FITTNIG RESEARCH TO FARMING SYST EMS BASED ON OBSERVATIONS AND PRELIMINARY STUDIES OF TRADITIONAL AGRICULTURE IN EASTERN NIGERIA

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FITTING RESEARCH TO FARMING SYSTEMS :

BASED ON OBSERVATIONS AND PRELIMINARY STUDIES OF TRADITIONAL AGRICULTURE IN EASTERN NIGERIA

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INTRODUCTION

During the First International Seminar on Change in Agriculture, exactly six years ago in this same location, Professor Bunting aptly observed that 'In many parts of Africa, in recent years, progress seems to have come to a halt in which a precarious and easily disturbed equilibrium is preserved only by the virtue of the practically indestructible nature of African subsistence agriculture'. He then posed the 'sixty-four thousand dollar' question, which is still pertinent today, as to what features of African history or social organization have so far withheld from most areas of Africa the achievements in Agriculture recorded elsewhere. In this paper an attempt is made, based on past experience, the existing situation and problems encountered in efforts aimed at bringing about agricultural change in southeastern Nigeria to :

(i) provide some answers to Professor Bunting's question;

(ii) emphasize the relevance of the systems approach in tackling such problems in agricultural production and, above all,

(iii) outline guidelines for research necessary for the development of farming systems which are economically viable, more or less

permanently productive, adapted, and socially and culturally acceptable to farmers in the developing countries especially in the humid tropical areas of Africa.

Eastern Nigeria has been chosen in the case study for several reasons:

(1) it is the most thickly populated area in Nigeria and in fact one of the most thickly populated areas in Africa;

(2) its traditional agriculture appears to be of greater antiquity than is often realised and after many centuries of trial and error coupled with pressures of modernization and population explosion has evolved a range of farming systems of varying complexities and intensities not easily liable to change by the existing formal educational, research and extension methods;

(3) Eastern Nigeria in the early 1960's during the first few years of independence enthusiastically launched a number of projects aimed at revolutionizing agriculture but with the exception of limited progress in some prior aspects of agricultural development have failed to bring about much change and improvement in the agricultural and cultural landscape;

(4) there is still at present lacking in Eastern Nigeria or in any of the constituent states an organized interdisciplinary research effort in support of agricultural extension and integrated rural development projects of the type now being developed in the Northern States of Nigeria, Norman (1974) despite the increasing population pressure

and decreasing food and export crop production which have become more acute after the civil war.

REVIEW OF THE PHYSICAL BACKGROUND TO EASTERN NIGERIA

In this paper, the area referred to as Eastern Nigeria consists of South-eastern part of Nigeria made up of the East Central, South Eastern and Rivers States. It is rhomboidal in shape and about 76,334 square kilometres in area amounting to about 8.3 percent of the entire area of Nigeria. It lies between latitudes 4° 15' N 7° 05' N and longitudes 5° 31' and 9° 30' E being bounded in the south by the Gulf of Guinea in the north by southern boundaries of Kwara, Benue and North Eastern States, in the east by the Cameroun Republic and in the west by the River Niger and its tributaries. Most of the material in this review of the physical background is based on the work of Floyd (1969) and Uzozie (1971).

THE ENVIRONMENT

Most of Eastern Nigeria is a lowland area of less than 122 metres above sea level and made up of the basins of the Niger, Cross, Kwa and Imo Rivers with the Niger Delta occupying up to 20 percent of the lowlands. North of the complex of sandy lagoons, barrier beaches, creeks and swamps of the coast, the terrain rises gradually through open flat land broken up in places by ridges and valleys and some isolated hills and iselbergs. The two most outstanding geomorphological features consist of (1) a backbone of false-bedded sandstone plateau or cuesta on the west varying in elevation from 160 to over 300 metres

and running southwards from Nsukka in the northeast due south to Awgu and Okigwe from where it extends eastwards to Arochukwu, and (2) in the extreme west a highland area extending from the 910 metres Oban Hills east of the lower Cross River basin northwards to the Obudu Plateau in the northeast which attains 1930 metres.

Soils

The soils of Eastern Nigeria reflect the effects of climate, vegetation and other organisms on the underlying rocks that have undergone varying degrees of weathering over time resulting, according to Jungerius (1964) and on the basis of D'Hoore's classification of African soils, in the following (1) Lithosols on the steep slopes of the Nsukka - Okigwe and Arochukwu escarpement, (2) young soils derived from recently deposited alluvial materials on the banks of the main rivers and mangrove swamps of the coast, (3) ferruginous soils derived from basalt in the Upper Cross River region which constitues the most fertile soil in the region, (4) ferrallitic soils which are completely weathered infertile soils of complex sesquioxides and resistant minerals covering over 50 percent of the region and (5) hydromorphic soils in situations subject to seasonal water-logging and used for production of yams, rice and out of season vegetables.

Climate: Most of Eastern Nigeria lies within the tropical belt experiencing high intensities of solar radiation throughout the year but as a result of cloud cover and Harmattan haze bright sunshine hours may range from less than 30 - 60 percent in the dry season which varies in duration from less than one month in the extreme south to 6 months in the northernmost areas of the region. Temperatures are high with annual means above 24°C every where and rarely exceeding 29°C.

Monthly average temperatures range from a minimum of slightly less than 21°C to a maximum of 32°C. The mean annual rainfall exceeds 4,000 mm in the extreme south and northeast decreasing to 2,000 - 2,300 mm in the central areas to below 1,800 mm in the northwest.

Vegetation: The vegetation pattern is related to the climate of the area but has been greatly modified by human activities such as farming, burning, grazing and so on. Starting from the coast there are more or less parallel vegetation zones of varying width consisting of (1) mangrove forest and coastal vegetation of salt water swamp, (2) lowland Tropical Rain forest or Moist Forest, (3) Oil palm bush to the south and Derived Savanna or Woodland/savanna mosaic which as a result of human activities were formed from the moist forest vegetation and (4) isolated areas of montane vegetation around the Obudu Plateau.

