AN ECOLOGICAL FRAMEWORK FOR REGIONAL AGRICULTURAL DEVELOPMENT PLANNING IN WEST AFRICA

by

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B.Sc.(Agric.) University of Science and Technology, Kumasi, Ghana, 1967

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MASTER OF SCIENCE

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We accept this thesis as conforming to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

May, 1972
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School of Planning,
The University of British Columbia
Vancouver 8, Canada.

Date: 5th May, 1970.
Dedicated to my affectionate parents.
ABSTRACT

Agricultural development involves the large scale economic production of plant and animal crops through modification and exploitation of ecosystems. Since crop species themselves are integral parts of the ecosystemic complex, any effort to raise the productivity of tropical agriculture must acknowledge ecological constraints as well as the opportunities for improved production. In the tropics this fundamental principle has been overlooked in the reduction of diversity of the ecosystem through monoculture of a very few export crops. In addition to reducing ecosystemic stability this has led to reduced production of basic food staples. The rich fauna is being replaced by domestic cattle, sheep, goats, pigs and poultry. Monoculture has led to the adoption techniques requiring a large energy subsidy, i.e. selective breeding programmes, fertilization, mechanization and irrigation. Although the approach has proved conceptually sound in temperate regions and results in some practical benefits in the tropics, it has had a disastrous impact on the socio-economic stability of the traditional society. Undernourishment, poverty and the social unrest which have characterised Ghana in recent past are inevitable consequences of the mismanagement of agriculture.

The underlying hypothesis of the study is that the development of tropical agriculture within an ecologically sound framework is a fundamental pre-requisite to modernizing the system, to increasing productivity and to
providing a sound basis for agricultural development planning in West Africa. Properly implemented it would safeguard the future of tropical agriculture and the environment.

This study is based on an examination of available literature, information from a mailed questionnaire and personal familiarity with the study area. Since most of the data refer to Ghana, I have focussed on the Ghanaian situation while drawing on experience from elsewhere.

An ecological approach to tropical agricultural development is described, followed by a comparative study of systems of production in the tropical and temperate zones. This permits an assessment of the impact of the "Green Revolution" on tropical agrarian systems and reforms.

The consequences of mismanagement of tropical agricultural development are assessed with respect to socio-economic and political difficulties. Most of the source data support the hypothesis. Suggestions are made to redress the underlying causes of low tropical agricultural production. It is the conclusion of this thesis that tropical agriculture can be best developed by recognising the nature of tropical ecosystems.
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He is also indebted and most grateful to his patient wife, Margaret.
CHAPTER 1

INTRODUCTION

OBJECTIVE OF THIS STUDY

The objective of this study is twofold - first to assess the present state of agriculture in West African countries and second, to discuss the relevance and potential of the ecological approach to the development of tropical agriculture in the context of Regional Development Planning. In order to provide a basis and direction for the study the following hypothesis is advanced.

HYPOTHESIS

The development of tropical agriculture within an ecologically sound framework is a fundamental pre-requisite to modernising the system of cultivation and increasing production. Properly implemented it would provide the basis for balanced and integrated regional development planning in West Africa and by preserving the integrity of the ecosystems would safeguard the future of tropical agriculture.

METHODOLOGY

This study is based mainly on an examination of available literature and personal familiarity with the study area. To provide a cross-check on the accuracy and currency of issues that resulted from the bibliographic research a questionnaire was sent to individuals, mainly in West Africa, who are associated with tropical agriculture.
The questionnaire covered a wide range of subjects from aspects of the Teaching of Ecology, through Large Scale Commercial Farming, "Ecological Boomerangs" resulting from the use of temperate agricultural techniques in the tropics, Mechanization, research into Problems of Food Production including game, Shifting Cultivation, Farmers' Attitudes and Governmental Participation and Co-ordination. Since only fourteen out of forty-five copies of the questionnaire were returned, a detailed statistical analysis was not attempted. The response was analysed qualitatively and used along with bibliographic information to support the body of the thesis.

Five chapters were developed. The introductory chapter contains a statement of the objective and hypothesis of this study. A historical background of tropical agricultural development is traced, followed by a definition of an Ecosystem and the problem and factors of mismanagement which militate against increased agricultural production. The proposition is advanced that an ecologically sound framework is an essential prerequisite for agricultural development. A conceptual approach based on ecological reasoning is developed in Chapter 2. Chapter 3 is devoted to a comparative study of tropical and temperate systems of agricultural production. This has been done with the purpose of overcoming deficiencies inherent in the tropical systems of production. The Economics of Agriculture is examined and the consequences of mismanagement of the planning strategy are assessed in Chapter 4. This is related to undernourishment, poverty and social unrest which has characterised Ghana in the recent past. As a concluding section, Chapter 5 contains a series of recommendations for the advancement of agriculture in West Africa.
THE SIGNIFICANCE OF THE STUDY FOR REGIONAL PLANNING

Ghana and the other West African countries depend on agriculture as the main source of livelihood (F.A.O., 1970). Agriculture is, indeed, the indispensable element in any human society, and thus the Regional Planner who deals with the complexities of society particularly in the developing countries must involve himself in it. Unfortunately, the planning strategy developed for agricultural production in many such regions and including West Africa is deficient in scope and intent. The consequences of poor planning - undernourishment, poverty, social and political unrest which often characterise traditional societies in the modern world - are tragically wasteful but largely avoidable.

While the problem of feeding tropical people could become a political hotbed, the solution does not lie in any political philosophy but in the proper development of agricultural resources (Wrigley, 1961, p. 17).

In order to be able to redress these difficulties and also to provide for an adequate standard of living compatible with the increasing population Regional Planners must help to formulate policies regarding the servicing of agriculture. They must also hold the responsibility for making recommendations for its future. These policies must reflect an in-depth understanding of ecological realities which need be integrated with socio-economic factors native to his area of influence. Thus, this study provides the framework for agricultural development within an ecosystemic framework, an essential prerequisite for sound Regional Development Planning in West Africa.

HISTORICAL PERSPECTIVE

The course of agricultural development can be traced to the historical association of West Africa with Metropolitan Europe. This period dating
back to the fifteenth century, when West Africa had her initial contact with Europe, reflects a sad situation in which the African human and natural resources were used to produce raw materials solely for the economic interest of Europe (Boahen, 1966). This involved a shift from the traditional system of agriculture to the European cropping system and, ultimately, modern agriculture. This was not without ecological consequences. The period can best be divided into four important eras, beginning from the time preceding the advent of the white man, continuing through the slave trade era and the colonial era, to the post colonial administration.

(a) The Period Preceding the Advent of the White Man

This period was characterised by a subsistence economy supported by shifting cultivation and the ancillary practices of game cropping, nomadic herding, processing of sylvan produce and spinning and weaving of some expensive clothing like the Ghanaian Kente (Oluwasanmi, 1966). This period is important for this study because of the ecological suitability of the system of agriculture and also the stability of its society. It is estimated that prior to the slave trade era the population of the African continent was about one-fifth of the world's total population (Oluwasanmi, 1966).

(b) The Slave Trade

In the wake of plantation establishments in the Caribbean, in North America and Latin American countries the need for labour was greatly felt. Consequently the slave trade was developed to meet this demand. The effect of the slave trade on society and agriculture can be aptly summed up in the words of H. A. Oluwasanmi:

Apart from destroying whole communities, the slave trade demoralised society and seriously undermined the foundations on which law and order had been founded. What had been peaceful
agrarian societies were disrupted almost completely. The middle-man engaged in procuring slaves from the interior preyed upon the peasantry, spread anarchy and instigated inter-tribal wars which reduced the villages and the countryside to desolate the empty wilderness. What agriculture remained was static (Oluwasanmi, 1966, p. 9).

(c) The Colonial Era

This period is very important for it marked:

1. the end of the slave trade,
2. a shift from subsistence economy to commercial agriculture based on money,
3. the establishment of modern governmental machinery,
4. the infusion of European values into the social system, and
5. the introduction of institutions for formal education.

The declining importance and consequent abolition of the slave trade was the result of declining profits from investments in the West Indian Plantations where the slaves were largely employed. H. A. Oluwasanmi quotes Eric William to the effect that in 1773 twelve out of the thirty houses which dominated the slave trade in Liverpool had gone bankrupt (Oluwasanmi, 1966, p. 9). Meanwhile the industrial revolution provided a more profitable outlet for capital. In the wake of the industrial revolution there had been rapid urbanization of unprecedented dimensions. The urban dwellers needed light, soap and lubricants for machines, the demand for oil from plant sources changed the course of events. The desire of the industrialized societies, particularly, Britain, France and Germany, to control the sources of the raw materials led to the "Scramble for Africa" (Oluwasanmi, 1966, p. 10).

In West Africa four colonial powers participated in the partition drama - Britain, France, Portugal and Germany. Britain colonised the Gambia, Sierra Leone, Ghana and Nigeria; France colonised Mauritania, Senegal, Mali,
Ivory Coast, Upper Volta, Guinea and Dahomey Niger. Portugal had only one colony - Portuguese Guinea, Germany had two, namely, Togo and the Cameroons but lost them to France and Britain after the Second World War.

To promote orderly trade transactions between the colonialists and the native citizens it became necessary to establish peace among the citizens and also to transform the social structure and the subsistence agricultural economy.

Lugard wrote in 1893:

It is in order to foster growth of the trade of the country, and to find an outlet for our manufactures and our surplus energy, that our far-seeing statesmen and commercial men advocate colonial expansion ... If our advent in Africa introduces civilization, peace and good government, abolishes the slave trade, and effects other advantages for Africa, it must not be therefore supposed that this was our sole and only aim in going there. However greatly such objectives may weigh with a large and powerful section of the nation, I do not believe that in these days our national policy is based on philanthropy only (Lugard, 1893, pp. 381-2).

Many methods were employed to colonize West Africa during which period the Metropolitan powers deliberately encouraged development of a "colonial model" whose destiny was to supply certain raw materials and crops. From the agricultural point of view the steps were to establish the following:

1. plantations of cocoa (Theobroma cacao), oilpalm (Elaeis guineensis) and rubber (Hevea brasiliensis),
2. commercial livestock outfits,
3. monocultures of cereals - rice (Oryzea sativa), maize (Zea mays) and groundnuts (Arachis hypogaea)
4. communications, roads and railways, and
5. formal training of agricultural personnel.
Plantation agriculture was a novelty in West Africa but insofar as incentives were provided it took off nicely. Ghana had good prospects for cocoa growing. Prior to the advent of cocoa, *Theobroma cacao*, in the 1850's and 1860's in West Africa, the oilpalm, *Elaeis guineensis*, and rubber, *Funtumia elastica*, had been well established. These trees grew widely across West Africa. Palm oil was exported from Gold Coast (now Ghana) from about 1820 onward. By 1890 Ghana had become the world's third largest producer of rubber. But the rubber industry died because of reckless tapping and consequent destruction of trees, competition of Malayan rubber on the world market, and the establishment of the cocoa industry. (Adu, 1966).

The importance of the oilpalm industry also declined in Ghana, in part the result of the neglect of the palm trees and, in part, from the method of tapping them for palm wine whereby the trees were felled first. In most cases the trees were never replanted. Thus Ghana's agriculture became centred solely on the cocoa industry while Nigeria, Ivory Coast and some other countries developed a more diversified agricultural base.

Groundnuts were first produced at the present sites of Gambia and Sierra Leone after the railway linking the south to the north had been constructed. Production of timber, gum, coffee and cotton was encouraged in many countries of West Africa.

Commercial livestock husbandry was given little encouragement. Agricultural research institutions were established such as the West African Cocoa Research Institute (W.A.C.R.I.) based in Ghana and the West African Institute for Oilpalm Research (W.A.I.F.O.R.) in Nigeria.

Harbours, roads and railways were built to facilitate exploitation in the extractive industries and agriculture. In Ghana these were restricted
to the south which had the resource base. In Nigeria the railway lines were extended to the north and the road network was much more extensive but these were built with the sole intent of facilitating cultivation of ground-nuts. The development of the transportation systems in Ghana and Nigeria started in the 1910's (White, 1962; Oluwasanmi, 1966).

(d) Post-Colonial Administration

Colonial agricultural development, inherited from the Colonial Powers was unbalanced in scope and emphasis. Many African countries have therefore sought to rectify this anomaly. This is being done by a more liberal use of pesticides, irrigation, mechanical ploughing, harrowing, weeding, harvesting and the employment of specially bred or treated planting materials. There has also been an attempt to train students for technical and professional responsibilities such as planning, research and agricultural extension. A number of high level agricultural institutions and agricultural technical schools have been built where resources so permit. In Ghana the Government established a "Ghana State Farms Corporation" which was charged with responsibility for plantation agriculture; large scale farming of cereals and groundnuts and livestock production. Other farming organisations such as the Farmers' Co-operatives, the Builders Brigade etc. were also established. Despite these efforts, tropical agriculture based on technologies developed for temperate regions has been characterised by an unfortunate number of spectacular failures. Perhaps what remains to be done is to break from the traditional temperate system of agriculture to the development of agricultural techniques based on the characteristics and limits of tropical ecosystems.
DEFINITION OF ECOSYSTEM

By definition an ecosystem is "a biotic community of interrelated organisms, together with their common habitat" (Geertz, 1968, p.18).

Ecosystems may be studied from different perspectives. Structurally an ecosystem consists of (1) inorganic substances (C, N, CO₂, H₂O, K, etc.) involved in material cycles, (2) organic compounds (proteins, carbohydrates, lipids, humic substances), (3) climate regime (temperature and other physical factors), (4) producers, i.e. autotrophic organisms, largely green plants, which are able to manufacture complex food substances from simple inorganic substances, (5) macroconsumers, phagotrophs, heterotrophic organisms, chiefly animals which ingest organic matter, and (6) microconsumers, saprotrophs, or osmotrophs, heterotrophic organisms, chiefly bacteria and fungi which synthesise the complex compounds of dead protoplasms into forms that they could use and release inorganic substances which either provide energy sources or which may be inhibitory or stimulatory to other biotic compounds (Odum, 1971). The composition of temperate soil fauna differs markedly from the tropical soil fauna. The main difference is that termites are a dominant factor in the conversion cycle in tropical soils (Brammer, 1962, p. 122; Thomas, 1962 p. 162). The inorganic substances, organic compounds and climatic regimes constitute the abiotic components of ecosystems while producers, macroconsumers and microconsumers from the living weight or biomass (Odum, 1971).

An ecosystem may also be studied from a functional standpoint in the following terms: (1) energy circuits, (2) food chains, (3) diversity patterns in space and time, (4) nutrient (biogeochemical) cycles, (5) development and evolution and (6) control or cybernetics (Odum, 1971).

An ecosystem may also be viewed from a trophic standpoint, namely (1) an autotrophic component associated with photosynthesis or chemosynthesis
and (2) a heterotrophic component which subsists on complex food substances obtained mainly as a result of photosynthesis (Odum, 1971).

The following features characterise tropical ecosystems:

1. tremendous diversity of plant and animal life and complex trophic relationships,

2. a relatively stable and highly predictable physical environment (climate, etc.), and

3. energetic weathering as the result of high temperatures, high rainfall, and high microbial activity and soils that are prone to leaching, erosion and laterization.

PERCEPTION OF A PROBLEM

To say that agricultural productivity in West Africa is very low is to state the obvious. The problem is not peculiar to West African countries but is characteristic of many other countries in the tropics which have accepted temperate zone agricultural techniques as a basis for tropical agrarian reforms.

Low agricultural productivity results from the fact that imported temperate zone agricultural techniques have in many cases replaced the traditional systems of cultivation, without any attempt to develop a sound agricultural framework adapted to tropical conditions. Ironically, although the traditional systems provided the most elegant and sophisticated means of utilizing tropical ecosystems from ecological point of view (Rappaport, 1971) they have been dismissed as being primitive. Unfortunately in unmodified form they support small populations only (Questionnaire response).

Some of the temperate zone agricultural techniques have undoubtedly been beneficial at least in the short run, but many of them have also been disruptive. They have been dysfunctional in respect to the production of
vegetable food products, meat and fibre, and maintenance of the ecosystemic integrity.

As L. S. Harding remarked:

Thus production techniques developed in temperate zones do not always transfer readily to the tropical and sub-tropical regions ... (in Preface to Fletcher and Merril, 1968).

Other authors have made the same point:

The basic principles underlying agricultural practices are universal, but their application under tropical as compared with temperate conditions is markedly different (Tempany and Grist, 1962, p. xv).

This is the result of the striking difference between temperate and tropical ecosystems.

Unfortunately, in developing societies there is often the tendency to adopt applied research in preference to basic or fundamental research. "Urgency to produce results often makes fundamental research a luxury" (Sey, Respondent to questionnaire 1972). Although this is a natural reaction to the pressing demands of developing societies the specific technical know-how so essential for high agricultural productivity in the tropics can only result from fundamental research, especially if we are to avoid the recurrence of the past mistakes by wholesale application of temperate zone agricultural techniques.

In the early days of tropical planting too many mistakes were made by the application of farming practices suitable for temperate countries, but the pioneers had no alternative. To repeat many of the mistakes would be inexcusable, and tropical agriculture must rest on its own foundations (Wrigley, 1961, p. 18).

Higher and sustained productivity can result only from ecological planning based on thorough understanding of tropical ecosystems. Adopting some but not
all of the temperate zone agricultural techniques and improving tropically adapted techniques to create an ecologically sound plan will raise overall productivity.

Another unfortunate feature of West African agriculture which sadly reflects on production strategy is what may be termed "the temperate technical training mentality". This includes the tendency on the part of the tropical agriculturalists, planners, executives and government officials of many developing countries to be too much preoccupied with the agronomic needs of export crops to the neglect of staples for local consumption (Questionnaire response, 1972).

In many West African countries there are virtually no higher institutions or technical colleges for training agriculturalists and technical personnel. Even in those countries where such facilities exist, the standards are comparatively low and the scope of training relatively narrow. Hence the necessity of training at least some of the students in temperate agricultural institutions. Unfortunately these students return home on completion of their studies to fill positions without undergoing any programmes of re-orientation to familiarise them with conditions in their own country. It is essential that such programmes be arranged, "Otherwise the wrong methods are applied and agricultural extension becomes ineffective" (Director of Agriculture, Respondent to Questionnaire 1972). In Ghana foreign trained dentists and doctors serve a period of internship to re-orient them and qualify them to practise and I am suggesting that a similar policy should be adopted for foreign agricultural trainees returning home. The length of such a programme of orientation may vary according to the ecological bias of the students' previous academic curriculum.
Large sums of money are annually allocated for agricultural development but the money usually goes into training of temperate rather than tropically oriented agriculturalists, the research into management and agronomic needs of export crops and the production of such animals as cattle, goats, sheep, pigs and poultry. The rich indigenous fauna are exterminated by physical means (Nasimovich, 1970; Thomas, 1962) or by creating conditions in the natural environment under which they cannot survive (Questionnaire respondent, 1972). Viewed in this respect the criticism that only lip service has been paid to the importance of agriculture (Oluwasanmi, 1966) may not be wholly true at least for some West African countries. On the contrary, agriculture has received a fair share of the expenditure allocations as shown by Tables 1.1 and 1.2 of the Ghana Government Development Expenditure. Percentages of development expenditure allocated agriculture and natural resources over total Government Development Expenditures for the plan periods 1951-59 and 1959-64 are 6.4 and 9.9 respectively. Although these figures are low relative to amounts spent in some other sectors, the development of other sectors of the economy especially the establishment of infrastructure is an essential prerequisite to agricultural progress (Republic of Ghana 1957-8), and has been considered under the plan.

The need for developing export crops for foreign exchange cannot be underestimated but a proper balance needs to be developed and maintained between production of export crops and food staples for local populations. An examination of the agricultural targets shown under Table 1.2 shows that the staples had been neglected. The six top priorities of agriculture
Table 1.1: GHANA GOVERNMENT DEVELOPMENT EXPENDITURE 1951-1964

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<tr>
<td></td>
<td>£G.000</td>
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<td>Agriculture and Natural Resources</td>
<td>7,616 (6/4%)</td>
<td>24,668 (9.9%)</td>
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<tr>
<td>Industry and Trade</td>
<td>5,548</td>
<td>25,331</td>
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<tr>
<td>Electricity</td>
<td>4,440</td>
<td>8,765</td>
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<tr>
<td>Communications</td>
<td>35,955 (30.6%)</td>
<td>53,010 (21.1%)</td>
</tr>
<tr>
<td>Local and Regional Governments</td>
<td>6,000</td>
<td>18,852</td>
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<tr>
<td>Education</td>
<td>17,390 (14.8%)</td>
<td>27,852 (11.1%)</td>
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<tr>
<td>Information and Broadcasting</td>
<td>1,176</td>
<td>2,677</td>
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<td>Health, Sanitation and Water Supplies</td>
<td>15,033</td>
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<td>Housing</td>
<td>7,862</td>
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<td>Police and Prisons</td>
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<td>Contingencies</td>
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Table 1.2: AGRICULTURE - SUMMARY, SECOND PLAN: 1959 - 64

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<td>2,499</td>
</tr>
<tr>
<td>Forestry</td>
<td>1,502</td>
</tr>
<tr>
<td>Fisheries</td>
<td>500</td>
</tr>
<tr>
<td>Co-operation</td>
<td>194</td>
</tr>
<tr>
<td>Agricultural Development Corporation</td>
<td>6,000</td>
</tr>
<tr>
<td></td>
<td>24,668</td>
</tr>
</tbody>
</table>

Source: Nkrumah-Debate on Second Development Plan, p. 65.
under the Second Plan were as follows:

1. to raise the yields of the cocoa industry,
2. to establish large acreages in rubber and bananas (*Musa sapientum*) in the wet south-west,
3. to establish the foundations of the cattle industry,
4. to raise the yields of cereals in the Northern Region,
5. to bring the Volta flood plain under irrigation, and
6. to study and promote the use of fertilizers (Second Development Plan, p. 4).

Every encouragement was provided for increasing the yield of cocoa by provision of high yielding stocks, fertilizers and control of diseases and weeds. A programme of replanting cocoa farms in the Eastern Region was instituted whereby £G30 per acre was offered to those farmers who were affected by cutting out cocoa trees infected with swollen shoot virus disease. £G2,500,000 went into spraying cocoa trees against capsid attack and £G194,000 went into fertilizer demonstrations.

Rubber and bananas also received favourable attention. More than £G300,000 was set aside for clearing and planting subsidies. A subsidy of £G30 an acre for the first 50 acres was payable to farmers who would follow recommended practices of plantation establishments while planting loans were made available through the Agricultural Credit Board. Bananas were deemed potentially profitable, especially the"Gros Michel" variety, and interplanting with rubber was recommended for growing on the same land for the first four years of cultivation. Under the Plan the yield of cereals was to be stepped up in Northern Ghana through the increased application of fertilizers and planting hybrid maize.
On the other hand, millet and sorghum which are major staples in Northern Ghana have been neglected. Priority should have been given to developing these crops while looking into the prospects for large scale production of maize. The North is relatively dry and millet (*Eleusine coracena*), which is particularly drought-resistant, is a favourite crop among the Northerners. Similarly in the South the improvement and cultivation of plantains (*Musa paradiasica*) and cocoyams (which are staples for large sectors of the population) are totally neglected while cassava (*Manihot utilissima*), yams (*Dioscorea*), pawpaw (*Carica papaya*), mangoes (*Mangifera indica*) and other native vegetables and spices receive only nominal treatment. Application of fertilizers is strictly limited to export crops.

The Plan sees the increasing consumption of imported meat (primarily beef) and milk as a threat to Ghana's balance of payment and recommends cattle husbandry to the people. What a paradox! Even the so-called West African shorthorns, N'dama and White Fulani, which are the most important breeds of cattle, are not truly indigenous having been introduced only a few centuries ago (Thomas, 1962). They originated in south-central Asia, where during the course of evolution they differentiated into the zebu and the aurochs. While the aurochs spread over to the temperate regions the zebu remained in the tropics (Tempany and Grist, 1962). The zebu might have been introduced first by the Arabs into North Africa where the Tuareg herdsmen reared them and eventually to the Old West Sudan states of Ghana, Mali and Songhai. By cutting down trees to provide pasture and through the disastrous feeding habits of cattle, sheep and goats, ancient man favoured the course of development of the Sahara (Silverberg, 1969).
Animals well adapted to any ecosystem are essentially characterised by:

1. Minimum loss in body weight during exposure to stress such as heat, nutritional deficiency and transport,
2. high reproductive rate,
3. high resistance to disease, and
4. longevity and low mortality rate (Hafex, 1967).

