

Changes in shifting cultivation in Africa

Seven case studies

FAO Forestry Department

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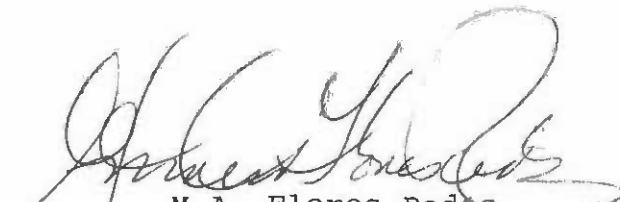
FOREWORD

In recent years shifting cultivation has received growing attention from FAO governing and advisory bodies. The Organization has been asked to study the biological, social, economic and cultural aspects of this food production system and to draw up multidisciplinary programmes and guidelines for improving its productivity.

Within the context of this mandate from member countries, the FAO Forestry Department carried out in 1982-83 a comprehensive study entitled "Alternatives to shifting cultivation in the use of forest land". This work was coordinated by a working group which included officers of the Agriculture and the Economic and Social Policy Departments of FAO, as well as a sociologist from the Overseas Development Institute UK (Dr. C. Oxby).

The main study has been published as FAO Forestry Paper 50: "Changes in shifting cultivation in Africa" (1984). The aim of that study, which was confined to those zones of Africa receiving 1000 mm or more of annual precipitation, was to assess the extent and distribution of shifting cultivation in Africa and to document and evaluate developments from recent demographic and other land pressures. The study also contained abridged versions of case studies.

This companion volume published as FAO Forestry Paper 50/1, contains the findings of seven full length case studies carried out in Ghana, Ivory Coast, Madagascar, Senegal, Sierra Leone and Tanzania.


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THE CASE
OF THE C.G.O.T. SECTOR,
SÉDHIOU (CASAMANCE), SENEGAL:

TRANSFORMATIONS OF TRADITIONAL AGRICULTURE
AFTER AN UNSUCCESSFUL LARGE-SCALE OPERATION
FOR MECHANIZED GROUNDNUT CULTIVATION IN FOREST ZONES

based on the work of

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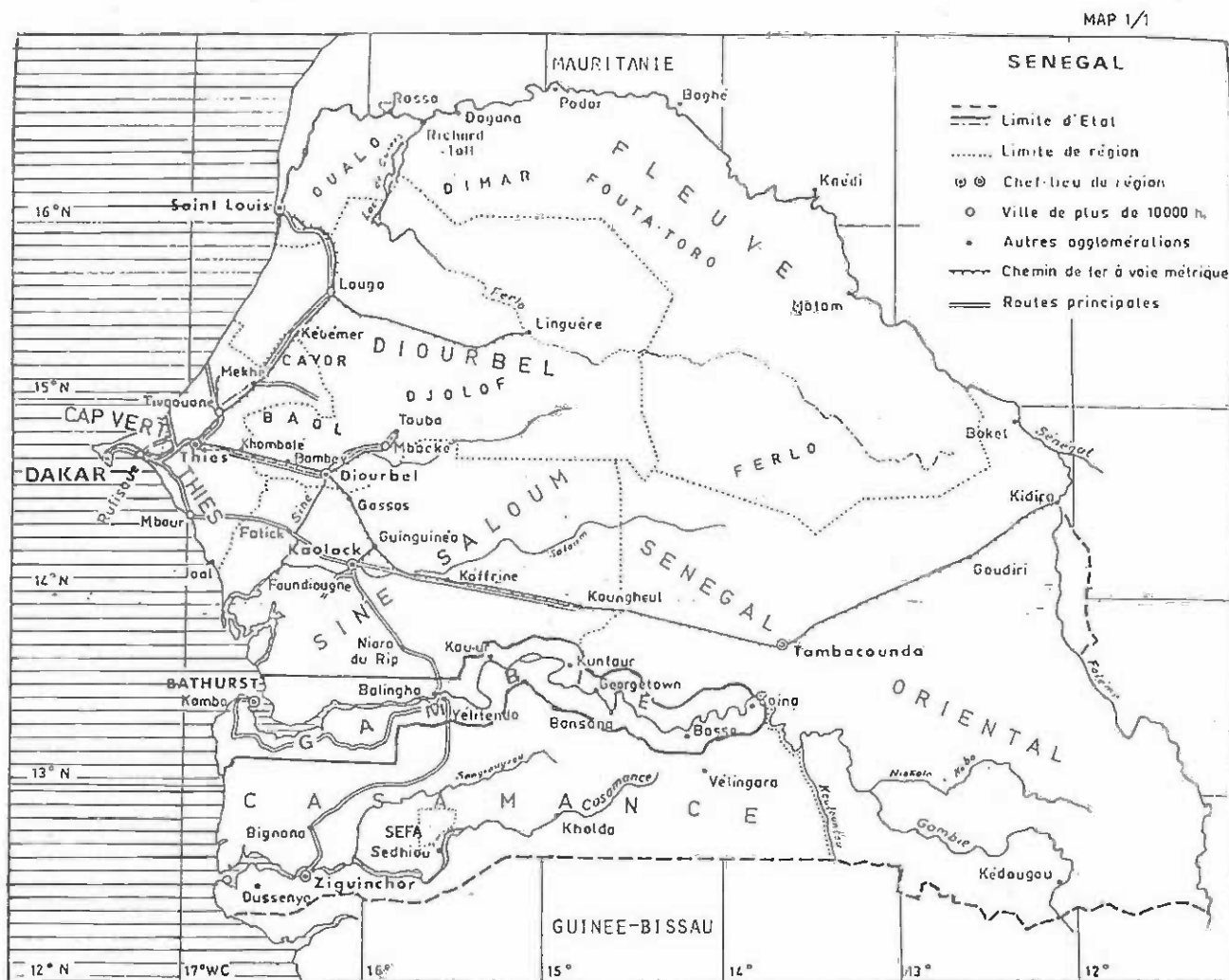


