FARMING SYSTEMS IN RELATION TO INCREASING POPULATION PRESSURE: The Case of Eastern Nigeria

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CONTENTS

INTRODUCTION

Most of the land in Eastern Nigeria is farmed by smallholders who cultivate their fields using traditional practices. The farms in the region are very small, and most of the households receive off-farm income. Part-time farming is typical in the area under consideration.

Eastern Nigeria has a climate (some 2200 mm rainfall per year) and soil types (deep acid sands) which are typical of large areas in the lowland humid tropics of Africa. However, population densities in Eastern Nigeria are much higher than in other regions of rural Africa.

As the objective of the study is to examine changes in resource productivity as pressure on land use increases, three villages were chosen for the study to provide information on farming systems under differing intensities of land use. Marked differences in population density were the dominant criterion for selecting the three villages (see Map 1).

A. THE PROBLEM

1. Boserup's Hypothesis

Ester BOSERUP was concerned with the relationship between population growth and food production. Instead of using the MALTHUSIAN approach Pg = f(Fs) (1), in which population growth is seen as the dependent variable, she used the inverse function: Fs = f(Pg).[2]

With examples from different countries, BOSERUP demonstrated that successful changes within agricultural systems have occurred when population densities were increasing. She argues that the adoption of new land-use systems is a consequence of increasing man/land ratios.

It is believed that both hypotheses mentioned above, the pessimistic one of MALTHUS and the optimistic one of BOSERUP, are oversimplifications of reality. It seems evident that men are able to change cultural

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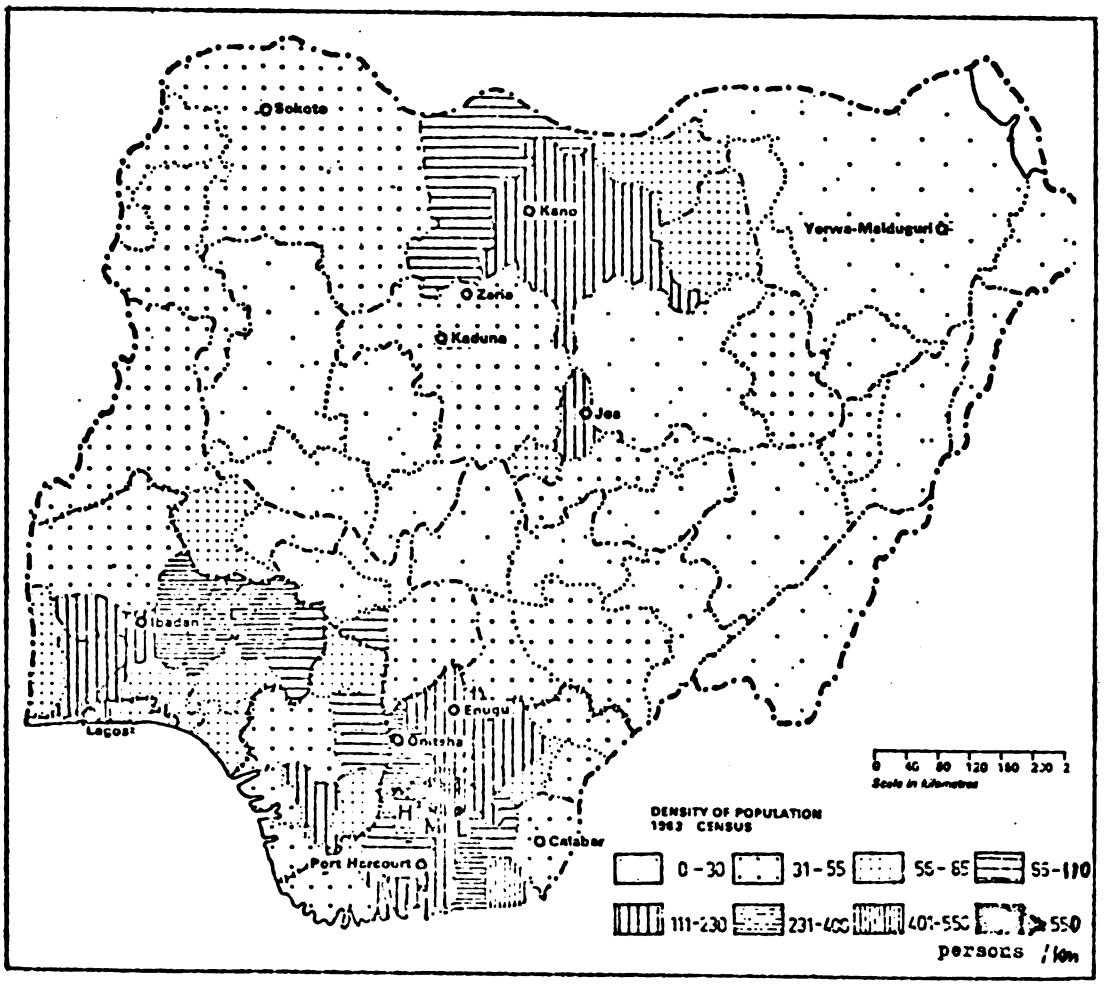
(1) Pg = Population growth; Fs = Food supply

(2) BOSERUP, E.: The Conditions of Agricultural Growth: The Economics of Agricultural Change under Population Pressure. Aldine, London, 1965, p. 11.

Map 1: Population density in the Federation of Nigeria



L = Okwe M = Umuokile H = Owerre-Ebeiri

Source: CORVINUS, F. (unpublished draft).

practices and also to adopt systems which enable them to feed their increasing populations. Depending on the natural and social conditions, this process will (sooner or later) reach a stage which it might be difficult to go beyond within the traditional setting. If such a situation occurs starvation and/or migration of people are inevitable.

The following hypothesis shall be tested for the case of Eastern Nigeria: that with growing population density the present farming systems lead to impoverishment of soils which then produce at a low-level equilibrium.

- During this process increasing adaptations have occurred and are still occurring.
- These adaptations slow down the process of impoverishment, but they are insufficient to stop the process of involution.
- Technical innovations are able to change the situation.

II. Genesis of the Farming System

Farming in Eastern Nigeria has gone through similar changes to farming in other regions of the humid tropical lowlands of Africa.(1) Shifting cultivation was practised, involving a few years of cultivation alternating with a long period of fallow. Under this system trees and bushes could regrow to a secondary forest.

A continuous increase in population, the production of more food crops and the expansion of more export crops-oil palms in this case - has led from shifting cultivation to bush fallowing. The stability of the bush fallow system depends on the number of years that the land remains under fallow. With increasing population density "...the length of fallow progressively decreases with resulting degradation of vegetation and deterioration of the soils".(2)

The expansion of cropping and the reduction in fallowing was accompanied by a change in cropping pattern. The first Europeans to bring new crops to the West African coastal areas were Portuguese traders in the 16th century. MORGAN and PUGH mention maize, cassava, groundnuts,

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(1) GROVE, A.T.: Land Use and Soil Conservation in Parts of Onitsha and Owerri Provinces. Geological Survey of Nigeria, Bulletin Nº 21, Lagos, 1951, p. 22.

(2) VERMEER, D.E.: Agricultural and Dietary Practices among the Tiv, Ibo and Birom Tribes, Univ. of Calif., 1964, p. 168.

sweet potatoes and American cotton.[1] The colonial agricultural departments later introduced higher oil-yielding, thin-shelled varieties of oil palm from the East Indies, and rice was introduced by traders and missionaries, but this crop was little cultivated in Eastern Nigeria before 1939. Of the crops mentioned above oil palms and cassava have made the highest impact.