Population: The people of Eastern Nigeria belong to several dominant linquistic groups often designated as 'tribes' including the Ibo, Ibibio, Efik, Ijaw, Ekaru-Yakurr, Nkembe, Boki, Yola etc. Population wise, this part of Nigeria has the highest population density in Africa with the exception of parts of the Nile valley and the area around Johannesburg in South Africa. The highest population densities occur in Nsukka Division, parts of Onitsha and Owerri provinces, Uyo and Ogoni Divisions. Available statistical data on the population of the present three States in Eastern Nigeria are as follows:

		Number of persons per km^2	
State	Area (km^2)	1963 Census	1973 Census
East Central State	22,644	319	356
South Eastern State	35,547	102	97
Rivers State	18,144	85	124
	76,335	162*	180*

* Averages.

The highest population densities of up to 541 per km^2 occur in Orlu and Okigwe Divisions and the lowest of from 80 - 200 per km^2 occurs in Abakaliki Division, parts of Ogoja and Rivers State. The socio-cultural differences among the different peoples and differences in population density and some local environmental factors have markedly affected the traditional farming systems and the kind and intensity of farming.

BACKGROUND TO THE AGRICULTURE AND TRADITIONAL FARMING SYSTEMS OF EASTERN NIGERIA

Historical Background

The existing pattern and systems of traditional agriculture in the Eastern States of Nigeria is the result of several centuries or perhaps thousands of years of trial and error in the manipulation by man of the available plant, animal and other natural resources in his local environment. Contacts with plants, animals and peoples from other parts of the world and in more recent times the colonial experience of many developing countries of Africa have ushered in drastic changes in traditional agriculture. Recent concepts on the origin of agriculture in West Africa (Coursey, 1972, Shaw, 1972) suggest that agriculture based on domestication and cultivation of African yams in addition to the exploitation of the oil palm and other plants of the 'vegecultural complex' of Porteres (1965) began about 3000 B.C. There are also botanical and cultural historical evidences in support of probably much earlier experimentations with, increased utilization, protection and partial domestication of tree crops such as the oil palm (*Elaeis guineensis*), the African breadfruit (*Treculia africana*) and the indigenous pear (*Dacroydes edulis*) prior to the domestication of yams in parts of Eastern Nigeria (Okigbo, 1973).

The cultivation of yams resulted in the development of an early slash and burn agriculture which was the forerunner of the traditional shifting cultivation of more recent times.

The development of local methods of yam preparation for food involving roasting, boiling and pounding laid the foundation for the rapid absorption into the traditional farming systems of Asian crops by the 1st millennium A.D. and later American crops which are amenable to similar methods of preparation as yams. The Asian crops included the water yam (Dioscorea alata), bananas and plantains (Musa spp.) and Taro (Colocasia esculenta) while the American crops included cassava (Manihot esculenta) the cocoyam (Xanthosoma saggitifolium) and maize (Zea mays). Each of these developments, namely, the domestication of yams, the introduction of Asian crops and American crops must have certainly been associated with population increases. This process has more recently been accelerated by better sanitation, advances in medical and related sciences culminating in the present population explosion and very high densities in parts of Eastern Nigeria. For sometime, shifting cultivation entailed long term bush fallows of some times up to 20 years for the recycling of nutrients and the restoration of soil fertility. Continuing increases in population pressure and reduction of periods of fallow caused reduction in soil fertility and decreased the period of natural bush regrowth and efficiency in nutrient recycling. Large scale clearing of vegetation under high intensity of farming culminated in the evolution of the Derived Savanna and serious soil erosion problems as evidenced by the deep gullies at Agulu, Nanka and the eastern edge of Nsukka-Udi plateau. The farmers' efforts at finding solutions to these problems led to the discovery of certain plants which are deep-rooted, reasonably fast growing, fairly fire

resistant and more efficient in the restoration of soil fertility than either natural regrowth or annual legumes. Thus, in parts of Eastern Nigeria there developed a regular practice of planting such plants as Acioa bateri and Anthonotha macrophylla, the protection of other plants as Dialium guineense and Harunga madagascariensis in addition to farm management practices which encouraged the attainment of a climax dominated by the above plant species and over sixty other less common species in the bush fallow system (Obi and Tuley, 1973). One other characteristic of planted fallow plants such as Acioa bateri is their multiferous uses in addition to termite resistance, which renders them suitable for use as stakes for yams and other climbers, manufacture of hoe handles and digging sticks. Acioa bateri and other plants also serve as brouse plants for sheep and goats.

During the early stages of European trade and colonial expansion, the oil palm became an important cash and export crop and was at first harvested from wild groves. Later, selected palms were either protected or planted and allowed to grow in greater densities close to human habitation, thus constituting a major feature of the compound farm system. Prior to the coming of Europeans , the objective of farming was mainly subsistence whereby the farmers' objective in farming included (a) provision of shelter and enough food and other materials for himself and his family, (b) obtaining by various resciprocity arrangements, materials not produced on the farm (c) maintenance of status in the society through acquiring more properties and status, and (d) building up surpluses for celebration of religious festivals and related rites. Aspects of modernization since the colonial era has forced on the farmer a greater range of needs which according to McLoughlin (1970) now include in addition to the above, payment

of taxes, services for water supply, sanitation etc., school fees, fees for membership of essential economic organizations and other necessities. These developments brought to an end the era of strictly subsistence agriculture and ushered in the development of a range of traditional farming systems described below which differ markedly in complexity and intensity than the classical shifting cultivation.

Traditional Farming Systems of Eastern Nigeria

The traditional farming systems now in vogue in different parts of Eastern Nigeria vary in the lengths of periods of fallow, intensity of cropping, range of plant species involved and distance from the farmer's homestead. Mixed cropping is the rule and only rarely does one encounter extensive farm land occupied by a sole crop of a single species and even when this occurs, it is largely limited to crops such as cocoyam or cassava which often at planting time constituted an intercrop which, as the last crop in a rotation, remains after the other components have been harvested. Limited areas of sole crops of rice may also be encountered in hydromorphic soils. Plantations of rubber and oil plams although few in number also involve sole or monocropping. The numerous and often seemingly pure stands and groves of oil palms in the oil palm belt are very deceptive since under their canopies are various food crops and other useful plants that are shade tolerant.