Temperate livestock represented by cattle, sheep and goats and to a lesser extent, pigs and poultry are thus ill adapted to tropical conditions (Tempany and Grist, 1962). The Second Development Plan cites disease, poor quality of cattle, poor grass and difficulty of dry season feeding and availability of water as the bottlenecks to successful establishment of the cattle industry and sets up elaborate plans to counteract such conditions in order that the industry might succeed. £G75,800 was allocated for the control of tsetse fly. The problem of dry season feeding was to be overcome by teaching farmers to make hay and silage. It is important to note that one of the reasons increased agricultural production was favoured in the North was to provide cheap food for cattle (Second Development Plan, 1959-64).

Rather than teaching the farmers to provide hay and silage for ill-adapted cattle at such a great cost, the farmers could have been more usefully employed growing millet, sorghum, groundnuts and maize to feed the population. For instance in January, 1969, a bag of 220 lbs of maize sold for not less than U.S. $20.00 which the masses of the people could ill-afford.

Many of the methods employed in improving livestock seem to have failed. The method of "grading up" has proved to be usefully rapid elsewhere but has not been successful in West Africa. This method involves crossing imported males with indigenous females, the underlying principle being to select
desirable qualities from the male (Tempany and Grist, 1962). In view of difficulty of acclimatization of these animals to the environment, introduction of new genes could be harmful. Lansbury (1962) has suggested that a rapid increase in cattle and other ruminants in West Africa is neither possible nor desirable. In Nigeria, Shaw and Colville (1950) have shown that European cattle are unable to withstand the tropical stresses due to heat, the low plane of nutrition and enzootic diseases. Cattle are characterised by slow growth rate and need longer periods in becoming sexually mature. For example it takes a West African bullock four to six years to reach the slaughter weight (Thomas, 1962). These characteristics of traditional temperate livestock cause temperate livestock husbandry to be a luxury in the West African setting; game provides the cheapest meat.

Although the once rich fauna of Ghana has been very much depleted, sufficient quantities still remain to re-establish viable herds. Thomas (1962) quoting Collins (1961) wrote that barely 50 years ago the plains of Ghana were teeming with game. Of course the bulk of the larger wild ungulates have been killed, and except in the Mole Game Reserve they are indeed rare. The Mole Game Reserve, occupying some 850 square miles to the North West of Ghana near Damongo, is believed to have a high population density of game similar to those in East Africa (Thomas, 1962). Squire (1962) estimated that there are 186 different species of mammals. Of this 95 species are confined to the forest regions, 59 species are in the savannah, 30 species are common to both the forest and savannah regions while the remaining three are aquatic. These mammals are summarised into Table 1.3.
<table>
<thead>
<tr>
<th>Type of Animal</th>
<th>Number of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Forest</td>
</tr>
<tr>
<td>Hedgehog (Hemiechinus and Paraechinus)</td>
<td>-</td>
</tr>
<tr>
<td>Shrew</td>
<td>3</td>
</tr>
<tr>
<td>Fruit bat (Pteropus niger)</td>
<td>7</td>
</tr>
<tr>
<td>Insectivorous bat</td>
<td>24</td>
</tr>
<tr>
<td>Potto (Perodicticus potto)</td>
<td>1</td>
</tr>
<tr>
<td>Bush baby (Galago spp.)</td>
<td>1</td>
</tr>
<tr>
<td>Monkey</td>
<td>8</td>
</tr>
<tr>
<td>Ape</td>
<td>1</td>
</tr>
<tr>
<td>Pangolin (Manis spp.)</td>
<td>2</td>
</tr>
<tr>
<td>Flying Squirrel (Petaurista spp.)</td>
<td>4</td>
</tr>
<tr>
<td>Squirrel (Sciurus spp.)</td>
<td>12</td>
</tr>
<tr>
<td>Dormouse (Graphiurus spp.)</td>
<td>1</td>
</tr>
<tr>
<td>Rats and mice</td>
<td>14</td>
</tr>
<tr>
<td>Gerbils</td>
<td>-</td>
</tr>
<tr>
<td>Mole rats</td>
<td>-</td>
</tr>
<tr>
<td>Porcupine</td>
<td>1</td>
</tr>
<tr>
<td>Cutting grass (Thryonomys swinderianus Temminik)</td>
<td>-</td>
</tr>
<tr>
<td>Hare (Lepus capensis Matschie)</td>
<td>-</td>
</tr>
<tr>
<td>Dog</td>
<td>-</td>
</tr>
<tr>
<td>Otter (Aonyx capensis)</td>
<td>-</td>
</tr>
<tr>
<td>Badger</td>
<td>-</td>
</tr>
<tr>
<td>Genet (Genetta spp.) and civet (Civetticities civetta)</td>
<td>2</td>
</tr>
<tr>
<td>Mongoose (Herpestes spp.)</td>
<td>2</td>
</tr>
<tr>
<td>Hyena (Hyaena hyaena)</td>
<td>-</td>
</tr>
<tr>
<td>Cats (including leopard and lion)</td>
<td>1</td>
</tr>
<tr>
<td>Aardvark (Orycteropus afer)</td>
<td>-</td>
</tr>
<tr>
<td>Elephant (Loxodonta africana Blum)</td>
<td>1</td>
</tr>
<tr>
<td>Hyrax (Dendrohyrax spp.)</td>
<td>1</td>
</tr>
<tr>
<td>Pig (Potamochoerus porcus porcus L.)</td>
<td>2</td>
</tr>
<tr>
<td>Chevrotain (Hyemoschus sp.)</td>
<td>-</td>
</tr>
<tr>
<td>Duiker (Cephalophus niger Gray)</td>
<td>5</td>
</tr>
<tr>
<td>Other antelope</td>
<td>2</td>
</tr>
<tr>
<td>Buffalo (Syncercus caffer beddingtoni Lyd)</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>95</strong></td>
</tr>
</tbody>
</table>

Among the reptiles there are at least 37 species of snakes of various shades of temperament and size and 12 species of lizards (Consdale, 1955). There are also snails both aquatic and terrestrial. West Africa is particularly rich in variety and abundance of birds - the parrots, hornbills, kingfishers, eagles, kites, herons, cuckoos, nightjars, sunbirds, doves, pigeons, egrets, snakebirds, swallows, vultures and plaintain eaters. Fishes include herring, lungfish, mullfish, sharks, barracudas, halfbeaks, and stingrays, as well as mussels, crabs, crayfish, oysters and edible turtles. Insects are particularly numerous and they include beneficial, harmless and harmful beetles, ants, termites, butterflies and their larvae, crickets, bugs, and major public health pests: mosquitoes, tsetse flies and blackflies (Encyclopaedia Britanica, 1965, Vol. 10).

This list offers a wide range of prospects. Wildlife in West Africa has traditionally contributed immensely to protein supply, use being made of both large and small game. Among the edible animals are deer, antelopes, duikers, bush cow or buffalo, hartebeeste, rodents (including rats, grasscutters), rabbits, wild hogs, monkeys, some of the big snakes (such as pythons), elephants, hippopotamuses, some types of crocodiles, ten species of tortoises and turtles, snails, and many birds and locusts.

Game meat is much more appreciated than meat of domestic livestock, given an assured supply; this is borne out by interviews conducted among West African students at U.B.C. and respondents from West Africa. Bush meat as it is called, is sold on some of the important roads in West Africa and at the local markets. One has only to visit Kajetia near Kumasi Municipal Bus Terminal - a spot christened the "Ashanti Bush Meat Association" - to see the people who flock there to buy bush meat. It is the height of folly to
neglect this important industry "in the name of civilization". Francis Aylward, contributing to a symposium of the Nutrition Society on the Place of Food Science and Technology in the Campaign against Malnutrition, 1961, attributes in part the low consumption of meat to the fact that West Africa lacks a tradition of animal production and warns that "the place of wildlife in the food pattern will inevitably decline as populations increase, unless special conservation efforts are made; hence proposals for 'game farming'" (Aylward, 1962, p. 7).

In East Africa it has been shown that native game are more productive in terms of biomass, are better adapted and can be reared at less cost to human and natural resources than introduced livestock (Nasimovich, 1970; Adu, 1964; Darling, 1962; Pearsall, 1962). Similarly Ghanaian fauna are better adapted than the domestic livestock. Endemic forms have evolved in the environment for millions of years and have performed a climax community. There is little doubt that they are potentially more productive, as is the case in East Africa, than the exotic livestock which have been introduced only a few centuries ago (Thomas, 1962). West Africa can benefit from the East African experience. While it is necessary for wild animals such as ungulates to be semi-domesticated, other animals such as snails, rodents and others are very much docile. Tourism is a novelty in West Africa and again the experiences in East Africa could be used profitably to bring in money. The impact of developing game husbandry can be seen in the case of Tanzania which in 1960 derived no revenue from tourism but owing to developing game husbandry derived more than 50 per cent of her 1966/68 fiscal year revenue from tourism (Nasimovich, 1970; Owen, 1969). Many West African countries operate game reserves like the Mole Game Reserve in Ghana. Game
reserves per se have very little economic significance; it is proper
cconservation measures that make the difference, and which must ensure not only
the preservation of a quality environment but also a continuous yield of
useful plants, animals and materials by establishing a balance cycle of
harvest and renewal (Odum, 1971). This is a field for students of African
conservation which calls for special studies.

West African countries are seeking to diversify their agricultural base.
One of such approaches is the plant introduction programme. But instead of
looking solely to the plant introduction programme as an avenue for identi-
fying exportable commodities, West African countries stand a better chance
of developing some of the native forest products for export. West Africa is
rich in variety of plant forms. It is estimated that Ghana has about 3,300
species of flowering plants alone. Thus, for example, the sweet berries of
Synsepalum dulcificum - "whose fruits when eaten have the curious property of
making everything else eaten for some time afterwards taste sweet" (Lawson,
1970b, p. 13) are shade tolerant shrubs that grow well in the forest zones of
Ghana. The sweet taste of the sweet berries is due to the presence of a
soluble biodegradable protein called "monellin", a low-calorie sweetener said
to be 3,000 times more intense than sugar. Monellin has recently been isolated.
The Chief Researcher described it in a recent press release as the first
protein known to man to elicit a sweet taste, adding "I was immediately struck
by the persistent quality of the sweetness" (Vancouver Province, Friday,
February 25, 1972). A crop like this could be developed. With the banning
of cyclamates in the U.S. as artificial sweeteners, the potential of sweet
berries as foreign exchange earner is really great (Lawson, 1970b).
CHAPTER 2

ECOLOGICAL APPROACH TO AGRICULTURAL PRODUCTION

The underlying premise of this study is that optimal agricultural development requires recognition of the specific characteristics of the ecosystem to be modified. Agricultural techniques must necessarily be developed in relation to the properties of ecosystems which present on the one hand a set of constraints and on the other hand a wide spectrum of prospects. The "sum" of the relevant variables helps to determine the scope and direction of agriculture. To illustrate the importance of the ecological approach to agricultural development it is intended to identify at this stage the important variables in order to work out a reasonable ecological framework.

Characteristics of Ecosystems

A study of ecosystems emphasizes:

1. The obligatory relationship and causal relationship between elements of the biotic community, climatic and causal factors.
2. The energy environment; i.e. the linear flow of energy by way of the autotroph-consumer-decomposer chain. Although energy cannot be destroyed nor created it can be transferred from one form to another by degradation from a concentrated to a dispersed form (these are the first and second laws of thermodynamics). Intact ecosystems are the most stable means of utilizing energy in agricultural practices.
3. The biogeochemical cycling of matter through the various trophic levels of the biotic component of the ecosystem to the physical environment and back again.
4. The homeostasis of ecosystems. Ecosystems are capable of self-maintenance and self-regulation in the face of stress. It will be seen therefore that cybernetics or the science of controls also applies in ecology. Nevertheless there is a threshold level beyond which ecosystem's homeostatic mechanisms are no longer able to compensate. The resulting change in character (e.g. species composition) of the ecosystem is one form of "ecological backlash" or "ecological boomerang" which Odum defines as "unforeseen detrimental consequence of an environmental modification which cancels out projected gain or, as is too often the case, actually creates more problems than it solves" (Odum, 1971, p. 409).

5. The complexity and diversity in plant and animal life, in excesses and deficiencies of temperature and rainfall, and in soil life.

6. The adaptations to their habitats of associations of plants and animals. Native species or species from identical habitats are best adapted (Odum, 1971; Rappaport, 1971; Geertz, 1968).

The general ecological perspectives outlined above provide the basic principles for agricultural development. The relevance of the ecological approach as a basis for the development of tropical agriculture would be better appreciated by first studying the climate, soil and vegetation of Ghana.

The Climate

In Ghana like the rest of West Africa, the direction and persistence of the moisture-laden winds blowing from the Atlantic Ocean and the dry harmattan winds from the Sahara have a major influence on the weather. As one would expect the southern country within the forest zone is generally more humid than the northern part of the country and the narrow strip of coastal savannah belt.
GHANA: ADMINISTRATIVE REGIONS.

Temperatures in Ghana are high. As seen from the temperature data for various reporting stations (Figure 2), the average daily maximum temperatures increase from the coast northwards. Conversely, as Figure 3 shows, daily minimum temperatures increase in the southward direction. Areas with daily maximum temperatures above and below 33.5°C (95.9°F) and minimum temperatures below and above 18.0°C (64.4°F) (Papadakis, 1966) are also shown on Figures 2 and 3.

Rainfall is seasonal so the climate is characterised by distinct dry and wet seasons particularly in the north. While in the southern end of the country the rain comes in two peaks, in the north the rain comes in one peak. As is shown in Figure 4, Southern Ghana is wetter by far than Northern Ghana. For example Axim and Tafo both in the south have an annual rainfall of 213 cm. and 164 cm. respectively; comparative figures for Tamale and Navrongo are 108 cm. and 109 cm. respectively. Except for the coastal savannah belt southern Ghana has more than seven wet months with intensity of rainfall increasing in the south-west direction. Northern Ghana has a distinct dry period of about six months and six months of wet season. Rainfall is erratic throughout the country (Walker, 1962; Brammer, 1962; Ahn, 1970).

Bioclimatic Belts

The bioclimatic belts of Ghana and their salient features are presented in Figure 4 and in Appendix II respectively. The climatic belts have been formed under the influence of rainfall, temperature, parent rock material and biotic agencies. The interacting effect of these factors is important in crop production. Two widely separate geographical areas may have the same amount of rainfall and be in entirely different bioclimatic belts. For
GHANA: MAXIMUM TEMPERATURES.

KEY: ▲ Average daily maximum of the warmest month, centigrades.

NB: Numbers refer to points (not to regions).

<table>
<thead>
<tr>
<th>Above 33.5°C</th>
<th>Below 33.5°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲</td>
<td></td>
</tr>
</tbody>
</table>

GHANA: MINIMUM TEMPERATURES.

KEY: Average daily minimum of the coldest month, centigrades.

N.B. Numbers refer to points (not regions).

- Equatorial above 18-0°C (64-4°F).
- Tropical below 18-0°C (64-4°F).

Figure 4.

GHANA: VEGETATION REGIONS, ANNUAL RAINFALL & POTENTIAL EVAPOTRANSPIRATION.

Scale: 1 Inch = 50 Miles.

KEY:

- Moist Evergreen Forest.
- Moist Semi-Deciduous Forest.
- Deciduous Thicket—Guinea Savannah.
- Deciduous Thicket—Coastal Savannah.

Δ Rainfall / Potential Evapotranspiration (in centimeters)
When only one number is given it refers to rainfall.
Numbers refer to points (not to regions).

example, Copenhagen in Denmark and Nara in Mali have the same annual rainfall of 23 inches, but Nara is arid while Copenhagen is temperate sub-humid (Papadakis, 1966). Thus it is necessary to devise different cultural practices for agricultural production.

An important practical criterion for deciding whether a climate is dry or adequately wet is to decide which crops will grow well under available rainfall and temperature conditions. Accordingly "potential evapotranspiration" and "water surplus" have been used as climatic measures (Papadakis, 1966). Evapotranspiration is defined in terms of water loss due to evaporation from free surface and water loss due to transpiration from plants. Thus "water surplus" is the total annual rainfall less evapotranspiration. Water surplus is a very important concept for agroecological consideration since it can be used to delineate areas where crops can be grown based on their water requirements. In Figure 4 "water surplus" data for selected localities are also given.

Similarly water surplus in combination with edaphic factors and human agency is important for the study of vegetation. Where the water surplus exceeds 20% of potential evapotranspiration the climax vegetation is woody and dense, while grassland vegetation is formed where the water surplus is markedly less than evapotranspiration (Papadakis, 1966). The vegetation of the Interior Savannah including the Ho-Keta plain consists of shrubs and trees irregularly interspersed in a matrix of grassland, dominated by perennial grasses such as *Andropogon* and *Hyparrhenia* species. In the Coastal Savannah belt stands of shrubs and trees are denser than those of the Interior Savannah (Innes 1962). In farming areas where pressure resulting from farming activities is intense, the trees are almost destroyed
and perennial grasses are replaced by short annual grasses. In the south the forest is floristically divided into evergreen rain forest and moist semi-deciduous forest. The physiognomy consists of different trees of various sizes, in which the layers are distinct. Where farming is intensive there has been invasion by grasses. The derived savannah is fire climax (Baker, 1962; Ahn, 1970).

Soil Regions of Ghana

There are seven soil regions in Ghana as shown by Figure 5. The physical and chemical characteristics are summarised in Appendix III. There are, in addition to the soil regions shown on Figure 5, two other soil groups, namely the flood plain land and young soils. They are present in small amounts in all the seven major soils. The characteristics of the seven major soils will be presented briefly:

1. The coconut sands occur as narrow strips of land at the extreme south-western and south-eastern ends of the country. This group of soils consists of pure sand and is poor in bases.

2. Located next to the coconut sand are soils of the forest oxysols. These soils are strongly leached and characterized by the presence of excessive concretions of gravel or iron pan occurring near the soil surface. The region includes some of the poorest soils in the country. They are acidic and have low humus content.

3. The forest ochrosols are generally well drained. The soil texture is associated with parent materials. Soils associated with peneplain remnants may contain massive iron pan or ironstone concretions. In the absence of concretions they are easily tilled. The fertility of such soils is very high but available plant nutrients are concentrated in the humus top-soil. The
GHANA: SOIL REGIONS.

KEY:
- Coconut Sands.
- Forest Oxisols.
- Forest Ochrosols.
- Savannah Ochrosols.
- Terre de Barre.
- The Volta Basin.
- The Lower Volta Basin.

clay content has high nutrient holding capacity.

There are forest ochrosol-oxysol integrates. They occur under humid conditions such as prevail on the Atewa range near Asiakwa. Soils of the forest ochrosol-oxysol integrates are slightly acidic usually below pH 5.5.

4. Savannah ochrosols are similar to the forest ochrosols but are very poor in organic matter even in the surface layer. The soils are red and brown in colour and are texturally friable and porous. Characteristically there may be a thin iron pan capping the soil.

5. Terre de Barre consists of small group of soils that occur at the extreme south-east corner of Ghana. It is almost free of concretions and very fertile.

6. The Voltain basin is by far the largest single soil region in the country. The soils are poorly drained due to presence of groundwater laterites and unweatherable materials.

7. Lastly, the Lower Volta Plains Basin: They are also characterised by occurrence of groundwater laterites. The soils of the Lower Volta Plains are rich in bases but they are difficult to till (Papadakis, 1966).

Soils

Because of high rainfalls and high temperatures tropical soils are badly leached. Papadakis (1966) classified soils of the world into five groups according to degree of leaching. High leaching grades of 3, 4 and 5 are associated with tropical soils while temperate soils have comparatively low figures of 1 and 2. As a result of high leaching intensities the content of alkaline metals is minimal and presence of aluminium and iron compounds is high. In many cases laterites have been formed. A laterite is defined as "a massive vesicular or concretionary ironstone formation, nearly always
associated throughout the world with uplifted peneplains and undoubtedly formed on areas of low relief subject to high tables" (Prescott and Pendleton, 1952, p. 42).

Weathering is very energetic and soils are highly leached and highly lateritic. Soils with lateritic profiles are generally formed from acidic rocks. Lateritic soils are generally impermeable and may occur at varying depths in the soil profile as shown in Figure 6. Conversely soils formed from basic rocks have free iron particles present in the soil profile but no lateritic horizon is formed. Such soils are generally very permeable.

Low fertility status of tropical soils may be associated also with the clay content. There are two types of clay soils designated as 1:1 and 2:1 clay types together with their integrates. Tropical soils show dominance of 1:1 clay types which are unfortunately, the least fertile of all the clay types. Soils of 2:1 clay types are more fertile than 1:1 clay type of soils but where in tropical areas they are subject to high leaching intensity their fertility status has also fallen. Generally the fertility of soils under tropical vegetative cover is appreciably high where the amount of organic matter present in the soils is high (Papadakis, 1966).

Ecosystems and Agriculture

A detailed working definition of the ecosystemic variables enables one to better understand risks inherent in agricultural development in the tropics. Risks of encountering ecological boomerangs become more imminent when temperate agricultural techniques are used liberally without reference to the nature of the native ecosystems. In West Africa sheet erosion, possible changes in such climatic factors as rainfall and evaporation, change of vegetation, health hazards (e.g. bilharzia) and the threat to, and loss of
Figure 6  EXAMPLES OF SOIL PROFILES FROM DIFFERENT SOIL REGIONS SHOWING OCCURRENCE OF LATERITES

(a) Akumadan (left) and Wenchi illustrating a Forest Ochrosol over Lower Birrimian Phyllite and a peneplain residual. Figures refer to pH.

(b) Damongo (right) Zed (left) illustrating Savannah ochrosols over Voltain Sand and Lower Birrimian Phyllite. Figures refer to pH.

(c) WACRI (left) and Susan illustrating Ochrosol-oxysol intergrades. Figures refer to pH.

wildlife are very serious ecological boomerangs that could result from large scale application of such techniques. Gully erosion, decline in soil fertility and threat to watersheds resulting from removal of plant cover are considered serious. Changes in soil structure, pest resurgence after crop treatment with pesticides and nutritional problems such as low protein content of cereals are serious (Questionnaire response).

As previously noted a distinct characteristic of tropical ecosystems is the high diversity of plant and animal life (Geertz, 1961). Tropical regions have many more species of most taxa than temperate areas of similar size and small areas in the tropics have many different plant species. Species interaction may therefore be more important in the tropics than in the temperate areas (MacArthur, 1969). The stability and high productivity of tropical ecosystems is associated with effective transformation of energy and unimpeded circulation of matter which is made possible by the interaction between the biotic community, climate and edaphic factors (Odum, 1959; 1972). Tropical ecosystems are characterised by a "particularly delicately balanced relationship between the physical factors of the climate and soil and the natural biological communities that have become established. This balance is very easily upset and any major upset is likely to be disastrous, for it could lead to the destruction of the habitat from the point of view of biological productivity" (Adu, 1964; p. 4).

Accepting the fact that plant and animal crops are an integral part of ecosystems the quality and quantity of yield will therefore be determined in relation to the mechanism of the ecosystems. Considerations for crop production must include:

1. Intrinsic factors: These relate to the genotype or the genetic characteristics of the crop, and
2. Extrinsic factors which are largely environmental factors and include distribution and intensity of temperature and rainfall, the relative length of day and night (which is important for photoperiodism), amount of solar radiation, topographical conditions, disease and pest hazards, edaphic conditions and cultural practices (Azzi, 1956).

Solar radiation intensity, air temperature, relative humidity, wind, and the relative lengths of day and night affect growth. The various biochemical events and life phenomena are either temperature or light dependent or both. For example respiration is a thermo-chemical process while photosynthesis involves both photochemical and thermo-chemical events (Gates, 1960).

Consequently the first step involves identifying crops that will give the highest yields under prevailing conditions. Often crops which are known to be high yielding in their natural habitats do not grow well elsewhere. This has been shown by experience derived from plants and animals imported into the tropics. The unexpectedly poor performance results from their inability to withstand the environmental stresses of the tropics.