Figure 1/1. Senegal, showing the site of the C.G.O.T. sector.

THE CASE
OF THE C.G.O.T. SECTOR,
SEDHIOU (CASAMANCE), SENEGAL

1. Physical and Socio-Economic Environment

The area reported on (see Fig. 1/1) consists of 200 to 250 km² north of Sédhiou, Department of the Middle Casamance, in southern Senegal; Sedhiou itself lies on the Casamance River. The geographical position is between 12° 45' and 12° 55' North latitude and 15° 31' to 15° 38' West longitude; the altitude is between 15 and 25 m.

Geographically, the Casamance region is a low-lying plain, rarely reaching an altitude of 40 m. This flatness explains why the area is poorly drained, by the Casamance River, during the rainy season, while during the dry season the water flow is reduced to zero except in the Casamance itself and its northern tributary, the Soungrougrou. The Casamance River, apparently an imposing watercourse, is in reality an estuary penetrating deeply into the lowlands (Aubreville, 1948). The remainder of the hydrographic network is made up of broad, shallow branches ("marigots"), cutting deeply into the plateaux and disappearing in very flat, swampy plains, but bearing water only during the rainy season. There are two types of low plains: the swamp plains created by the marigots and the flood plains, slightly higher, probably originally river or marine terraces.

The soils are constituted from strata formed during the continental period at the end of the tertiary era (miocene). For agricultural purposes, they may be divided into two categories, between which there is no significant difference for the purposes of this paper: ferrallitic ("red") soils and tropical ferruginous ("beige") soils. These homogeneous geological formations yield a landscape of little character, marked by flat plateaux (slopes, always near the rivers, rarely exceeding 2%); laterite outcroppings

are frequent on the slopes. At the time of clearing, the soils were composed of 40-53% fine sand, 25-40% coarse sand, 8-15% clay (0-10 cm), 1-7% silt, and 1-2% total organic matter; the pH ranged from 6.3 to 6.5.

This study deals almost exclusively with farms on the Pacao plateau, which lies between the Casamance and the Soungrougrou.

The annual rainfall in the region averages about 1350 mm, concentrated in a single rainy season of 4-5 months. From the end of June to the beginning of July, the rains fall with hurricane strength, exercising a powerful degrading effect on the totally dried-out soils. From the end of July to the end of August the monsoon, well established, brings continuous, regular rains; 700 mm fall in 30 days. The rains are irregular during the remainder of the period, which ends in mid-October.

The mean annual temperature is about 27° C. The maxima are recorded during the three months preceding the rains, and the minima from December to February; the monthly variation is about 3°.

