivation (Phase III), $L = 2-4$

4. Compound farming and extensive subsistence agriculture:
   shifting cultivation (Phase IV), $L < 2$

5. Terrace farming and floodland agriculture

6. Mediterranean agriculture (traditional)

B. Modern farming systems and their local adaptations

1. Mixed farming

2. Livestock ranching

3. Intensive livestock production (poultry, pigs, dairying)

4. Large scale farms and plantations
   a) Large scale food and arable crop farms based on natural rainfall
   b) Irrigation projects involving crop production
   c) Large scale tree crop plantations

5. Specialized horticulture
   a) Market gardening
   b) Truck gardening and fruit plantations
   c) Commercial fruit and vegetable production for processing.

6. Mediterranean agriculture (modern)

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[2] $L = C+F/C$ where C = Cropping Period, F = Fallow Period, L = Land Use Factor.

Source, Okigbo and Greenland, 1977.

Table 3 - Tropical Africa

Africa: Prevailing systems of agricultural production and the associated crop and animal components in different climatic zones (Adapted with modifications from Mcdowell and Hildebrand, 1980).

Farming System	Major Crops	Major Animals	Main Regions	Feed Source
A. TRADITIONAL & TRANSITIONAL FARMING				
1. a) Nomadic or Pastoral Herding	Usually none, sometimes vegetables and early maturing crops near temporary huts.	Cattle, sheep, goats.	Sudan, Sahel, Savannas, migration sometimes to northern Guinea savanna or to wetter areas in dry season.	Natural range browse plants, forage, grasses and legumes.
b) Shifting Cultivation Phase I, L ≥ 10	Maize/yams/Rice/Plantains Maize, rice, yams, cassava plantains, cocoyams, vegetables, oil palms, citrus and other tree crops.	Goats, sheep, poultry.	Humid to sub-humid tropics	Browse plants fallow land crop residues kitchen/compound waste.
2. Bush Fallow Shifting Cultivation Phase II, L = 5-10	Sorghum/Millet Sorghum, millet, maize cowpeas, cassava, sugar cane, vegetables, locust beans, sesame.	Cattle, sheep, goats, horses, poultry, donkeys.	Southern Guinea Savanna - Sudan Savanna or equivalents in E.Africa.	Fallow, browse plants, crop residues-vines straw, cull roots.
	Yams/Rice/Plantains Yams, rice, plantains or banana; cassava, maize, vegetables, tree crops, cocoyams.	Goats, sheep, poultry, some swine.	Humid - Subhumid tropics.	Fallow, browse trees and shrubs, crop & compound waste.
	Sorghum/Millet Sorghum, millet, maize, soybeans, sugar cane, vegetables, bananas, yams, tobacco, cowpea.	Cattle, goats, sheep, poultry, horses, donkeys.	Forest/Savanna mosaic, Southern & Northern Guinea Savanna.	Fallows, browse plants, pasture, crop residues stover, vines, cull roots.

..../2

Table 3 cont'd

Farming System	Major Crops	Major Animals	Main Regions	Feed Source
3. Rudimentary Sedentary Agriculture. Shifting Cultivation Phase III, L = 2-4	Rice/Yams/Plantain Yams, rice, maize, plantains and bananas, cassava, vegetables, tree crops (oil palm, rubber, cocoa, citrus, etc), cocoyam	Goats, sheep poultry some swine.	Humid and Subhumid tropics.	Fallow, browse plants, crop residues, compound house refuse.
	Sorghum/Millet Sorghum, millet, maize, vegetables, sesame, sugar cane, cotton, tobacco, groundnuts, bananas, cassava, locust beans, shea butter, mango, other tree crops.	Cattle, goats, sheep, poultry, donkeys, horses.	Forest/savanna mosaic, Guinea, Sudan, and Sahel savanna.	Fallows, pasture, crop residues, stover vines, cull roots, groundnut cake, bran, etc.
4. Compound Farming and Intensive subsistence Agriculture. Shifting Cultivation Phase IV, L = <2.	Yams/Rice/Plantain/Tree Crops Yams, plantains, bananas, rice, tree crops, cassava, maize, vegetables, cocoyams.	Goats, sheep, swine poultry.	Humid and subhumid tropics.	Browse plants, crop residues, cull tubers and roots, tree crops, byproducts, household refuse.
	Vegetables Vegetables, sugar cane, maize, tobacco, sesame, groundnuts.	Goats, sheep, poultry, swine.	Forest/savanna	Browse, crop residues, tree crop byproducts, vines, kitchen refuse.
	Sorghum/Millet Sorghum, millet, maize, vegetables, cowpea, cassava, cotton, tobacco, melon.	Cattle, goats, sheep.	Savanna, Northern Guinea, Sudan and Sahel Savanna.	Fallow browse, plants, crop residue residues, vines, groundnuts, haulms.