It is also recognised in plants that the genotype plays a dominant role in the control of natural phenomena. Gates (1960) found that the size and shape of a leaf is essential for controlling internal temperature, absorptiveness of radiation depending on thickness of the leaf, the internal structure, pigment content and surface characteristics, leaf reflectiveness and transmission. Leaf thickness and internal composition are all genotypically influenced. Hiessey et al. (1967) showed that photosynthesis and respiratory rates are genotypically influenced though temperature and light also exert some influence. The fact that plants from cold climatic
zones have relatively low optima compared with plants from warmer climates indicates this influence (Gates, 1960). This phenomenon may explain at least partly why cool loving plants do not grow well in hot climates. A relatively low temperature range of 68\°F and 86\°F is deemed necessary for maximum photosynthesis in such species. Lower temperatures may be essential where there are other inhibitory factors (Papadakis, 1966). It is therefore advisable to use native plant species or species from identical habitats. Examples of subdivisions of habitats identical to those in Ghana have been presented in Appendix II. The intent is to facilitate plant introduction programmes. Many of the currently important food and export items were imported from identical habitats elsewhere. Examples of these crops are cassava, maize and cacao from the New World and rice from the Far East (Aylward, 1962).

Another important factor which favours the cultivation of potential native species or species from similar environments is that fact that they are already photoperiodically adapted to the local environment. Plants and animals can be divided into three groups according to their adaptation to specific lengths of day and night. Tropical crops are generally short day plants while temperate crops are long day plants. Between these are plants which are indifferent to photoperiod. Variation in the lengths of day and night has a marked effect on crop performance, accelerating, retarding or preventing flowering in photoperiodic plants (Tempany and Grist, 1958). In Ghana light intensity is low especially near the coast and this does not favour economic production of long day plants. The alternation of short cloudy days with long warm nights does however favour vegetative growth of temperate vegetables such as lettuce, cabbage, cauliflower, onion, Irish potato and carrot, at the expense of such storage organs as bulbs, roots
roots and tubers, or fruits and heads (Papadakis, 1966).

Rather than introducing high yielding temperate crops which are ill-adapted to the tropics we must reverse the usual concepts of agriculture (i.e. growing familiar food in a new environment) by discovering plants which grow best and making new foods of them (Pirie, 1963). Or to extend Pirie's contention we must investigate which animals thrive and make the best use of existing endemic plants (Ledger, Sachs and Smith, 1967).

Parallel to the selection of potential crops is the problem of devising the cultural techniques that will ensure optimum growth. There are two effective means of utilizing natural habitats (Geerts, 1968). The first approach involves transforming the ecosystem into a monoculture of a particular crop. This is the system adopted by temperate agriculture. The other approach maintains the overall pattern or composition of the forest flora only replacing some species by some human foods. The second approach is traditional in the tropics.

From the point of view of agricultural ecology it may be more rewarding in the long run to use the ecosystem according to its capacity without any serious modifications. It is recognized that often unsatisfactory results are obtained by modifying, in a major way, the environmental conditions native to any given geographical area in order to enhance crop production. Satisfactory results which can be achieved by transforming environmental conditions are few indeed (Azzi, 1956).

In view of the precarious nature of tropical ecosystems the following strategy may be advisable.

1. Crop ecological zones need to be delineated. The parameters to be employed should be natural rather than physical, defined by climatic factors
or soil conditions or both. Crop ecological zones follow climatic variations and soil distributions and may, therefore, vary in size from a small topographical area to a whole region (Papadakis, 1966). Generally crops which are found in the same ecological zone have similar ecological requirements. On the one hand, crops in the drier zones of the Guinea Savannah, such as millet, Guinea corn, groundnut and others are drought resistant although they require some period of wet conditions for growth. On the other hand, crops in the forest zones are generally moisture loving and are tolerant to high humidities, shade and cloudy weather. But as Azzi (1956) points out, the climatic conditions within any crop ecological zone may only indicate average growth conditions. This leads to the second step.

2. Plants in particular have observable periodical or phenological phenomena during which their environmental requirements in terms of nutrients, moisture and temperature vary. The ecological requirements during the various phenological phases of plants are very critical for ensuring high yields. Azzi (1956) has proposed the concept of "meteorological equivalent" which is a combination of the degrees of temperature and amount of rainfall which distinguish normal conditions from those defined as abnormal, both in respect to excess and insufficiency.

To grow any crop in any area, there must be sufficient time in the season for the plant to complete its development from sprouting to full maturity. During this period adverse atmospheric conditions should not reach an intensity that will lower the yield below expectations. Cultivation of cocoa illustrates this point.
The growth cycles of cocoa may be divided into five phenological phases, viz:

(a) from budding to flowering;
(b) from flowering to formation of the fruits;
(c) from formation of the fruits to the first stages in maturity;
(d) from maturity to harvest;
(e) from the beginning to the end of harvest (Azzi, 1956).

The fourth phase (d) is very critical. In Ghana cocoa grows under a wide diurnal range: 55-95°F, but if the weekly mean maximum temperature falls below 83°F flushing (flowering) is suppressed. It has also been observed that where the weekly mean temperature falls below 85°F there is a reduction in the number of flowers two months later (Adams and McKelvie, 1955). During the same period excessive moisture leads to black pod disease caused by Phytophthora palmivora - a pathogenic fungus in the humid tropics (Wharton, 1962).

Shade may under certain circumstances be a limiting factor to yield. Wrigley (1961) using the results of the experiment presented in Table 2.1 stated that although a crop may be shade tolerant its production may be enhanced by good management. It seems clear that the table indicates that shade is an important factor in increasing yield only in the absence of treatment. The post treatment figures indicate that the treatment is the most important factor in producing yields. There was a decline in yield during the third year of post treatment. Subsequent figures would be essential for confirming the conclusion which the research officers at W.A.C.R.I. have drawn.
Table 2.1: SHADE AND MANURIAL TRIAL (Annual Yields in lbs of Dry Cocoa/Acre)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yields - Pre-treatment</th>
<th>Yield - Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gliricidia shade without fertilizer</td>
<td>30</td>
<td>44</td>
</tr>
<tr>
<td>Gliricidia shade with fertilizer</td>
<td>24</td>
<td>32</td>
</tr>
<tr>
<td>No shade - no fertilizer</td>
<td>19</td>
<td>29</td>
</tr>
<tr>
<td>No shade with fertilizer</td>
<td>20</td>
<td>18</td>
</tr>
</tbody>
</table>

The Amelonada cocoa was planted in 1947.

The fertilizer treatments were as follows:

- October 1956
  - Ammonium Phosphate \( N \) 13.4 lb/acre
  - Single Superphosphate \( P_2O_5 \) 90.7 lb/acre
  - Sulphate of Potash \( K_2O \) 90.4 lb/acre

- April 1957
  - Urea \( N \) 50 lb/acre
  - Triple Superphosphate \( P_2O_5 \) 30 lb/acre

- September 1957
  - Urea \( N \) 50 lb/acre

Field was sprayed against capsid damage.


Wrigley: 1961, p. 63

Gordon Wrigley has given a general discussion of the role of shade in tropical agriculture. The advantages of shade are:

i. The range of the air temperature within the crop is less e.g. on Mount Elgon, Uganda, "hot and cold" disease of arabica coffee is associated with this change and occurs less frequently in shaded crops.
ii. The range of the soil temperature under shade is less.

iii. The humidity within the crop is higher.

iv. The surface soil moisture is higher, particularly important where a dry season occurs.

v. Shade trees act as a drain in removing excess rainfall.

vi. The wind effect is reduced. Apart from the physical damage from the wind, hot dry winds such as the Harmattan in West African can increase transpiration to a serious level.

vii. Shade trees add organic matter.

viii. Shade trees bring up nutrients from the deep subsoil and add it to the surface leaf mould. The deep penetrating roots open up the subsoil.

ix. Leguminous shade trees add nitrogen to the leaf mould. *Albizia chinensis* shade often increases the tea yield in North India by an amount equivalent to adding 90 lbs of nitrogen per acre (A. R. Tocklai, 1959).

x. Weed growth, particularly of undesirable grasses is less under shade. A well grown crop canopy should do this.

xi. Shade may reduce the incidence of pests and diseases. Cocoa capsid and coffee thrips prefer unshaded crops. In Costa Rica, unshaded cocoa has more severe *Phytophthora* infections due to the heavier dew. Tea bushes under leguminous shade trees are attacked less by red spider than are unshaded bushes (Hainsworth, 1952). In the Douars tea district of North Bengal, shade was removed from tea then replanted to reduce red spider attacks. It is a question of economics whether the pest would be best controlled chemically.

xii. Some crops, including tea and young cacao, do better with a reduced light intensity.

xiii. Shade plants may themselves be crops, e.g. Fibres (bark-cloth) in coffee, bananas in coffee and cocoa, timber species, rubber in coffee.
xiv. Unshaded forest soil rapidly loses its structure. A good crop canopy and mulching will prevent this.

xv. Shade tends to reduce overbearing and "die-hard" of coffee. This can be largely prevented by the use of manure and fertilizers.

The disadvantages of high shade are:

i. Shade plants compete with the crop for nutrients.

ii. Shade plants compete with the crop for water in the dry season. This can be evaded by using a deciduous shade tree such as *Terminalia superba*, which drops its leaves to form a mulch at the start of the dry season.

iii. Shade plants compete with the crop for oxygen in the wet season.

iv. Shade reduces the light intensity which certain crops can utilize fully.

v. Some shade trees are incompatible with the crop.

vi. Some shade trees are alternative hosts for pests and diseases.

vii. Shade trees or their branches may fall and cause serious damage.

(Wrigley, 1961, pp. 67 and 68).

The importance of meteorological equivalents is to enable a researcher to determine what combinations of the relative values of these inter-related environmental factors are necessary for optimum conservation. In the light of the above discussion, it is concluded that agricultural development plans in the tropics must seriously consider the full range of biotic and geo-climatic factors characteristic of such areas.
CHAPTER 3

SYSTEMS OF TRADITIONAL PRACTICES VIS-A-VIS AGRICULTURAL TECHNIQUES DEVELOPED IN NORTH AMERICA AND OTHER TEMPERATE AREAS

A comparative study of shifting cultivation and permanent agriculture is presented in this chapter. In order to provide a better comparison of the two systems an in-depth description of the technique and philosophy of shifting cultivation is also given. Attention will then be focussed on the Green Revolution in order to ascertain its impact on tropical agricultural development. The chapter will end by reviewing the potential of pastoralism and game management.

Shifting Cultivation

From time immemorial shifting cultivation has been employed as a means whereby a "natural forest is transformed into a harvestable forest" (Geertz, 1969; p. 14). It is practised under different soil, vegetation and climatic conditions and by people of different origins and cultures, so that there are variations in crops grown, methods of cultivation and periods of fallowing (Nye and Greenland, 1960).

Shifting cultivation, widely practised in the tropics describes the traditional experience of the local people with the land. The International Union (1952) defines the system of shifting cultivation as follows:

"The system whereby cultivation is carried on for a few years and then the land is allowed to rest, perhaps for a considerable period, before the scrub or grass which grows up is again cleared and the land recultivated" (Wills, 1962, p. 201).

The term "shifting cultivation" is sometimes used interchangeably with "land rotation", often with some confusion. In land rotation the associated
settlement is more permanent than it is with true shifting cultivation (Wills, 1962). Nevertheless, both systems share one major characteristic, viz. they leave land under natural fallow to recuperate from loss of productivity. In Ghana both shifting cultivation and land rotation are practiced. In this text shifting cultivation applies to the technique of land use rather than the permanency of associated settlement.

In the forest zones of Ghana farms are prepared by clearing the undergrowth and the small trees are felled with an axe or machete, leaving some of the bigger trees to provide irregular shade. The mass of vegetation is burned and the ash is left on the ground. In some cases the vegetation may be left on the ground to decay.

On good soils cocoyam and plantain are among the first crops to be grown, planted as corms and suckers respectively at irregular intervals of time and space. These crops grow rapidly and provide a leafy cover which shades and protects the soil from excessive insolation and rainfall. Other crops such as okra (Gossypium sp.), tomatoes (Lycopersicon esculentum), pepper (Piper nigrum), sugar cane (Saccharum officinarum) and maize may be grown. The number of kinds of crops grown may be as high as twenty or even more. In cocoa and coffee (Coffea sp.) growing areas, cocoa or coffee seeds may be planted under the shade provided by the food crops, especially where the farm has been cleared from virgin forest. Rubber and oilpalm may replace cocoa and coffee where annual rainfall is high. The cocoyams and plantains continue to yield from new suckers growing at the base of the old ones for up to three years or more depending on soil fertility.
If the cocoa or other tree crops grow successfully, the farms are maintained by weeding regularly and the tree crops are made to take over from the food crops.

On secondary farms or less fertile soils, however, it may be more desirable to grow food crops instead of tree crops. In this case the cropping phase may start with maize, then plantain and lastly cassava which is the least demanding of all crops. In the damper valley bottoms, sugar cane or rice ($Oryza sativa$) may be grown (Ahn, 1970). The farms are left under natural fallow after an average of three years continuous use.

In Savannah areas dominated by grass, the ground cover is first burned and the burned stalks of grass and shrubs are then cleared with hoe or machete. In such areas the only trees which survive are the so-called fire resistant trees; these are usually characterised by very thick bark. Valuable trees such as shea butter nut tree ($Butyrospermum parkii$) and other small trees are left for training yam vines.

In a typical cropping sequence yam mounds are constructed with hand hoes at the end of the rains when the soil is still moist. Yams ($Dioscorea$ sp.) are planted in the mounds while a variety of crops including maize are planted in the intervening spaces between the mounds. In the following year the yams are harvested and the mounds are levelled to facilitate the planting of maize and sorghum ($Sorghum vulgare$). In the subsequent year groundnuts are interplanted with millet ($Eleusine coracana$) which completes the cropping cycle and the land is then left under natural fallow.

Vegetation Regrowth under Natural Fallow

The tempo of regrowth depends upon the soil, climate, regenerative
capacity of coppice shoots, viability and dormancy of seeds of the previous forest cover and the adjoining forests, the previous history of cultivation and the size of the clearings (Ahn, 1970). One hundred acres is harder to regenerate than ten, and ten harder than two or three acres.

Outlines of secondary formations and vegetation climax (with special reference to Africa) and nutrient storage in typical tropical fallows are presented in Tables 3.1 and 3.2 respectively. These outlines exclude areas of high altitudes, desert and semi-desert zones, and low lying or swampy areas.

**TABLE 3.1**

**ARRANGEMENT OF VEGETATION CLIMAX AND SECONDARY FORMATIONS WITH SPECIAL REFERENCE TO AFRICA**

<table>
<thead>
<tr>
<th>Rainfall in. p.a.</th>
<th>Climatic Climax Formations</th>
<th>Secondary Formations</th>
<th>Mainly Woody</th>
<th>Mainly Grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>Moist evergreen forest</td>
<td>Secondary brush,</td>
<td>Secondary forest</td>
<td>Imperata cylindrica var.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Secondary forest</td>
<td></td>
<td>Major grassland (Asian form)</td>
</tr>
<tr>
<td>45 - 90</td>
<td>Moist semi-deciduous forest</td>
<td>Secondary bush,</td>
<td>Secondary forest, Semi-deciduous thicket</td>
<td>High grass savannah - Imperata cylindrica var.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Secondary forest,</td>
<td>Semi-deciduous thicket</td>
<td>Africana (African form)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Imperata cylindrica var.</td>
<td></td>
<td>Pennisetum purpureum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Andropogon spp.</td>
<td></td>
<td>Hypharrhenia spp.</td>
</tr>
<tr>
<td>35 - 65</td>
<td>Dry deciduous forest</td>
<td>Deciduous thicket</td>
<td>Deciduous thicket woodland</td>
<td>Tall bunch-grass savannah</td>
</tr>
<tr>
<td>40</td>
<td>Deciduous thicket</td>
<td></td>
<td></td>
<td>Short bunch-grass savannah</td>
</tr>
</tbody>
</table>


Regrowth of vegetation in West Africa has been described by Nye and Greenland (1960), Richards (1952), and Ahn (1970). In forest areas the initial
regrowth is dominated by soft-stemmed, leafy, quick-growing herbs. This stage is known as forb regrowth. Thicket regrowth takes place when shrubs and coppice shoots and various climbers become dominant forming an impenetrable regrowth. Six to ten years after the farms have been abandoned, young secondary forest is formed consisting of even aged trees dominated by one tree, the umbrella tree or parasolier (*Musanga cecropioides*) in West Africa. The first dominant species dies out without replacing itself and is succeeded by other dominants. With maturity the species composition of secondary forest changes giving place to slower growing, shade tolerant trees. This process continues gradually until a mature forest is formed.

The secondary vegetation of the dry deciduous forest may consist of a dense semi-deciduous thicket. A good example is the Guinea Coastal Savannah Semi-deciduous Thicket to the south of the high forest in West Africa with annual rainfall of 30 to 45 inches.

The regrowth vegetation which develops on abandoned farms in the savannah areas consists of short grasses. These may be grazed by cattle or burned annually, so that regeneration of the soil is relatively slow even if the fallow periods are long.

**The Role of Natural Fallow**

The function of natural fallows is twofold. The first function lies in the expulsion of weeds resulting from cultivation. As seen from Table 3.1 the troublesome weeds are totally expelled by the time the climatic climax is formed. This is very important bearing in mind that the problem of weed control is one of the fundamental reasons for abandoning farms. The second function is to build up nutrient capital in soils for the benefit of
# TABLE 3.2

## NUTRIENTS STORED IN TYPICAL TROPICAL FALLOWS

<table>
<thead>
<tr>
<th>Place</th>
<th>Rain (in. p.a.)</th>
<th>Length of Fallow</th>
<th>Part of Vegetation</th>
<th>Oven-dry Wt. 1,000 lb./acre</th>
<th>Composition %</th>
<th>Nutrients Stored lb./acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N  P  K  Ca  Mg</td>
<td>N  P  K  Ca  Mg</td>
</tr>
<tr>
<td><strong>Moist Evergreen Forest</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N  P  K  Ca  Mg</td>
<td>N  P  K  Ca  Mg</td>
</tr>
<tr>
<td>Kade, Ghana</td>
<td>65</td>
<td>40 year mature</td>
<td>Trash</td>
<td>22.7</td>
<td>1.88 0.126 0.76 1.90 0.26</td>
<td>428 29 173 433 59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>secondary forest</td>
<td>Lianes</td>
<td>12.9</td>
<td>1.18 0.051 0.43 1.94 0.15</td>
<td>152 7 56 250 19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wood with bark</td>
<td>154.5</td>
<td>0.42 0.026 0.24 0.58 0.09</td>
<td>652 40 378 897 149</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dead wood</td>
<td>64.1</td>
<td>0.32 0.026 0.05 0.73 0.07</td>
<td>205 17 32 468 46</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stumps</td>
<td>43.7</td>
<td>0.38 0.040 0.19 0.38 0.07</td>
<td>166 18 83 166 31</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Litter</td>
<td>2.0</td>
<td>1.54 0.057 0.45 1.98 0.24</td>
<td>31 1 9 40 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Roots</td>
<td>22.1</td>
<td>0.86 0.045 0.35 0.59 0.18</td>
<td>191 10 78 130 39</td>
</tr>
<tr>
<td><strong>Total (excluding roots)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1634 112 731 2254 309</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Moist Semi-Deciduous Forest</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kumasi, Ghana</td>
<td>60</td>
<td>20 year (approx.)</td>
<td>Leaves</td>
<td>5*</td>
<td>2.52 0.136 0.85 1.54 0.48</td>
<td>126* 7* 43* 77* 24*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>secondary forest</td>
<td>Stem</td>
<td>100*</td>
<td>0.32 0.025 0.30 0.31 0.15</td>
<td>320* 25<em>300</em> 310<em>150</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>mean values for 14 Litter</td>
<td>5*</td>
<td>1.29 0.054 0.44 1.59 0.31</td>
<td>65* 3* 22* 80* 16*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>semi-decid. spp.</td>
<td></td>
<td></td>
<td>511* 35<em>365</em> 467<em>190</em></td>
</tr>
</tbody>
</table>

*Figures estimated or measured very approximately.

Source: Nye, P.H. and Greenland, D.J., 1960
The Soil Under Shifting Cultivation, Tech. Comm. No. 51
succeeding crops. Typical amounts of nutrients stored, i.e. the nutrient capital, is shown in Table 3.2.

The restoration of productivity of soils under natural fallows is also associated with the build-up of organic matter during the fallow period. It is estimated that in typical forest regrowth, about six to eight tons per acre of organic matter are added annually. In the savannah areas the amount of organic matter added is about one ton per acre. The rate of mineralization of humus appears to vary with the organic matter present: the higher the amount of humus the higher the rate of mineralization. Consequently the rate of mineralization is relatively slower in the savannah regions. A colloidal matrix is formed by the humus in which nutrients are absorbed to be drawn upon as need be. The extensive root system of intensely competitive plants ensures maximum absorption of nutrients. Thus, despite the heavy rains, loss of minerals due to run-off is so minimal that it can be compensated for through fixation of nitrogen in leguminous plants and absorption of minerals released by weathering of rocks (Geertz, 1969). Humus also improves the physical qualities of the soil particularly the structure and aeration. The bulk of humus concentrates at the soil surface thus contributing to the stability of crumb structure and hence the pore spaces favourable to plant growth. Humus also increases the moisture holding capacity of soils. It stores sufficient amounts of water in its colloidal matrix while allowing gentle run-off with minimum erosional hazards.

Problem of Comparison

It may appear senseless to compare two systems of agriculture developed in different ecosystems. However, this is necessary in order to explore means to improve shifting cultivation.
The disadvantages of shifting cultivation are more obvious than the advantages. It is labour intensive. This may be an advantage in unindustrialized agricultural societies. It becomes a problem only when a predominantly agricultural economy tends to concentrate on other economic activity needing urgent supply of labour in event such as discovery of petroleum. Shifting cultivation is often criticised for unproductive use of land since the long time assigned to natural fallows may lead to pressures on land. Viewed in this respect, it may be argued that shifting cultivation does not lend itself to economic use of land. It follows from the fact that the system is only suitable as long as fallow periods can be maintained for adequate periods, that yields of crops can be expected to decline when the fallow period is reduced; so that the system works only when the ratio of land in fallow to land in use is appreciably high (Ahn, 1970). The system is susceptible to breakdown through irreversible ecological deterioration. In South-East Asia as a result of insufficient fallow and burning period the forest was replaced by the notorious savannah grass called imperata which has turned much of Asia into a "green" desert (Gourou, 1953). There is a considerable loss from the nutrient capital following burning. Between 600 and 900 pounds of nitrogen burns out of a single acre of forest and furthermore, much of the nutrients in the ash is washed away before there is time for its utilization by plants. Cultivars are less hardy than the original species in forest communities and hence the technique of accelerating and channelling nutrient transfer through deliberate production of ash hardly works, hence the erosion of nutrients (Gourou, 1953).
To sum up the disadvantages, the F.A.O. (1957) writes:

Shifting cultivation in the humid tropical countries is the greatest obstacle not only to the immediate increase of agricultural production, but also to the conservation of the production potential of the future, in the form of soils and forests.

In reacting to the F.A.O. Nye and Greenland (1960) write:

Yet, though primitive and apparently wasteful, when not pushed to excess, shifting cultivation has for centuries given man his livelihood in the humid tropics, and it is significant that even now, after a quarter of a century of experiment in the African tropics, we have failed to introduce to the forest regions any method of staple food production superior to the system of natural fallowing used in shifting cultivation. On the contrary, failure to appreciate its nice adjustment to the tropical environment has led to many disappointments ... the disasters brought on by agricultural methods which have taken no account of the treasures of wisdom and experience accumulated in the old tropical system are a sufficient proof of the latter's value. It can be improved, but only if the reasons for its processes are fully understood (Greenland and Nye, 1960, p. vi).

The view that shifting cultivation is incapable of coping with population and economic pressures can only be received with skepticism. Contrary to popular opinion the author of this study shares the view of two respondents of the questionnaire (1972), that no genuine attempts have been made to improve upon the system. The prevailing attitude until the Second World War was to condemn the system and seek to replace it by a more European type of agriculture. It was only recently that the basic principles of soil science on which true understanding of tropical soils can be based was formulated. As Nye and Greenland (1960) have suggested it is premature for F.A.O., for instance, to write that "shifting cultivation in the humid tropical countries is the greatest obstacle not only to immediate increase of agricultural production, but also to the conservation of the production potential of the future in the form of soils and forests". (Nye and Greenland,
The F.A.O.'s assistance in tropical agricultural development is oriented to the cultivation of export crops, i.e. the crops which are more important internationally. Even to date agronomic needs of the important staples such as plaintain, cocoyam (*Colocasia antiquorum*), millet (*Eleusine coracana*), Guinea corn or sorghum and others have not been attended to. Fertilizers are prepared specially for specific crops such as maize and rice. Even in temperate agricultural zones where soil fertility is supposedly high, fertilizers are applied liberally to all useful agricultural crops.