On the basis of a 1947 survey, Aubreville (1948) defines four natural forest types in the Middle Casamance:

- 1) A dry, clear forest consisting of several species which become dominant from place to place: stands of Bombax costatum, Sterculia setigera, Erythrophloeum africanum, Daniellia oliveri, Pterocarpus erinaceus, Prosopis africana, Parkia biglobosa, Afzelia africana, Terminalia macroptera, etc, with undergrowth of Combretum spp., Bauhinia thonningii, Cassia sieberiana, Crossopteryx febrifuga, Hymenocardia acida, Strychnos spinosa, etc., alternating with clumps of Abyssinian bamboo (Oxythenanthera abyssinica), which tend to invade clearings opened for cultivation.
- 2) Stands of Daniellia oliveri, a tree characteristic of

the countries in the region. It normally has a very regular appearance, with a straight, cylindrical trunk and a pyramidal top, but in this area the clumps appear to be pressed closely together in small stands with a high trunk density. The trunks are generally not upright, but curve in all directions, while the tops, pressed together, form a continuous cover under which the undergrowth is sparse. These woods do not cover large areas, but are encountered frequently.

- 3) The wooded savannas, type of vegetation very frequent in Africa, with more or less dense stands of small trees and shrubs. The bush burns every year during the dry season, leaving the vegetation stunted and scraggy, with twisted trunks and tops which remain thin until they are high enough to escape the direct flames of the bush fires. The composition of the flora varies. To the species already mentioned for the dry forest may be added Dichrostachys nutans, Trichilia emetica, Bridelia micrantha, Dalbergia boehmii, Gardenia terni-folia, Hannoa undulata, Entada sudanica, Ekebergia senegalensis, Securidaca longipedunculata, etc.
- 4) The forest galleries, in which, in addition to several of the species growing in the dry clear forests, are found elements of the flora of the Lower Casamance, such as Parinaria excelsa, Khaya senegalensis, Anthostemma senegalense, Detarium senegalense, Vitex cuneata, Anthocleista procera, Erythrophleum guineense, Cordia cordifolia, Schrebera arborea, Afzelia africana and Pseudospondias microcarpa.

This rapidly changing forest vegetation, without transitions, even over short distances, owes its rapid variations to the influence of brush fires and of clearing for cultivation. Brush fires degrade the forest in several stages. The burning of the undergrowth at the end of the dry season, fostered by a litter of dry leaves, attacks the base of the large trees. In the following years, the fire passes still more easily, the early scars on the tree trunks are aggrava-

ted, and after a few years the trees, burned almost through at the foot, fall, to be burned completely on the ground during the fire of the following year. Further, while the brush fires cause, at first, only slight damage to the trunks, a large dry trunk, in burning, gives off enough heat to dry out and burn all the trees around it.

The population density of the region is low, about 12 persons/km², but even this number is unequally distributed. The villages are frequently situated at the base of the plateaux, which themselves are practically unpopulated. The region in which the C.G.O.T. operation was installed was almost uninhabited. In earlier times it had been cultivated, but for various reasons the villages had become concentrated along the watercourses. (C.G.O.T., 1957).

2. Former Traditional Agricultural System

Dumont (1951) describes the village of Salikanie, just north of Sédhiou and on the outskirts of the C.G.O.T. concession. While it must be borne in mind that the area is very thinly populated, the report can be considered as giving a fair picture of agricultural organization in the sector prior to the installation of the C.G.O.T. Dumont distinguishes four types of cultivation:

- a) Farm-yard or garden cultivation within or on the outskirts of the village: fruit and other trees (citrus, papaya, mango, baobab), cassava, tobacco (Nicotiana rustica), and miscellaneous vegetables (cucumber, yam, sweet potatoes, eggplant). Some grains (sorgo, fonio), groundnuts or niébé may be grown in association with the vegetables. When the farmer owns livestock, these gardens are fertilized with their excreta.
- b) Fields cultivated near the village, under a three-year crop cycle (groundnut-millet-sorgho), followed by four years of fallow. Infestation by striga may lead the farmer to abandon his fields to a long period of fallow

and move elsewhere.

- c) Fields remote from the village: A two-year cycle of sorgho + groundnut followed by fonio is grown until the reduction in soil fertility and the invasion of the millet fields by striga force the farmer to abandon cultivation and leave the field in fallow. At that time the trees take over, because the many trunks which are not removed when the fields are cleared send up shoots in every rainy season, and after a few years the savanna regains its tree cover.
- d) Rice cultivation takes place in the marshes. The rice is sown in seed-beds during the rainy season, and staggered transplantation takes place toward the end of the season and even, in the lowest-lying lands, until the beginning of the dry season.