In the early days of shifting cultivation most of Eastern Nigeria was sparsely populated and farms were scattered. With development of more sedentary culture and increase in population pressure, farms grew closer together and farming communities aggregated to form villages and towns sometimes separated by large tracts of land in which shifting cultivation and bush fallow systems are

practised. This resulted in mixed cropping systems involving crop combinations in which one, two, three or more staples such as yams, cassava, maize and plantains are dominant. These cropping combinations were grouped into five traditional systems of cultivation according to Floyd (1969) consisting of shifting cultivation, bush fallowing, rudimentary sedentary cultivation, compound farming and terrace farming. Shifting cultivation is restricted to areas of very low population density while rudimentary sedentary cultivation and compound farming are found in areas of high population density. The terrace farming system at Maku, south of Enugu, is a unique intensive cropping system on terraces built on defensive hilly slopes, perhaps as far back as the slave raiding days with frequent inter-tribal wars. Here, as in compound farms, fertility is maintained by use of animal waste and household refuse with the fallow period completely absent or reduced to one or two years. Large acreages of cocoyams and vegetables are grown in varying patterns ranging from small patches of farmland or gardens of two or three crops combinations to combinations involving more than twenty crop plant species.

The salient characteristics of the traditional farming systems in Eastern Nigeria of relevance in the consideration of improved alternative farming systems may be summarized as follows:

1. There are four main groups of farming systems of decreasing cropping intensity in the following order

   Compound Farming > Rudimentary sedentary cultivation > Bush or Planted Fallows > Transitional shifting cultivation (sometimes called land rotation).

2. On compound farms the most common rotations usually involve continuous cultivation and rarely fallow periods of more than one year. Soil fertility is maintained by the use of animal waste, mulches and compound refuse.

3. The compound farms usually involve a range of intricate cropping mixtures of arable crops, permanent crops for food and other products and of course, weeds. It thus approximates the bush or forest condition representing an ecosystem of marked stability with the number of crop plants and other useful species in the mixture sometimes exceeding 60 in half a hectare of compound farmland.

4. Mixed or intercropping in traditional agriculture has several advantages, including (i) it involves a built-in rotation in which compatible crops utilize nutrients at various levels and may symbiotically affect one another (ii) it constitutes an insurance against crop failure due to diseases, pests and other adverse environmental conditions (Norman, 1968) (iii) especially in the humid tropics, intercropping provides continuous cover of the soil throughout the year and protects the soil against erosion (iv) it supplies the farmer with a range of foodstuffs which are available at different times of the year thus ensuring that he has a balanced diet while also reducing storage problems; (v) mixed cropping of the compound farm type includes plants that can be put to multiferous uses for shelter, staking materials, fibre, beverages etc. thereby

constituting some savings in labour or cash if the farmer were forced to obtain them from elsewhere; moreover some plants in the compound farm are of major cultural importance to the farmer since they are involved in social and religious practices; (vi) it constitutes a reserve of potentially useful germplasm of plants with beneficial characteristics; (vii) mixtures of crop plants constitute efficient utilization of resources since they facilitate the growing together of heliophytes and shade loving plants with the density of plant growth often reducing the magnitude of the weed control problem.

5. A major disadvantage of mixed cropping is that it renders the use of certain inputs such as fertilizers, machinery and pesticides impossible or impractical. Very often in compound farms where oil palm groves or permanent tree crop density is not controlled, non-shade loving arable crops either fail or perform very poorly.

6. In the African humid tropics, traditional farming systems also include aspects of mixed farming in which small animals such as poultry, sheep, goats, pigs are kept. These are important as (a) sources of meat, (b) thrifty scavengers converting farm waste into food, (c) sources of manure used in maintaining soil fertility and adequate levels of soil organic matter, and (d) a sort of savings which yield cash in emergencies. Among the Ibo in the East Central State, livestock tenancy is of economic importance in the spread of risks among relatives and friends (Uchendu 1965).

7. Although communal ownerships of land still exists in certain areas of Eastern Nigeria, the prevailing land tenure systems in many

areas especially in areas of high population density have resulted in fragmentation of holdings which reduce farm size to sometimes uneconomic sizes and renders mechanization, where possible impractical. This also forces the farmer to operate on small farms often far away from farmers homes and scattered in several locations. Surveys in Eastern Nigeria indicate that up to 42 percent of the farms are less than 0.2 ha. in size, 72 percent are less than 0.4 ha. and 80 percent are up to and below 1 ha.

8. Some of the general conclusions that can be drawn on relationships and tendencies in traditional farming systems discussed above include:

(i) Increase in the number of years of fallow is often associated with increasing distance of farms from centre of intensive compound farming communities;

(ii) There is a tendency for the proportion of staple food crops species in the cropping mixtures to increase as the distance from compound farms to open bush fallow farms in the outskirts increases.

(iii) Crops in bush fallow areas in the outskirts of villages constitute mainly of major staples and a few vegetables unlike in compound farms where many tree crops and vegetables occur with the major staples.

(iv) In alluvial and deep sandy soils, planting is usually on the flat but in other situations crops are planted on mounds or on beds - the mounds attaining their maximum size in

hydromorphic soils. In such large mounds, yams, maize and cassava are planted on top of the mound, cocoyams are planted lower down the sides and rice on the flat between mounds.

It is therefore obvious that traditional agriculture though primitive is generally more complex than often meets the eye and involves a serious attempt by farmers to achieve optimum utilization of resources.