There are essentially two main reasons why tropical farmers practise shifting cultivation. The first reason is due to declining fertility which they have no means to preserve other than to leave the farms fallow (Ahn, 1970; Rappaport, 1971). Virgin lands are cropped longer than secondary forest lands because the former are more productive. By failing to fertilize the crops on local farms, by destruction of the shade, by discouraging mixed planting, among other techniques, the agricultural elite have discouraged the traditional system of farming without first checking its efficacy. The other reason for practising shifting cultivation is due to the problem of weeds. In the tropics the application of available herbicides may destroy the soil microbiota. An improvement upon simple traditional tools might prove to be a better and more conservative means of checking weed growth and also of protecting the soil structure and erosion hazard and of course laterization. So far in the tropics it is only with rice that monoculture as an approach to crop development has been successful (Geertz, 1968).
A sympathetic assessment of the value of shifting cultivation is desirable. Besides offering an ecologically suitable technique for utilizing energy from a delicate system it is also economically and socially adapted to the resources of the farmers.

Schlippe aptly states:

Originally every human group has built its culture "from the ground up". Food production, which in all except the most primitive societies takes the form of agriculture, is its foundation. Agriculture is one of the main links between a human group and the "landscape" in which it lives and which it exploits. Through agriculture every environment has taught its inhabitants a certain way of life. The teacher of a culture is its environment, and agriculture is its classroom. The more refined functions of a culture, laws and customs, social and political organizations, morals and beliefs, are in a sense the superstructure on the foundation of agriculture. (Schlippe, 1955; p. vii).

Shifting cultivation in the forest regions is adapted to the annual cycle of farming activities. The dry season provides the opportunity of drying and burning the cleared material before the rains. The newly planted crops benefit from the ash; despite loss of nitrogenous compounds it is interesting to note that nitrate is at its highest level at the beginning of the rains, which favour a vigorous vegetative growth. The shade left over after clearing gives some protection to the soil, as do the existing roots which are left undisturbed; only a relatively superficial cultivation is practised by means of machete and hoe to plant seeds or suckers. Mixed cropping also presents a protective coverage for the soil. Though a weed problem exists insofar as it may reduce yields, inadequate weeding, particularly towards the end of the cropping season, protects the soil against heating up and erosion, and when farms are abandoned to fallow, weeds facilitate vegetation growth. Establishment and maintenance of farms is
inexpensive as very little capital expenditure is involved for purchasing
hand tools and hiring labour. Provided that fallow periods are long enough
soil regeneration is usually efficient.

However, many of the advantages of shifting cultivation mentioned above
apply only to the forest region and not the savannah areas, because of the
absence of vegetative cover and shade.

A very striking difference between shifting cultivation and permanent
agriculture as practised in the temperate agricultural zone is that net
primary productivity is lower in the tropics than it is in the temperate
zone, where a much more efficient system of agriculture seems to have
developed in the present century. This phenomenal success is associated
with the parallel use of auxiliary energy flow. In Table 3.3 are shown
the annual yields of edible food and estimated net primary production of
major food crops at three levels: (1) fuel subsidized agriculture (U.S.,
Netherlands, Canada or Japan); (2) little or no fuel subsidy (India,
Brazil, Indonesia or Cuba) and (3) world average.

The sad irony of the situation is that while only thirty per cent of
the world's population live in these developed countries with per capita
G.N.P. of usually more than $1,000 per annum and a low population growth
rate of about one per cent, 65 per cent of the world's population lives in
developing countries mostly in the tropics with a per capita G.N.P. of less
than $100 per annum but having a high rate of population growth of more
than two per cent (Odum, 1971). It is also ironic that in order to force
up production the super-efficient Western countries put into growing every
pound of grain etc. more energy in the form of fuel than can be extracted
in the form of biomass. In other words, the developed countries are living
TABLE 3.3: ANNUAL YIELDS OF EDIBLE FOOD AND ESTIMATED NET PRIMARY PRODUCTION OF MAJOR FOOD CROPS AT THREE LEVELS

(1) Fuel Subsidized Agriculture (U.S., Netherlands, Canada or Japan) (2) Little or No Fuel Subsidy (India, Brazil, Indonesia or Cuba) (3) World Average

<table>
<thead>
<tr>
<th></th>
<th>EDIBLE PORTIONS</th>
<th>ESTIMATED NET PRIMARY PRODUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Harvest Weight* (Kg/ha)</td>
<td>Caloric Content† (Kcal/m²)</td>
</tr>
<tr>
<td>Wheat - Netherlands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>900</td>
<td>300</td>
</tr>
<tr>
<td>World average</td>
<td>1,300</td>
<td>430</td>
</tr>
<tr>
<td>Corn - U.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>11,000</td>
<td>350</td>
</tr>
<tr>
<td>World average</td>
<td>2,300</td>
<td>810</td>
</tr>
<tr>
<td>Rice - Japan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>1,600</td>
<td>580</td>
</tr>
<tr>
<td>World average</td>
<td>2,100</td>
<td>760</td>
</tr>
<tr>
<td>White Potatoes - U.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>7,700</td>
<td>700</td>
</tr>
<tr>
<td>World average</td>
<td>12,100</td>
<td>1,090</td>
</tr>
<tr>
<td>Sweet Potatoes and Yams - Japan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>6,300</td>
<td>570</td>
</tr>
<tr>
<td>World average</td>
<td>8,300</td>
<td>750</td>
</tr>
<tr>
<td>Soybeans - Canada</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>640</td>
<td>260</td>
</tr>
<tr>
<td>World average</td>
<td>1,200</td>
<td>480</td>
</tr>
<tr>
<td>Sugar - Hawaii (from cane)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherlands (from beet)</td>
<td>6,600</td>
<td>2,440</td>
</tr>
<tr>
<td>Cuba (from cane)</td>
<td>3,300</td>
<td>1,220</td>
</tr>
<tr>
<td>World average (all sugar: beans and cane)</td>
<td>3,300</td>
<td>1,220</td>
</tr>
</tbody>
</table>


†Conversion, Kcal/gm harvested weight as follows: Wheat, 3.3; Corn, 3.5; Rice, 3.6; Soybeans, 4.0; Potatoes, 0.9; Crude Sugar, 3.7 (see USDA Agriculture Handbook No. 8, 1963).

‡Estimated on basis of 3X edible portion for grains, soybeans and sugar, 2X for potatoes (see text for explanation).

^Estimated to be six months (180 days) except sugar cane where sugar yields are calculated on 12 months growing season (265 days).

on the world's capital of fossil fuels. A consequence of low food production and low per capita income, and aggravated by the upsurge in population, is low food consumption in the tropics. In Table 3.4 the estimated protein, calorie and fat contents of some West African and North American national diets are compared. The picture presented by this table shows the representative tropical countries to be consumers of food low in quality and quantity, which tends to reduce resistance to disease. Against this background has arisen the need to improve upon the traditional system of agricultural production or to develop alternate ways of food production. The first approach as has been suggested by Odum (1967) involves "the process of applying auxiliary work circuits into plant and animal systems from such energy rich sources as fossil and atomic energy" (p. 71); the second approach is complementary rather than alternative to the first approach and includes utilizing game. These topics will be discussed in turn as part of the concept of "the green revolution".

### Table 3.4

**Estimated Protein, Calorie and Fat Contents of Some West African and North American National Per Capita Daily Diets**

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Total Protein</th>
<th>Animal Protein</th>
<th>Calorie</th>
<th>Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>1960-2</td>
<td>91.2</td>
<td>60.4</td>
<td>3,020</td>
<td>136.6</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>1960-2</td>
<td>91.4</td>
<td>64.3</td>
<td>3,120</td>
<td>145.9</td>
</tr>
<tr>
<td>Gambia</td>
<td>1961-3</td>
<td>60.4</td>
<td>12.2</td>
<td>2,100</td>
<td>43.3</td>
</tr>
<tr>
<td>Ghana</td>
<td>1961-3</td>
<td>48.6</td>
<td>10.5</td>
<td>2,160</td>
<td>34.7</td>
</tr>
<tr>
<td>Ivory Coast</td>
<td>1961-3</td>
<td>52.3</td>
<td>10.3</td>
<td>2,290</td>
<td>80.6</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1961-3</td>
<td>59.2</td>
<td>5.3</td>
<td>2,180</td>
<td>38.6</td>
</tr>
<tr>
<td>Mali</td>
<td>1961-3</td>
<td>64.2</td>
<td>10.9</td>
<td>2,120</td>
<td>41.0</td>
</tr>
</tbody>
</table>

Green Revolution in the Tropics

The green revolution has as its basis a revolutionary drive deriving its impetus from auxiliary energy flows. The dictionary definition of revolution is complete change, turning upside down, a great reversal of conditions (Oxford, 5th Ed., p. 1069). What this means in the tropics is the supercession of the traditional system of farming by temperate agricultural techniques. The auxiliary work circuit or energy subsidy must include selective breeding, fertilization, irrigation, mechanization and chemical control of pests including weeds. "Those who attempt to improve foreign agriculture without supplying the auxiliary work from the industrial system do not understand the facts of life. Recommendations to underdeveloped countries based on experience of advanced countries cannot succeed if they are not accompanied by a tap-in to major auxiliary energy sources" (Odum, 1967; p. 71).

The question to which we must address ourselves is whether energy subsidies could enhance the development of tropical agriculture. There seems to be no simple answer: a "yes" or "no" answer may be an irrational response without a thoughtful appraisal of the receptivity of the tropical ecosystems to such technologies. As E. P. Odum (1971) points out, a factor which under one set of environmental conditions acts as a subsidy in the sense that it enhances productivity may under a different set of environmental factors act as an energy drain which reduces productivity; hence, for example, the failure of the British Government Groundnut Scheme in Tanganyika in East Africa which was largely due to misconception of the intricate nature of topical ecosystems. Assuming that the abiotic components of the ecosystems were similar to those in temperate zones, the British Agricultural experts removed by means of robust machinery the
protective cover to prepare the land for agriculture. The incidence of ecological boomerangs including erosion, loss of soil fertility and deprivation of soil structure etc. resulted in abysmal failure of the gigantic project (Phillips, 1959; Thomas, 1962). Similarly in Iota the Brazilian Government cleared large tracts of land with machinery and crops were planted. The result was very disappointing. McNeil sums up her observations as follows:

What had appeared to be a rich soil, with a promising cover of humus, disintegrated after the first or second planting. Under the equatorial sun the iron rich soil began to bake into brick. In less than five years the cleared fields became virtually pavements of rock. Today Iota is a drab, despairing colony that testifies eloquently to the formidable problem laterite presents throughout the tropics. (McNeil, 1964; p. 100)

Dahomey also has had similar experience on a wholesale scale of agricultural activity. Establishment of plantations resulted in deep leaching of the soil which in about 60 years converted large areas into lateritic bricks (McNeil, 1964).

The impact of an advanced farming system on an indigenous socio-economic system is also a subject of much concern on which social and natural scientists are speculating and making inferential judgements. Auxiliary energy flows have served as the secret miracle behind the phenomenal success of temperate agriculture, but whether they succeed or not in the tropics, will depend on our ability to deploy them wisely in the face of ecological and social constraints.

Selective Breeding

Selective breeding is economically significant in agriculture. The hybrids of two corn inbreds, technically called the first filial generation yield many times as much as those of the parents (Brewbaker, 1964).
Many crops including poultry, livestock, corn, tomatoes, and sorghum are bred for commercial use. There are however attendant problems.

The genetic expression of the beneficial effects of hybridization (technically known as heterosis) is due to the dominance of one of the interacting homozygous genes in the first filial generation. The first problem encountered is that heterosis may change in subsequent filial generations due to segregation and recombination of genes. The only means of fixing heterosis is by asexual reproduction. The commercial bananas from Gros Michel and Cavendish varieties of bananas are produced asexually by apomixis which is the development of seeds in the absence of fertilization. However asexual reproduction has relatively limited application (Brewbaker, 1964). Selective breeding therefore must be a continuous process. It is not something that is done once and forgotten.

The second problem of selective breeding is that the cultivars are poor in withstanding environmental stress; they tend to be susceptible to drought, disease and other limiting factors which can be offset only by providing irrigation and control of pests and weeds. While studying how best to derive maximum benefits from selective breeding it is essential to select naturally evolved high yielding crops from indigenous varieties. These can be intercropped which is a more desirable cultural practice in the tropics. Some of the virtues of inter-cropping are the negation of incidence of disease and pest and the protective cover which they provide (Wrigley, 1961).

Fertilization

Fertilizer can be beneficial but the ability to employ it usefully depends on a range of interacting factors including the level of training of government officials, and field workers as well as the chemistry and means
of application of the fertilizers. The type and quantity of application will depend on the soil type, soil pH, existing level of fertility, presence of sufficient quantities of humus and others. Most of the problems attendant to application come about when fertilizer is applied to soils poor in organic matter. On such soils run-off of fertilizers into streams is excessive. This in turn causes chemical pollution of water and eutrophication. Eutrophication is the result of inorganic nitrates and phosphates being discharged or leached into water bodies such as lakes. The fertilizer compounds provide a rich medium for the growth of algae. The death and decay of the algae deprives the water of oxygen so that fish and other living things suffocate to death. Unwise use of fertilizers can also exhaust the soil, which follows from depletion of the organic matter content of soils. It has been estimated that in the U.S. for example as a result of unprecedentedly heavy application of inorganic fertilizers some one hundred million acres have been exhausted within a century (Dangon, 1970). Excessive consumption of nitrate contaminated drinking water may cause a physiological disorder known as methemoglobinemia, which is the result of reduced oxygen carrying capacity of the blood. It is particularly dangerous to children under the age of five years.

In West Africa sufficient studies have not been made into nutrient requirements and fertilization. This is not to deny the fact that in some of the old research stations such as the W.A.C.R.I. or W.A.I.F.O.R. fertilizer trials have been made. But even then, they are aimed at finding the agro-nomic needs of one crop or another. Widespread fertilizer demonstration started only in 1962 in Nigeria, Togoland, Ghana, Gambia and Senegal by F.A.O., within the Freedom from Hunger Fertilizer Campaign with the broad aim of
demonstrating the economic gain to farmers from fertilizer use. The results show that fertilizer application is profitable. However the demonstrations were not carefully conducted. Results have also tended to shelve wide and important differences in response; the results are therefore average of the existing situation (Ahn, 1970).

In order to obtain the maximum benefit from fertilizers it is necessary to undertake intensive research into all local factors, including socio-economic considerations, because fertilizer recommendations must be based on empirical facts rather than experience from elsewhere. Research to determine the agronomic needs of crops should not be limited to export crops only as has been the practice (Questionnaire response, 1972). The F.A.O. and the other responsible agencies associated with agricultural development in the tropics must realise that the problem of chronic food shortages facing tropical countries can be redressed only by focussing attention in the first instance on production of basic staples.

**Pesticides**

These include all the chemical compounds which are used to control pests and diseases and noxious weeds, trees and herbs. Agricultural insecticides have long been in use in West Africa. Research on herbicides however, has only recently started and they are not likely to be used extensively in the near future (M. A. Adansi, questionnaire respondent, 1972). Caution in the use of pesticides is necessary for three reasons at least, namely, their non-specificity, their longevity or persistence, and their threat to soil microbiota, wild-life and humanity.

No commercially available pesticide is specific to the pest against which it is directed. Pesticides usually have an effect on the whole
ecosystem in which the crop and pest are living, i.e., the various animals, insects and plants which provide food for one another so that they continue to co-exist in the same place in an intricate population equilibrium. Even the simplest ecosystems contain many species of plants and animals. Ecosystems in the wet tropics are the most complex of all. Insecticides thus kill harmful and beneficial insects alike. There is also to be considered insect resistance to pesticides such as the resistance of cocoa mirids to Gamma B.H.C. in Ghana (Questionnaire response, 1972). Due to the large number of generations that occur in the course of a few years mutant strains develop which are able to resist the insecticides in use. These must then be superseded by new biocides or the dosage of current control agents increased.

Chlorinated hydrocarbon pesticides are very soluble in fatty substances but much less soluble in water. Thus they tend to increase in concentration from one trophic level to another through the food chain. The concentration in birds at the end of a food chain may be hundreds of times as high as that in animals further down the chain. In fish eating predatory birds the concentration of DDT can cause genetic defects, sterility and death. Since man's position in the food chain is also at the top, he is exposed to serious hazards (Ehrlich and Ehrlich, 1970).

Table 3.5 shows the mean concentration of DDT in human fat measured in parts per million. In many tropical countries DDT has been and is still extensively used for the control of malaria and for specific crop pests. This explains why India has such a high mean value. In U.S. among the developed nations the mean concentration reflects intensity of use in
agriculture (Ehrlich and Ehrlich, 1970). Figures for Ghana may be very high, for the use of DDT has not been limited to agricultural and health needs. There have been reported cases where the insecticide has been used in fishing in the Volta (Lawson, 1970a) and in other rivers.

**TABLE 3.5**

<table>
<thead>
<tr>
<th></th>
<th>India</th>
<th>U.S.</th>
<th>U.K.</th>
<th>Canada</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean concentration of DDT in human fat (ppm)</td>
<td>26</td>
<td>7</td>
<td>3.3</td>
<td>3.8</td>
<td>2.2</td>
</tr>
</tbody>
</table>


The effect of pesticides on soils is a subject on which not much is known. However, it is suspected that some pesticides kill bacteria and other microorganisms in the soil, thereby disturbing the soil ecosystem. The complex processes by which these organisms return the dead organic matter to plants in the form of nutrients, may thereby be threatened. In the tropics this could badly affect the stability of farming. There is considerable evidence to suggest that insecticides may reduce soil fertility in this manner (Ehrlich and Ehrlich, 1970). In summary broad spectrum biocides, while providing short term economic and public health gains, are an ecologically naive means of pest control.

**Irrigation**

A reliable supply of water in dry lands is essential both for agriculture and domestic purposes. In the Northern and Upper Regions of Ghana there is a substantial water surplus during the rainy season. However, during the dry spell most of the streams and wells dry up and in many cases some people have to travel several miles each morning to draw water from
perennial rivers. What an exacting experience! Some farmers have in the circumstances reverted to being nomadic (Yirenkyi, 1970). In response to the need to raise agricultural productivity and to settle nomadic herdsmen permanently the Government of Ghana has undertaken many irrigation projects particularly in Northern Ghana. Unfortunately the special report prepared for the Ghana Government on irrigation in Ghana was not available at the time of writing.

In West Africa small dams are successful (Ahn, 1970). They are particularly important in dry season vegetable gardening. A big dam, such as the Volta River dam, has obvious economic advantages. It could serve as a pivot for industrial development of Ghana and neighbouring counties. It is also now providing water transportation between Ghana, Mali and Upper Volta (Anakwah, 1972). The water in the man-made lake could also provide water for irrigation. Nevertheless, big dams may easily upset the hydrologic cycle and cause other ecological hazards whose impact in the long-term consideration may be quite substantial.

One of the negative effects of diversion of river water on to land by means of canal system is the raising of the water table. An example may be cited from West Pakistan where, as a result of canal irrigation, the water table has risen as much as 79 feet in fifty years. The root zone in such areas becomes waterlogged. This, in the first place, leads to inhibition of plant roots and in the second place as water evaporates through the surface soils it leaves a concentrated deposit of salts in the upper few inches. In the early 1960's West Pakistan was losing 60,000 acres of fertile cropland per year from waterlogging and salination (Naylor, 1963).
Dams have a further negative effect. They prevent downstream replenishment of nutrients as occurs annually during the flood. The effect of the Volta Dam on agriculture upstream through the vast tract of lands in the savannah regions has not yet been studied, but the known effect of the dam on the riparian community below the dam is quite serious. The people have traditionally depended on the seasonal regime of the water flow for their agricultural and fishing activity. The annual Volta floods have been associated with filling adjacent creeks that lie adjacent to the river.

"The combined irrigating and silting effect on the flooded land made it a specially favoured area for agriculture, and the creeks, fertilized each year by new water containing nutrients, were also highly prized for the fish they supported. A further feature of the economic life of the area was the clam industry in the river itself. The clams (*Egeria radiata*) grew in quantities in the bottom of the river and were collected by women for sale" (Lawson, 1970a). The elimination of the clam has led to irreversible socio-economic consequences which will affect the riparian communities both upstream and downstream. The annual fertilization of the agricultural lands is no more and the fertility of such lands cannot be maintained even under the most sophisticated management. The seasonal flow has been superseded by a steady flow greater than previous seasonal low flow rates in the downstream area, which means decreased salinity as the steady flow pushes out the sea water. This also ends the clam industry, for although the Volta clam grows well in fresh water it needs a periodic inundation of sea water to complete its life cycle.

The creation of big dams also brings attendant health problems. In the construction of the Kariba dam an extensive clearing was carried out
before inundation. This was necessary in order to prevent fishing nets from getting fouled by the submerged stumps and also to ease lake transport. In the case of the Volta extensive clearing could not be done except on a limited scale around important settlements, for the expense involved would have been formidable. Unfortunately, bilharzia, a debilitating disease caused by a parasitic flatworm and transmitted through an intermediate snail host, has been reported in the cleared areas. The incidence of bilharzia is apparently associated with the fact that aquatic weeds quickly establish themselves in the cleared areas favouring the build-up of the bilharzia snail (*Bulinus rector*) (Lawson, 1970a). Perhaps it would have been advisable to have left the trees uncleared. The incidence of river blindness or onchocerciasis, is also increasing.

The effect of the dam on the fishing industry in the main body of the Volta is too little documented to permit any rational assessment. A study of possible effects of the dam on the climate has perhaps not yet been undertaken. Dams have definite life spans which tend to shorten due to silting. A long range holistic or pluralistic socio-economic, agro-ecological and engineering plan is essential if Ghana is to benefit from the Volta Dam and from the dams in the North.

**Agricultural Mechanization**

Agricultural mechanization is "the application of all forms of power to agricultural operations of all types, so that the farmer is less and less dependent on his own physical labour and that of those helping him" (Ahn, 1970, p. 251).

Agricultural mechanization includes (1) the processing of food products such as rice and coffee hulling, (2) mechanical and chemical control of weeds
of cultivation, (3) mechanical planting, harvesting, handling and fertilizer application to crops, and (4) the mechanization of land preparation including clearing, ploughing, harrowing and other operations. Of the four aspects of mechanization listed above the fourth item is the most contentious.

The advantages of mechanization are usually seen as labour saving devices. Mechanization makes it possible to cultivate more land but unless regeneration is possible by a quicker means than natural fallows, more cultivation only increases the pressure on land and reduces the resting periods. What often escapes the attention of experts is that mechanization does not necessarily increase yield per acre, although it may increase the daily output of work per man. Even in temperate agricultural zones large scale mechanization is sometimes associated with lower yields than are obtained by more labour intensive methods (Ahn, 1970).

Considerations for mechanization of land preparation must include relief: where there are steep slopes as in the forest zones of southern West Africa heavy mechanization is a hazardous venture. In the case of the savannah region, however, the relief is more nearly ideal for mechanization. Moreover, savannah crops such as guinea corn, millet, groundnut and cotton are more amenable to mechanised cultivation than forest crops such as cocoyam, plantain and tree crops. The soil types and associated climates are also issues for serious consideration. Mechanization involves high capitalization. It is not enough just to import tractors, ploughs, harrows and the rest, there must be servicing and repair facilities. Neglected or abused machines deteriorate fast and in the long run mechanization may become more expensive than hand methods.
There are also agro-ecological factors to consider. Mechanization encourages quick farming of too large areas at the expense of careful farming and also places undesirable emphasis on certain crops which are more amenable to mechanization than others. Since it is well suited to large farms, mechanization tends to favour the consolidation of present day small farms. A very serious limiting factor of mechanization is its unsuitability to the needs of tropical agriculture. The smaller types of tractors which are suitable in temperate regions are often too light and deficient in power for heavy work and rough conditions in the tropics.

"No continuous system of arable mechanized cultivation has yet proved workable and economic in the conditions which prevail in the forest zone of West Africa" (Ahn, 1970, pp. 252-3). It becomes doubtful whether those who advise large scale mechanization in Ghana are fully appreciative of the political, social and agro-ecological implications.