It will be observed that this system of agriculture is partly stabilized (farm-yard and garden crops) and partly shifting (fields remote from the village); it is difficult to classify the system on the fields near the villages, because the period of fallow and the relationship between the length of the crop cycle and the length of fallow are subject to excessively wide variations. Pelissier (1966), discussing the same general region 15 years later, points out that it is the slight density of the population and its concentration in large villages that make it possible for each community to have available to it large forest areas on the plateaux, for the practice of "the habitual cycle of 'shifting' agriculture."

3. Description of the New System

"At the outset," writes Pelissier (1966), "the fields in the brush were given over to millet. In the forest, they constituted only temporary enclaves, reduced in size, from which each concession sought to supplement the production of the rice-fields and the garden plots near the village.

When groundnut cultivation began, it expelled millet toward the forest, and by now it has invaded the entire territory of plateau agriculture. More and more, millet has come to represent only an auxiliary crop, indispensable for opening the forest and literally preparing the ground. But until now the crop cycles have had nothing in common with a rational rotation, leading to the establishment of a developed agriculture capable of meeting both food needs and the requirements of the commercial sector: their sole purpose is to ensure that groundnuts hold, if not necessarily an exclusive place, at least the largest place possible...

"The elimination of the forest cover and the cultivation of cereals are designed to reduce the level of organic matter and humic acid in the soil, and at the same time to allow run-off to eliminate part of the clay in its upper horizon, rendering it more sandy. As soon as the soil is judged sufficiently "sandy", the groundnut appears. For an average of five or six years, groundnuts and millet alternate; for the next three consecutive seasons, groundnuts (sometimes + kinto) occupy the ground; then one fonio crop may be planted to take advantage of the clearing before the field is allowed to revert to forest fallow."

But the importance attached to the groundnut crop has led to shortening the period of forest fallow. "More and more," continues Pelissier (1965), "and especially in the more densely populated areas, such as the right bank of the Casamance below Sédhiou, exploited forest areas are no longer left for long periods of fallow but are transformed into 'permanent' fields planted one year with groundnut and left in fallow the next, with scattered plantations of fonio."

In the agricultural context of the Casamance region in 1948, it may be wondered whether a change in the original farming system as described above for one village was really necessary. The region is sparsely populated, land availa-

bility is high, and in fact the concession of 10 000 ha to the C.G.O.T. (= Compagnie générale des Oléagineux tropicaux) was in no way intended to promote local agricultural development. Its purpose was defined (Pétre, 1972) as "to create a continuous development zone of 30 000 ha, concentrated, after clearing, on groundnut cultivation under a completely mechanized system." The time was ripe, because there was a strong demand for vegetable oils at the time, shortly after the end of World War II.

In practice, however, only 6 500 ha of the first block of 10 000 ha were cleared, and of these only 2 600 ha were windrowed, and only 1 000 ha were placed under cultivation. It was shortly found that, for a number of reasons to be examined below, the scheme was not profitable, and a system of cultivation in association was adopted. From the standpoint of development, this system was, at least theoretically, somewhat justified: it involved the farm population (not only the locals but also, especially at the outset, the immigrants) in an operation in which part of the work (soil preparation, burial of green fertilizer, spreading of fertilizer) was carried out by the mechanized sector and the remainder (sowing, weeding, harvesting) by the individual farmers. Rural development thus became a by-product of a project that was unconcerned with it at the time of its initiation.

The clearing operations in the sector, near Séfa, are described by Charreau and Fauck (1970). During the rainy season, the trees were cut down by the passage of a heavy chain suspended between two tractors. In the dry season, the trees were towed off the parcel by bulldozer, the large stumps were uprooted, the entire area was worked over with a root-cutter with a 20 cm straight blade and then raked, and finally the surface was leveled off.

To the extent possible, clearing took place on strips 200 m wide, separated by forest strips of 50 m which were

left intact; the fallen trees, stumps, etc., were towed to the skirts of this strip. The cleared strips were themselves cut off every 300 m by a 50-metre strip of forest acting as a windbreak and playing a limited role in preventing erosion.

Soil preparation techniques were gradually modified as awareness grew of the negative effects of violent treatment of soils whose surface structure was already seriously degraded by the clearing operations. After one or two years, the cultivation techniques that were developed and applied to all crops (groundnut, millet, sorgho, rice) were roughly as follows: stubble-ploughing with a 16-disc plough, after about 40 mm of rain; spreading of fertilizer; second stubble-ploughing, about 10 days after the first; harrowing; sowing; two or three hoeings, one of which, on groundnuts, accompanied by earthing-up to facilitate rooting up; mechanical harvesting (groundnuts only).