In the survey area, oil palm production has experienced a gradual change in objectives. Initially it was a major export crop grown on virgin land. Then oil palms became to some degree incorporated into the bush fallow system, producing kernels for export and fat from the epicarp for home consumption. With increasing land shortage, oil palms have become fully incorporated into the subsistence crop.

The change in oil palm production was accompanied by a change in the cropping pattern of arable farming. Originally food starches were obtained from yams and cocoyams. It is thought that cassava began to spread most rapidly in the late 19th century, when the problems of shorter fallows became more acute. Although the importance of cassava differs between the regions, it has now become the major stable crop in Eastern Nigeria.

The problem of declining soil fertility resulting from the washing and leaching of the principal soil nutrients led to the question of whether continuous cultivation could be introduced. Researchers conducted experiments with green manuring in order to replace fallowing, but all trials failed.[2]

The search for a feasible technology which is able to hold or even improve soil fertility under continuous cultivation has not found an adequate answer and this is still one of the main problems for research in the humid tropics.

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(1) MORGAN, W.B. and PUGH, J.C.: West African University Press, London, 1969, p. 470.

(2) UMUDIKE, A.R.S.: Annual Report, 1931, p. 1.

B. DESCRIPTION OF THE FARMING SYSTEM

1. The Resource Base

The average household in the survey area of the Ibo land had eight members (see: Table 1). It is important to note that on average 1.8 household members in villages with medium and high populations are away from home. They supply, however, significant amounts of money to the remaining family members. In addition part-time farming plays an important role in the study area. Farmers themselves or other household members work in the villages or nearby townships as traders, cyclists, truck pushers, oil palm processers, raffia palm tappers, carpenters, etc. This fact is reflected in the number of man equivalents available for agricultural work. Umuokile and Owerre-Ebeiri have on average 2.4 and 2.5 man equivalents available for farm work and Okwe 3.9 man equivalents, which indicates a higher labour force where land is more ample and the pressure of earning an additional income is not so pronounced.

As anticipated the area cultivated per farm decreases with increasing population density. Okwe has on average 0.4 ha under cultivation, Umuokile 0.27 ha and Owerre-Ebeiri the smallest area of 0.23 ha. A comparison of the resource base of land must include the areas under bush or grass fallows from which farmers receive annual returns in the form of fruits from various trees, firewood, livestock feed, bush meet and further mulching material for the compound fields.

Total farm size is on average 2.4 ha in Okwe, 1.0 ha in Umuokile and 0.4 ha in Owerre-Ebeiri. The typical farm is divided into several fields which are scattered throughout the land controlled by the village. This results in smaller plot sizes the higher the pressure on land (see: Table 1).

The prevalence of tsetse flies in the area limits the range of livestock which can be kept in Eastern Nigeria. Hence the major livestock are goats and chickens as opposed to cattle. On an average the households own two goats and 15 chickens. It is quite obvious that the importance of livestock increases simultaneously with the population density (see: Table 1). The higher the population density the larger are the compounds which are fertilized with animal dung.

Table 1. Characteristics of the resource base of smallholders in three villages in Eastern Nigeria, 1974. (1)

	Okwe	Umuokile	Owerre-Ebeiri
Population density persons per sq.km	100-200	350-500	750-1000
Persons/household	8.7	7.3	8.8
Household members away from home	0.4	1.8	1.8
Labour force, ME(2)	3.9	2.4	2.5
Cultivated area, ha.	0.4	0.27	0.23
Size of compounds, ha	0.0	0.04	0.08
Total farm size, ha	2.4	1.0	0.4
Size of fields, m^2	880	620	340
Livestock:			
Goats	1.4	2.0	3.2
Chickens	9.1	15.6	20.6

(1) the figures indicate average numbers

(2) Man equivalents (ME) used in the study:

Labour class	Age	ME
child	8-15	0.3
fem. adult	16-60	0.8
male adult	16-60	1.0
adult	over 60	0.5

Source: compiled by the author

The information on the resouce base indicates that a great number of people live mainly by farming tiny plots with hand tools (mainly hoes and cutlass). Subsistence production prevails and the food demand of

household members is such that there is very little scope for commercial farming. What we find is a peasantry in a high population density area living by mining soils, with traditional farming techniques, and without capital formation. Non-farm employment seems to be the only recognised possibility of escaping from the low-level equilibrium trap.

II. The Organization of Land Use

The land use pattern reflects the outcome of a continuous progress of adaptation of farming to increasing land shortage and declining soil fertility. There exists a spatial differentiation in land use which becomes more pronounced the higher the population density. On most holdings three types of plots have to be distinguished:

- The compounds have a high density of trees and a large range of food crops and vegetables. They are situated around the houses (1).
- Near fields, close to the compound, are usually dominated by oil palms and other useful trees, and produce food crops within an intensive bush-fallow system.
- Most of the starchy food is produced within an extensive bush-fallow system on the distant fields. They are larger in size than the near fields and have a low density of trees. In some areas the fields are open, mainly where land is not so scarce.

1. Compounds

Directly around the house, where manure, mulch and ashes are applied, there is a dense growth of tree and arable crops with different requirements for available nutrients, water and sunshine. The further away a field is from the house, the less manure and mulch is applied. The compounds are not strictly separated from the nearby fields; indeed, there is only a gradual transition from one type of field to the other.

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(1) Compound farming is not practised in Okwe. Land there is more ample than in the other villages, and farmers have not been forced, up to now, to intensify their cultivation on small areas.

Compound farming is a type of land use which is of general importance in the humid tropics (1). In the case of Eastern Nigeria it is characterized by a number of specific features which distinguish it from field farming.

a) Cropping Principles

In traditional agricultural systems farmers usually grow a number of crops in each field. This is particularly pronounced in the compounds of the survey villages where a large number of tree and arable crops were found. A multi-storey system (2) is predominant.

Various trees (3) form the upper part of the storey whereas arable crops (4) grow under the shade of the trees. The leaf canopy becomes denser the closer it is to the ground, and hence reduces erosion by absorbing rainfall, shades the land and so reduces soil temperatures, provides a leaf litter for nutrient recycling, maintains reasonable levels of organic matter and conserves soil moisture during dry periods.

All different plants of trees, shrubs and arable crops are recorded by OKIGBO from compounds in the survey villages. The total number of species on all plots was above 40, with an average of 47. This range of crops with its high density approximates to "...the bush or forest conditions, representing an ecosystem of marked stability"(5).

The density of cropping in the compounds was found to increase with land scarcity. On average 700 - 900 trees and shrubs were counted and in addition 22,000 - 32,000 standes of arable crops. Although the actual density is much higher, due to the fact that only the four main arable

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(1) e.g.: Wahaya agriculture in Tanzania, Kikuju agriculture in Kenya and on the highly populated Gazelle Peninsula of New Britain.

(2) A "multi-storey system" is defined as the growing of two or more arable and tree crops in the same field at the same time.

(3) Oil palms, coconuts (height: 20-25 m); breadfruit, raffia palm, oil beans, pears (12-20 m); colanut, mango (8-15 m); orange, grapes, lime, paw-paw (5-10 m); bananas, plantains (3-8 m).

(4) Cocoyams, Yams, cassava, maize, pepper, groundnuts, melon, okra, telferia and other native vegetables.

(5) OKIGBO, B.N.: Fitting Research to Farming Systems, based on Observations and Preliminary Studies of Traditional Agriculture in Eastern Nigeria. IITA, Ibadan, 1974. p.17.

crops (1) were included, the figures indicate an increase of 41% in tree crop density and 42% in arable crop density in Owerre-Ebeiri compared with Umuokile.

b) Husbandry Practices

The cultivation techniques are adapted to the needs of each plant and to the micro-environment of the surface conditions. A common feature in compound farming is the extraordinary care with which the various crops are cultivated. The practices differ from crop to crop and most of the farmers treat different species of the same crop in a special way.