**Animal Husbandry**

Active livestock husbandry is synonymous with the advent of the white man on the African continent. This is not to underestimate the importance of livestock husbandry but where, as in Ghana, its efficiency is limited it becomes advisable to consider alternative means of producing meat.

Domestication of livestock and poultry started some 4,000 years ago (Pirie, 1969). It stands to reason that the possibility of including some African fauna might have been overlooked. It is also possible today to develop in Ghana game husbandry as it is now practised in the Transvaal in South Africa, Rhodesia and parts of East Africa.

Conventional livestock production is more convenient by far than game. The popularity of a livestock industry is associated with the docile nature
of domestic animals and the ease with which these animals can be herded, doctored and slaughtered compared to native game (Ledger et al., 1967).

Consequently, in the wake of the colonization of Africa the biotypes of several animals were transformed or destroyed. In Tanganyika the destruction of game, especially the Zebra, was encouraged by distribution of premiums (Nasimovich, 1970). Game compete with livestock for pasture and watering places while certain ones are believed to be carriers of various diseases, including trypanosomiasis causing sleeping sickness in man and nagana in livestock. This lent psychological support for the deliberate destruction of game. John Phillips writes:

"Justifiably many veterinarians believe that the wild fauna of Africa, unless controlled in numbers, migration and contact with areas in which livestock interests are paramount, is a serious threat to the well-being of domesticated animals. It is thus essential that the problems be studied, so that suitable action be taken wherever the threats are imminent and serious (Philips, 1957, p. 71)."

The profitability of domestic animals in Africa is now seriously questioned. It is realised today that with some degree of domestication, game animals are far more profitable on large range than livestock. The relatively higher productivity of game is explained by the fact that they are better adapted to the tropical environment than livestock.

Ecological considerations impose limits on animal husbandry. Climate affects animal production both directly and indirectly; direct effects result from such factors as temperature, radiation, humidity and length of daylight, while indirect effects operate through such factors as feed supply, parasites and diseases.

All domestic livestocks are homeothermic. In other words they need to maintain their body temperature within the narrow range most suitable for
optimal metabolism while maintaining thermal balance between their heat production and loss or gain from the environment. This thermal balance can be expressed by the equation:

\[ M - E - F - Cd - Cv - R = 0 \]

where,
- \( M \) = metabolic heat production
- \( E \) = heat loss from skin and respiratory passages by evaporation
- \( F \) = heat loss or gain by bringing ingesta to body temperature
- \( Cd \) = heat lost or gained by direct contact between skin and surrounding surfaces
- \( Cv \) = heat lost or gained by convections due to contact between air and contact
- \( R \) = heat lost or gained by radiation.

Brody (1956) described the comfort zone of cattle as the temperature zone within which no excess demands are made on the temperature regulating mechanisms. This comfort zone is between 30° and 60°F. for temperate type cattle and 50° and 80°F. for tropical type cattle. In tropical regions where cattle have to contend with high temperatures, various reactions occur which tend to maintain the animals in a condition of thermostability. Above the upper limit of the comfort zone (80°F.) the thermoregulative mechanisms begin to fail. This causes an abrupt rise in rectal temperature, a decline in feed intake, an increase in water intake and a decrease in productive growth processes.

Observations on beef cattle in Tropical Queensland by Larkin (1954) have shown that high temperatures reduce daytime grazing. Davis and Merilen (1960) have also shown that at environmental temperature of 90°F. feed consumption of lactating holstein cows was depressed twenty per cent, while above 105°F. feed intake virtually stopped.
There is little experimental evidence on the effects of high temperature on growth rates of tropical type cattle. Most of the individual breeds are small at birth and grow slowly. Literature reviewed by Findlay (1954) and Hancock (1954) has shown that milk yield, butter fat content and solids are depressed by high air temperature. Hancock and Payne (1955) in their experiment with eight sets of identical twin cattle (half of which were reared in the Fiji Islands - tropical; and the other half in New Zealand - sub-tropical or temperate) found that the average milk production of the twins in the temperate climate was 56 per cent higher than that of cows raised in the tropic zone. Cobble and Herman (1951) indicated a rise in the chloride content and a fall in the lactose and total nitrogen content of the milk when temperature rises above 90°F. It would be seen from Figures 2 and 3 of Chapter 2 that the comfort zone is outside both the coastal and Guinea savannah areas where cattle and other domestic animals are reared. Besides high temperatures the short day lengths do not favour the growth of domestic livestock.

The low productivity of cattle and other livestock is also in part due to their relatively higher susceptibility to tropical diseases including rinderpest, foot and mouth disease, anthrax, trypanosomiasis, deficiency diseases, and those caused by poisonous plants (Abeywickrama, 1964; Thomas, 1962). Phillips (1957) alluded to the fact that the uniformly high temperatures and high rainfalls and humidities do not favour growth; the animals become sparse, small, slow in maturing and have low productivity. This is more often seen in imported animals, and of course is a problem not encountered in native and therefore well adapted game animals. The same point has been made by Shaw and Corville (1950).
The need to provide feed at uneconomic rates also militates against livestock in the tropics. Typical grassland climates do not exist in the tropics. In fact the vast savannah regions as we know them today are fire climaxes which have originated from man's influence (Nye and Greenland, 1960; Abeywickrama, 1964). Successful livestock production involves the provision of a sward dominated by a single or very few plant species, supplemented with grains, hay and/or silage which could only be maintained at great human cost. At a time when Ghana is faced with low food production we must question the wisdom of splitting the resources for food production with goats, cattle, sheep, pigs and poultry since the rate of food energy conversion in livestock is so low. Of the starch equivalent consumed by grazing animals only about ten per cent is converted into edible animal products (Abeywickrama, 1962). Indeed continued overemphasis on livestock husbandry could seriously contribute to low food production.

Livestock husbandry almost always results in over-grazing, because ideal husbandry measures are difficult to practise in the tropics. The feeding habits of cattle, sheep and goats also contribute to the problem. For instance grazing cattle tend to group together and move to and fro along the same paths, destroying the foot mats and disrupting the stability of the soil structure. Savannah soils are easily eroded. Sheep and goats on over-grazed land tear to ground level all available grass exposing the soil to the elements. As the result of overgrazing, the Masai people of Kenya for example have lost much of their agricultural land and are now restricted to comparatively small areas in the valleys and low plateaus. Estimates show that ten years ago the Kenya Masai had 973,000 head of cattle, 660,000 sheep
and goats and a large number of donkeys, which was about double the carrying capacity of the land (Glover and Gwyne, 1961). Worthington (1962) reported that in the same year there was a severe drought which killed in Masailand in both Kenya and Tanganyika about three-fifths of the cattle.

It is known that game are more specialized than domestic livestock in their feeding habits. Some ungulates are capable of utilizing producer species on marginal land unsuitable for domestic animals. Game are browsers or browser-grazers capable of utilizing the shrubs and trees which hold the bulk of producer biomass. Further a wide spectrum of game can utilize this resource at different levels with no competition for food and space, and without doing any serious damage (Thomas 1962). Warthogs and pigs grub roots from underground, snails eat decomposing vegetation and fruits, antelopes browse the shrub, grasscutters (Thryonomys swinderianus Temminik) cut grass and the elephants and monkeys feed from the top of trees. "The vegetation is complex, the fauna is complex, yet all blend together to feed in a well-coordinated pattern in harmony with the physical factors of the land" (Adu, 1964, p. 13). Where there is an adapted herbivorous fauna present in large numbers there is usually a migratory movement or periodic population shift among them, thus easing pressure on the land.

Talbot et al. (1962) have shown that game animals have a rapid weight gain, reaching economically marketable size at an earlier age than domestic animals. Daily average gain of 0.06 kg for Thomson's gazelle to 0.24 kg for eland has been noted which compares with daily average gain of 0.14 kg for poorly managed cattle on unimproved rangeland in Rhodesia. Talbot et al. (1962) have also shown that game have relatively high reproductive potential.
The live weights and weights of some mature animals are shown in Table 3.6. Columns 1 to 4 show the liveweights, carcass weight, carcass as percentage of liveweight and carcass lean as percentage of liveweight. In Column 3 the figures show that with the exception of the hippopotamuses all game species gave higher yields of usable meat than the thin zebu cows. The yields of eland, waterbuck, oryx, Grant's gazelle and Thompson's gazelle are comparable with those of the well-conditioned zebu bulls and steers reared in a more favourable environment while the lesser kudu, Grant's gazelle and gerenuk yield much better than fat zebu cows. It is interesting to note that kudu and gerenuk are the least dependent on water of all browsing animals but have the highest meat yields of all the species.

It is important to note that the carcasses of cattle contain substantially more fat than those of game. Thin, store, prime and fat cattle could be expected to yield carcasses with 45 per cent, 50 per cent, 58 per cent and 63 per cent usable meat containing percentages of fat in the order of 12 per cent, 18 per cent, 28 per cent and 25 per cent respectively. The percentage of fat in game is relatively low, and the amount of muscular tissue therefore greater. It has been shown that game are superior to cattle in their ability to produce a greater weight of animal protein per unit of liveweight.

Game husbandry is till a novelty in many African countries but game harvesting on an organized commercial basis is an old industry practised among Ghanaians at least who "have a largely untapped fund of knowledge regarding wild life and conservation that could perhaps be usefully incorporated into management techniques and might produce ideas for further research" (Thomson, 1962, p. 173). In particular the hunters and farmers are well knowledgeable about life cycles, feeding habits and habitats of game.
<table>
<thead>
<tr>
<th>Species</th>
<th>Sex</th>
<th>N.</th>
<th>Liveweights</th>
<th>Dressed Carcass Weights</th>
<th>Carcass as % Liveweight</th>
<th>Carcass lean as % of Liveweight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Column 1</td>
<td>Column 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hippopotamus</td>
<td>M</td>
<td>4</td>
<td>1489.8</td>
<td>640.4</td>
<td>43.0</td>
<td>32.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3284)</td>
<td>(1412)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>4</td>
<td>1277.2</td>
<td>535.3</td>
<td>41.9</td>
<td>29.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2816)</td>
<td>(1180)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buffalo</td>
<td>M</td>
<td>8</td>
<td>753.0</td>
<td>380.5</td>
<td>50.5</td>
<td>40.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1660)</td>
<td>(839)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eland</td>
<td>M</td>
<td>5</td>
<td>508.1</td>
<td>301.2</td>
<td>59.1</td>
<td>46.7</td>
</tr>
<tr>
<td>Zebu bulls</td>
<td>M</td>
<td>10</td>
<td>483.9</td>
<td>280.4</td>
<td>58.0</td>
<td>39.8</td>
</tr>
<tr>
<td>Zebu steers</td>
<td>M</td>
<td>70</td>
<td>469.8</td>
<td>270.6</td>
<td>57.6</td>
<td>31.6</td>
</tr>
<tr>
<td>Zebu fat cows</td>
<td>F</td>
<td>4</td>
<td>394.8</td>
<td>234.7</td>
<td>59.4</td>
<td>31.9</td>
</tr>
<tr>
<td>Zebu thin cows</td>
<td>F</td>
<td>9</td>
<td>298.4</td>
<td>139.9</td>
<td>46.8</td>
<td>30.3</td>
</tr>
<tr>
<td>Zebra</td>
<td>M</td>
<td>5</td>
<td>256.7</td>
<td>141.2</td>
<td>55.0</td>
<td>43.2</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>5</td>
<td>214.1</td>
<td>114.9</td>
<td>53.6</td>
<td>42.5</td>
</tr>
<tr>
<td>Wildebeest (K)</td>
<td>M</td>
<td>10</td>
<td>243.3</td>
<td>135.5</td>
<td>55.7</td>
<td>43.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(536)</td>
<td>(299)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>192.0</td>
<td>102.2</td>
<td>53.2</td>
<td>40.9</td>
</tr>
<tr>
<td>Waterbuck</td>
<td>M</td>
<td>10</td>
<td>237.7</td>
<td>139.6</td>
<td>58.6</td>
<td>48.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(524)</td>
<td>(308)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>181.0</td>
<td>106.6</td>
<td>58.9</td>
<td>46.5</td>
</tr>
<tr>
<td>Wildebeest (S)</td>
<td>M</td>
<td>10</td>
<td>203.0</td>
<td>101.5</td>
<td>50.0</td>
<td>39.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(448)</td>
<td>(224)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oryx</td>
<td>M</td>
<td>10</td>
<td>176.4</td>
<td>100.6</td>
<td>57.0</td>
<td>45.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(389)</td>
<td>(222)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kongoni (Hartebeeste)</td>
<td>M</td>
<td>5</td>
<td>142.5</td>
<td>81.5</td>
<td>57.2</td>
<td>46.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(314)</td>
<td>(180)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>5</td>
<td>126.2</td>
<td>73.2</td>
<td>58.1</td>
<td>45.9</td>
</tr>
</tbody>
</table>

Note: All values in Kilos and S.D. are in parentheses.
<table>
<thead>
<tr>
<th>Species</th>
<th>Sex</th>
<th>N.</th>
<th>Column 1 Liveweights</th>
<th>Column 2 Dressed Carcass Weights</th>
<th>Column 3 Carcass as % Liveweight</th>
<th>Column 4 Carcass lean as % of Liveweight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( \bar{X} )</td>
<td>( \text{S.D.} )</td>
<td>( \bar{X} )</td>
<td>( \text{S.D.} )</td>
</tr>
<tr>
<td>Topi</td>
<td>M</td>
<td>10</td>
<td>130.8</td>
<td>9.1 (288)</td>
<td>70.8</td>
<td>4.9 (156)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>103.9</td>
<td>8.0 (229)</td>
<td>56.2</td>
<td>5.4 (124)</td>
</tr>
<tr>
<td>Kob</td>
<td>M</td>
<td>10</td>
<td>96.7</td>
<td>5.8 (213)</td>
<td>55.8</td>
<td>4.3 (123)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>62.1</td>
<td>4.2 (137)</td>
<td>36.2</td>
<td>2.9 (80)</td>
</tr>
<tr>
<td>Lesser kudu</td>
<td>M</td>
<td>10</td>
<td>92.1</td>
<td>14.4 (203)</td>
<td>57.1</td>
<td>8.6 (126)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>60.2</td>
<td>7.9 (133)</td>
<td>33.5</td>
<td>4.8 (74)</td>
</tr>
<tr>
<td>Warthog</td>
<td>M</td>
<td>10</td>
<td>87.8</td>
<td>7.5 (194)</td>
<td>48.2</td>
<td>5.8 (106)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>60.2</td>
<td>7.9 (133)</td>
<td>33.5</td>
<td>4.8 (74)</td>
</tr>
<tr>
<td>Grant's gazelle</td>
<td>M</td>
<td>6</td>
<td>60.1</td>
<td>6.2 (133)</td>
<td>36.4</td>
<td>3.7 (80)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>5</td>
<td>41.3</td>
<td>1.5 (91)</td>
<td>24.4</td>
<td>1.9 (54)</td>
</tr>
<tr>
<td>Impala</td>
<td>M</td>
<td>10</td>
<td>56.7</td>
<td>2.6 (125)</td>
<td>33.0</td>
<td>1.6 (73)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>42.0</td>
<td>2.6 (93)</td>
<td>24.5</td>
<td>2.0 (54)</td>
</tr>
<tr>
<td>Gerenuk</td>
<td>M</td>
<td>5</td>
<td>31.2</td>
<td>2.1 (69)</td>
<td>20.3</td>
<td>1.0 (45)</td>
</tr>
<tr>
<td>Thomson's gazelle</td>
<td>M</td>
<td>10</td>
<td>25.3</td>
<td>1.6 (56)</td>
<td>14.8</td>
<td>1.0 (33)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>18.4</td>
<td>1.2 (41)</td>
<td>10.5</td>
<td>0.8 (23)</td>
</tr>
<tr>
<td>Thomson's gazelle (S)</td>
<td>M</td>
<td>10</td>
<td>20.3</td>
<td>1.7 (45)</td>
<td>11.0</td>
<td>1.1 (24)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>10</td>
<td>16.9</td>
<td>1.3 (37)</td>
<td>9.1</td>
<td>1.0 (20)</td>
</tr>
</tbody>
</table>

\( \bar{X} \) - average weights (kilograms and pounds)  
\( \text{S.D.} \) - standard deviation  
\( K \) - Kajiado, Kenya  
\( S \) - Serengeti, Tanzania

Wildlife and Food Production - World Review of Animal Production # II, pp. 18-19.
They are less well informed about the diseases of game. The Research Institutions, including the Division of Animal Health in the Ministry of Agriculture, the Universities and the Council for Scientific and Industrial Research (C.S.I.R.) can fulfill their role in this respect.

It is believed that there are still substantial quantities of various animals in the game reserve and elsewhere. The Department of Forestry, Ministry of Agriculture, the universities and the Council must co-operate in a joint effort to develop the Mole Game Reserve and the others into viable economic units. As previously stated game reserves per se have very little economic significance; it is proper conservation reserves that make the difference. This must ensure not only the preservation of a quality environment but must also ensure a continuous yield of useful plants, animals and materials by establishing a balanced cycle of harvest and renewal. The Mole Game Reserve could also be developed as a recreational resort. Well planned and implemented it could serve as a model for other reserves in various parts of the country.
CHAPTER 4

ECONOMICS OF AGRICULTURAL PRODUCTION

Ghana as an Agricultural Country

That Ghana is an agricultural country is indicated by the importance of agriculture to the general economy. Agriculture is the largest and the most important single industry absorbing the bulk of the labour force and contributing immensely to the Gross National Produce (G.N.P.). As seen in Table 4.1 the percent of population in agriculture and the percent of the population that is economically active in agriculture is very high in Ghana and the other West African countries relative to those of more developed countries such as Canada and the U.S.. Percent of population in agriculture includes all persons depending on agriculture, forestry and hunting and fishing for their livelihood and percent of population economically active in agriculture includes all persons engaged in economic activity whether as employees own-account workers, salaried employees or unpaid workers assisting in the operation of a family farm or business (F.A.O. 1970, p. 301).

- 80 -
TABLE 4.1

AGRICULTURAL POPULATION AND POPULATION ECONOMICALLY ACTIVE IN AGRICULTURE AS PERCENTAGE OF TOTAL POPULATION AS ESTIMATED FOR 1965 PRESENTED FOR WEST AFRICA AS AGAINST AMERICAN COUNTRIES

<table>
<thead>
<tr>
<th>Country</th>
<th>% in Agric.</th>
<th>% Economically Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nigeria</td>
<td>79</td>
<td>80</td>
</tr>
<tr>
<td>Dahomey</td>
<td>84</td>
<td>84</td>
</tr>
<tr>
<td>Togoland</td>
<td>79</td>
<td>79</td>
</tr>
<tr>
<td>Ghana</td>
<td>60</td>
<td>56</td>
</tr>
<tr>
<td>Ivory Coast</td>
<td>86</td>
<td>86</td>
</tr>
<tr>
<td>Liberia</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Gambia</td>
<td>88</td>
<td>86</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>89</td>
<td>75</td>
</tr>
<tr>
<td>Mali</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Guinea</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Upper Volta</td>
<td>88</td>
<td>87</td>
</tr>
<tr>
<td>Cameroon</td>
<td>84</td>
<td>84</td>
</tr>
<tr>
<td>Canada</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>


In Table 4.2 percentages of agricultural produce in overall export commodities for the period 1966 to 1969 inclusive are shown. While in Sierra
Leone agricultural export as percentage of total national export is relatively small, agriculture is the economic base and the most important economic activity in all West African countries.

TABLE 4.2: PERCENTAGE CONTRIBUTION OF AGRICULTURAL PRODUCE IN OVERALL EXPORT AND PERCENTAGES OF MAJOR EXPORT CROPS IN SELECTED WEST AFRICAN COUNTRIES

<table>
<thead>
<tr>
<th>Country</th>
<th>Commodity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghana</td>
<td>Agric. in total export</td>
<td>68.6</td>
</tr>
<tr>
<td></td>
<td>Cocoa in total agric. crops exported</td>
<td>96.8</td>
</tr>
<tr>
<td></td>
<td>Other crops in total agric. exported</td>
<td>3.2</td>
</tr>
<tr>
<td>Nigeria</td>
<td>Agric. in total export</td>
<td>50.8</td>
</tr>
<tr>
<td></td>
<td>Cocoa in total agric. export</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Groundnut in total agric. export</td>
<td>35.</td>
</tr>
<tr>
<td>Togoland</td>
<td>Agric. in total export</td>
<td>96.2</td>
</tr>
<tr>
<td></td>
<td>Coffee in total agric. export</td>
<td>22.9</td>
</tr>
<tr>
<td></td>
<td>Cocoa in total agric. export</td>
<td>19.8</td>
</tr>
<tr>
<td></td>
<td>Palm products in total agric. export</td>
<td>15.6</td>
</tr>
<tr>
<td></td>
<td>Groundnuts in total agric. export</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Cotton in total agric. export</td>
<td>3.6</td>
</tr>
<tr>
<td>Mali</td>
<td>Agric. in total export</td>
<td>98.8</td>
</tr>
<tr>
<td></td>
<td>Livestock products in total agric. exp.</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Oilseeds,oilnibs,oil kernels in total agric. export</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>Groundnut in total agric. export</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td>Raw cotton in total agric. export</td>
<td>23.9</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>Agric. in total export</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Coffee in total agric. export</td>
<td>18.1</td>
</tr>
<tr>
<td></td>
<td>Cocoa in total agric. export</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>Palm kernel and oil in total agric. exp.</td>
<td>45.6</td>
</tr>
<tr>
<td>Upper Volta</td>
<td>Agric. in total export</td>
<td>92.5</td>
</tr>
<tr>
<td></td>
<td>Livestock in agric. exports</td>
<td>67.3</td>
</tr>
<tr>
<td></td>
<td>Palm products in total agric. exports</td>
<td>13.0</td>
</tr>
<tr>
<td></td>
<td>Groundnuts in total agric. exports</td>
<td>5.7</td>
</tr>
</tbody>
</table>

Other features characterising Ghana's agricultural system include low productivity, labour oriented agriculture, low per capita incomes, low levels of consumption and investment, and a weak base oriented to the production of a few export crops, particularly cocoa.

The Role of Agriculture in the General Economy

Because of the key role of agriculture in the economics of tropical countries and the comparative advantage which tropical countries have in agriculture over other industries at the present level of economic development, it is imperative that the agricultural sector be well developed.

Unfortunately the importance of agriculture in economic development tends to be overlooked or downgraded by misuse of the money allocated to agriculture, which ultimately places agriculture at a disadvantage. In the 1950's most development economists argued in favour of industrialization on the grounds that this is the key to economic development. It was not until Arthur W. Lewis (1954) put forward his classic exposition on the role of agriculture, which was confirmed through research by other economists, that the attitude changed. Lewis (1954) wrote:

> It is not profitable to produce a growing volume of manufactures unless agricultural production is growing simultaneously. This is why industrial and agrarian revolutions always go together, and why economies in which agriculture is stagnant do not show industrial development. (Lewis, 1954; p. ).

Important as industrialization is in economic development, it is essential to develop a balanced relationship between industry and agriculture in order to avert serious economic difficulties such as those which Soviet Russia and Argentina, for example, have encountered (Baxter, 1964). Too rapid industrial capitalization tends to retard economic growth since there may be insufficient supply of agricultural raw materials to feed the industry.
Similarly, the agricultural sector may not have been sufficiently adjusted to release labour, and as is too often the case the people in agriculture may be financially weak to support an industrial market.

The role of agriculture in economic growth consists essentially of increasing food supplies while releasing labour to industry, increasing capital formation and contributing to the stability of market economies. The extent to which these functions have been fulfilled could best be answered by a careful assessment of the role of agriculture in the economy.