PROJECTS AIMED AT MODERNIZING AGRICULTURE IN EASTERN NIGERIA

Although space does not permit a detailed evaluation of projects aimed at modernizing traditional agriculture in Eastern Nigeria, it is relevant in planning research on farming systems to bear in mind the successes, limitations and failures of such projects. In the early 1960's following Nigeria's newly won independence, many bold projects aimed at revolutionizing agriculture were launched by the various governmentsof the Federation. The projects in Eastern Nigeria consist of (1) Eastern Nigeria Development Corporation plantations and estates (2) farm settlements and (3) community plantations of the Ministry of Rural Development. Other projects included the smallholder oil palm rehabilitation scheme, vegetable garden project and a poultry production scheme. Details on the scope, development and operations of these projects up to the start of the civil war in 1967 have been reported by Wells (1969) and Floyd (1969). These projects and related services involved government allocations and expenditures during the period 1962/63 to 1966/67 estimated at £6.62 million capital and £8 million recurrent costs. The projects were capital intensive and involved institutional changes. Large scale plantations most of which ranged from 1000 to 5000 hectares were to be developed for the production of traditional export crops

consisting of rubber and oil palms and only minor attention was given to either food crops or livestock projects.

The ENDC rubber, oil palm, and cocoa plantations were sited in many locations selected on often political grounds in areas of low population density. The farm settlements modelled after the Israeli Moshavin system were similarly located but were initially aimed at solving the problems of unemployment among school leavers through centrally organized cooperative ownership and operation during the early periods of establishment. There was provision for each settler to grow in addition to tree crops some food crops for his subsistence needs on a slightly more than a hectare plot of land according to a rotation recommended by the Ministry. The oilpalm rehabilitation scheme involved the replacement of wild, unimproved, and old palm groves by improved palms in a minimum of 2 hectares of land. With the exception of influential persons and chiefs, few farmers could cough up 2 hectares of land as to benefit from this project. The Community Development Project of the Ministry of Rural Development Programme involved some aspects of a cooperative effort at land consolidation whereby under-used and unutilized land were pooled into plantations of reasonable size and operated with minimal government financial support and communal development of related infrastructures such as roads, bridges etc. These plantations were also devoted to oil palms and rubber. Altogether there was less intensive capital expenditure on food crops such as rice and vegetable crops. The poultry project aimed at supplying day-old chicks and feed to farmers for eggs and broiler production and a cattle ranch at Obudu constituted the livestock projects.

In a detailed evaluation of government expenditure on agriculture in the period 1962/63 up to the time of the civil war, Wells (1969) concluded that "The growth of Nigerian agriculture - up to 1967 at least - has been almost entirely accomplished by the activities of private peasant producers. Government efforts of any significance have concentrated on (a) research efforts, (b) provision of infrastructure, and (c) the extension efforts of the agricultural agents'. He further observed that in many cases the actual results of the investments appeared disappointing. During this period it was estimated that plantations contributed only 5 percent of rubber and 3.5 percent of oil palms to the exports of the Eastern States.

Reasons for failure of the projects included (a) the citing of some projects in unfavourable locations based solely on political expediency, (b) the citing of projects in locations where no reliable results of research are available for the soils and crops involved in the projects, (c) inexperience of extension staff who supervised projects (d) government interference in the case of ENDC plantations resulting in over-employment and employment of unqualified personnel, (e) poor management especially in plantations, (f) age of settlers in farm settlements and the socio-cultural shock some of them suffer due to drastic changes in environment (g) use of provisional inputs and preliminary recommendations in farm management and lack of effective research information or inputs for solving problems that may arise. The disruption of agricultural development activities by the civil war aggravated the disappointing performance of these projects, but even so the above evaluation was limited to the period before 1967.

Some successes were however, recorded in the growth of poultry industry which eliminated the importation of eggs from Europe and elsewhere. The Ministry of Agriculture was able to supply day-old chicks, veterinary services and to some extent, feed. However, problems of marketing and fluctuations in quality of feed developed until foreign expertise such as that of Pfizer was able to introduce better quality feed and develop an efficient distribution systems. Up till now high costs of feed continue to plague the industry as a result of inability of the country to produce sufficient amounts of maize and other ingredients locally and cheaply. It is pertinent, however, to emphasize that the suitable package of technology for poultry production was only available to some well capitalized entrepreneurs rather than poor traditional farmers who were content with buying a few ready-to-lay hens of improved poultry breeds to run around with their unimproved cocks or vice versa. Another successful development is the introduction of rice in the early 1940's and its rapid growth as a result of supply of improved seeds, encouraging returns from rice in relation to cost of production, extension work in nursery establishment and planting techniques, and development of rice processing and milling machines which constituted a partial mechanization process. This contributed significantly to increases in area under rice cultivation.

It can be concluded from the above that although the traditional farmer may appear to be conservative, he is always ready to take advantage of demonstrable profitable innovations especially where, as in rice production, he is able to fit the improved inputs into the traditional farming systems. Similarly, success in yam beetle control with aldrin dust was due to the fact that

its use did not represent a very drastic change in traditional farming practices. These factors must be borne in mind in the development of appropriate research programs in farming systems.

THE FARMING SYSTEMS CONCEPT

A recent development in the newly established international agricultural institutes such as CIAT, IRRI and ICRISAT is the inclusion of a farming systems programs in the organization of their major activity programs or departments. The systems approach is based on the experience that one of the reasons for failure of many agricultural research institutes, especially in the developing countries, to generate innovations that can be easily adopted by the farmer is the adherence in research in agricultural production to the investigation of individual components or inputs of agricultural production often one at a time along the lines of individual familiar scientific disciplines. Yet each farming system forms a complex whole including the location (soils and environment) of the farm business, a selection of crop varieties and breeds of livestock, cultural practices, plant and animal protection measures, harvesting, storage and processing, residues, marketing etc. (Moomaw and Hedley, 1971) as shown in Fig. 1. It is therefore necessary in agricultural research to adopt a holistic approach to the solution of agricultural problems. The major but interacting areas of research that contribute to economically viable socially acceptable farming systems adapted to the farmers conditions and satisfying his needs are discussed below as a basis for the planning and execution of fitting research to farming systems.