Yams are planted in heaps in roughly straight lines. The holes are sometimes dug several months before the tubers are planted. In the meantime, the farmers fill the holes with leaves from trees and residues from oil palm bunches which later provide manure for the yam plants.

Maize is usually planted on the flat between the mounds and cassava and cocoyam on smaller mounds between the yam heeps. Some farmers plant their cocoyam in holes. When the cocoyam tubers grow above the earth, they fill the holes with mulching materials and compost soil, to provide a steady supply of nutrients to the plants.

The careful methods of manuring are the base of a successful continuos cultivation. Export of nutrients is limited to the edible parts of the harvested crops, all residues remaining in the fields. The import of organic materials from outer fields, fallow land and through household purchases is substantial. The goats are stabled during the main crop season and are fed with oil palm leaves, crop residues and household remains. Goat manure is highly valued as a source of plant nutrients. With the practice of manuring systematically, the farmers have built up the fertility of the soil in the compounds.

2. Near and Distant Fields

Continuos multi-storey cropping in the compounds contrasts with field farming on plots belonging to the households. In the compounds soil ferti-

(1) Yams, cocoyams (1 plant = 1 stand), cassava, maize (3 plants = 1 stand).

lity is maintained by fertilizing. The outer fields are cropped in a fallow system, through which soil fertility is regenerated, and the length of the fallow varies with the population density.

a) Cropping Principles

On both field types of the villages with medium and high populations and on near fields in low density areas, annual crops are grown under a tree canopy. As the pressure on land use decreases, tree cover tends to diminish on the outlying zones.

The number of trees and shrubs per hectare is far less than in the compounds. 300-500 trees and shrubs are usual for outer fields, whereas in the compounds 700-900 trees and shrubs per hectare are typical.

Oil palm, raffia palm, colanut, coconut and oil beans are the most important trees on the outer fields. The cultivation of cassava, intercropped with yam, cocoyam, maize and other arable crops increases the further away the fields are from the compounds. The importance of cocoyam and yam declines.

In all cases plant densities are extremely high. Most fields carry more trees and shrubs than commercial tree crop plantations. In addition, 13,000-40,000 stands of arable crops are found. This is partly due to the fact that most plants are not vigorous due to lack of soil fertility. The other related reason is the deliberate effort by the farmers to maintain a dense vegetation in order to reduce leaching and erosion.

Apart from these general characteristics, there are important differences between the three villages:

- The number of arable crops grown in one field at the same time is about twice as high in the densely populated villages in comparison to the other less densely populated village.
- The density of tree and arable crops increases from the low to the highly populated village.

The cropping pattern is related to the length of the fallow period and the resulting status in soil fertility. Farmers established the fact

that vegetative growth is less on infertile soils and they have adapted their cropping to the changing conditions:

- With a higher density of cropping, the soil can be more effectively covered in order to reduce the leaching of available nutrients and to reduce soil temperature.
- Different compatible crops utilise nutrients more efficiently and can effect each other in a positive way (e.g. the introduction of legumes in the cropping mixtures).

b) Husbandry Practices

Farming activities start during the first three months of the year with clearing and burning of the bush fallow and trimming of most of the trees. In the highly populated village grasses are found (e.g. Imperata cylindrica), because with a fallow period of 1-2 years bush fallowing has been replaced by grass fallowing.

Most of the crops are planted on the flat or on slightly raised heaps. An exeption is yam which is grown on small mounds on pieces of land where farmers think soil fertility is relatively high. Mulching and manuring is not a common practice in the low and medium populated villages. In the village with high population density, the soil is covered with mulching material, ashes and goat manure.

In summary, production on near and distant fields, even though there are differences between the villages, is by no means as carefully organised as production on compounds. The fields contribute, however, to the output of the compounds by providing most of the starch (root crops) and fat (oil palms) for the household members, and in addition they supply most of the organic matter for mulching the compounds. The interactions between compounds and outer fields are very pronounced.

III. Soil Fertility Status of the Fields

Originally soil fertility in the three survey areas was rather similar, and soils were almost identical. (1) Varying cropping intensities and varying lengths of fallowing , however, have changed the situation and wide

(1) LAGEMANN, J.: op. cit. p. 180.

differences in soil fertility are now found in the area.

Table 2 indicates that soils are poorer the higher the population density and secondly that soil fertility declines with increasing distance from the house. It has to be noted that the outer fields not only support the stable food production but also supply nutrients and organic matter to the compounds. The data indicate the details:

- No significant difference between compounds and outer fields was observed in the level of organic matter and nitrogen. The loss of organic matter and nitrogen due to continuos cultivation was offset by mulching and depositing household refuse.

- The pH of the compound soils had not deteriorated when compared with near and distant fields; indeed, it had significantly increased due to the import of alkaline materials (shells, bones, ashes).

- Calcium + magnesium, potassium and phosphorus were also significantly higher in the compounds than in outer fields, due to the import of plant nutrients from non-compound fields, from beyond the farm, and of ash and household refuse.

Two trends are apparent from the data on soil fertility:

(1) Within a village compound plots are more fertile than near fields, and near fields tend to be more fertile than distant fields. Soil fertility indicators improve with increasing land use intensity. This may be explained by fertilizing practices and by the effect of tree crops, where the root systems act as nutrient pumps.

(2) Between the villages there are pronounced differences in the fertility status of the soils. The higher the population density and subsequently less fallowing result in lower levels of organic matter, nitrogen and phosphorus in the soils of the medium and high density villages. The effort of mulching the fields in Owerre-Ebeiri is apparently not enough to maintain soil fertility, but it seems to prevent a further decline of the depleted soils, or at least reduces the rate of nutrient decline.

Table 2: Means and Coefficients of Variations of Soil Fertility Indicators of Compounds, Near and Distant Fields in three Survey Villages with Differing Man/Land Ratios in Eastern Nigeria

Compounds	Okwe (L) (a)	Umuokile (M)		Owerre-Ebeiri (H)	
		n = 25		n = 63	
		mean	CV as %	mean	CV as %
Org. C %	n.a.	2.06	49.9	1.06	40.7
pH	n.a.	5.06	8.5	5.06	11.5
Ca+Mg me/100 gm	n.a.	3.50	57.2	2.77	71.2
K me/100 gm	n.a.	0.14	54.2	0.17	72.5
P me/100 gm	n.a.	36.18	74.1	19.18	72.8
N me/100 gm	n.a.	0.168	41.9	0.085	41.7

Near fields	n = 35		n = 32		n = 81	
	mean	CV as %	mean	CV as %	mean	CV as %
Org. C. %	2.35	17.7	2.30	42.0	1.20	52.8
pH	4.59	8.8	4.71	7.7	4.45	9.1
Ca+Mg me/100 gm	1.64	124.1	1.90	73.1	1.28	101.9
K me/100 gm	0.09	60.0	0.06	46.3	0.11	82.0
P me/100 gm	25.01	99.0	10.58	123.1	9.77	46.9
N me/100 gm	0.178	32.0	0.170	32.1	0.092	50.8

Distant fields	n = 33		n = 44		n = 17	
	mean	CV as %	mean	CV as %	mean	CV as %
Org. C %	2.37	19.8	1.94	47.4	1.00	14.0
pH	4.47	9.9	4.71	6.9	4.26	5.4
Ca+Mg me/100 gm	0.89	127.6	1.61	59.3	0.69	55.6
K me/100 gm	0.08	61.4	0.05	22.6	0.08	32.3
P me/100 gm	9.78	107.1	8.03	48.4	9.98	43.0
N me/100 gm	0.169	25.9	0.151	28.0	0.067	100.8

(a) Okwe does not have well developed compounds.