On the one hand the contribution made by agriculture to sustain the growth of the Ghanaian economy is substantial. Agriculture absorbs between 56 and 60 per cent of the labour force (Table 4.1). It is also the main source of national revenues. For example, in 1961 alone domestic food production accounted for £167 million which was roughly one-third of the Gross Domestic Product of Ghana. Agriculture alone provided more than 50 per cent of some £500 million worth of tax revenues from all economic activities. Since the 19th century International Trade has been a great stimulant to the growth of the economy of Ghana. Most of the commodities consisted of agricultural products, first rubber and then oilpalm until the advent of the cocoa industry during the early part of the present century. It is out of agricultural exports that Ghana has financed those imports of capital and consumer goods which have contributed to the maintenance of a rapid rate of economic growth and a general standard of living that is accepted as amongst the highest in Africa (Seven-Year Development Plan, 1964; Ch. 4, p. 1). Since the Second World War income from the agricultural sector has almost single-handedly financed all advances in the way of modernization of Ghana including education of Ghanaians both locally and in overseas
institutions, the building of Ghana's universities, secondary schools, trade and technical institutions, and elementary schools, the development of a telecommunications network, hydro-electric power and other economic projects. Of a total income of £700 million earned from export of cocoa during the period 1951 to 1961, £420 million was paid directly to the cocoa farmers. The bulk of this money went into private investment, such as building modern houses, roads, and water supplies. In many villages "Town Development Committees" were formed which provided guidance for general development in those villages. The rapid growth in urbanization is largely associated with the prosperity of the cocoa industry. The remaining 280 million which the Government retained went to maintain public services, to finance development and to build up foreign exchange reserves.

On the other hand, the impressive record of the agricultural sector is somewhat marred by mismanagement of planning strategy governing the system of production. The most pervasive effect of this mismanagement is found in low domestic food production and instability in the domestic market economy. The main causes for mismanagement of the system of agricultural production are two-fold, namely: (1) the political fact of colonial and semi-colonial dependency leading to the establishment of a weakly-based agricultural economy dominated by the cocoa industry, and (2) the mechanical transfer and implementation of mechanization and other techniques which are inappropriate to the tropical situation (Ward, 1966). These causes will be discussed together with their impact on the economy.

The Political Fact of Colonial and SemiColonial Dependency

The development of the cocoa industry in Ghana was in response to the industrial needs of Britain in the wake of the Industrial Revolution.
Although the modernization of the Gold Coast (as Ghana used to be called) was initiated by Britain it was largely the industry and diligence of Ghanaians that made the programme of modernization possible (Hill, 1963). Yet Ghanaians were denied any say in the course of development, let alone being allowed to make decisions to change the pattern and quality of their economic life. For example, following the outbreak of swollen shoot virus disease in cocoa trees in 1947, the Ashanti Confederacy Council in their wisdom expressed deep concern over the economic advisability of continued adherence to a one-crop economy (Stamp, 1953). This was not heeded by the Colonial Administration for obvious reasons. The Colonial Administration found an excuse in the traditional belief in laissez-faire. The truth was that a successful cocoa industry in Ghana favoured the interests of British Colonial investment and the sustained growth of the British economy at large. A strong Nationalist Government was needed to change the course of history (Ward, 1966).

Prior to the establishment of the cocoa industry agriculture was at subsistence level. Nevertheless, farmers produced food in sufficient quantities to feed the people at minimal cost. Rubber and oilpalm cultivation had been commercialized but had barely advanced beyond a mediocre level. The first major attempt towards commercial farming came with the establishment of the cocoa industry.

Cultivation of cocoa was encouraged by providing better marketing facilities. Indeed in the 1930's the production of cocoa had become the most profitable agricultural activity. According to the F.A.O. scale of values cocoa was six times as profitable as maize. In an attempt to insulate the Ghanaian cocoa farmer from the uncertainties of the world cocoa market the Cocoa Marketing Board, C.M.B., was established as the sole buyer,
grader, seller and exporter of cocoa (Fitch and Oppenheimer, 1966).

In Table 4.3, the producer and export prices of cocoa are presented which shows that, at least in part, the theory behind the formation of C.M.B. was consciously executed. Throughout 1950 the price paid to producers fluctuated within narrow limits from £112 to a maximum of £149 per ton while the export price moved between £189 to £358 per ton. Although the producer price was lower than the export price, the operation of the C.M.B. provided the necessary assurances against the risks and uncertainties of marketing.

**TABLE 4.3**

**COCOA PRODUCER PRICES AND EXPORT PRICES 1947-48 TO 1960-61**

<table>
<thead>
<tr>
<th>Crop Year</th>
<th>Producer Price</th>
<th>Average Export Price</th>
<th>Producer Price as Percentage of Export Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947-48</td>
<td>75</td>
<td>201</td>
<td>37.3</td>
</tr>
<tr>
<td>1948-49</td>
<td>121</td>
<td>137</td>
<td>88.3</td>
</tr>
<tr>
<td>1949-50</td>
<td>84</td>
<td>178</td>
<td>47.2</td>
</tr>
<tr>
<td>1950-51</td>
<td>131</td>
<td>269</td>
<td>48.7</td>
</tr>
<tr>
<td>1951-52</td>
<td>149</td>
<td>245</td>
<td>60.8</td>
</tr>
<tr>
<td>1952-53</td>
<td>131</td>
<td>231</td>
<td>56.7</td>
</tr>
<tr>
<td>1953-54</td>
<td>134</td>
<td>358</td>
<td>37.4</td>
</tr>
<tr>
<td>1954-55</td>
<td>134</td>
<td>353</td>
<td>38.0</td>
</tr>
<tr>
<td>1955-56</td>
<td>149</td>
<td>222</td>
<td>67.1</td>
</tr>
<tr>
<td>1956-57</td>
<td>149</td>
<td>189</td>
<td>78.8</td>
</tr>
<tr>
<td>1957-58</td>
<td>134</td>
<td>304</td>
<td>44.1</td>
</tr>
<tr>
<td>1958-59</td>
<td>134</td>
<td>280</td>
<td>48.0</td>
</tr>
<tr>
<td>1959-60</td>
<td>112</td>
<td>226</td>
<td>49.6</td>
</tr>
<tr>
<td>1960-61</td>
<td>112</td>
<td>175</td>
<td>64.0</td>
</tr>
</tbody>
</table>

Thus cocoa farms sprang up like mushrooms. First it was in the Eastern Region from where it spread to the Volta Region, the Central Region, Ashanti and Brong Ahafo. In the wake of the cocoa industry there followed a spontaneous immigration of workers from Northern Ghana and Volta Region as well as some neighbouring countries including Mali, Guinea and the Upper Volta. To provide for agronomic needs and control measures against pest and disease, the W.A.C.R.I. was established.

As if by design the cultivation of food staples was left neglected throughout the country. The cocoa farmers of Ghana and Western Nigeria who made the cultivation of cocoa their main economic activity "became more deeply immersed in the market mechanism and learned to accept increasing depersonalized provision of consumption goods, even to the extent of obtaining a large part of their food supply by purchase" (Jones, 1965; p. 37).

**Effect of One-Crop Economy**

While it may be argued that the cocoa-dominated economy has played a useful role, nevertheless the industry is regionalised. Consequently, the cocoa growing areas especially Ashanti, the Eastern Region, the Central Region and to a less extent the Volta Region and the Western Region, are more developed than the Upper and Northern Regions, which have served as sources of cheap labour for the Government and business institutions. This was the beginning of the creation of regional disparities. From the national point of view such an economy is unbalanced; it is only by a properly planned agricultural development that the least developed regions will be freed from the shackles of poverty and illiteracy.

Neglect of production of staple foods leads to an increase in the cost of living and its impact is felt throughout the country. As shown in Table 4.4
### TABLE 4.4

**FOOD EXPENDITURE AS A PERCENTAGE OF INCOME AND WELFARE INDEX**

<table>
<thead>
<tr>
<th>Countries</th>
<th>Food Expenditure as a percentage of income</th>
<th>Welfare Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ivory Coast</td>
<td>80</td>
<td>1.25*</td>
</tr>
<tr>
<td>Thailand</td>
<td>71</td>
<td>1.41*</td>
</tr>
<tr>
<td>Iraq</td>
<td>70</td>
<td>1.43*</td>
</tr>
<tr>
<td>Jamaica</td>
<td>69</td>
<td>1.45*</td>
</tr>
<tr>
<td>India</td>
<td>66</td>
<td>1.57*</td>
</tr>
<tr>
<td>Egypt</td>
<td>66</td>
<td>1.57*</td>
</tr>
<tr>
<td>Ghana</td>
<td>66</td>
<td>1.57*</td>
</tr>
<tr>
<td>Colombia</td>
<td>43</td>
<td>1.58*</td>
</tr>
<tr>
<td>Japan</td>
<td>49</td>
<td>2.04*</td>
</tr>
<tr>
<td>Netherlands</td>
<td>38</td>
<td>2.60*</td>
</tr>
<tr>
<td>U.K.</td>
<td>33</td>
<td>3.03 ¹</td>
</tr>
<tr>
<td>U.S.</td>
<td>31</td>
<td>3.22 ²</td>
</tr>
</tbody>
</table>

Source: F.A.O. 1959, *The State of Food and Agriculture*

*Copied from: Encyclopaedia Britannica 1971 Consumption Vol. 6, p. 413

²Copied from: W. Brand 1964 *Economic Features of a Traditional Society,* in: *Agricultural Planning Course,* F.A.O. Rome

In the developing societies including Ghana, Egypt, India and the Ivory Coast, the relation between income and expenditure expressed as welfare index is lower than the welfare index for the more developed societies. This means that after paying for food they have very little money left for other necessities of life. The situation worsens when the world price of cocoa goes down, as the present trend has shown.
In a study on "The Ecology of Child Health and Nutrition in some West Nigerian Villages", W. R. F. Collins and others (1962) established a negative correlation between nutritional levels and the agricultural prosperity of the cocoa villages they studied. Therefore, Western Nigeria is faced with the same economic hardship as Ghana when world markets for cocoa are weak, cocoa being the economic base of the economy. Clarifying the cause of the social disorganization amongst the cocoa villagers they wrote:

The reason for this is that it is not enough to introduce a highly paying cash crop to an illiterate peasantry and expect them to profit by it. What happens is that it tends to kill their traditional life, merely putting money in their pockets for a short period in the year, during which time they enjoy themselves. When the money gets scarce, months before the next harvest, they find themselves short of everything ... With money running out they can only buy the cheapest food, e.g. cassava and yams. Also the cocoa season is short and the cocoa farmer has very little to do for the remaining part of the year but sit around. Such idleness is not refreshing rest that comes after labour, but sterile boredom in which man's mind and body degenerate, leaving him unhappy and discontented (Collins et al., 1962; pp. 223-24).

The Eastern Region of Ghana is in a similar position though the impact on the nation as a whole is more serious than Nigeria. Since cocoa is not the mainstay of its economy, Nigeria is less affected than Ghana by the declining prosperity of the cocoa industry. Ghana is in a dilemma. Year in and year out the country has to import substantial amounts of food which badly affects the staggering economy. According to the Seven-Year Development Plan:

... Ghana's agriculture has not been able to keep up with the growing demand for food in recent years and local food prices have risen steadily while a part of the demand for food has been met by increased imports. By 1961 the burden of food imports had become a contributory factor in the worsening balance of payments situation. Ghana had to spend over £26 million that year on food imports alone, which was almost exactly equal to the total deficit on visible trade for the year. Ten years before the food import bill had amounted to £9.8 million, and it is estimated that with the rate of economic growth anticipated under the present development plan food imports, if unchecked, will have grown to some £50 million by 1970.
It is obvious that the Government cannot subsidize imported food to the extent which the average Ghanaian could afford in sufficient quantity and quality. As the result many people especially those within the low income bracket are under-fed. Nutritional diseases such as kwashiorkor and marasmus in Ghana are taken as a matter of course. Kwashiorkor is a post-weaning protein deficiency disease which in Africa affects about one million children in the one to four year age group. Marasmus is caused in children who simply do not have enough food to eat.

**Political Hazards**

Patterns are emerging which suggest that there are serious political changes attendant on the declining prosperity of the cocoa industry. Three recent successful changes of government, two of which were by military coup d'état and the third through democratic process, are all underlain by good intentions to set the economy right. A Ghanaian proverb says that when you cut off the head of a snake the rest is nothing but a string. The snake's head symbolises Ghana's cocoa industry. This being crushed, the very destiny of Ghana would be broken. There are a number of Ghanaians who strongly believe that control of the world price of cocoa is a political weapon which the western powers have used against Ghana.

The overthrow of Dr. Kwame Nkrumah's government in 1966 was partly associated with the declining prosperity of the cocoa industry. He had introduced stiff economic measures which infringed on the standard of living of Ghanaians. Ghanaians, having enjoyed one of the highest standards of living, are apt to resist any economic measures which infringe on their standard of living. Therefore, even the least politically minded citizens are likely to reject the leaders and pledge loyalty to any organised
opposition to the ruling elite. Since 1957, the year of Ghana's National Independence, all efforts to reach a favourable international agreement on the world price for cocoa has failed.

Meanwhile the foreign reserves have been rapidly depleted which made it difficult to provide for household and industrial consumption. Many Ghanaians had felt that with the overthrow of Dr. Kwame Nkrumah the economy would be set right forthwith. By the same token Dr. K. A. Busia, subsequent civilian executive after Dr. Nkrumah became a victim of economic circumstances, when he devalued the cedi (Ghanaian currency) on December 29, 1971. In his statement devaluing the cedi, he said among other things:

...inflation and increased prices in turn led to increase in unemployment in countries like Britain and the United States. That has meant less industrial activity and less income for the people of these countries. Since they have less to spend and less activity, there has been less demand for raw materials and for primary products like cocoa. Today's price for cocoa has thus come down to less than half the level it was when we came into office two years ago (Busia, 1971; p. 1).

His Government was toppled in a military coup on January 13, 1972, barely two weeks later. Again some Ghanaians applauded the coup in the hope that stability in the economy would return. It is too early to pass comment.

The weak base agricultural economy is a colonial legacy bestowed on the Independent State of Ghana. The British Colonial Administration working in its own interest failed to diversify the agricultural base. Against this background it can be argued that only an Independent Nationalist Government can rectify the imbalance in production strategy. But as Lady Barbara Ward (1966) has pointed out it does not always follow that when power descends into the hands of the local people the right decisions will always be made. It seems that some serious mistakes have been made by the independent regimes.
There is no doubt that the Government of Ghana appreciated the dynamic interrelationship of industry and agriculture. This appreciation seems to be reflected in the comprehensiveness of all the development plans, beginning from 1957. Dr. Nkrumah used to say quite often that what had taken the more developed nations many decades to accomplish needed to be accomplished within a decade or less in the developing countries, adding that the best is always good for Africa. True to his words the Seven Year Development Plan set forth elaborate plans to produce sufficient food, including large scale mechanized farms to be managed by the "State Farms Corporation", the Workers Brigade and Farmers" Co-operatives as well as private individuals. This unprecedented venture into the realm of economic development is in line with Adlai Stevenson's "Revolution of Rising Expectations". The Seven Year Development Plan recognises that labour is a major limiting factor in agricultural production. Against this background it was therefore envisaged that large-scale mechanized farms would provide an answer to the chronic problem of low food production. A look at Table 4.5 shows this determination.

**TABLE 4.5**

<table>
<thead>
<tr>
<th>GHANA GOVERNMENT INVESTMENT IN AGRICULTURAL MACHINERY</th>
<th>£G.000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1957</td>
<td>151</td>
</tr>
<tr>
<td>1958</td>
<td>182</td>
</tr>
<tr>
<td>1959</td>
<td>291</td>
</tr>
<tr>
<td>1960</td>
<td>733</td>
</tr>
</tbody>
</table>

While these figures are unimportant in absolute terms they reflect an increasing trend towards mechanization (Republic of Ghana, 1957-8). Ghana was the first developing African country to embark on mechanization in an endeavour to modernize the traditional system of farming. She has been commended for that (Brokensha, 1961).

It is obviously desirable to be able to feed one's people. But unfortunately, as was pointed out in the discussion on the impact of the "Green Revolution" on tropical agriculture in the previous chapter, wholesale import of certain technologies such as is inherent in modern agricultural machinery is frequently inappropriate in the tropical setting.

By adopting the wrong approach the Government of Ghana did more harm than good to the sick economy which they sought to resuscitate. The inappropriateness of such blind application of technology is what Lady Barbara Ward refers to as "technological disproportion". In an obvious reference to the use of tractors and ancillary machinery in Ghana she writes:

One can see the consequence of the maladjustments very clearly in some parts of Africa today. Inexperienced governments, trying out their hand in economic decision-making, find it terribly tempting to buy the most up-to-date machinery which persuasive gentlemen from the North Atlantic area come to sell them. These salesmen call their efforts "investment". In fact they only offer suppliers' credits at fairly high rates of interest and at prices which tend to be far above the international level. They are, as it were, plumbing down great gobbits of advanced industrial technology into countries where there is neither the market nor the skills nor the managerial capacity nor indeed any of the preconditions for such a technology to work successfully.

These policies constitute not only a big block in the way of development, but they do little to improve economic relations between the North and South. They are bound, as in Ghana today, to precipitate a crisis in the balance of payments. For how can these suppliers' credits be repaid when they have been invested in industrial structures which have absolutely no hope of paying their way? They were not related organically to any accurate economic
analysis in the first place. They were fancy goods sold from the western shop window and they are inappropriate in technology and inappropriate as a stimulus to growth inside the economy. The factory chimneys may smoke indeed, but they are factories operating at one-third of capacity and producing goods which nobody can afford to buy locally and which do not compete on the world market. Under such conditions, a country may nominally industrialize and "develop" but in fact its standard of living actually falls (Ward, 1966, p. 17).

She has been proved right. Barely six years after she had written, Colonel Achcampong who led the coup against Busia's government has declared his intention to repudiate Ghana's debt incurred through dubious suppliers' credit.

Mechanization, which is a labour saving device designed to substitute machinery for manpower on a large scale, is the least desirable method in a country like Ghana where labour is still cheap (Ahn, 1970). It is pathetic that the Government overlooked this economic consideration. The Development Plans: 1959-64, and the Seven Year Development Plan sought to employ the rural population more profitably and to reduce disguised employment. One of the expected roles stipulated by the Plan is to organise agriculture so as to be able to release human resources to industry. In pursuit of this aim the "Ghana State Farms Corporation", the Workers Brigade and Farmers' Co-operatives were established (Republic of Ghana, 1957-8).

These ideas might apply to temperate agriculture but were obviously out of context in the Ghanaian situation. By creating these farming organizations, the Government of Ghana made it possible for farmers to quit their farms. For lack of necessary ecological consideration in concert with lack of proper organization and other factors, the Government sponsored farms were not very successful. The effect of the failure of the State Farms etc. (Questionnaire response, McNeil 1964) was two-fold. In the first place it
affected domestic food production adversely since the food supply from the Government sponsored farms could hardly compensate for the reduction in the food supply resulting from the departure of peasant farmers from their farms. In the second place these Government sponsored farms were run at a loss, to the detriment of the economy. Following the overthrow of Dr. Kwame Nkrumah's government, later decisions to reduce the operation resulted in the lay-off of many workers. Economic problems have been created which will be hard to solve.

Professor Evans-Pritchard said in his classic monograph *The Nuer* that "...political institutions cannot be understood without taking into account the environment and modes of livelihood" (Brokensha, 1965, p. 2). After attainment of independence the continued viability of the political unit can be sustained only when the country seriously assesses its potential in terms of the things it can produce at the least cost to financial, human and natural resources. Dr. Nkrumah's dictum: "Seek ye first the political kingdom and its righteousness" would have had more impact if he had seriously considered these factors. Since these factors were not considered the country is still tied to the apron-strings of foreign domination.

The developed nations have been able to control and dictate the pace of economic development in the poor nations through the so-called "aid" programme. R. A. Rappaport (1971) has attempted to show that economic imperialism and ecological imperialism are fundamentally interrelated. Natural phenomena are characterised by exchanges among systems which differ in complexity - the flow of energy and material resources are from the less complex to the more complex system. This principle is not limited to such ecological relationships as predator-prey dynamics but also to relations between developed and less developed nations. Using arguments first raised by Gunden Frank, he
notes that in the development of agrarian societies through "aid" from industrialized nations the flow of wealth is from the former to the latter. As is now known, economic development under the impact of temperate agricultural techniques favours ecological simplification, encouraging a shift from diverse subsistence agriculture to the cultivation of a few crops for export.

To conclude, Rappaport said:

It may not be improper to characterize as ecological imperialism the elaboration of a world organization that is centred in industrial societies and degrades the ecosystems of the agrarian societies it absorbs. Ecological imperialism is in some ways similar to economic imperialism. In both there is a flow of energy and material from the less organized system to the more organized one, and both may simply be different aspects of the same relations. Both may also be masked by the same euphemisms, among which "progress" and "development" are prominent (Rappaport, 1971; p. 132).

If such things as ecological imperialism and economic imperialism exist it is the view of this study that it is the former which manifests itself in the latter. This stance is based on the fact that ecological imperialism is the tool by which material resources drain from developing to the developed societies.

Economics of Research

Tropical countries regard fundamental research as a luxury. Many African countries are desperately short of money. At the present stage of economic development they find it advisable to invest in local projects capable of immediate returns. Unfortunately, this is why it has been the practice to transfer technologies in a mechanical fashion.

There are very good reasons why fundamental research must be pursued. It must be borne in mind that temperate technologies have evolved under different ecosystemic, social and political conditions. By mechanical transfer of techniques from temperate into tropical countries we have simply
succeeded in adding another serious dimension to the problems already facing the latter. In spite of the high level of technological achievement in Canada and the U.S., for example, they continue to invest large sums of money in research. They do so in the belief that their knowledge about their environment is imperfect and only fundamental research can provide answers to the range of problems which show up through time.

Through fundamental research Ghana as well as other tropical countries can unearth and solve some of the problems that militate against progress. Ideally fundamental research should be all embracing but where resources do not so permit priorities must be drawn. In agriculture it must assess the interactions of the climate, soils, vegetation and other biotic life processes on crops - plants and animals - that can grow best, and the type of machinery that can be used. Maintenance of soil fertility and the avoidance of erosion, laterization and other such "ecological boomerangs", must engage the serious consideration of fundamental research. Research must not be limited to the physical and natural sciences. Research should also be extended to determine social values and implications for satisfaction in the face of ecological, social and political constraints.

The rate at which Ghana is turning out scientists is very encouraging because it is my belief that science and technology are indispensable tools for material advancement and civilization. It is sometimes questionable, however, whether a cost benefit appraisal of their training would justify the investment. It is an open secret that in many offices trained personnel - engineers, agriculturalists, foresters etc. - spend time with nothing to do. These people are not lazy nor are they insensitive to the moral responsibility which their training puts on them. It is because the machinery which makes
it possible to employ them usefully has not yet been developed.

Research is needed also into the economics of the optimum size of holdings. The tendency to replace farm people by machinery is great. It becomes dangerous when the farm workers so replaced cannot be gainfully employed in secondary and tertiary industries. Experience in North America has shown that large farms are more economically viable but there are still very good reasons why small holdings should be encouraged:

1. Farmers may have alternative objectives to profit maximization, maximizing satisfaction rather than profit.

2. Although returns on some resources are low, notably the farmers own labour, they may in fact be greater than the operator could earn elsewhere.

3. Small farms provide greater employment opportunities for the farm family, which helps to reduce unemployment problems. Canada and the U.S. pay welfare grants to the unemployed which developing societies could hardly afford.

4. The farmer may face a budget constraint. He may be wiser to operate on his small resources with assured return however small, than to operate on credit with a high risk factor (Metcalf, 1969).
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

In the preceding sections a foundation for applying the ecological viewpoint critically to current practices in agricultural production was provided. It has been shown that mismanagement of the planning strategy has led to undernourishment, poverty and social unrest. In this concluding chapter a review of situations is given with suggestions to redress the underlying causes of low agricultural production.

In the present circumstances of economic difficulties the need for Ghana to be self-sufficient in food production cannot be overemphasized. To be able to provide for food in large quantities and at an economical rate demands a break from the traditional European approach to agriculture. In doing so it is important that the traditional systems of food production be improved, but not necessarily replaced, by some of the temperate regions' techniques which can be profitably employed in the tropics. It must be remembered that the local staples are more economically produced in the local setting. Agriculture must primarily meet the needs of domestic consumption. Similarly, since game are better adapted than the domestic animals in West Africa, game husbandry should be given special attention. Thomas (1962) has pointed out that the savannah areas are unsuitable for intensive cultivation. This deficiency is associated with the low nutrient exchange capacity of the soils, the low content of humus, the susceptibility of the area to leaching and erosion, the problems of laterization and drought. He therefore recommended that large areas be developed for game husbandry.
Lawson (1962) also shares this viewpoint. Since "bush meat" is a favourite meat among the indigenous population the need to develop some of the large tracts of forest reserves and other idling lands is great.