Table 3 cont'd

	Farming System	Major Crops	Major Animals	Main Regions	Feed Source
5.	Highland Agriculture	Maize/Yams/Rice/Plantains Maize/yams, rice, plantains, cocoyams, tea, coffee, tropical and subtropical vegetables.	Goats, sheep, poultry, swine.	Humid and subhumid tropical forest/savanna mosaic.	Fallow, trees and shrubs as browse crop residues
		Sorghum/Tef/Wheat/Maize Sorghum, Tef, wheat, maize, beans, cowpea, millets, groundnuts, subtropical vegetables and fruits, coffee, tea, sugar cane, sesame.	Cattle, sheep, goats, poultry, horses, donkeys.	Savanna, montane climate.	Fallow, pastures, crop residues.
6.	Flood Land Agriculture Valley bottoms	Yam/Rice/Banana Yams, rice, vegetables, bananas, sugar cane, maize, cocoyams, groundnuts.	Goats, sheep in household gardens associated with fields systems.	Humid and sub-humid.	Crop residues some browse plants.
		Rice/Banana/Sugar cane Rice, banana, maize, sugar cane, vegetables, yams, groundnuts, cowpeas, cocoyam.	No animals except in associated field systems.	Savanna - Guinea to Sahel.	Crop residues fed to animals in compound garden.
B.	'MODERN' SYSTEMS AND THEIR LOCAL ADAPTATIONS				
1.	Mixed Farming (Best developed as European type farms in East Africa, Sudan Savanna area round Kano) Note: Most compound farms in the humid tropics strictly mixed farms.	Sorghum, cotton, millets, vegetables, cowpeas, few tree crops (locust bean Acacia).	Cattle, sheep, goats, poultry, horses, donkeys.	Sudan to Sahel-savanna.	Pasture, fallow grass, crop residues.

Table 3 cont'd.

Farming System	Major Crops	Major Animals	Main Regions	Feed Source
2. Livestock Ranching	-- None usually - based on grass/legume and range plants.	Cattle	Sudan to Sahel Savanna.	Natural ranges with or without seeding of forage species.
3. Intensive livestock production (Dairy, Poultry)	Fodder grass/legume and pastures Maize for silage, elephant grass (vegetables & fruit trees in compound).	Cattle, Poultry	Humid to savanna, best in highland tropics, montane vegetation.	Pasture, fodder grass/legumes, hay.
4. Large scale European type farms and Plantations.				
a) Plantations	Coconut, cocoa, oil palms, Rubber, Tea	Usually no livestock but sometimes with dairy & poultry.	Humid and subhumid tropics & wetter savanna areas.	Pasture of grasses and or legumes especially under coconuts.
b) Irrigation projects	Rice/Cotton/Maize Sorghum, wheat, vegetables e.g. tomato.	Usually no animals except cattle.	Savanna areas.	Pasture of animals are present + fallow and crop residues
c) Largescale field Crops projects based on natural rainfall only.	Maize, rice, cassava, groundnut.	Usually no animals, may need cattle as draught animals in the tse-tse free areas.	Humid to subhumid.	Some pasture crop residues.

Table 3 cont'd.

Farming System	Major Crop	Major Animals	Main Regions	Feed Source
5. Specialized Horticulture				
a) Market gardening	Vegetables, fruits and ornamentals. Local (e.g. okra, celosia) and subtropical exotic vegetables & fruits, (e.g. lettuce, Indian spinach, citrus, papaya.	Usually no animals. Sometimes animals such as poultry.	Humid tropics to Sahel savanna.	Fallows or Crop residues and byproducts of animal.
b) Truck garden and Forest Plantations (mainly for export)	Tomatoes and vegetables, beans, peppers, pine-apples, avocado, bananas.	No animals usually.	Humid tropics to Sahel savanna. All tropics highland areas and savanna irrigation.	No animals generally.