Source: Soil Sampling under the Direction of F.R. MOORMANN, Pedologist at IITA. Soil-chemistry analysis conducted by analytical Services Laboratory IITA, Ibadan.

In summary, if soil fertility is to be maintained with short or even without fallowing, then counteracting efforts by the farmers have to be very intensive to increase the nutrient supply. The importance of organic carbon on maize yield has been tested by experiments on farmers' fields in the study villages. Organic matter levels of the plots appear to have been the most critical soil factor.[1]

(1) FLINN, J.C. and LAGEMANN, J.: Evaluating Technical Innovations under Low-Resource Farmer Conditions, in: Expl. Agriculture, 1980, Vol. 16, p. 94.

IV. Crop Production and Yield Relationships

1. Total Output per Cultivated Hectare

a) In Physical Terms

As was discussed in the previous chapter, the differences in land use intensity between plot types and villages influence the soil fertility and, as will be demonstrated, the output of the farming systems.

In figure 1 it is shown that:

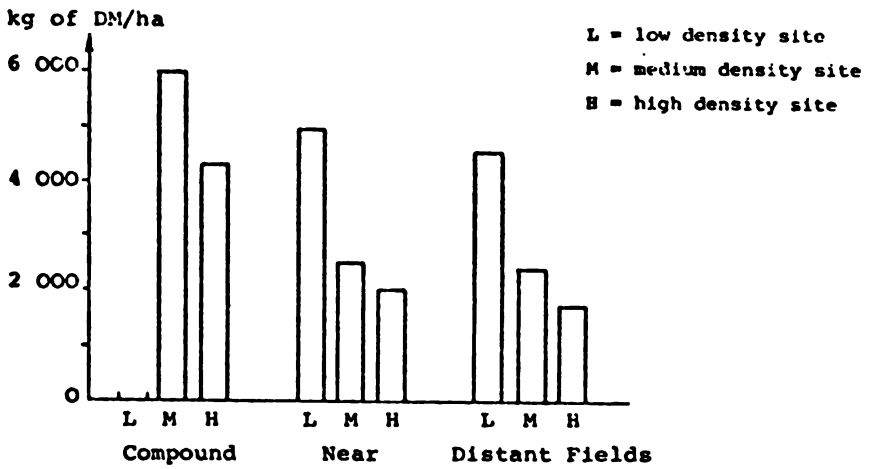
- within the same plot type yields fall from the low to the high density villages;
- within the villages, yields decline the further the fields are from the house.

Yields on outer fields in Okwe are much higher compared with the other two villages, and this partly suggests why intensive compound cropping has not yet developed there. Umuokile (M) and Owerre-Ebeiri (H) show marked differences in yield between outer fields and compounds. Farmers in these highly populated areas apparently find it more productive to concentrate farming on a small area and produce on the outer fields within an extensive system of cultivation. The degree of soil mining on the outer fields tends to be higher the more acute the land shortage, which results in poorer soil fertility and in lower yields on the outer fields.

The shift towards compound farming which occurs with increasing population density is accompanied by the growing importance of trees. Figure 2 shows that the total yield per hectare of arable and tree crops on outer fields declines only slightly from Umuokile (M) to Owerre-Ebeiri (H). This result leads to the conclusion that tree crops, with their deeper rooting systems, are not as sensitive to depleted soils as are the arable crops.

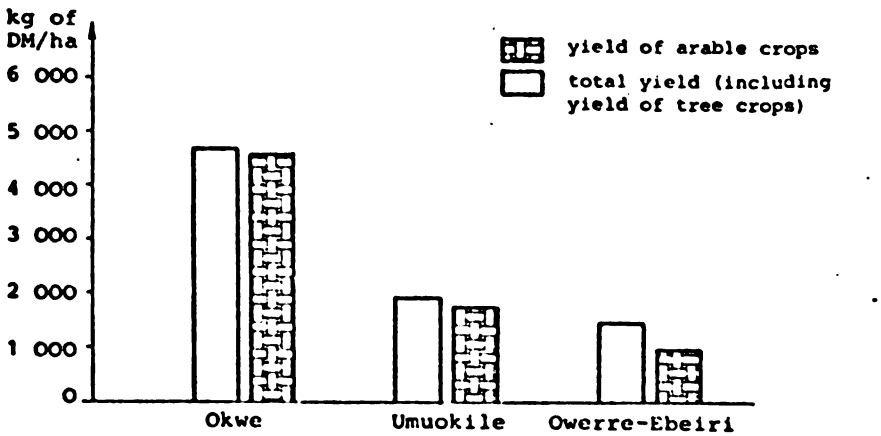
More important than this is the fact that compounds in the densely populated village yield less than in the medium populated village, in spite of the fact that the plant densities are much higher in Owerre-Ebeiri (H) than in Umuokile (M). Both villages are sited, however, on soils of about the same original fertility. It is reasonable to assume, therefore, that the quantities of organic materials are insufficient to

Fig. 1 : Average Total Dry Matter Production per ha on Compounds, Near and Distant Fields in Three Villages in Eastern Nigeria, 1974/75



Source: compiled by the author.

Fig. 2 : Average Dry Matter Production per ha from Arable Crops and Average Total Dry Matter Production per ha on Outer Fields in Three Villages in Eastern Nigeria, 1974/75



Source: compiled by the author.

maintain soil fertility in the compounds of the highly populated village. Furthermore, depleted outer fields may supply mulching material which has less nutrients than that of more fertile fields.

The ingenuity of farmers achieves a slowing down of the process of soil depletion, but -- given the climate and the soils of the area -- it is apparently insufficient to stop the process of soil mining. The farming system seems to be beyond the stage where human effort could regain a balanced land use system without the import of nutrients from the outside.

b) In Monetary Terms

A comparison of the output in terms of value (Naira) shows that the compounds produce five to ten times as much per ha as the outer fields. (see Table 3). The intensively cultivated compounds in Umuokile (M) produce crops valued on average at N 3100.00 per ha. This is extremely high and can only be explained by the special attention which is paid to all crops growing on the small areas around the houses and huts.

The value of output per cultivated ha also declines from the low to the high population villages. An exception is the near fields in Owerre-Ebeiri (H), where about 68% of arable crops consist of yams, cocoyams and maize, which have a much higher value than cassava.

Table 3: Average Output per Hectare (a) in Three Survey Villages in Eastern Nigeria, 1974/75.

Village	Okwe (L)	Umuokile (M)	Owerre-Ebeiri (H)
Compounds			
value N/ha	-	3100	1786
of which: tree crops	-	34%	25%
arable crops	-	66%	75%
Near fields			
value N/ha	811	290	445
of which: tree crops	1%	5%	40%
arable crops	99%	95%	60%
Distant fields			
value N/ha	616	314	295
of which: tree crops	0%	10%	41%
arable crops	100%	90%	59%

(a) - The yield figures are net values, allowances being made for planting material.