FITTING RESEARCH TO FARMING SYSTEMS : ITS NATURE, SCOPE AND MANAGEMENT

In the discussion on the above topic presented below, fitting research to farming systems may be regarded as consisting of investigations and related activities based on the scientific method and techniques with the sole objective of acquiring new knowledge and where necessary disproving or modifying existing knowledge about the farmers environment, the operation of his business, the socio-economic and cultural matrix in which he operates, the resources available to him, and the changes which they undergo as a basis for arriving at meaningful and practicable decisions by farmers, scientists and policy makers in the choice of one or more out of a range of alternatives that maximize agricultural production and efficiency of utilization of natural resources. Research that will satisfy the above objective in the development of economically viable farming systems acceptable to farmers and adapted to various ecological and environmental situations usually involves the participation and interaction of scientists in many disciplines. Moreover, in the light of past experience and the current changes that beset mankind in every part of the globe, other relevant objectives which should constitute meaningful guidelines for research in farming systems include the following:

1. The recognition that in many developing countries farmers constitute a major proportion of the population and operate on small holdings. It is not likely that in the foreseeable future, rapid industrialization which places heavy emphasis on prestigeous, costly and poorly managed industries relying on diminishing resources

some of which are imported in addition to other non-agricultural occupations will soon absorb a considerable proportion of the continuously increasing population to an extent that will reduce the number of farmers and increase farm size to more than just a few hectares. Consequently, efforts must be directed on research aimed at developing farming systems that maximize production on a unit of land so as to save enough land for other pressing needs.

2. The level of education of farmers in the developing countries and the financial resources available to them call for innovations that are technically within their abilities and do not involve drastic changes in their lives.

3. The present concern about the environment and the experience in the developed countries call for farming systems that involve scientific and careful management of resources in such a way that agriculture does not contribute to wastage of resources and pollution.

4. The current energy crisis and concern about the limitness of mineral resources are having very adverse effects on the supply and cost of several agricultural inputs. Research in farming systems should aim at ways of minimizing the extent of their use, increasing the efficiency of their use or finding alternatives that are cheaper and locally available.

5. While there is understandably much concern about producing enough food to feed the ever increasing population, research strategy should aim at a wide range of farming systems which could diversify

agricultural production, facilitate import substitution, and afford the developing countries the opportunity of developing experties in biological production systems in support of agrobased industries which offer the best scope for the kind of industrialization that will enhance their existence in complementarity with the developed countries.

6. Research on farming systems for the tropics should give emphasis to the evolution of permanent production systems with built-in flexibility for change by being continuously involved in the monitoring of the environment so that changes can be foreseen and necessary measures taken.

7. Research activities in farming systems should be carried out in such a way as to ensure that all scientists concerned constantly come in contact with the farmer and the realities of his world so that their investigations are related to the problems of farmers. Isolation of scientists from the farmers environment or the real world outside their laboratories does not encourage their sufficiently living with their problems to hasten intuitive generation of innovations.

8. Scientists in research especially in developing countries should be very careful to avoid over-dramatization of the potentialities of their discoveries in such a way as to lure policy makers to assume undue optimism in a one-way or only agricultural solution of the current population growth and food supply problems.

9. Finally, in farming systems research, priority should be given to improving the way of life of the generality of mankind rather than by developing farming systems that maximize production based on innovations that are available only to the rich. This places the poor farmer at a disadvantage and either widens the gap between the rich and the poor or makes the poorer farmers slaves to the heavily capitalized producers.

It is on the basis of the above consideration and strategy that the following major but interacting areas of research that will contribute to farming systems are discussed.

Socio-economic Research: In many developing countries such as Nigeria, the contributions that economists could make in agricultural development and research were not recognized until within the last decade. Moreover the roles of rural sociologists and economic or social anthropologists in agricultural research and development are either under-estimated or not appreciated at all. In fact, many agriculturists are often not interested in works in these disciplines which sometimes have significant bearing on their day to day problems.

Norman (1974) in his review of the services and experience of the Rural Economy research unit in Northern Nigeria emphasized the importance of inter-disciplinary research in rural development in which agriculture has a major part to play. He also emphasized the need for socio-economic studies consisting of (a) basic studies aimed at describing, explaining and understanding the agricultural environment based on detailed village studies and (b) change studies which seek to assess the potential value of improved technology in agriculture

and the associated programmes as a basis for introducing them to the farmer.

Basic studies of the farmers environment should include studies and investigations on (1) physical features of the farmer's environment in terms of climate, weather, soils, and vegetation; (2) settlement patterns; (3) land tenure and farm size; (4) land use patterns and cropping systems; (5) inventory of crops and animals on the farm; (6) importance of various crops and/or animals in the farm business; (7) labour requirements and distribution throughout the year; (8) input output data and economic analysis of the farm enterprise; (9) kinds of tools used; (10) nutritional status of the farmer and his family; (11) social organizations and division of labour in the community; (12) harvesting, handling, processing and storage of food stuffs and other products; (13) problems of marketing and relative prices of various products; (14) sources of credit available to the farmer; (15) farmers attitudes with respect to choice of crops grown or animals kept, and (16) extent of extension activities getting to the farmer. These studies will require the contributions of sociologists, economists, social or economic anthropologists, geographers and to some extent, at least consultations with soil scientists, botanists and agronomists. The IITA small-holders studies in different parts of Nigeria belong to this category.

Change studies involve the assessment of extension activities getting to the farmer, the nature of recommendations made to him, the evaluation of their feasibility and extent of adoption in relation to their acceptability and impact on the farmers earnings. Studies of diffusion of innovations and the role government and various agencies may play are also relevant. Although the scope of these studies enumerated above may appear formidable initial review of available information from various sources and literature may considerably save time and resources.