There are, however, some problems associated with game husbandry; the most pervasive of all is the lack of a national policy regarding game. As a respondent observed, the future prospects for research and production of game in West Africa will depend on government policy. It is to the credit of the West African countries that they have found it advisable to operate game reserves. Nevertheless, game reserves per se are non-productive economically. It must be reiterated that proper conservation measures make the difference between productivity and non-productivity. It would be advisable to train people in this field to study all aspects of game including their taxonomy and ecology. Game do not have to be fully domesticated to be profitable as experience in East Africa has shown. East Africa and South Africa are far advanced in game production (For political reasons East Africa is the place to train people in game husbandry).

Concern has been expressed about the economical use of farm holdings. The F.A.O. and other authorities favour the consolidation of farms into economical units. This is a field of much controversy. I suspect that the staff of the F.A.O. are again using practices of the temperate agricultural zones as a "blue print" for tropical agriculture. Large scale agriculture has larger economies of scale in the temperates but in the tropical environment diseconomies of scale tend to be great! In view of the nature of tropical ecosystems as well as socio-economic considerations it would be advisable to maintain the small peasantry farm units. Any tendency to replace the peasant farmers with trained agriculturalists must be discouraged.
Obviously trained agriculturalists may fail at the present time of limited knowledge of tropical agriculture. A viable industry depending on large-scale mechanization which may sustain their standard of living cannot be developed presently. So far I can only think of the rice industry but even in this field there is more need for research than the theoretical exposition which comes out mainly from the literature of temperate agriculture.

However, there is the need to encourage and train young elementary school graduates to take up farming. As has been observed by one respondent, education is the greatest factor in furthering the use of science in food production. Young people can better understand scientific techniques and will be more innovative than the old people. It has been shown by Quao et al. (1961) through a farm survey in the Kade area in Ghana that only old people are left on the farms, hence the need to train young people who will replace farmers when they have outlived their useful years. Farm settlement schemes have not been successful in West Africa due to a lack of ecological foresight. For example in Western Nigeria the siting of farm settlements based on political rather than ecological factors has cost the Nigerian Government £12,000 per person to date but the results have been appalling. Institution of Farm Settlement is another field in which little work has been done. This is a field for inter-disciplinary study.

It has been explicitly shown in this study that lack of proper ecological reasoning has been largely responsible for low agricultural production. Almost all the top ranking agriculturalists were trained in temperate agricultural institutions and so the tradition has been established which may be hard to break. I believe it is only the tropical agriculturalists
who will be able to rectify the anomaly. That will only be possible if the academic curriculum is adjusted to reflect a change from a temperate oriented curriculum for agricultural training to a tropical oriented academic curriculum. In-service training should also be organized for the benefit of ex-school students. Similarly, agricultural trainees from abroad should be made to undergo a period of internship to refamiliarise them with the conditions of their countries before they are allowed to fill positions.

It is particularly important to note that tropical agriculture is not free from external pressures and influences. The most important are the Food and Agricultural Organization of the United Nations (F.A.O.), the United Nations Education, Scientific and Cultural Organization (U.N.E.S.C.O.), the World Bank and agencies of foreign governments notably the United States Aid for International Development (U.S.A.I.D.), the Canadian International Development Agency (C.I.D.A.) and similar agencies of Britain, France, West Germany, Soviet Union etc. These foreign institutions have been responsible for selling foreign techniques and expertise, farm equipment and other technical farm inputs to tropical farmers regardless of their appropriateness to the tropical setting. The foreign institutions have also been responsible for encouraging cultivation of export crops and rearing of domestic animals at the expense of production of local food staples for domestic consumption. They have also been guilty of discouraging development of game which is, ironically, the traditional protein source of the indigenous population. It is also ironic that the ruling elite of the independent countries have not rid themselves of "the temperate technical training mentality" which supports meddling by temperate
agriculturalists in tropical agriculture. The danger with the employment of temperate trained agriculturalists is that this prevents development of a sound ecological framework within which tropical agriculture can be best developed. Without a proper understanding of the nature of tropical ecosystems, such agriculturalists have helped only to downgrade tropical agriculture. It is suggested that the substantial sums of money be spent by the United Nations, the World Bank and foreign governments involved in tropical agriculture should be used, in conjunction with the financial resources of developing countries, to develop a better approach to agriculture in the tropics. A scheme for the development of tropical agriculture is advanced below.

SCHEMATIC PLANNING STRATEGY FOR TROPICAL AGRICULTURE

Five institutions are presented. They include a National Executive, a National Research Council, Agricultural Extension, the farmers and foreign institutions. The arrows indicate where the direction of communication among the institutions represented should be.

It is proposed that negotiations for physical, technical and financial aid must be limited to the National Executive, the National Research Council
and the agencies of foreign institutions which are associated with agricultural development in the respective developing country.

The F.A.O., U.S.A.I.D. and other agencies of foreign institutions should be discouraged from direct involvement in agricultural extension. On the one hand, the danger of some farmers practising newly introduced techniques without questioning their suitability is great. On the other hand, it often turns out that results from government sponsored farms such as those of the Seed Multiplication Division of the Ministry of Agriculture, established without previous knowledge of agro-ecological factors in specific geographical areas, are very disappointing. This goes a long way to discredit the Ministry of Agriculture. Instances of such abysmal failure emerging from government farms, established with the assistance of foreign institutions, were many in the Northern Region of Ghana where I once worked as an Agricultural Extension Officer and later as an Assistant Regional Planning Officer.

The composition of the National Reserarch Council must include enthusiastic and knowledgeable representatives of the University Faculties of Agriculture, Forestry, Engineering, Geography, and the Biological sciences; the Ministries of Agriculture and Fisheries; Economic Planning, Forestry and representatives of the existing Research Councils. Where there is an already established Research Council such as the (C.S.I.R. in Ghana), the membership must be reconstituted to include representatives of the above where they are not hitherto represented. The National Research Council must be charged with the responsibility for:

1. Reviewing critically all current cultural practices in relation to their suitability to tropical conditions.
2. Advising both the National Executive and the agencies of the foreign institutions on the agro-ecological and socio-economic implications of those foreign agricultural techniques being recommended.

3. Developing a better appreciation of the problems of tropical agrarian reforms.

4. Resolving problems emerging from farms and transmitting results to the farming society through the intermediary of the extension service.

The functions of the National Research Council are extremely important. The success of their programme will demand a great service and dedication of the rank and file of the staff. Success of their programme will also depend upon the availability of research grants. Obviously, inadequate financial resources are a mitigating factor in agricultural development. But if it is understood that research is the key to knowledge, developing countries should endeavour to provide the money; otherwise, there is hardly any chance of progress towards material civilization. There are three possibilities which could be explored. Ghana could try to solicit assistance from the F.A.O., U.N.E.S.C.O., the World Bank, the U.S.A.I.D. or any other friendly foreign government in financing her research programmes. It is realised that aid cannot often be granted by the foreign governments without "strings" being attached. This is within the realm of political science. The second possibility is for West African countries to pool their resources in order to establish joint research programmes. This has also some political implications which can be handled best by political scientists. The third possibility is for Ghana to finance the research programmes single-handedly.

There is much talk about the insolvency of Ghana. Any suggestion of making grants available for research is likely to be rebuffed. But the
political elite must realise that Ghana cannot advance any further - indeed she will retrogress - unless she is able to diagnose her problems, unearth her potential and find the cheapest way to develop. This can be done only through research. Research is expensive, admittedly, but it can be rendered inexpensive through proper planning. Planning for research is a speciality in itself.

The Faculty of Engineering in Kumasi is one of the few engineering faculties in West Africa which can be used to advance research into the need for mechanical implements which could be used in furtherance of agricultural development. It must be recognised that there is local expertise in the manufacture of simple tools like hoes, axes and machet (cutlass). I am convinced that, given the necessary financial and moral support, the Engineering Faculty, in co-operation with the Faculty of Agriculture of the same University of Science and Technology, Kumasi, will be able to improve and even design more ingenious tools that can be used in the tropics. Reports have shown that, during the recent Nigerian Civil War, "the seceding Biafrans" manufactured some advanced military equipment which made it possible during certain periods of the war to withstand the might of the Nigerian Army. This is an example par excellence in the field of innovation which shows that, given proper direction and encouragement, the African human resources could be used to advance knowledge.
This chapter presents the results of a questionnaire mailed to individuals and institutions associated with tropical agriculture. All but one copy of the questionnaire were sent to West Africa. The responses of fourteen respondents are summarised under ten main subjects raised in the questionnaire.

1. Teaching of Ecology

Questions on the teaching of ecology were specifically addressed to those respondents employed at teaching institutions and to those who had once taught but are not currently employed at institutions. There were eleven respondents in the first group and only three in the second group.

At present ecology is generally taught as a distinct subject in the degree level in the University of Science and Technology, Kumasi, Ghana; University of Ghana, Legon; University of Ibadan, Nigeria and University of Ife, Nigeria although it may be offered to Promotion and Diploma students as is practised in the Universities of Ghana and Ife. Among the titles of courses offered are Introductory and General Principles, Production Ecology, Statistical Ecology, Principles of Conservation, Structure of the Ecosystem, Plant Geography, Vegetation Description, Quantitative Ecology, Animal Ecology, Animal Ecology and General Ecology. It is noted that emphasis is on tropical rather than Temperate Ecology. Various aspects of Agriculture, Forestry, Fishery, Livestock, Factors, Ecosystem, Aquatic Ecology, Plant Ecology, Range Ecology, Weed Ecology, Statistical Methods, Insect Ecology and General Ecology are covered. Except at the University of Science and Technology, Kumasi, many basic textbooks are used. They include Lawson:
In certain cases ecology is taught as part of other courses such as agriculture, biology and physical geography. In Gambia agricultural institutes have not been developed as is the case in other Western African countries.

Only one respondent not currently employed at a teaching institute answered the second portion of Question 1. He intimated that temperate ecology was taught as a distinct discipline during his formal education in the second and third years of a Degree programme. An Agriculture/Botany course was offered.

2. Large-Scale Commercial Farming

It has been suggested that the failure of the British Government Scheme in Tanganyika was the result of ecological short-sightedness (Phillips, 1959; Thompson, 1964). Respondents were asked to state whether the failure of the "Ghana State Farms Corporation" large scale farms and other similar ventures in West Africa can be attributed to similar factors. The general concensus expressed by nine of the respondents was that the statement is true although managerial factors also contributed to the failure. One respondent remarked that this failure may have occurred in the Tanzanian case because politicians were made managers in preference to competent technical men. This type of problem also applies to the siting of farm settlements in Western Nigeria,
where the choice of site was often based on political considerations and not on sound ecological information. Some of the contributory factors of the failure included lack of experience with tropical soils, climate and vegetation; hasty mechanization, poor organization and lack of proper training for personnel. It was noted that erosion and soil compaction are consequences of poor techniques, not causes of failure in themselves. All ten respondents agreed with the statement that pilot schemes should be undertaken prior to any large scale agricultural developments.

3. Research

In developing societies there is often a tendency to adopt "applied" research in preference to "basic" research. Five out of six respondents agreed with this statement. It was noted that "urgency to produce results often makes fundamental research a luxury" (S. Sey, Questionnaire respondent, 1972). There is always very limited money for research and therefore, any research done should have immediate applicability. It was noted that in Ghana it is only the Universities which could afford to undertake basic research whereas research officers at the Research Stations are required to solve problems without delay. In Kumasi 90 per cent of the total budget of the Faculty of Agriculture goes into agricultural research.

It was intimated that the percentage of the total budget which goes into agricultural research is very small. For example at the Oilpalm Research Station, Kade, Ghana, only one percent of the budget allocation goes into research which is divided evenly between basic and applied research. At the University of Ibadan less than one percent of the total budget goes into agricultural research. This is the general situation throughout West Africa.
Examples of research projects are herbicidal control of weeds in oilpalm plantations; fungicidal control of *Cercospora* and *Anthracnose*; investigations into the best method of raising oilpalm seedlings (in Ghana); agronomic research on farm equipment (in Gambia); nutrient requirements of tropical pasture crops; biology and control of seed-borne fungi of economic plants; studies on the chemical and biological changes in savannah ecosystems following annual burning (at Ibadan, Nigeria); the biology of the Guinea fowl; aspects of swine nutrition; aspects of poultry and ruminant nutrition; effect of fertilization on grassland; the use of urea for dry season feeding; the use of silage for pigs (Ghana).

The numerical strength of academic staff varies from less than ten in a Department within the Faculty of Agriculture at the University of Ghana to 35 in the Faculty of Agriculture, Forestry and Veterinary Sciences at the University of Ibadan. Generally the proportion of the academic staff devoted to full time research as opposed to part time research is very small. The percentage of nationals within the total number of research personnel varies among various institutions. In Ibadan 47 out of the 62 research officers are Nigerians. In Kumasi 30 out of 35 are Ghanaians. At the University of Ghana the number of Ghanaians on the academic staff is also relatively low. Five out of the nine academic staff of the Department of Animal Science are Ghanaians.

Recurrent problems were noted as being associated with conducting empirical research on tropical ecosystems. Mention may be made of budgetary constraints, lack of properly trained professionals, inadequacy of equipment and servicing of available equipment, shortage of well-trained technicians,
poor national planning policy for research, taxonomic difficulties and continuity of research by personnel.

4. **Ecological Boomerangs or Biogeoclimatic Hazards**

Answers received from 12 respondents are presented. A number of "ecological boomerangs" result from the use of temperate agricultural techniques in the tropical setting. These were ranked as very serious, moderately serious, serious, not serious and negligible. Very serious ecological boomerangs are: sheet erosion, possible changes in such climatic factors as rainfall and evaporation, change of vegetation, health hazards (e.g. bilharzia) and the threat to and loss of wildlife. Gully erosion, decline in soil fertility and threat to watersheds from removal of plant cover are considered moderately serious; changes in soil structure, pest resurgence after crop treatment with pesticides and nutritional problems such as low protein content of cereals are serious, and pesticidal pollution of rivers, threat to humans by pesticides, threat to planting materials by pesticides, and nutritional problems such as the palatability of cereals being incompatible with local demands are considered not serious.

The currently most serious ecological boomerangs were ranked in the following order of importance: (i) sheet erosion, health hazards and threat to wildlife, (ii) change of vegetation, (iii) threat to watersheds and possible changes in climatic factors, (iv) health hazards, and (v) pest resurgence after crop treatment with pesticides. Examples of pests showing resurgence following continued spraying of DDT and BHC are aphids and white flies. The ecological boomerangs that may become serious in the future could be ranked in the following order of importance; (i) change of
vegetation, threat to wildlife and resistance to pesticides, for example, the resistance of cocoa mirids to Gamma BHC in Ghana and Western Nigeria, and health hazards, (ii) changes in soil structure, nutritional problems and erosion, (iii) decline in soil fertility, pesticidal pollution of rivers, and pest resurgence and (iv) soil erosion, laterization, threat to planting materials and decline in soil fertility.

5. Mechanization

The following statement was presented: "There is a lot of talk about mechanizing tropical agriculture. The British tried it in Sudan and Tanganyika. Dr. Nkrumah dreamt about it when he established the Ghana State Farms Corporation and the Americans are currently involved in it in the Amazon". Respondents were asked to list the social costs and benefits of mechanization. Answers were received from 12 respondents.

On social costs of mechanization it was noted that mechanization drains foreign exchange, creates unemployment following displacement of labour from farms, decreases unit yield as a result of thorough cultivation and causes social unrest as a result of land acquisition on a permanent basis. There are, however, social benefits which include removal of drudgery, in certain cases increased production leading to increased income, and relatively more leisure and more assurance of food production.

A number of factors inhibit the mechanization of agriculture (ploughing, harrowing, combine harvesting and weeding) in West Africa. Respondents were in general agreement that the following are the most important: low purchasing power of farmers, unsuitable machinery, lack of trained farmers, inadequacy of machinery, tree density and stumps, rapid decomposition of humus, low purchasing power of governments, lateritic soils, topography,
stony soils, destruction of vegetation and wildlife, high initial cost and often the absence of maintenance and repair facilities. These factors are ranked in the following order of importance: (i) low purchasing power of farmers, unsuitable machinery, and tree density and stumps, (ii) lack of trained farmers, and lateritic soils, (iii) destruction of vegetation, (iv) low purchasing power of governments and topography, (v) destruction of vegetation and wildlife and high initial cost and often the absence of maintenance and repair facilities.

One of the big problems facing tropical agriculture involves the suitability of machinery since most of the machinery being imported to the tropics is inappropriate to the tropical setting. Respondents agreed that mechanical devices which are necessary for improved farming in the forest zones must be capable of clearing the undergrowth without disturbing the soil. They stressed a need for equipment that can be used for clearing, processing, hauling and storing both in the forest and savannah regions. In the savannah areas the use of irrigation equipment was deemed important by a majority of the respondents. Regarding tillage, it was suggested that animal drawn multi-purpose machinery for ploughing, ridging, weeding and harvesting would be ideal.

6. Wildlife Production

Nasimovich writes:

Modern animal husbandry in most areas in Africa is mainly based on cattle (European and Zebu-like Indian), and also sheep, goats and to some extent pigs. The profitability of such animal husbandry is lately seriously questioned. The indigenous wild ungulates are far better adapted to natural African conditions than cattle exotic for the given area. They are easily manoeuvred into selecting the biotypes better provided with food and water supplies. Living in the same area, but in different habitats, and
utilizing different food, the wild ungulates not only compete little with each other, but complement each other, and on the whole utilize forage resources incomparably better than the cattle which is represented by only three to four species (Nasimovich, 1970, p. 4).

Five out of nine respondents agreed with the statement: There are no programmes for game husbandry per se, although the Animal Research Institute of the C.S.I.R. is currently investigating husbandry of the grass cutter. At present many West African countries including Nigeria, Ghana and Gambia operate game reserves. In Ghana, it was intimated that there is some co-operation between the University of Ghana and the Division of Game and Wildlife in the Ministry of Forestry. The general consensus is that game are better adapted than livestock in West African biogeoclimatic zones, but it is believed that game and livestock are equally productive. Due to lack of records this statement stands open to question. Again almost all the respondents had had no experience in game husbandry. It was unanimously agreed among respondents that game is the preferred meat of the average West African given an assured supply. An agricultural ecologist in Ghana wrote: "Based on current supply and price game is a delicacy" (F. K. Fianu, questionnaire respondent, 1972). This statement agrees with the viewpoint expressed by some West African students at U.B.C. who were interviewed in this regard. Unfortunately, unlike East or South Africa, no research has yet been done to determine the relative merits of game cropping in West Africa. The name of Mr. Asibey, the Ghanaian Chief of Game and Wildlife Division was suggested by many respondents as a contact for up-to-date information on prospects of game husbandry in Ghana. Unfortunately Mr. Asibey did not complete his copy of the questionnaire.
There are a number of problems associated with game husbandry. There is no national policy regarding game husbandry. This makes it difficult for ecologists interested in this field to undertake any meaningful study of game. Not many people have been trained in this field and knowledge about the ecology, population dynamics, food requirements, etc. of the game animals is lacking. A fear was expressed that game husbandry may increase competition for productive land in areas where there is scarce supply of land.

It has been suggested that agriculturalists in the tropics are generally reluctant in researching the possibilities of game production. Ideas were divided on this. One school of thought disagreed pointing out that at present, the Animal Research Institute of the C.S.I.R. is investigating the grass cutter. The other school of thought, while agreeing with the statement, points out that agriculturalists are few and need to tackle primary agricultural problems first. Whether the future prospects for research into, and production of, game in West Africa are bright or remote will depend on Government policy.

Respondents confirmed the fact that insufficient attention has been devoted to the agronomic needs of some of the staple food crops such as cocoyams, plantains, yams and cassava and vegetables such as pepper, okra and others. It was agreed that increasing consumption of bread and other food items imported from temperate regions is largely due to an insufficient supply of local food staples. Low yields with poor storage and distribution facilities are major contributory factors. But it was also noted that the higher the educational level of the local people, the greater is the tendency to adopt European diets. Urbanites in particular have cultivated a taste for wheat bread, potatoes etc.
It is intimated that the Faculties of Agriculture and the Research Institutions in Ghana have research programmes designed to develop high yielding and disease-resistant varieties from some of the native crops. Similarly in Nigeria work is going on with maize, cow peas, cocoa and oilpalm. The International Institute for Tropical Agriculture in Ibadan is mainly concerned with food crops. There are obvious drawbacks, the most important has always been lack of funds and the requisite professional and technical staff.

7. **Shifting Cultivation**

Ten out of eleven respondents expressed the view that shifting cultivation is incapable of coping with population and economic pressures although a more productive system of cultivation has not been developed anywhere in the tropics that could replace it. It was pointed out though, that alternative productive systems have been developed such as tree cultivation in Ghana and Nigeria and other cash crop farming, including cotton in Sudan and rice.

In East Pakistan the management of water and rotation of crops allows for three crop periods per year which creates expanded production. Other attempts which have been made to develop alternative methods including rotational systems involving various years of cropping in leys. Faculties of Agriculture in the Ghanaian Universities are currently investigating economic cropping sequences as an alternative to shifting cultivation.

Two respondents argued that no attempts have been made to improve upon shifting cultivation. Researchers have mainly wanted to change to crop rotation without wishing to modify shifting cultivation. One of the two respondents explained that this situation may be associated with the lack of personnel to tackle the problem and perhaps the financial involvement.
It is noted that not all farmers use fertilizers on their traditional farms. Even where fertilizers are used they usually are applied to specific export or cash crops. There are two reasons why farmers do not apply fertilizers to all crops, and the F.A.O. and U.N.E.S.C.O. in conjunction with the Agricultural Extension are responsible for this anomaly. These institutions handle all fertilizer supplies, which are prepared solely for cash crops. Research into the agronomic needs of the basic food staples, as noted earlier, has been neglected. Under such circumstances there is no means whereby a farmer can apply fertilizer to enhance the yield of his entire crop. The second factor which was pointed out is the relative poverty of farmers which makes it difficult for them to purchase fertilizer. Increase in yields resulting from fertilization varies from ten percent to one hundred percent.

An important characteristic of shifting cultivation is mixed cropping. This is the practice whereby many crop plants are interplanted and harvested at different times since they do not come to maturity together. Respondents were unanimous that monoculture, which is fast replacing mixed cropping, is prone to disease and pest hazards which often occur on a large scale. Six out of nine respondents dismissed the idea that shifting cultivation as practised in the topics is the most ecologically sound system of agriculture. Three respondents agreed with the statement to the effect that shifting cultivation is an ecologically sound practice, but with reservation, pointing out that it is an uneconomical method of production in the face of mounting population pressure.

8. Impact of Temperate Agricultural Techniques on Tropical Agriculture

Eleven respondents observed that there can be serious trouble using temperate agricultural techniques under local conditions unless such techniques
have been tested and found desirable. Such ecological boomerangs as earlier mentioned are obvious consequences of the misuse of temperate agricultural techniques. However, there are some benefits to be derived by using temperate agricultural techniques as compared to traditional agricultural techniques. There is a possibility of larger business and increased production from increased acreages, with fertilization and the use of pesticides. With good management it is also possible to maintain sustained soil fertility.

Respondents were divided on the advisability of adopting temperate agricultural techniques in tropical ecosystems. Arguing that temperate agricultural techniques are generally inappropriate to conditions in the tropics, the respondents against their use consider that there is a need for what they call "our own" suitable techniques to increase production. Exponents of the contrary view argue that the people in the tropics are hungry generally and must adopt any techniques that will increase production. The more conservative adherents of this view favour using such techniques only when they are found suitable for local conditions. It was further stated that tried systems are beneficial, new techniques have been and are being developed in temperate regions which could be used profitably in the tropics. Of the temperate techniques or technologies being adopted the following were mentioned: settled farming; mechanical and chemical control of pests, diseases and weeds; selective breeding; improved processing and storage. Respondents observe a tendency towards replacing the traditional techniques by temperate agricultural techniques.

It was not possible to obtain the percentage of local agriculturalists trained in Agricultural Institutions in temperate countries. This number is believed to be high because until the past decade or so almost all the native
agriculturalists were trained overseas. Some of the more familiar countries where students go to study agricultural science are the U.K., U.S.A., Germany, Canada and Russia. In Ghana and Nigeria, at least, such foreign trainees do not undergo a programme of orientation to refamiliarise them with their countries' conditions. Concern was expressed over such an anomaly. A respondent observed that such a programme is necessary otherwise the wrong things are applied and extension becomes ineffective. It was also noted that such a programme is necessary since it broadens one's experience and outlook.