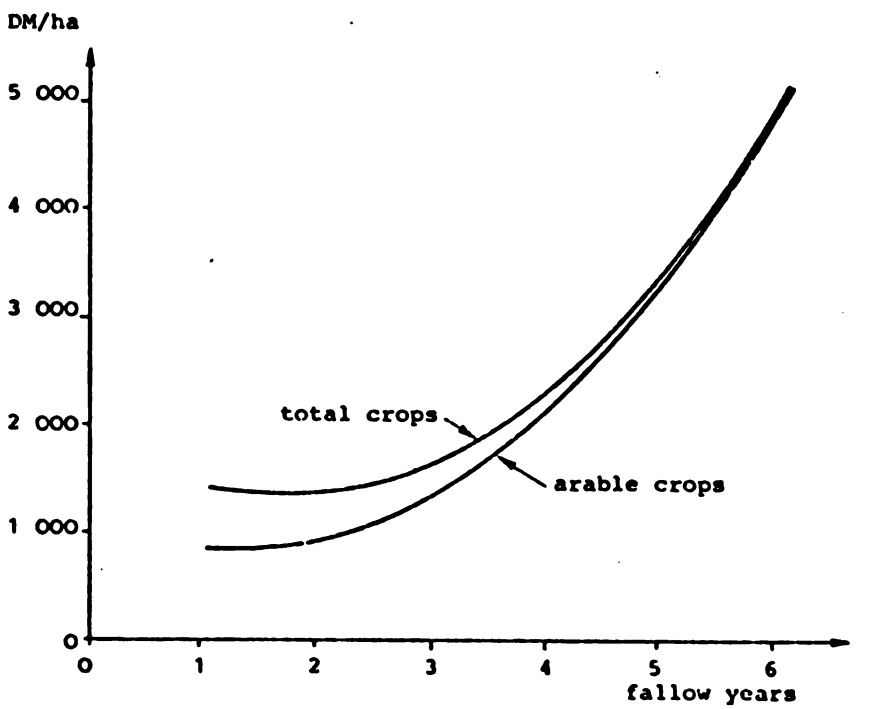
- For inter-village comparison, prices from a major market in Eastern Nigeria (Onitsha) were used. The prices from 1973 were taken in order to make a comparison with other survey data more meaningful. The high inflation rate in 1974/75 has increased the food prices by more than 50%.

Source: LAGEMANN, J., FLINN, J.C. and RUTHENBERG, H.: op. cit., p. 215.

2. Relationships between fallow period and crop yields

Prior to collecting the field data, the relationship between the length of the bush fallow and the yield was taken hypothetically to form a curve with gradually decreasing marginal returns. Fallow periods on outer fields in the three villages ranged from zero to seven years. The data were analysed via least squares regression in order to examine the relationships between length of fallow and output of the fields. The quadratic function explains the relationship best. It might therefore be hypothesized that the soil type influences the type of relationship: on light or sandy soils such as prevail in Eastern Nigeria - the productivity increases are non-linear with increasing marginal returns (see Fig. 3), whereas on heavy or clay soils the productivity will probably increase with decreasing marginal returns (1).

Fig. 3 Relationship between Total Output of Arable Crops on Outer Fields and Length of Fallow Period Prior to Cultivation



Source: compiled by the author.

(1) The explanation refers only to the range of observations (0-7 years fallow).

The most important conclusions from the regression analysis are as follows:

- The significant relationship between yield of arable crops and length of fallow indicates that the latter variable is an important factor influencing yield in this type of land use system. (Fallow explains 60% of the observed variation in total yield of arable crops).
- Within the range of observation, the marginal return of each year of fallow increases. The added return for two years fallow is estimated to be 239 kg dry matter/ha, and for six years fallow it is 1681 kg dry matter/ha. It may be assumed that decreasing marginal returns will apply for longer fallowing, but this cannot be verified from the available data.
- When the yield from tree crops is taken into account, we find that the yield level is much higher on plots with no or few years of fallow, but the annual increase of total crop production due to fallowing is lower than in the case of arable crop production only (1).

In summary, the length of the fallow period, which is influenced by the population density, is an important explanatory variable of the crop yield in Eastern Nigeria. There is a rapid decline in output the shorter the fallow period. In other words, the higher the pressure on land or the population density the lower the yields.

V. The Livestock Economy

Farmers in Eastern Nigeria produce their main food requirements through the cultivation of arable crops and tree crops. Livestock production plays

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(1) This refers to a fallow period of up to 4 years. Tree crop production is insignificant on fields with 5 or more years' fallow.

only a supplementary role, and it is not necessarily expected to constitute a normal diet item. In general, livestock is kept on a small scale and little attention is paid to the animals. Livestock serves as a financial reserve, for social and cultural purposes and in the higher population density areas animal waste is regarded as very useful manure for the compound crops.

The estimated total annual livestock production had an average value of about Naira 39.00 per household. The value of livestock production per household increased from the low to the high population village.

VI. The Labour Economy

In the survey area, farm and non-farm work is carried out by both men and women. Children are also engaged in farming and other activities, but 95% of them attend primary or secondary schools which occupy most of their time.

The actual farm work in the fields (without the walk to and from the fields) requires 203 man-hours per man equivalent per year in the three survey villages. The labour input per man equivalent increased with increasing pressure on land: one man equivalent in the low density village worked 188 man-hours per year; in the medium density village the figure averaged 191 man-hours, whereas in the high density village one man equivalent worked 231 man-hours per year.

The figures on field work are much lower than those derived by other researchers in West Africa (1) and reflect the small farm sizes.

1. Distribution of Field Work

The main cultivation period is the first four to five months of the year, where about 60 to 80% of the total field work is required (see Fig. 4).

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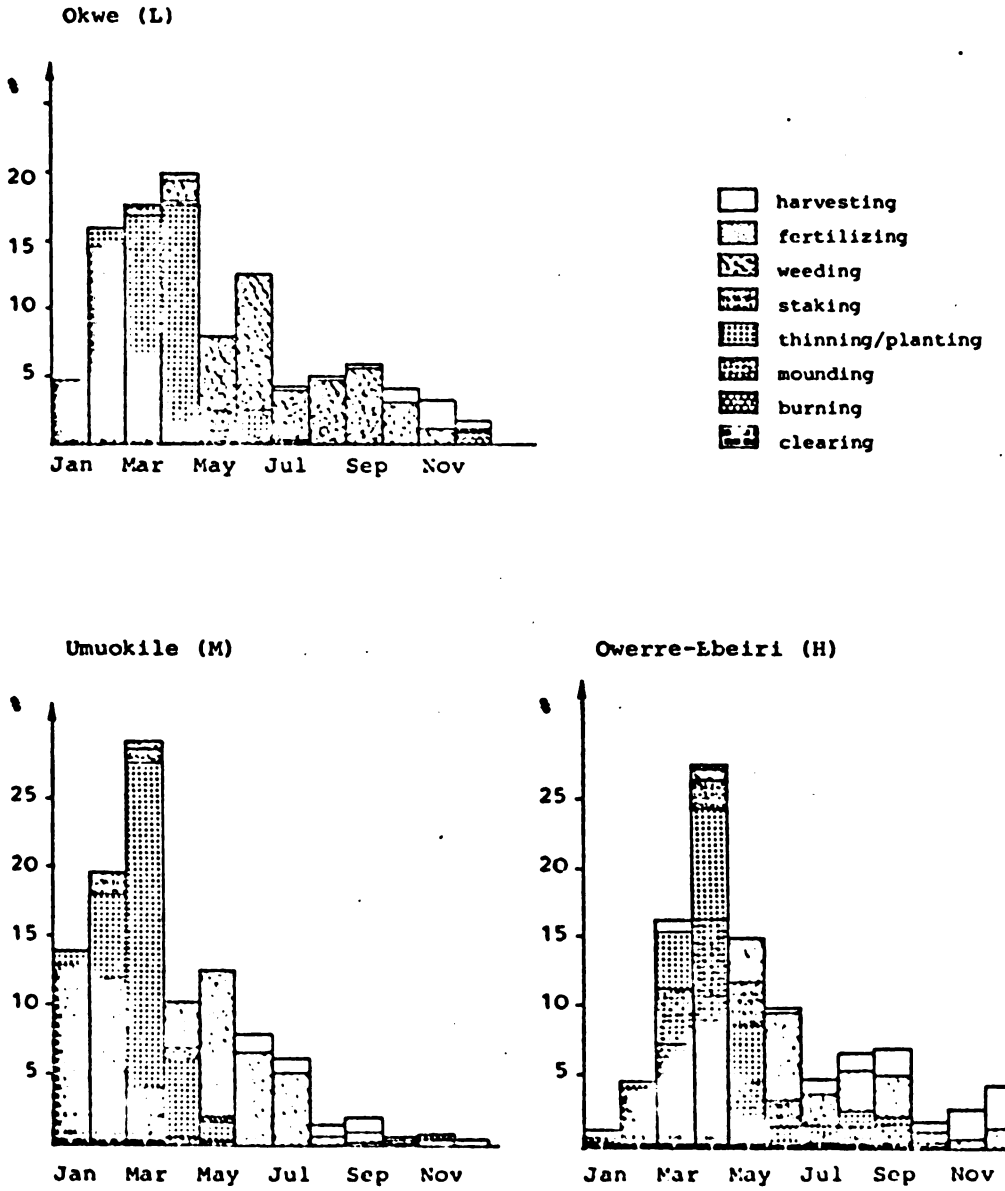
(1) NORMAN, D.W.: An Economic Study of Three Villages in Zaria Province, Samaru, Zaria, Nigeria, 1967, p.23.
CLEAVE, J.H.: African Farmers: Labour in the Development of Smallholder Agriculture, Praeger, New York, 1974, pp.38 et seq.