Soils and Soil Management Studies: One of the important natural resources in agricultural production is the soil. It is a dynamic medium that has developed over hundreds of years as a function of and changes in climate, vegetation, topography and organisms including man. In areas of traditional agriculture in which shifting cultivation still involves long term fallow approximating natural forest conditions, natural recycling of nutrients and ecological balance in the system results in a state of equilibrium. Under such conditions most of the plant nutrients of importance to agriculture are located in the surface horizons.

Shortening of the periods of fallow, burning and constant clearing of the forest results in loss of fertility, change in soil physical and chemical characteristics, change in microflora and erosion. Research in soils include initially basic pedological studies involving comprehensive and integrated surveys, land use capability classifications etc. Of importance in development of farming systems are standardized pedological investigations, descriptions and mapping which facilitate establishment of relationships among soils in different locations and situations. These are important in evaluating response of crops to fertilizer practices and in monitoring changes related to their management. Also of relevance are toposequence studies aimed at facilitating optimum utilization of soils in different topographic situations and recommendations on management practices.

Pedological investigations may require the contributions of a geologist. Soil chemical and fertility studies are also important in assessing the potentialities of soils for production of different crops, correlation of crop performance with soil analytical data, routine chemical analysis as a basis for recommendations of fertilizer mixtures and amounts to be applied, understanding of chemical processes taking place in soils, determination of nutrient deficiencies and toxicities,

determination of time, frequency and method of application, and so on. One important aspect of soil chemical and fertility studies consists of crop response studies conducted jointly with agricultural economists which enable optimum fertilizer mixtures to be worked out for different soils and crops. Soil chemical studies may involve the cooperation of soil scientists with plant physiologists. The present concern about environment requires that monitoring of chemical changes in soils may be used to study the fate of fertilizers and changes in soil chemical properties under different management practices.

Soil physical studies are also of importance in soil conservation and management. Measurement of soil physical characteristics are useful in making recommendations of management practices, and in explaining aspects of crop performance in certain soils and changes taking place under different management practices. The soil physicist and agroclimatologist often cooperate in evaluating the effects of climatic factors on soil physical characteristics and management in different climatic conditions. A major development in soil management resulting from soil physical research at IITA is the development of minimum tillage techniques which reduces labour in weeding, reduces nematode populations and protects the soil from erosion while reducing soil temperatures and increasing the organic matter content of the soil.

The soil microbiologist is becoming increasingly important in tropical agriculture especially with respect to the study of the biological processes in different soils under different management practices. One very important area of concern in tropical soils is that of lack of realization of nitrogen fixing potentialities of rhizobia in leguminous plants as in temperate soils. The microbiologist also functions in monitoring of the changes in soil organisms in

relation to the effects or changes pesticides applied to crops have or undergo in soils respectively. Cooperation or interaction of soil scientists in general is very important in development of integrated soil management practices. The microbiologist also needs to interact with crop scientists, botanists, biochemists, zoologists and other biologists.

Agroclimatic Investigations: The agroclimatologist's work involves two major activities. Firstly, he performs routine collection of climatic data, interpretes them, and makes them available to all interested. Secondly, he carries out research correlating climatic factors with crop and animal performance. Aspects of his research also include measurement of evapotranspiration, radiation flux, etc. The agroclimatologist makes vital contributions in the evaluation fabrication, and adaptation of special equipment and techniques to the study of the micro-environment of crops and animals. He has to deal with the very dynamic changes taking place in the restricted zone close to the earth's surface where plants and animals exist and live. The agroclimatologist's work requires cooperation with physiologists, agronomists, physicists and agricultural engineers.

Crop Improvement and Management: We are all familiar with the role of the plant breeder in crop improvement. Several aspects of plant breeding are important in developing farming systems for the tropical farmer. Resistance to pests and diseases is a very important aspect of integrated pest control and management. This reduces the reliance on costly biocides which constitute harzards to the environment and the illiterate farmer. Improved farming systems need to involve plants that are (1) adapted to adverse environmental conditions; (2) mature at convenient times for harvesting and processing in relation to other crops with which they may be grown either in rotations, relay cropping or multiple cropping systems. Specific

plant structures may be required for different cropping systems. Nutritional quality should also be given emphasis in farming systems research in the tropics, as well as keeping quality in storage. Stability in performance in a range of conditions and levels of application of limited amounts of costly inputs merits some attention because of the energy crisis.

Crop management investigations in the past have emphasized crop response and performance in monocropping involving the use of costly inputs such as fertilizers and herbicides. With the limited areas of land available to the farmer in the tropics and the instability of monoculture agro-ecosystems, more studies of crop performance and management in multiple and mixed cropping systems be carried out. These offer opportunities in pest and erosion control, more efficient utilization of resources, and maximizing production per unit area of land. Moreover, mixed cropping may be more acceptable to the farmer since it is already similar to his traditional farming system. Research in management of crops, mixed cropping and multiple cropping systems should also give attention to patterns and arrangements of crops that allow for mechanization and application of certain inputs as may be necessary. In both crop improvement and management studies not only is cooperation among breeders and agronomists necessary but physiologists and economists could make valuable contributions.

Animal Improvement and Management: Aspects of animal improvement that should be given emphasis in farming systems research in the tropics include adaptation to adverse weather and environmental conditions. There is need for research on the development of breeds of animals that are thrifty enough and perform well under lower levels of nutrition or when fed on feeds which do not compete with

human food requirements. This is very important since at present, a lot of the feed grains which are more nutritious than tropical root and tuber crops are fed to animals in developed countries. Breeding of animals for better performance as work animals constitutes an aspect of mechanisation and removal of drudgery in farming.

Animal management systems for the developing countries should aim at increased production of animal feed ingredients from cheap local sources and increased use of waste materials in animal feeds. In traditional farming systems feeding of goats, sheep and poultry on farm and compound wastes constitutes a land saving device since more animals are kept than the carrying capacities of the limited area of land available permits. The animal production specialists, forage and range management agronomist(s), economists and veterinarians play major roles in animal production but research in more effective manipulation of the environment in animal management could reduce the extent of reliance on the veterinarian. Improved animal management systems for the tropics should also involve the engineer in providing structures for animal housing that are cheap and obtainable locally rather than rely on costly structural materials that are manufactured elsewhere.