Table 4. World Population and Food Production, 1977*

	World	Developed Countries[1]	Developing Countries[1]		
			Total	Sub-Sahara Africa	Other Regions
Population (millions)	4205 (100)	1139 (27)	3066 (73)	311 (7)	2755 (66)
Food production (million tons):					
Major staple food crops	1686 (100)	830 (49)	856 (51)	68 (4)	788 (47)
Cereals	1476 (100)	771 (52)	705 (48)	36 (3)	669 (5)
Noncereals[2]	210 (100)	59 (23)	151 (72)	32 15)	119 (57)
Livestock and Poultry products:					
Meat[3]	128 (100)	84 (65)	44 (35)	3 (2)	41 (33)
Milk[4]	449 (100)	351 (78)	99 (22)	6 (1)	93 (21)
Eggs	25 (100)	17 (67)	8 (33)	* (2)	8 (31)

* Less than half a million tons.
1. Following the FAO classification.
2. Aggregate of rootcrops, pulses, groundnuts, and bananas and plantains; in cereal equivalent.
3. Aggregate meat of indigenous cattle, sheep, goats and pigs, and poultry meat; in carcass weight equivalent.
4. Aggregate for cow, sheep and goat milk, but excluding camel milk.

Note: Figures may not add up to totals because of rounding; those in parenthesis represent percentages of the world total.

*Source, IFPRI (1981).

Table 5. Composition of Sub-Saharan Food Production and Consumption, 1977*

Commodity	Production		Consumption[1]	
	(000 MT)	(percent)[2]	(000 MT)	(percent)[2]
Major staple food crops[3]	67,717	100.0	72,859	100.0
Cereals	36.149	53.4	42,221	57.9
Millet & Sorghum	15,524	22.9	16,486	22.6
Maize	13,521	20.0	14,223	19.5
Rice (milled)	3,555	5.2	5,020	6.9
Wheat	1,051	1.6	3,821	5.2
Others	2,498	3.7	2,671	3.7
Noncereals	31,568	46.6	30,638	42.1
Rootcrops	(20,857)	(30.8)	(21,170)	(29.1)
Pulses	(3,816)	(5.6)	(4,135)	(5.7)
Groundnuts	(3,529)	(5.2)	(2,330)	(3.2)
Bananas & Plantains	(3,366)	(5.0)	(3.00)	(4.1)
Meat[4]	3,050.3	100.0	2,973.7	100.0
Cattle	1,733.1	56.8	1,660.9	55.9
Sheep & Goat	631.5	20.7	611.2	20.6
Pig	230.9	7.6	242.9	8.2
Poultry	455.5	14.9	458.7	15.4
Milk[5]	5,849.5	100.0	7,437.4	100.0
Cow	4,556.0	77.9	6,077.1	81.7
Sheep	222.9	3.8	275.4	3.7
Goat	757.2	12.9	771.6	10.4
Camel	313.3	5.4	313.4	4.2
Eggs	414.1	100.0	424.2	100.0
Hen	408.2	98.6	418.3	98.6
Other	5.8	1.4	5.8	1.4

Note: Figures may not add to totals because of rounding.

1. Consumption refers to total domestic utilization, terms of primary commodity equivalent.
2. Percentages refer to major commodity group.
3. Quantities in cereal equivalent.
4. Quantities in carcass weight equivalent; bovine, ovine, and pig meat production is from indigenous animals.
5. Quantities in whole milk equivalent.

*Source, IFPRI, (1981).

Table 6. Mean annual growth (%) in consumption of cereals, non cereals, meat, milk in few countries and groups of countries in SubSaharan Africa 1961-65 to 1973-1977 (IFPRI, 1981)*

Country/group of countries	Population[3]	Cereals	Non-Cereals	Meat[4]	Milk[5]	Eggs
Ethiopia	2.5	1.5	1.8	-0.4	1.4	1.5
Kenya	3.6	2.6	1.5	1.4	-9.3	4.9
Nigeria	3.0	1.3	2.2	1.5	6.6	3.0
Tanzania	2.8	3.1	2.6	3.2	2.1	4.7
Zaire[1]/Zambia[2]	2.3[1] 3.7[2]	5.3[1]	2.6[1]	5.5[2]	1.5[2]	2.7[2]
Sahel[6]	2.6	1.3	2.2	4.0	1.2	2.3
SubSaharan Africa	2.7	2.3	2.3	2.0	2.1	3.5

[1] Zaire

[2] Zimbabwe

[3] Based on U.N. population for 1963 and 1975.