Fig. 4: Seasonal Distribution of Field Work in Three Villages in Eastern Nigeria, 1974/75



Source: compiled by the author.

Clearing and burning starts at the end of the dry season, in January and February. In Owerre-Ebeiri the major part of clearing is done in March and April. Farmers in this village start their cultivation period on their outer fields when the moisture content of the soil is relatively high, in order to reduce the risk due to unreliable rainfall at the beginning of the cropping season (1).

Preparation of the fields is done immediately after the plots are cleared, and followed by planting of the various crops. By the end of May most of the crops are in the ground, except the remaining cassava in the high population density village, which is planted throughout the rainy season.

The second half of the year is a rather 'slack' period with respect to field work. Weeding of the fields and harvesting of yams are the major operations. Information collected does not include sporadically harvested crops nor, importantly, the labour input for cassava harvest. The main stable crop is harvested throughout the year.

2. Division of Labour between Household Members

The rigidity in the division of labour - which was very pronounced in the past (2) - seems to have decreased during the last decade. Although work with tree crops remains in the hands of men the major part of the annual work on arable crops is shared by all family members and hired labourers. A major operation for men still is the staking of yams.

In Eastern Nigeria non-farm activities are apparently performed to a greater extent by men, which results in the increasing engagement of women in agricultural work. This is very pronounced in the high population areas,

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(1) The water holding capacity of the soils in Owerre-Ebeiri are generally lower than of soils in the other two villages. This is probably due o the shorter fallow period and the resulting low content of organic matter.

(2) SMOCK, D.R.: Agr. Dev. and Community Plantations in Eastern Nigeria, The Ford Foundation, Lagos, 1965, pp. 4 et seq.

where part-time farming is typical, and where most of the income is derived from off-farm activities. Farmers hire more labour the higher their non-farm income.

3. Labour Input and Labour Productivity

The analysis of labour input and labour productivity has to be treated with caution, because the method of labour data collection allowed only rough estimates of the actual hours worked in the fields to be made. The available information indicates high labour inputs for all villages and field types, with an average input of 2909 man-hours per hectare. Compared with information reported by NORMAN and ROTENHAN (1), the data for Eastern Nigeria indicate two to six times higher labour inputs. Farmers in other parts of Africa usually work between 500 and 1500 man-hours per hectare. Intercropping with a large number of arable and tree crops and the small plot sizes are probably the main reasons for the high labour input in the survey villages. Particularly interesting is the fact that the labour input in the compounds is not much higher than in the outer fields. Although this information gives only a rough estimation of the labour input, the data seem to indicate that multi-storey cropping is a more effective traditional system of land and labour use than open field farming.

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(1) NORMAN, D.W.: op. cit., p. 59., ROTENHAN, D. von: Cotton Farming in Sukumaland, Tanzania, 1968, p. 72.

Table 4: Average Labour Productivity on Compounds and Outer Fields in three villages in Eastern Nigeria, 1974/75

Village	Pop. density	Naira / man-hour	
		Compounds	Outer Fields
Okwe	low	n.a.	0.23
Umuokile	medium	1.12	0.14
Owerre-Ebeiri	high	0.53	0.11

Source: Compiled by the author

The estimated labour productivities indicate marked differences between the villages as well as between compounds and the outlying fields within the same villages. We may conclude from the results in Table 4 that:

- The average gross return per man-hour in the compounds is some four to eight times higher than those of outer fields in the respective villages, and
- Labour productivity is found to diminish on compounds and outer fields the higher the population density.

These findings are interesting in several respects. Mixed arable cropping normally produces more per hectare, but less per hour of work. NORMAN reported in his Zaria study that the average production per man-hour input for crop mixture was about 80% of that for sole crops. However, during the peak labour demand, in June and July, the average gross return per man-hour input was 23% higher for crop mixtures than for sole crops (1). Multi-storey physiognomies seem to have high labour productivity, and in addition, it has to be considered that work in the shade of the compound trees has probably less disutility than in open fields. The labour problem of multi-storey cropping systems is apparently less one of maintenance than of establishment.

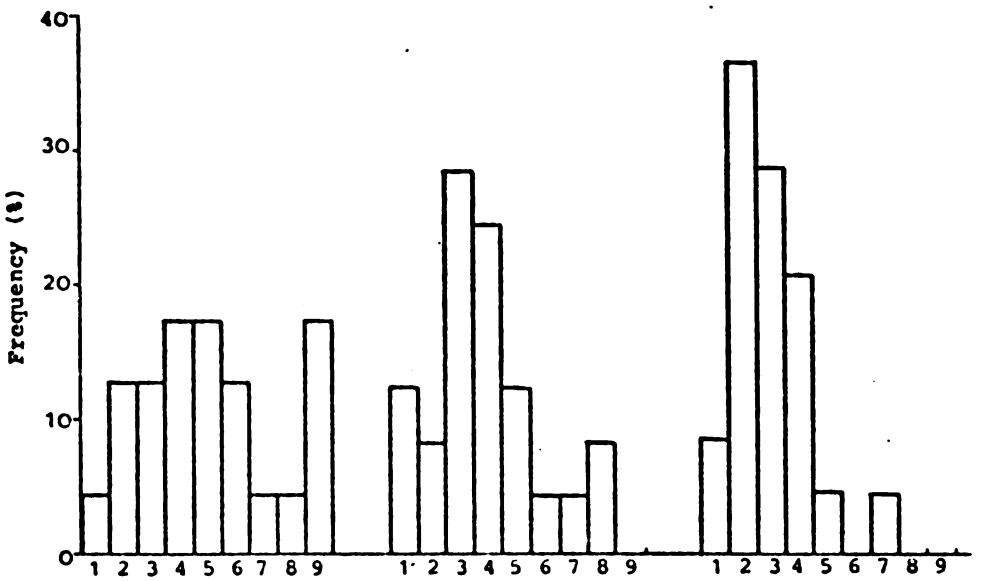
(1) NORMAN, D.W.: op. cit., pp. 85 et seq.