Crop and Animal Protection: The most effective widely practised method of crop protection used in modern agriculture involves the short-gun approach of frequent use of pesticides applied at specified intervals during the various stages of growth of the crop. The present concern about the environment, the harzards that pesticides pose to illiterate farmers and the cost of pesticides and equipment for their application requires that priority be given to developing farming systems employing integrated control. This involves the use of a range of

compatible cultural, physical, biological and other methods of pest management based on ecological principles and knowledge of population dynamics. This would restrict use of pesticides to a minimum and to strategic applications at certain stages of development. Research in this area is multidisciplinary in nature and requires better knowledge of organisms and their environment. Ecologists, entomologists, weed scientists, biochemists, agroclimatologists and economists would be involved. A similar strategy could be adopted in animal protection by emphasizing research aimed at breeding for resistance to pests and adaptation to adverse climatic conditions. Coupled with this would be research aimed at utilizing the knowledge of animal physiology, ecology and micro-climatology in constructing cheap structures for housing animals under conditions that minimize various stresses to which animals are exposed.

Agricultural Engineering: One of the most important areas of farming systems research in the tropics is agricultural engineering involving mechanization of various operations, farm structures, and soil and water management. In the development of farming systems for the tropics cheap labour saving devices are required. Although it used to be a foregone conclusion that sooner or later large scale mechanization must eventually take place in tropical farming systems. There is need for mechanization that is cheap, involves minimum use of costly sources of energy and adapted to local crops and soils. Although this calls for mechanization of the intermediate or appropriate technology type not much priority has been given to exploiting this fast enough to stem the tide of youth leaving the farm for the cities or in increasing the area of land that the farmer can cultivate. The place of solar, wind and other non-conventional sources of power have not been fully investigated. Farming systems research in the tropics should give

very serious attention to land clearing studies since land clearing is very expensive and when carried out with heavy equipment in high forest, may disturb the soil to an extent that adversely affects soil properties and lowers soil productivity. Processing and storage investigations related to the utilization of local foodstuffs will reduce dependence on easily handled food preparations imported from abroad. Cheap storage facilities could even out supplies of products throughout the year and facilitate multiple cropping systems since certain crops such as grain legumes restricted to production during periods when they mature in the dry season could be harvested green and early if they can be canned. Under such conditions they could be double-cropped during each year and harvested early enough to give way to other crops in the system. Cheap storage facilities also facilitate holding of produce till they can be sold at the highest profit margins. Agricultural mechanization aimed at adapting cheap small tractors and animal or hand operated equipment to farm operations could markedly increase output.

Soil and water engineering research is very vital in the development of farming systems in certain ecological situations. Apart from research connected with irrigation and water management in large scale projects, small holders in the developing countries require cheap irrigation structures that could facilitate development of small watersheds and conservation of water. A lot of water is lost in surface run-off on the one hand while on the other hand drainage in hydromorphic soils and swamps could contribute to increased agricultural production. The use of simple water storage and carrying structures has not been fully exploited. The potentialities of such facilities in production of off-season crops and vegetables are immense and could significantly improve

nutritional quality Investigations of water requirements of tropical crops especially under supplemental irrigation is worthwhile. Perhaps the most important aspect of water management research in the tropics is the study of social and ecological implications of widespread development of water management or irrigation projects of various kinds and scales. Although these may not significantly affect the small-holder, certain effects of such projects may necessitate changes in farming. For example, commercial small holder yam production on the alluvial flood plains of the Niger may be adversely affected by the Kainji Dam since some of the silt which used to enrich the plains are now being deposited in the Kainji lake.

INTEGRATED FARMING SYSTEMS RESEARCH AND STRATEGY

In research aimed at developing a range of farming systems there is need for provisions to facilitate integrated research projects which combine inputs from the interdisciplinary investigations considered above. The relevance of these inputs can only be determined by measuring their performance in individual candidate farming systems trials under field conditions. Results from evaluation of inputs in various combinations supply feed back information to various scientists involved in generating the inputs. For example, the performance of a maize variety in combinations with cassava or cowpeas will supply information on whether a different plant structure is needed in intercropping or whether it breaks down to some disease in such combinations. At IITA, the tentative strategy in the integrated farming systems research which may be modified with experience involves the following:-

1. Development of some basic assumptions and priorities of requirements of potential farming systems based on results of socio-economic study of traditional agriculture with emphasis on the small holder.

2. Preliminary short-term field studies the main objective of which is the testing of many treatments on crop combinations and sequences. These will yield suitable combinations of treatments and inputs in complete package farming systems involving multiple cropping, relay cropping, or rotational cropping. In these preliminary studies necessary attention is given to statistical niceties in their execution.

3. Long term Field Experiments in which selected cropping systems are tried out. These will involve few treatments of selected cropping combinations on large plot sizes on which are superimposed pest and weed control treatments, fertilizer treatments, cultivations treatments, etc. that further increase the scope in the number of input combinations and timing being tested. Some of the promising combinations are grown in large plots for economic assessment of cost of operations in relation to returns accruing therefrom. In these long term multiple cropping intercropping or relay cropping experiments entomologists, nematologists, soil scientists, and phylopathologists will monitor agroeconomic conditions, pesticide residues, and other changes.

4. Off-site experiments in experiment stations and in farmer's fields in a range of ecological zones. These experiments will involve crops and input combinations which have performed well under field conditions. Their testing is limited to locations where they are relevant to specific ecological conditions and prevailing farming systems.

5. Adaptive Experiments: These are used to test promising farming systems or innovations developed elsewhere, for example, rice multiple cropping systems developed at IRRI may be tried out using crops relevant to tropical Africa.

6. Modelling and simulation experiments. These will be used to study the operation of inputs in traditional farming systems and test the performance of improved inputs. They also could supply prior information on cropping systems experiments to be tested in the field. Systems analysis based on data from multiple and intercropping experiments may be used to generate a range of viable cropping systems that could be adopted without field further testing. Systems scientists, production economists and statisticians participate in this activity.