Until 1952, the mechanized cultivation of groundnuts was carried out exclusively by hired labour. Under the system of cultivation in association, the choice of crops underwent a number of changes. In 1957, according to the C.G.O. T., a 6-hectare farm normally consisted of four 1.5 ha parcels: two under groundnut, one under cereals (normally 0.5 ha of millet + sorgho and 1 ha of rain-fed rice) and one under green manure (buried millet or sorgho). The crops were rotated in the order green manure-groundnut-cereal-groundnut, a rational cycle alternating grasses and legumes. In 1958, the rain-fed rice was still cultivated directly by the C.G.O.T., since the authorities considered that it would be difficult to have rice grown directly by the associates in the same way as millet or groundnut.

Frequently the buried green manure was replaced by a less satisfactory "buried fallow". Subsequently, maize appeared in the crop cycle, and the following rotation was recommended (Charreau and Fauck, 1970): buried fallow or

green manure-maize-rice or millet-groundnut-millet or rice. In this system, sowing takes place as early as possible; the soil is ploughed in depth, annually in principle, some ploughing being done in the autumn. The seed bed is prepared carefully, immediately after ploughing. Whenever practical, advantage is taken of deep ploughing to incorporate plant matter (green manure, strawy crop residues, etc.) into the soil. The fallow or green manure is cut at the end of August and carried away as animal feed or left on the field as mulch; the new shoots are buried in October, and the land is worked over again with a light plough as soon as the rainy season ends, if possible.

It should be observed that this stage was reached gradually, and that the evolution of the situation was accompanied by a number of structural changes. The chronology can be briefly summarized as follows:

- 1948-51 The C.G.O.T. initiates clearing and cultivation operations, fully mechanized, with hired labour.
- 1952-59 Mechanization is gradually phased out in favour of a semi-mechanized system of cultivation in association. Machinery is used only for work that cannot be executed manually. The associates turn over part of their groundnut crop in payment for services received.
- 1959-62 The C.G.O.T. introduces rice as a new crop for cultivation in association.
- 1963 Largely as a result of the independence of Senegal, the C.G.O.T. is replaced by a Senegalese enterprise, the Société de développement agricole et industrielle de la Casamance (SODAICA).
- 1963-72 The SODAICA provides supervision and support to the farmers installed on the former C.G.O.T. concession.
- 1972 The Société de développement et de vulgarisation agricole (SODEVA) assumes responsibility for the SODAICA's extension and supervisory functions.

1972-82 Several bodies, successively or simultaneously, assume responsibility for all or part of the operations. In addition to the SODEVA, mention may be made of the two phases of a World Bank project, P.R.S. I: Projet rizicole de Sédhiou (1972-76), and P.R.S. II: Projet rural de Sédhiou; the Projet international de développement agricole de la Casamance (PIDAC), and the Société de mise en valeur de la Casamance (SOMIVAC), set up in July 1976 to assume general responsibility for, and coordinate, various projects including those mentioned.

4. Analysis

The original soils under forest cover had generally satisfactory physical properties, and their satisfactory exploitation could be reasonably expected. Unfortunately, the deforestation work, as described above, degraded the soil considerably. The topsoil became powdery as a result of the passage of tractor caterpillars, the rolling of tree trunks, the haulage of stumps and the passage of leveling equipment; the end result was a spectacular level of wind erosion. This degradation of the physical properties of the soil must be attributed not only to deforestation but also to cultivation, and it is impossible to evaluate the respective degree of responsibility of the two activities.

As a consequence of the degradation of the physical properties of the soil, water erosion set in without delay, on the flat plateau, to the surprise of observers.

- * Run-off which represented 1% of the rainfall under forest cover, averaged 25% under crops, varying sharply with the slope: 16.3% on a 1% slope and 30% on a 2% slope. The nature of the crop appears to have played no role in this phenomenon, but it was found that mechanized cultivation increased run-off to an average of 33%.
- * Erosion represented about 0.2 tonnes/ha under forest but never fell below 2 t/ha under crops and averaged

about 10 t/ha; the nature of the crop had little influence on the erosion level. As soon as this tendency was known, a number of erosion control measures were taken: all cultivation was halted on slopes exceeding 1.5%, the access roads were partially reoriented, the most seriously affected zones were terraced, and parcels were consolidated on the basis of the topography. By 1956, however, on one 2 400 ha unit, 300 ha (i.e. 12.5%) had had to be abandoned, despite the high clearance cost that had been incurred.