VII. ECONOMIC RETURNS AND USE OF CASH INCOME

1. Gross Return

The average gross return of the smallholdings was estimated to be Naira 358.00. Farmers in the low density village produce within their extensive bush fallow system nearly twice as much as farmers on the depleted soils in the highly populated village. However, within the villages the variations are pronounced. The distribution of gross returns (see Fig. 5) indicates the range of total production in the three villages as well as major differences between the areas.

Fig. 21: Distribution of Gross Returns in Three Villages in Eastern Nigeria, 1974/75



Source: compiled by the author.

Modes of gross returns decrease as well as means the higher the land scarcity. in Owerre-Ebeiri 64% of the survey farmers produced an output valued at between Naira 100.00 and Naira 300.00; in Umuokile 52% produced an output valued at between Naira 200.00 and Naira 400.00; whereas total output in Okwe is more equally distributed over all classes. This phenomenon is consistent with the distribution of the cultivated areas in the three villages.

Information on gross returns from various plot types is listed in Table 5. The estimates show that:

- The small compounds produce more than 50% of total production from land under cultivation (fallow land excluded).

- The gross return of production per unit area on compounds in Umuokile is higher than in Owerre-Ebeiri. Compounds in the medium density village consist of 11% of cultivated area but produce 52% of the output, whereas compounds in the high density village consist of 26% of the land and produce 59% of the crop output.

- The land under fallow is productive both through the regeneration of soil fertility and through the value of tree crops harvested. A substantial proportion of the gross return, although declining from the low to the high density area, is derived from the uncultivated plots.

TABLE 5. AVERAGE CROP PRODUCTION (IN NAIRA) ON COMPOUNDS, OUTER FIELDS AND FALLOW LAND IN THREE VILLAGES IN EASTERN NIGERIA, 1974/75

Village	Crops	Compounds	Outer-Fields	Fallow	Total
Okwe (L)	arable	n.a.	265	5	270
	tree	n.a.	4	165	169
	total	n.a.	269	170	439
Umuokile (M)	arable	64	80	2	146
	tree	28	6	103	137
	total	92	86	105	283
Owerre-Ebeiri (H)	arable	70	44	2	116
	tree	29	26	43	98
	total	99	70	45	214

SOURCE: LAGEMANN, J., op. cit.

2. Family Income from Farming

The farm income available for the households is derived from deducting farm expenses (mainly yam sets and wages for hired labour) from gross

returns. This amount averaged Naira 318.00 in the survey villages in 1974/75. Pronounced differences were found between the villages (see Table 6). As with gross returns, the farm family income was found to decline from the low to the high density village.

Table 6. AVERAGE FAMILY INCOME FROM FARMING IN THREE VILLAGES IN EASTERN NIGERIA, 1974/75 (IN NAIRA)

	Okwe (L)	Umuokile (M)	Owerre-Ebeiri (H)
Gross return	480	321	272
Purchased inputs	22	3	33
Farm income	458	318	239
Wages for hired labour	37	10	14
Farm family income	421	308	225
Farm family income per household member	48	42	26

SOURCE: LAGEMANN, J., op. cit

3. Total Family Income

All farmers in the three villages obtained income from sources other than farming during the survey period. The magnitude of non-farm income increases the lower the income from farming (see Table 7). Farmers in Okwe acquire 42% of their total family income from off-farm sources, while in Umuokile off-farm income constitutes 53% and in Owerre-Ebeiri it is clearly the main source of livelihood and constitutes 76% of the total family income. Trading and employment are the major off-farm activities, accounting for 56-89% of the total non-farm income.

Table 7. AVERAGE NON-FARM INCOME OF HOUSEHOLDS IN THREE VILLAGES IN EASTERN NIGERIA, 1974/75.

Village	Okwe (L)	Umuokile (M)	Owerre-Ebeiri (H)
Population density	low	medium	high
Non-farm income	300	347	721
CV as %	145	117	95
Non-farm income as % of total family income	42	53	76

SOURCE: LAGEMANN, J., op. cit.

The inclusion of non-farm income in the total family income changes the income situation of the households significantly. Although there are wide variations within the villages, the average income figures show the highest values for the high density village (see table 8). The higher the population density the higher the total income per man equivalent, and the better off is each household member.

The results show clearly the great importance of non-farm income, and that the exclusion of the non-agricultural sector would have led to a totally misleading picture.

Table 8. TOTAL FAMILY INCOME (IN NAIRA) IN THREE VILLAGES IN EASTERN NIGERIA, 1974/75.

Village	Okwe(L)	Umuokile(M)	Owerre-Ebeiri(H)
Population density	low	medium	high
Total family income(a)	721	655	946
Total family income per ME	180	252	305
Total family income per household member	83	90	108

(a) Total family income = Farm family income + non-farm income

SOURCE: LAGEMANN, J., op. cit.

This is of crucial importance for the main hypothesis of the study: Boserup's hypothesis, according to which food supply is a function of population growth and not population growth a function of food supply - as expressed by Malthus - is verified only provided off-farm activities are developed. Within a purely agricultural setting Malthus' hypothesis seems to be right. The process of Malthusian impoverishment in an agricultural setting is, however, slowed down by the farmers' efforts to adapt their farming systems to declining soil fertility by an increasing inter-farm differentiation between compounds and the outer fields.

VIII. CONCLUSIONS

The results of the data collected in the three villages show the tremendous impact of the population density on agricultural production as well as on income derived from non-farm sources. The higher the population density the smaller the farm sizes per household. This pressure on land has the following results in the farming systems of the survey area:

- Reduced fallowing diminishes soil fertility, and consequently results in lower yields and lower labour productivities.
- The internal farm differentiation gains in importance. The outer fields supply fertilizing material which are accumulated on the compounds. The compounds produce more than 50% of the total production from the land under cultivation.
- The density of trees and arable crops increases. Trees especially act as nutrient pumps, and seem to slow down the decline in soil fertility.
- Manuring practices gain in importance. The crops are supplied with ashes and organic material.
- The relative importance of livestock as a source of farm-family income increases.
- Although farm sizes decrease with increasing population density, the field work per man equivalent per year increases.

The adaptations were obviously able to slow down the process of diminishing yields, but they are insufficient to stop the process.

Without additional income from off-farm employment, the households in the

high population density areas could not provide their daily food requirements.

The importance of non-farm income increases the higher the population density: 42% of the total family income in Okwe (L) is derived from off-farm sources, in Umuokile (M) the figure averages 53%, and in Owerre-Ebeiri (H) 76% of the total family income is derived from off-farm sources. This information indicates that the total family income per household member is higher the higher the population density. Population growth has forced people to work outside the farm, to educate their children, and to migrate to other areas.

These results imply that an increase in food production requires innovations which are so rewarding that the additional income obtained is higher than possible incomes from off-farm sources. Off-farm employment, though not always available, is very often the alternative for the farmers, and especially for the younger generation. Farmers' experience with the multi-storey cropping system suggests it is a type of land use which could well be used as a starting point for the development of the farming system in Eastern Nigeria.

C. POSSIBILITIES OF INCREASING PRODUCTION AND PRODUCTIVITY OF THE SMALLHOLDERS.

The information available on land use development in Eastern Nigeria indicates a tendency towards a farming system at a "low level equilibrium"; cropping on outer fields in highly populated areas has already reached that stage. Counteracting efforts by the farmers has led to the establisment of highly productive multi-storey cropping systems on the compounds.

The improvement and expansion of the multi-storey cropping system seems to be of particular relevance in the high populated area of Eastern Nigeria. Wet rice production in valley bottoms and tree crop production on uplands are established land use systems which have proved their effectiveness in a great number of cases.