[4] Includes cattle sheep, goat, pigs and poultry, meat, in carcass weight equivalent.

[5] Includes Gambia, Chad, Mali, Mauritania, Niger, Senegal and Upper Volta.

*Source, IFPRI (1981).

Table 7. Export, Imports, Net Trade and Sufficiency ratios of major staples and livestock including poultry products in selected countries and country groups in sub-Saharan Africa 1961-65 and 1973-77*

Country/group of Countries	Exports 1961/5 (000 MT)	Exports 1973/77 (000 MT)	Rate Change (%)	Imports 1961/65 (000 MT)	Imports 1973/77 (000 MT)	Rate Change (%)	Net Trade 1961/65 (000 MT)	Net Trade 1973/77 (000 MT)	Sufficiency Ratio[2] 1961/65	Sufficiency Ratio[2] 1973/77
Ethiopia	89	119	+34	12	106	+818	77	13	1.02	1.00
Kenya	112	166	+36	90	46	-49	22	120	1.11	1.04
Nigeria	824	70	-91	123	787	+541	701	(77)	1.05	0.96
Tanzania	78	24	-69	109	267	+144	(31)	(243)	0.99	0.93
Zaire	4	1	-88	158	414	+162	(154)	(413)	0.96	0.92
Sahel[3]	672	282	-58	337	838	+149	335	(556)	1.06	0.92
Sub-Sahara Africa										
Crops	2543	1113	-56	2090	4640	+122	453	3527	1.01	0.35
Livestock										
Meat[4]	2615.5	301.2	14.3	195.2	209.2	9.2	68.3	92.0	1.032	1.034
Milk[5]	33.0	52.6	59.4	488.5	1254.1	156.7	(455.5)	(1201.4)	0.912	0.870
Eggs	1.1	0.6	-45.7	1.2	2.3	83.4	(0.1)	(1.6)	1.00	0.996

1. Exports - Imports; net import figures are in parenthesis.
2. Ratio of domestic supply; net imports to total domestic utilization.
3. Includes Chad, Gambia, Mali Mauritania, Niger, Senegal & Upper Volta.
4. Includes goats, sheep, cattle, pigs, poultry, meat, adjusted for trade in animals (in carcas wt. equivalent)
5. Includes sheep, goats, camel milk, milk products (whole milk equivalent)

*Source IFPRI, (1981).

Table 8. Value in millions of dollars of Nigerian oil exports, percentage of petroleum export in comparison with imports and proportion of Food Imports (African Business, October, 1978)**

Year	Total Exports (10^6)	Percentage of oil exports	Total Imports (10^6)	Value of Food Imports	Percentage of 1969 Food Import
1969	,006.9	55	795.8	66.7	100
1970	1,403.4	67	1,210.2	92.3	138
1971	2,049.3	95	1,726.2	140.6	211
1972	2,238.6	85	1,592.0	152.2	228
1973	3,644.8	81	1,958.4	201.6	302
1974	9,219.2	94	2,744.0	248.0	372
1975	7,980.8	93	5,947.2	371.2	556
1976	10,596.8	94	8,224.0	706.9	1,059
1977	13,876.8	92	11,673.6	1,264.0	1,895*

* Estimated
Note: 1977 = GDP = $29120 million
DDP/capita = $356.6

**Source, Okigbo (1978).

Table 9. Additional food availability requirements for selected countries in Sub-Saharan Africa between 1972-74 and 1985 000 tons.