- * During the dry season, the temperature of soil horizon A reached 8° C higher on cleared soils than under forest, and this, at least in the first analysis, had an influence on the microbial level in the soil and on evaporation.
- * Contrary to what might have been expected, bringing the land under cultivation did not result in the gradual drying out of the zone, nor in lowering the groundwater level. There are several possible explanations of this surprising phenomenon: the most reasonable are that the groundwater sheet was fed by the run-off, and that evaporation under the forest strips continued during the dry season, while post-harvest evaporation fell to very low levels.

The chemical properties of the soil (Charreau and Fauck, 1970) also underwent extensive changes:

- * The cation exchange capacity was observed to have fallen sharply in the 0-10 cm horizon of the soil after 15 years of cultivation. Similarly, the total exchangeable ions dropped sharply after deforestation and continued to fall regularly as the combined result of leaching and crop carry-off. The pH fell regularly, and considerably, on all cultivated soils: from an initial level under forest of 6.4, it had reached 5.69 after 7 years of cultivation, and after 15 years the levels were 4.6-4.9 on beige soils and 4.7-5.1 on red soils. After the same period, the loss of calcium can be estimated at 1-4 t/ha,

and since crop carry-off can account for 300 kg of this at best, the difference can only be explained by strong leaching action.

- * At the end of six years, the level of exchangeable potassium in the upper horizon (0-15 cm) had fallen from 0.15 me/100 g to 0.10 me/100 g, leading to the appearance of clear signs of potassium deficiency on the groundnut. The loss of potassium in the horizon can be estimated at 100-200 kg/ha, and since crop carry-off may vary between 100 and 600 kg/ha according to the minimum and maximum hypotheses, only a slight quantity of potassium can have been lost by leaching.
- * The phosphorus content of soils under forest was low to medium. Post-harvest deficiencies appeared rapidly, while phosphorus is not leached and drainage carry-off can be considered as practically zero. This deficiency, which at the outset is the most obvious, seems therefore to be the one which can be corrected the most easily and efficiently.

As regards the biological characteristics of the soil, several points are worthy of note:

- * After land clearing and the beginning of cultivation, a severe drop (-30%) was observed in the carbon and nitrogen content of the soil. Thereafter, the rate of decrease was much lower, and it is difficult to determine whether a state of equilibrium had been reached or whether the organic matter continued to be degraded under crops. The loss over 15 years is estimated at 18 t/ha of an original level of 43.5 t/ha (41%).
- * Taking "humus" in the limited sense of humic and fulvic acids, the rates of humification under crops as found by Fauck et al. (1969) were slightly higher than under forest (an average of 46% as against 41%), but the difference was not significant.
- * In red forest soils, total microbiological activity in the 0-10 cm horizon was fairly high, whereas 15 years later it was low to very low; the degradation in the

beige soils was somewhat less marked. In both, decreases in microbiological activity changed little between 1962 and 1966, and a new equilibrium appears to have come about under natural conditions of exploitation.

- * Ammonification was high under forest in beige soils and medium in red soils. After 15 years of cultivation, the decrease was about 90% in both, roughly the same as the decrease in total microbiological activity.
- * Following a peak after deforestation, the mineralisation of organic matter in the soil remained high after 15 years of cultivation, despite the decrease in total organic matter content.
- * The activity of the cellulolytic microflora in red forest soils was strongest in the 0-5 cm horizon, and it was found that cultivation reduced their density by an average of 55% for the total 0-10 cm horizon. In the beige soils, in which the density was originally higher, cultivation reduced the level by nearly 80%. In both soil types, however, it was found that cultivated soils had a higher proportion of fungi in the microflora than the soils under forest.

Continuous and complete production figures are unfortunately not available for all the crops in the cycle and over the entire period. It can be observed, however, that groundnut yields over the period 1951-59 were very poor as compared with those of 20 years later, under P.R.S. II, although the latter probably benefitted from improved fertilization. While the figures for the latter period cover a zone much larger than the original C.G.O.T. concession, and therefore presumably include farms operating under better circumstances than the latter, differences in millet, groundnut and upland rice yields appear excessive, and this probably reflects better management by SODAICA than by C.G.O.T.