1. VALLEY BOTTOM DEVELOPMENT

Population growth in the humid tropical lowlands of Asia led to the

intensification of land use in valley bottoms, while hillsides and uplands were, and to some extent remain, either vacant, used for extensive types of fallow cultivation, or planted with tree crops (1). One of the most striking aspects of land use in Eastern Nigeria is the fact the valley bottoms are wasteland, except for some minor development which has begun in recent years. Farmers were extremely skilful in adapting upland farming to the condition of decreasing soil fertility. They have been optimisers within the framework of traditionally known techniques, but they have ignored the high potential of valley bottoms.

Results from experiments and agricultural projects in the survey area indicates that valley development with wet rice is highly profitable. Yields of 3 t per hectare can be expected under farmers conditions, and the estimated gross margin of Naira 760.00 is very attractive. The gross margin of rice produced in a five month period was two to three times higher than that from a traditional land use system in an 18-month period.

With the possibilities of growing a second crop in the valley in the same year the profitability of developing these hydromorphic bottoms lands becomes clear. Prices of rice were high and increased during 1975/76 more than those of other stable food crops, which provides a further incentive for rice production.

II. MODERN TREE CROP PLANTATIONS

Food crop production in the valley bottoms could be supplemented by tree crop production on the upland, because erosion and leaching are much more easily reduced by tree crops than by annual or biannual crops. The obvious choice for Eastern Nigeria would be the planting of high yielding varieties of oil palms.

Yield data from wild and improved oil palms in different regions show that the yield from new varieties is more than four times higher than from the traditional type (1). Information collected during the survey indicates that modern oil-palms under smallholders conditions

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(1) BUCK, J.L.: Land Utilization in China, Paragon, New York, 1964.

are a competitive crop in the area. A total yield of 8 tons of fruit bunches per ha and year was realised without mineral fertilizer or a cover crop.

Gross returns of oil palms in the case study are lower than gross returns of traditional farming in the area, but it has to be considered that hand extraction is practised. With modern techniques gross returns should be about two to three times higher. However, the return per hour of work is several times higher. Oil palms in the case study yielded Naira 0.57 per man-hour, compared with 0.11-0.23 per man-hour in the outer fields of the survey villages. A combination of modern oil-palms on the uplands and intensive farming in the valley bottoms would allow high labour productivities and a prevention of a further decline in soil fertility.

However, "...under traditional conditions the system is leading towards the competition for land between an extending plantation of modern oil-palms for cash and the requirements for fallow land to maintain yield of food crops"(2).

These observations are very important in high population density areas, where farms are small and only a few farmers are able to grow oil without the interculture of food crops which is practised with the traditional oil palms.

III. IMPROVEMENT AND EXPANSION OF THE MULTI-STOREY CROPPING SYSTEM

Continuos cultivation throughout the year has proved its value in the survey area when tree and arable crops are combined and the land receives large quantities of organic material. The land use system of compound farming resembles the ecological conditions of a tropical for - est and has therefore the following advantages:

- Leaves of tree and arable crops can assimilate throughout the year. Solar energy is used at various levels of the storey. "Intercropping combinations generally develop a higher leaf area index and cover the ground more rapidly than do plants in monoculture"(1). Soil temperature is therefore optimal and the subsoil has a good moisture content.

(1) RUTHENBERG, H.: Farming Systems in the Tropics, Clarendon Press, Oxford, 1980.

(2) RUTHENBERG, H.: ibid, p. 107.

- Growth of weeds is suppressed by the close cover of the leaf canopy.
- Negative effects of heavy rainfall are minimized in a multi-storey cropping system. The roots of tree and arable crops at various depths can absorb moisture and nutrients effectively.
- Crops, fruits and fibre are produced throughout the year and serve the requirements of the households.
- Nutrients supplied by fertilizers are used efficiently due to the dense root system.

Improvements and expansion of multi-storey cropping systems could be a possible avenue for the introduction of permanent cultivation under smallholders conditions. The provision of nutrients and organic matter seems to be of crucial importance.

Under low-resource farmer conditions "alternatives for increasing the productivity of these farming systems might include the partial substitution of fertilizers for the recycling of nutrient through bush fallow, introducing fallow species that have multiple uses and are efficient nutrient recyclers or producers of organic matter (e.g. Leucaena spp., Acioa spp.)."[1]

Most of the agricultural research up to now has focused on monocropping and open fields. The idea of developing varieties which fit into the crop combination of a multi-storey physiognomy is relatively recent. There is reason to assume that the output could be significantly improved by varieties which are especially developed to fit into the system with regard to light, shade tolerance, vegetation cycle and nutrient requirements. The potential of multi-storey cropping system is high and the environmental benefits of this type of land use for the humid tropics are obvious.

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(1) FLINN, J.C. and LAGEMANN, J. op. cit., p. 100.

IV. CONCLUSIONS

Permanent cultivation in the lowland humid tropics of Eastern Nigeria is - with the present state of the art - possible only with wet rice production in valley bottoms and with tree crop production in areas where population densities are low. Therefore, both innovations are only within the reach for a relatively small part of the total population.

Smallholders, in particular subsistence farmers, have to produce first of all food crops to secure their daily food requirements. Multistorey cropping systems, as practised in the compounds of Eastern Nigeria, have shown possible avenues for development and agricultural research has to provide an answer to the constraints which actually prevent farmers to extend this type of land use.

Technical solutions are very important prerequisites for an improvement of the farming system but their implementation requires an adaptation to the socio-economic environment of the target group and institutions and policies which make it attractive to small farmers to increase their production.

BIBLIOGRAPHY

AGRI. RESEARCH STATION UMUDIKE: Annual Report, Nigeria, 1931.

BOSERUP, E.: The Conditions of Agricultural Growth: The Economics of Agricultural Change under Population Pressure, Aldine, London, 1965.

BUCK, J.L.: Land Utilization in China, Paragon, New York, 1964.

CLEAVE, J.H.: African Farmers: Labour in the Development of Smallholder Agriculture, Praeger, New York, 1974.

FLINN, J.C. and LAGEMANN, J.: Evaluating Technical Innovations under Low-Resource Farmer Conditions, in: Expl. Agriculture, 1980, Vol. 16.

GROVE, A.T.: Land use and Soil Conservation in Parts of Onitsha and Owerri Provinces, Geological Survey of Nigeria, Bulletin Nº 21, Lagos, 1951.

LAGEMANN, J., FLINN, J.C. and RUTHENBERG, H.: Land Use, Soil Fertility and Agricultural Productivity as influenced by Population Density in Eastern Nigeria, in: Zeits, f. Ausl. Landwirtschaft, Heft 2, 1976.

LAGEMANN, J.: Traditional African Farming Systems in Eastern Nigeria, Afrika Studie 98, Weltforum Verlag, Munich, 1977.

MORGAN, W.B. and PUGH, J.C.: West African...., Universtity Press, London, 1969.

NORMAN, D.W.: An Economic Study of Three Villages in Zaria Province, Samaru, Zaria, 1967.

OKIGBO, B.N.: Fitting Research to Farming Systems, IITA, Ibadan, 1974.

ROTENHAN, D.: Cotton Farming in Sukumaland, Tanzania, in: RUTHENBERG, H.: Smallholder Farming and Development in Tanzania, Munich, 1968.

RUTHENBERG, H.: Farming Systems in the Tropics, Clarendon Press, Oxford, 1980.

SMOCK, D.R.: Agr. Dev. and Community Plantations in Eastern Nigeria, The Ford Foundation, Lagos, 1965.

VERMEER, D.E.: Agricultural and Dietary Practices among the Tiv, Ibo and Birom Tribes, Univ. of California, 1964.