Country	Cereals	Roots and Tubers
Algeria	1,269	185
Angola	214	754
Benin	127	330
Botswana	46	3
Chad	308	53
Ethiopia	1,786	365
Guinea	259	226
Kenya	850	482
Liberia	768	1,575
Mali	551	49
Mauritania	71	4
Mozambique	322	1,128
Niger	398	96
Nigeria	3,517	9,890
Rwanda	80	452
Sao Tome & Principe	3	4
Somalia	208	18
Swaziland	27	4
Tanzania	649	1,832
Uganda	352	588
Upper Volta	540	61
Zaire	407	4,700
Zambia	405	107

Source: Mazumdar (1980).

Table 10. Contribution of production and imports in per caput food availability during (1972-74 in Kcal/day) for selected countries in Sub-Saharan Africa.

Domestic	Imported	Total	% Imported
1,656	409	2,065	19.8
1,823	174	1,997	8.7
1,915	125	2,040	6.2
859	1,166	2,025	57.6
1,638	127	1,765	7.2
2,041	10	2,051	0.5
1,826	168	1,994	8.4
2,025	112	2,137	5.2
1,630	346	1,976	17.5
1,465	294	1,759	16.7
930	937	1,867	50.3
1,894	95	1,989	4.8
1,775	82	1,857	4.4
2,000	73	2,073	3.5
2,081	21	2,102	1.0
902	1,228	2,130	57.6
1,615	301	1,916	15.7
1,504	614	2,118	29.0
1,789	172	1,958	8.8
2,094	47	2,141	2.2
1,638	90	1,728	5.2
1,739	109	1,848	5.9
1,690	326	2,016	16.2

Source: Mazumdar (1980)

Table 11. Projected required growth rates between 1972-74 and 1985 under different alternatives for selected countries in Sub-Saharan Africa.

Country	I		II		III
	Annual prod.	Cum. imports	Annual prod.	Cum. imports	Annual prod.
Algeria	4.3	66	4.5	49	6.2
Angola	3.6	53	3.7	35	4.4
Benin	3.4	50	3.5	39	4.0
Botswana	3.7	55	4.7	41	11.4
Chad	4.3	65	4.4	29	4.9
Ethiopia	3.2	46	3.2	34	3.3
Guinea	3.5	51	3.6	36	4.3
Kenya	3.7	54	3.7	49	4.1
Liberia	3.5	52	3.7	35	5.2
Mali	4.7	73	5.0	36	6.3
Mauritania	3.7	54	5.0	29	9.9
Mozambique	3.5	50	3.5	33	3.8
Niger	4.4	68	4.5	39	4.8
Nigeria	3.7	55	3.7	41	4.0
Rwanda	3.4	49	3.4	42	3.5
Sao Tome & Principe	3.2	46	3.8	39	10.9
Somalia	4.2	63	4.4	41	5.3
Swaziland	3.4	49	3.5	43	6.3
Tanzania	4.3	65	4.4	45	6.5
Uganda	3.4	49	3.4	44	3.5
Upper Volta	4.6	72	4.7	32	5.1
Zaire	3.9	58	3.9	38	4.4
Zambia	4.0	61	4.2	46	5.6

Source: Mazumdar (1980).

Table 12. Land resource potentials, irrigation, fertilizer and pesticide use in major regions of the developing world*.

	Resource or Agricultural Activity	Africa	Asia	Latin America	Near East
1)	Arable Land use (ha per caput) 1980	0.55	0.21	0.52	0.39
2)	Potential Arable Land (ha per caput) 1980	1.71	0.28	1.79	0.60
3)	Potential Arable Land Reserves (mill.ha) 1975	433	90	476	44
4)					
4)	Potential Arable Land % of Total	68	25	73	34
5)	Arable Area (mill.ha) 1980:				
	Irrigated -	4	66	14	20
	Rainfed -	200	198	177	65
	Total -	204	264	191	85
6)	Harvested Area (mill.ha) 1980:				
	Irrigated -	4	82	12	18
	Rainfed -	108	204	107	39
	Total -	112	286	119	57
7)	Cropping Intensity 1980:				
	Irrigated -	101	124	86	90
	Rainfed -	53	102	60	60
	Total -	55	108	62	68
8)	Importance of Irrigation (%)	2	25	7	23
9)	Fertilizer Use (mill.t. N.P.K) 1980	1	9.8	5.4	2.8
10)	Pesticide "se ($.mill. U.S.) 1980	344	725	749	265

*Source: FAD (1979) Agriculture Towards 2000.