When operations began, the local population was very little involved in them and, as already mentioned, the work

was carried out by salaried immigrants to the zone. Fifteen years later, the SEDES (1965) reported that the instability of the associates remained very high throughout the experiment. In 50% of cases, associates did not remain on the concession for more than two years. A semi-mechanized system of groundnut and rice cultivation failed to transform the associates into farmers: they behaved more like employees than like farmers.

By 1972, however, a study of SODAICA (SATEC, 1973) indicated that while the associates remained highly mobile, some farmers appeared to be well established in the village. Two villages consisted of 75 farmers, each of whom had received 10 ha of land to be cultivated, in principle, 5 ha under groundnut, 1 ha each under maize, upland rice and millet, and 2 in fallow. The number of associates fluctuated; 350-400 was the usual annual figure. As before, most associates remained on the land for only one or two years. They received only 2-3 ha of land, to be cultivated manually, except that soil preparation was executed mechanically by SODAICA at a price equivalent to a subsidy. The "associate"-type farm unit presumably did not ensure a farm family a normal existence.

The effects of the C.G.O.T. experiment on farm revenues is a matter of some debate. As early as 1954, the C.G.O.T. itself considered that the income of the associates was twice that of incomes obtained under traditional cultivation, but this view was challenged by the SEDES (1965) on several grounds. It was considered that incomes from traditional farming had been underestimated, in that they had included only that from groundnut and millet, whereas many other products were grown on the traditional farms of the Casamance: citrus, papaya, maize, cassava and miscellaneous vegetables (Dumont, 1951). Further, in calculating the individual revenues of the immigrant associates, the C.G.O.T. had taken into account only the number of persons actually installed on the holding and had left aside the number of fa-

mily members remaining in the zone of origin, while the entire families of local farmers, installed on the unit, had been included. Finally, the C.G.O.T. had calculated mean incomes of associates by multiplying average yields on all the holdings cultivated in association the previous year by the cultivated area and the growers' prices at Sédhio: this approach assumed that yields were relatively constant and that the associates as a whole obtained such yields, but these assumptions were unfounded. The SEDES concluded that a large proportion of the associates earned less than average incomes, and therefore that a system based on mechanization alone did not lead to increased yields and could even reduce them below levels reached under traditional farming, both systems being equally subject to variations in weather conditions.

5. Conclusions

A third of a century after the clearing of the Casamance forest began, and in the light of the many events which came about as a result, a number of conclusions can be drawn. It must be borne in mind, however, that in so doing we have the benefit of hindsight.

The negative aspects of the experiment are numerous. Most published opinions of the C.G.O.T. operation and its prolongation by SODAICA are severe. As early as 1953, an article in Marchés coloniaux was entitled "The errors of over-equipped are distressingly evident in the Casamance".

The first criticism aimed at the project was its excessive cost and its doubtful prospects. In addition to technical errors, the need to establish a system of cultivation that could amortize the costs of tractors, equipment, road construction, buildings, etc., was a heavy charge on public finance. As early as 1951, it was recognized that more than half of the 1.1 billion CFA francs (1) allocated to the

(1) Roughly US\$ 7 million at 1950 exchange rates.

C.G.O.T. by the Fonds d'investissements pour le développement économique et social (FIDES) would have to be written off. Indeed, under the technical conditions described above, and particularly the low level of yields, the financial situation could never be healthy, whether under C.G.O.T. or SODAICA management. Pétré (1972), writing at the time when the SODEVA was to assume responsibility for much of the operation, estimated the "inevitable" annual deficit at 30 million CFA francs. Over-staffing was a major contributing factor to the deficit: in 1972, the structure of the SODAICA included a director general, an assistant director, a secretary general, three bureaux and three directorates, comprising six services, 29 divisions and 90 sections.

The scientific follow-up of the C.G.O.T.'s operations pointed up the damaging influence of the radical clearing methods adopted in 1948, and especially the disastrous results of using bulldozers on and dragging trunks and stumps over the cleared surfaces, leading to the loss of the upper soil layer. The mechanical farming techniques employed during the early years after clearing were also catastrophic, leading rapidly to the major erosion phenomena already described, which appeared to be extraordinary on soils with little or no slope. In fact, the technical concepts of this period were unsuited to the ecological conditions of the sector, taking into account neither the fragility of the soils nor the violence of the rain in the tropical context which characterizes the Casamance. The short- and long-term consequences of these errors were serious, and the erosion control works that they rendered necessary were costly.