9. Farmers' Attitudes

Eight respondents observed that West African farmers are conservative and that they do not differ from farmers elsewhere. Some farmers are very eager to learn though. Respondents differed in their beliefs as to any tendency to replace farmers by trained agriculturalists. At any rate it is doubtful whether trained agriculturalists are willing to work on farms. Four respondents think that agriculturalists are not willing to do so. As one respondent observed: "There is no incentive - hard work, low income". Other respondents believe that if the general incentives such as credit and marketing facilities and land tenure are improved, trained agriculturalists would readily take to farming.

Nearly all the respondents felt it is advisable to train younger people to settle on the land for agriculture. Education is the greatest factor in furthering the use of science in food production. Young people can better and more easily understand and apply scientific techniques and carry out innovations, than old people. A programme of farm settlement of young people will cut down the drift from rural areas and help to provide future
generations of modern farmers. But it seems farm settlement schemes have not been successful in West Africa, especially in Western Nigeria. Farm settlement schemes which commenced in 1959 have cost the Nigerian Government £12,000 per person to date, but results have been appallingly insignificant.

10. Governmental Participation and Co-Ordination

Nearly the same Ministries of the Civil Service are involved in agricultural development in all the West African countries. In Ghana government departments involved in agricultural development are the Ministry of Agriculture, Economic Planning and the Agricultural Development Bank. In Nigeria the departments are the Ministry of Agriculture and Natural Resources and the Ministry of Economic Planning. In Gambia these ministries fall into the following departments: Department of Agriculture, Department of Veterinary, Department of Co-operation and Department of Fisheries.

Co-ordination of the activities of the Division of Agriculture in Gambia is accomplished by the Ministry of Agriculture. In Ghana a respondent explained that there is no co-ordinating agency but activities of the Divisions are geared to the government objectives. However, other respondents believe that the Ministry of Agriculture is generally responsible for inter-divisional activities.

In Ghana the Ministry of Agriculture is responsible for co-ordinating the activities of government departments for the purpose of agricultural development. In Nigeria the responsibility for co-ordination at the national level falls on the Nigerian Council for Scientific Research while the responsibility at the regional level falls on the Ministry of Agriculture. Unfortunately, co-ordination has not been effective due to red-tape and unrealistic government policies as well as hardships resulting from government economic policies.
As regards the sort of inter-departmental activities needed for ensuring steady agricultural development in the various African countries the following suggestions were made: (i) Conferences and joint projects; (ii) A planning committee for consultations and exchange of ideas, inter-departmental seminars and in-training courses; (iii) co-operation and consultation, and (iv) improved information.

The following inter-West Africa Governmental activities were felt necessary for ensuring Regional Agricultural Development: International Conferences and Joint research schemes; already existing is the West African Rice Development Association.

Respondents suggested the following aid or assistance would be needed from the more developed countries for the purpose of agricultural development:

(i) Technical in-supply of input factors such as fertilizers, equipment, interest-free loans to train technical personnel anywhere in the world, not only in the donor countries;

(ii) Financial aid, supply of machinery, trained personnel if unavailable locally;

(iii) Commodity agreements, for example, cocoa; investment in farming projects; removal of tariffs on exports;

(iv) Research and development assistance especially in the engineering fields.
## The Bioclimatic Belts of Ghana

### Climates

<table>
<thead>
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<th>Climates</th>
<th>Subdivisions</th>
<th>Examples Outside Ghana</th>
<th>Characteristics</th>
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<tr>
<td>Forest-belt without dry season</td>
<td>1</td>
<td>Tabou, Ivory Coast; Lagos, Nigeria; and outside West Africa, Yangambi, Congo (Leopoldville); Jakarta (Indonesia).</td>
<td>Seasonal surplus of rainfall, i.e. surplus over evapotranspiration, is below 78.7 in. Humid season continuous.</td>
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<td></td>
<td>2</td>
<td>Abidjan, Ivory Coast; and outside West Africa: Eala, Congo (Leopoldville); Kuyper, Indonesia.</td>
<td>Surplus of rainfall is below 78.7 in.; humid season interrupted in July and/or August.</td>
</tr>
<tr>
<td>Forest-belt with one to three dry months</td>
<td>1</td>
<td>Suakoko, Liberia; Ondo, Nigeria; and outside West Africa: Sho Tome, Port of Spain, Trinidad.</td>
<td>Seasonal surplus of rainfall below 39.4 in.; humid season continuous.</td>
</tr>
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<td></td>
<td>2</td>
<td>Abengourou, Ivory Coast; and outside West Africa: Mombasa, Kenya, Dar es Salaam, Tanzania</td>
<td>Seven or more humid months and discontinuous humid season.</td>
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<td>3</td>
<td>Porto Novo, Dahomey; north-west of Ikeja, Nigeria, and outside of West Africa: Willis Islands</td>
<td>Six or less humid months, humid season discontinuous.</td>
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<tr>
<td>Coastal Savannah belt</td>
<td>1</td>
<td>Honolulu, Hawaii; Maiguetia, Venezuela</td>
<td>Dry coast with four to five dry months</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Lome, Togo; Niaouli, Dahomey; and outside West Africa: Grand Turk, Bahamas; Banana, Congo (Leopoldville)</td>
<td>Rainfall low, but so humid that plantation crops, more especially oil palm and coconut, which can absorb water from great depth, are grown with little inundation or sub-irrigation.</td>
</tr>
<tr>
<td>Guinea Savannah Belt</td>
<td>1</td>
<td>Bouake, Ivory Coast; Anre Mono, Togo; and outside West Africa: Sunginge, Angola; Barra do Corda, Brazil</td>
<td>Low rainfall, surplus is less than 20% of annual potential evapotranspiration; five or more humid months continuous.</td>
</tr>
<tr>
<td>CLIMATIC BELTS</td>
<td>SUB-DIVISIONS</td>
<td>EXAMPLES OUTSIDE GHANA</td>
<td>CHARACTERISTICS</td>
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<tr>
<td>Guinea Savannah Belt - continued</td>
<td>2</td>
<td>Bondoukou, Ivory Coast; Athieme, Dahomey; and outside West Africa: Port-au-Prince, Haiti.</td>
<td>Low rainfall, surplus less than 20% of annual potential evapotranspiration; four or less dry months; humid season discontinuous.</td>
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<td>3</td>
<td>Dapango Tongo, Togo; and outside West Africa: Kitgun, Uganda; Ibepeetuba, Brazil</td>
<td>Low rainfall, seasonal surplus less than 20% of potential evapotranspiration, and four or less humid months.</td>
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<td>4</td>
<td>Palime, Togo; and outside West Africa: Semarang, Indonesia; Echagnue, Philippines</td>
<td>Annual rainfall higher than potential evapotranspiration; moderate seasonal surplus if rainfall below 39.4 in. Three or less dry months.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Seguela, Ivory Coast; Sokode, Togo; Tchaourou, Dahomey; Ilorin, Nigeria; and outside West Africa: Guayaramerín, Bolivia; Nakorm Rajasima, Thailand</td>
<td>Seasonal surplus of rainfall less than 39.4 in.; six humid months; humid season continuous.</td>
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<tr>
<td></td>
<td>6</td>
<td>Ferkessedougou, Ivory Coast; outside West Africa: Pavana, Brazil, Cocanada, India</td>
<td>Five humid months; dry for plantation crops</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Samaru, Nigeria; and outside West Africa: Bougouni, Mali; Port George IV, Australia; Patna, India</td>
<td>Four humid months; dry except for cereals and peanuts (groundnuts)</td>
</tr>
</tbody>
</table>

### APPENDIX III
(See also Fig. 5)

**GHANA SOIL REGIONS AND CHARACTERISTICS**

<table>
<thead>
<tr>
<th>SOIL REGION</th>
<th>PHYSICAL CHARACTERISTICS</th>
<th>CHEMICAL CHARACTERISTICS</th>
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</thead>
<tbody>
<tr>
<td>1. Coconut Sands</td>
<td>Pure Sand</td>
<td>Poor in bases. Potash deficiency</td>
</tr>
<tr>
<td>2. Forest Oxysols</td>
<td>Deeply weathered to depth of 20 feet or more; excessive concretionary gravel or iron pan near the surface; organic matter concentrated markedly in top few inches, associated with exchange capacity. Colour of mineral soil usually brown or orange brown.</td>
<td>Mineral fertility low; pH is 4.0-4.5 in top soil gradually increasing to 4.5-5.0 at depth. C/N ratio usually over 15. Profound changes take place when forest cut and burned.</td>
</tr>
<tr>
<td>3. Forest Ochrosols</td>
<td>Some areas may be rich in concretionary gravel; colour of soil is reddish brown; rich in organic matter.</td>
<td>Top soil neutral or slightly acidic, with increasing acidity at depth; mineral fertility of surface horizons usually high. C/N ratio of the humus is 10-12 and microbial population relatively stable.</td>
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<tr>
<td>4. Savannah Ochrosols</td>
<td>Soils shallower than soils of forest ochrosols; some areas rich in concretionary gravel; organic matter content is usually less than comparative organic matter in forest ochrosols.</td>
<td>pH of topsoil slightly acidic to acidic, and falls with depth. Content of exchangeable cations and of total and available phosphorus lower than in semi-deciduous forest.</td>
</tr>
<tr>
<td>5. Terre de Barre</td>
<td>Almost free from concretions</td>
<td>Mineral fertility is appreciably high. Very good soils, capable of supporting continuous cropping.</td>
</tr>
<tr>
<td>6. Voltain Basin</td>
<td>Poor drainage, unweatherable materials; groundwater laterites. Flooding regulation and/or irrigation often necessary</td>
<td>Mineral fertility is low.</td>
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<thead>
<tr>
<th>SOIL REGIONS</th>
<th>PHYSICAL CHARACTERISTICS</th>
<th>CHEMICAL CHARACTERISTICS</th>
</tr>
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<tbody>
<tr>
<td>7. Lower Volta Plains</td>
<td>Black earth, grey earth, groundwater laterites may be present, saline alkaline prevail</td>
<td>Rich in bases, but drainage problem; black earths are difficult to till with hoe.</td>
</tr>
<tr>
<td>8. Fadama or Flood Plain Land</td>
<td>Present in all regions especially in the forest and savannah ochrosols. Require flood regulation, drainage and/or irrigation.</td>
<td>Rich in bases.</td>
</tr>
<tr>
<td>9. Young soils</td>
<td>Found in all regions, the so-called brown forest.</td>
<td>Rich in bases. Excellent soils for all crops especially legumes provided they are not very stony and sufficiently deep.</td>
</tr>
</tbody>
</table>
Sirs:

re: Tropical Ecosystems - Implications for Regional Agricultural Development in West Africa

I am a Ghanaian currently studying Regional Planning at the University of British Columbia, Vancouver, Canada. I graduated from the Faculty of Agriculture, University of Science and Technology, Kumasi, Ghana with a B.Sc. in 1967 and worked for two and a half years first as an Agricultural Extension Officer in the Ghana Civil Service and subsequently as an Assistant Regional Planning Officer. During this period I developed great interest in the development of the tropical agriculture and became convinced that an ecological framework provides the only rational approach to the development of tropical agriculture. I have therefore chosen for my M.Sc. Thesis the subject: "Tropical Ecosystems - Implications for Regional Agriculture Development Planning in West Africa".

The purpose of this letter is to solicit your assistance in the form of ideas, comments, etc. towards the preparation of this thesis. I have attached a questionnaire to this letter. The questionnaire covers a wide range of subject matter; you may therefore wish to attend to those which will relate to your position and expertise.

The object of my study is two-fold; to assess the present state of modern agriculture in the West African countries and the relevance of the ecological viewpoint as a basis for the development of tropical agriculture in the context of Regional Development Planning in West Africa.

As I expect to graduate in April 1972, I would greatly appreciate an early response to the questionnaire component. I would hope to have these data for analysis by January 20, 1972.

Your assistance will be much appreciated and acknowledged in the thesis.

Yours sincerely,

Emmanuel Ayeh Yirenkyi
1. (i) **TEACHING OF ECOLOGY**

For those respondents currently employed at teaching institutions,

(a) Is ecology taught as a distinct subject? Yes No

Give what kind of courses offered:

(b) If yes, at what level? 1st year 2nd year 3rd year 4th year

(i) Diploma? ... ... ... ...
(ii) Promotion? ... ... ... ...
(iii) Degree? ... ... ... ...

(c) What aspect of ecology is taught?

(i) Temperate Tropical
(ii) Agriculture, Forestry, Resource, Wildlife, Fishery, Livestock, Factors, Ecosystem, General, Other categories (please specify) _________________

(d) What basic textbooks in ecology are used? Please name

(i) ___________________________________________
(ii) ___________________________________________
(iii) ___________________________________________

(e) Did your institute run field courses? Yes No

(f) If yes, give course purpose and subject matter.

_________________________________________________________________

_________________________________________________________________
(g) If ecology is not presently taught, why not?
   (i) Lack of funds
   (ii) Lack of staff
   (iii) Lack of interest
   (iv) Lack of facilities
   (v) Others (specify)

(h) Do you hope to introduce it into your school programme some time?
   Yes  No

(ii) For those respondents not currently employed at a teaching institution.

(a) Was ecology taught as a distinct discipline during your formal education?
   Yes  No
   Give kind of courses offered:

   (b) If yes, at what level?  1st year  2nd year  3rd year  4th year
      (i) Diploma?  ...  ...  ...  ...
      (ii) Promotion?  ...  ...  ...  ...
      (iii) Degree?  ...  ...  ...  ...

(c) What aspect of ecology was taught?
   (i) Temperate  Tropical
   (ii) Agriculture, Forestry, Resource, Wildlife, Fishery, Livestock, Factors, Ecosystem, General,
        Other categories (please specify) __________________________

   (d) What basic text books in Ecology were used?
      (i) __________________________
      (ii) __________________________
      (iii) __________________________

(e) Did your institute conduct field courses?  Yes  No

(f) If yes, give courses purposes and subject matter.

   (g) If ecology was not taught, why?
      (i) Lack of funds
      (ii) Lack of staff,
      (iii) Lack of interest
      (iv) Lack of facilities
      (v) Other (specify) __________________________
2. LARGE SCALE COMMERCIAL FARMING

It has been suggested that the failure of the British Government Groundnut Scheme in Tanganyika was the result of ecological shortsightedness.

(a) The failure of the "Ghana State Farms Corporation" large scale farms and other similar ventures in West Africa can be attributed to similar factors.

Agree  Disagree

Please explain your view ________________________________________________________________

(b) Do you consider any of the following factors as contributory to these difficulties? If more than one factor is involved, please mark by numbering.

7. Poor organization  8. Lack of proper training of personnel: clerical, managerial, professionals, artisans, others (specify)

(c) Pilot schemes should be undertaken prior to large scale agricultural developments:

Agree  Disagree

3. RESEARCH

"In developing societies there is often the tendency to adopt 'applied' research in preference to 'basic' research".

(a) Do you agree with this statement?  Yes  No

(b) Explain your answer: ______________________________________________________________

(c) What percent of your total budget goes into agricultural research?

(d) What percent of your or most recent agricultural research allocation did/do you assign to "basic" research?

(e) Give examples of research projects run (title only)

(i) ________________________________________________________________
(ii) ________________________________________________________________
(iii) ________________________________________________________________

(f) What is/was the numerical strength of your academic staff?

(g) What percent of this number is/was devoted to:

(i) full-time research?

(ii) part-time research?
(h) How many of them are citizens of the country? 

(i) How many of the researchers have had working experience (time period over three years) with the tropics? 

(j) What are some of the problems associated with conducting empirical research on tropical ecosystems? Please list them in order of importance.

(i) 

(ii) 

(iii) 

(iv) 

4. The following factors may be considered among the serious biogeoclimatic hazards or developmental risks in West Africa.

(a) How do you rate their present seriousness in West Africa?

(i) Erosion 

<table>
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<tr>
<th>v.serious</th>
<th>m.serious</th>
<th>serious</th>
<th>not serious</th>
<th>negligible</th>
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<td>Sheet</td>
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<tr>
<td>Gulley</td>
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</table>

(ii) Laterization 

(iii) Possible changes in climatic factors:

| Rainfall      | ...       | ...     | ...         | ...        |
| Evapotranspiration | ...       | ...     | ...         | ...        |

(iv) Changes in soil structure 

(v) Change of vegetation 

(vi) Decline in soil fertility 

(vii) Threat to water sheds 

(viii) Pest resistance to pesticides (genetic adaptation) 

(ix) Pest resurgence after crop treatment with pesticides 

(x) Pesticidal pollution of rivers 

(xi) Health hazards (e.g. bilharzia) 

(xii) Threat to wildlife
(xiii) Threat to humans by pesticides

(xiv) Threat to planting materials

(xv) Nutritional Problem:
1. Protein content of cereals
2. Taste or palatability of cereals

(xvi) Other (specify)

(xvii) Give examples of (ix)

(xviii) Choose the five that you think are currently of most serious economic damage and rank them in order of importance.

(i) 

(ii) 

(iii) 

(iv) 

(v) 

(xix) Choose the five that you think could be serious in turn in the future and rank them.

(i) 

(ii) 

(iii) 

(iv) 

(v) 

5. MECHANIZATION

There is a lot of talk about mechanizing tropical agriculture. The British tried it in Sudan and Tanganyika. Dr. Nkrumah dreamt about it when he established the Ghana State Farms Corporation and the Americans are currently involved in it in the Amazon.

(a) List the possible social costs and benefits of mechanization.

______________________________
(b) Which of the following factors inhibit the use of mechanization of agriculture (ploughing, harrowing, combine harvesting and weeding) in West Africa?

(i) Purchasing power of governments
(ii) Purchasing power of farmers
(iii) Tree density
(iv) Training of farmers
(v) Inadequacy of machinery
(vi) Clayey soils
(vii) Loamy soils
(viii) Stony soils
(ix) Lateritic soils
(x) Topography
(xi) Unsuitable machinery
(xii) Rapid decomposition of humus
(xiii) Destruction of vegetation
(xiv) Destruction of wildlife
(xv) Others (specify)

(c) Choose the six you consider most serious and rank them in importance.

(i) 
(ii) 
(iii) 
(iv) 
(v) 
(vi) 

(d) What mechanical devices are necessary for improved farming in:

(i) the forest zone 

(ii) the savannah zones?

6. WILDLIFE PRODUCTION

Nasimovich writes:

"Modern animal husbandry in most areas in Africa is mainly based on cattle (European and Zebu-like Indian), and also sheep, goats and to some extent pigs. The profitability of such animal husbandry ... is lately seriously questioned ... The indigenous wild ungulates are far better adapted to natural African conditions than cattle exotic for the given area. They are easily manoeuvred into selecting the biotopes better provided with food and water supplies. Living in the same area, but in
different habitats, and utilizing different food, the wild ungulates not only compete little with each other, but complement each other, and on the whole utilize forage resources incomparably better than the cattle which is represented by only three to four species."

(A. A. Nasimovich, "Comparative Efficiency of Pasture Utilization by Domestic and Wildlife Ungulates" in Ecology, Translated from Russian, # 1, 1970. Consultants Bureau, N.Y., p. 4.)

(a) Do you agree with the above statement? Yes No

(b) Does your institution have a special programme for game husbandry? Yes No

(c) Which are adapted to West African biogeoclimatic regions?

Livestock    Wildlife

(d) Which are more productive (lbs./acre)? Livestock    Game

(e) Which are more profitable? Livestock    Game

(f) Have you academic ( ), field ( ) or no ( ) experience in game management?

(g) Which is the more preferred meat to a West African given an assured supply?

Livestock    Game

(h) Has any research been done to determine the relative economic merits of cropping anywhere in West Africa? Yes No

(i) If yes, give details (references, etc.)

(j) In your opinion, what are some of the problems associated with game husbandry?

(k) It has been suggested that agriculturalists in the tropics are generally reluctant in researching into production of game. Is this true? Yes No

Explain

(l) What are the future prospects for research and production of game in West Africa?
It has been suggested that insufficient attention has been devoted to the agronomic needs of some of the following basic staple food crops:

(i) cocoyam  Yes No
(ii) plantains  Yes No
(iii) Yams  Yes No
(iv) cassava  Yes No
(v) others (explain)

It has been suggested that insufficient supply of the native food staples is largely the result of the increasing consumption of bread and other food items from temperate regions?

Agree  Disagree

To the best of your knowledge what research efforts are being made to develop high-yielding and disease-resistant varieties from some of the native crops?

7. SHIFTING CULTIVATION

Clifford Geertz notes two approaches to effective human utilization of natural habitats namely:

1. Changing generalized communities into more specialized ones, and
2. Utilizing the habitats through altering their diversity indices, but through more or less maintaining its overall pattern of composition while changing selected component species, i.e. by substituting certain humanly preferred species for others in functional roles within the pre-existing biotic community.

The first approach is the system adopted by temperate agriculture and the second, shifting cultivation, traditional to West Africa.

(a) Is shifting cultivation incapable of coping with population and economic pressures?  Yes No

(b) Has a more productive system of cultivation been developed anywhere in the tropics that could replace shifting cultivation?  Yes No
(c) if yes, where and what is its technological nature? 

(d) Have any attempts been made to improve upon shifting cultivation?

Yes  No

(e) If no, why not?

(f) If yes, specify

(g) Do farmers use fertilizers on their traditional farms?

Yes  No

(h) If yes, are the crops responsive to fertilizer application?

Yes  No

(i) Scale the increase in yield: 100%, 75%, 50%, 25%, 10%, less

(j) Are fertilizers applied indiscriminately to all crops?

Yes  No

(k) If no, why not?

(l) To your knowledge which is the more productive system (on an individual crop per acre basis) and rate of fertilization of single stand of crops (monoculture) vis-a-vis mixed stand of crops?

Monoculture  Mixed cropping

(m) Which of the two agricultural techniques is more prone to:

   (i) Disease hazards
   (ii) Pest hazards

Monoculture  Mixed cropping  Monoculture  Mixed cropping

(n) It has been suggested that shifting cultivation as practised in the tropics is the most ecologically sound system of agriculture - given the factors of the country's available resources.

Agree  Disagree

8. IMPACT OF TEMPERATE AGRICULTURAL TECHNIQUES ON TROPICAL AGRICULTURE

(a) Describe briefly some of the adverse effects (if any) compared to native agriculture.
(b) Describe briefly some of the benefits (if any) compared to native agriculture.

(c) Do you favour the adoption of temperate agricultural techniques in tropical systems?  
   Yes  No  
   Give reasons briefly.

(d) What temperate techniques or technologies (e.g., pesticides) are being adopted?

(e) Do you see any tendency towards replacing the traditional techniques by techniques developed for temperate crops?  
   Yes  No

(f) What percent of the native agriculturalists of your country trained in Agricultural Institutions in temperate countries?

(g) Name some of the institutions.

(h) Do they undergo a programme of orientation to familiarize them with your country's conditions?  
   Yes  No

(i) Do you feel such a programme is necessary?  
   Yes  No  
   Give reasons.

9. FARMERS' ATTITUDES

(a) Are West African farmers conservative?  
   Extreme  Moderate  Conservative  Not

(b) Are they eager to learn?  
   Very eager  Moderately  Eager  Not

(c) Is there any tendency to replace farmers by trained agriculturalists?  
   Yes  No
(d) Are trained agriculturalists willing to work on farms?
   Yes  No

(e) If no, why not?

(f) Is it advisable to train younger people to settle on land for agriculture?
   Very advisable  Moderately  Advisable  Not
   Explain.

(g) How successful have farm settlement schemes been in West Africa?
   Very successful  Moderately  Successful  Less successful  Failure
   Cite examples

(h) Which is the more desirable: settling younger people or older people on land?
   Younger  Older

(i) What type of incentives are there for prospective farmers?

10. GOVERNMENTAL PARTICIPATION AND CO-ORDINATION

(a) What government departments are involved in agricultural development in your West African country?

(b) What agency is responsible for co-ordinating the activities of the Divisions of Agriculture?

(c) What sort of inter-departmental activities are needed for ensuring steady agricultural development in your West African country?

(d) What sort of inter West African Governmental activities are needed for ensuring Regional Agricultural Development?

(e) What sort of aid or assistance do West African countries need from the more developed temperate countries for the purpose of agricultural development?
(f) What governmental agency is responsible for co-ordinating the activities of government departments for the purpose of agricultural development at:

(i) National level

(ii) Regional level

(iii) District level

(g) To your knowledge how effective is this co-ordination?


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