Some underlying assumptions: In designing the above experiments priority is given to the problems of the traditional farmer. For example, it is assumed that these farmers will for a long term be producing most of their food on their farms since they cannot afford to purchase much of it. It is also assumed that farming systems involving maximizing production of individual crops in monoculture has not been acceptable to most farmers except with such crops as rice or plantation crops. Consequently, emphasis will be given to the evaluation of the potentialities of intercropping farming systems which involve more stable agroecosystems and are more related to what the farmer is already doing.

Problems of Interdisciplinary and Integrated Experiments: Execution of multi-disciplinary problem-oriented programs in farming systems involve many disciplines and all the relevant staff may not be available on the site at the same time. This

has to some extent been solved by fanning out projects to scientists in Universities and other research institutes and agencies. In this exercise priority is given to institutions of excellence in disciplines relevant to the problems to be solved. Visiting scientists programs and graduate training programs also assist in the solution of this problem.

Another problem is that of organization and management of scientists who have been trained in specific disciplines. It is hoped that this can be accomplished by having a coordinator who ensures that relevant scientist are brought into integrated farming systems programs. There is need for flexibility in also allowing scientists to carry on some research in their own disciplines and work out cooperation at the personal level provided that they are related to the established priorities and are not detrimental to their participation in the integrated research program. Finally, there are priblems of management of interdisciplinary research staff, of evaluation and rewarding of staff contributions in development of inputs. Should this be based on number of publications or on other criteria? It is fitting that performance and contributions in cooperative projects should be recognized whether they result in publications or not. Research that merit publications in learned journals do not always make contributions that are relevant to the small farmer.

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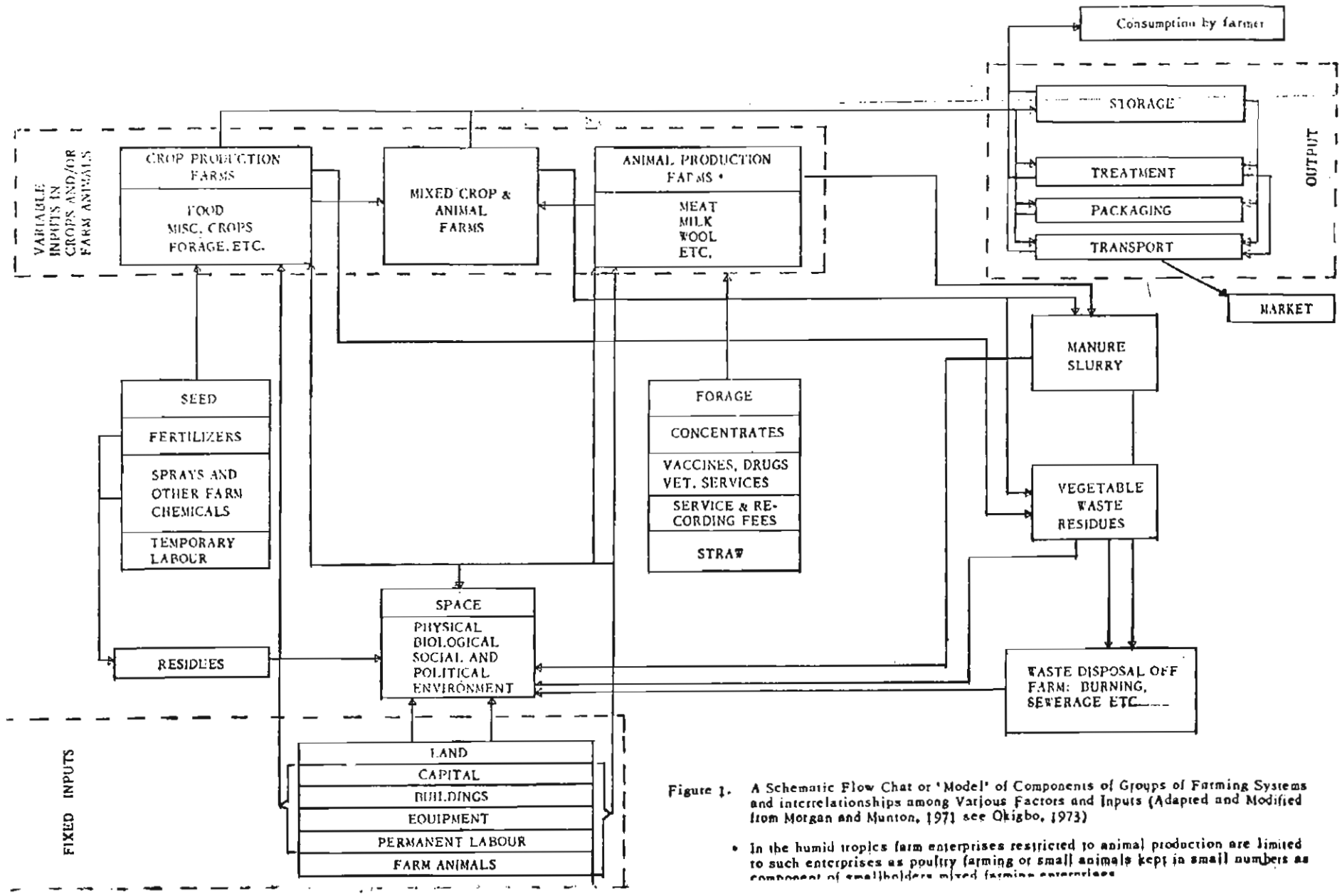

Figure 1. A Schematic Flow Chat or 'Model' of Components of Groups of Farming Systems and interrelationships among Various Factors and Inputs (Adapted and Modified from Morgan and Munton, 1971 see Okigbo, 1973)

* In the humid tropics farm enterprises restricted to animal production are limited to such enterprises as poultry farming or small animals kept in small numbers as component of smallholders mixed farming enterprises