None of the papers consulted which deal with the period of clearing refers to any use whatever of the wood cut down, yet it is likely that if the wood had been used, the C.G.O.T. documents would have mentioned the fact. There is no alternative but to suppose that on the 6 500 ha cleared, no use was made of the wood, whether for construction or as

fuel. According to Giffard (1974), forest stands in the Middle Casamance are capable of furnishing 150-200 m³/ha of wood. There was therefore a considerable clear loss, which can perhaps be explained by transport difficulties.

The C.G.O.T. can hardly be blamed for its behaviour on the social plane during the early years of its operations: it had itself announced that its purpose was not rural development but the production of groundnut under profitable conditions, with salaried labour. The complete reorientation of its activities that took place with the move to cultivation in association makes it possible, on the contrary, to examine the repercussions of its activities on the human environment. It would appear, according to the little information available, that the nucleus of the local population was only slightly concerned in the transformations that took place. That group, however, practiced a system involving shifting agriculture, "nibbling away" at the forest for part of their farm areas, and appearing only after some time to be interested in the operation and to have stabilized the shifting sector of their agricultural system.

The great majority of the associated farmers came from outside the zone and demonstrated a high degree of instability, apparently reluctant to establish themselves in the village settlements and to take advantage of the real efforts that were made to improve their technical formation (an extension agent was present in each village). Perhaps, too, those to whom farms were assigned, but without the low-lying rice fields to which they were accustomed, and thus living in circumstances very different from those of the local population, were obliged to seek out other agricultural resources in order to survive all year round. Many of them avoided this difficulty by "taking" five months of leave every year, returning to their native village and engaging in a little trade. This way of life was far from the ideal pattern foreseen by the C.G.O.T., which had defined

an "associate" as "a farmer who, while maintaining his full autonomy as a farmer, freely accepts direction within an organized agricultural unit" (cited in SEDES, 1965).

But the operation was by no means without positive aspects. The manner in which it was followed up during the C.G.O.T. and successive periods was exemplary from the scientific point of view. The results obtained are remarkable both for their continuity and for their quality; some of them reach considerably farther than a sector of a few thousand hectares in the Middle Casamance which constituted the theatre of operations.

The first result was the scientific observation of the erosion phenomena as they occurred, and which were reported in summary above. It was on the basis of these observations that research was able to recommend suitable corrective measures, in a series of technical directives to extension workers on all aspects of soil preparation, the crop calendar, rotation and fertilization. In this sense, the follow-up made it possible to define first what should not be done, and then what can be done to remedy the situation.

After this initial stage, research concentrated on plant improvement, and breeders were able to produce highly improved varieties of groundnut, rice and maize which are still in use not only in the Casamance but elsewhere in tropical Africa, and further serve as basic stock for new derived varieties, better suited to somewhat different local conditions.

It has been observed that the stabilization of the original shifting agriculture in the sector was late and partial, and that immigrants from other zones were mostly concerned. Nonetheless, a certain number of these immigrants did establish themselves in the new settlements, even if their number was smaller than might have been legitimately hoped. It should also be recognized, leaving out of

account the financial considerations, that these more or less completely stabilized farmers enjoy a standard of living that has been improved from certain points of view: roads, water supply, housing for a certain number of them, possibility of processing crops on the spot, etc.)

Improvement in incomes is more difficult to ascertain, since it depends not only on production but also on producers' prices and the farmer's own consumption. The evolution of producers' prices has been clearly in favour of groundnut (Tchakerian, 1980). In 1973-74, taking the groundnut price (unshelled at mill) as 100, the official price of paddy was 163 and that of maize 125. By 1977-78, the price of paddy had remained unchanged, and the relative indices were groundnut: 100, paddy: 100, and maize: 84. There was thus competition between groundnut and grains for the labour and land potential available after the farmers' subsistence requirements had been covered. This competition favoured groundnut, inasmuch as the crop requires less labour than rice and is more productive in extensive plateau cultivation in difficult climates, and because it is the only product to have the advantage of organized, guaranteed marketing. Government interventions of this type therefore modify the purely agro-economic aspects of the problem and confuse the issue.

This being so, no firm and final conclusions can yet be reached, since the so-called "traditional" agriculture has also evolved in line with what has been occurring in the directed sector. This evolution is itself a positive factor.

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INTEGRATED
RURAL DEVELOPMENT PROJECT
EASTERN PROVINCE,
SIERRA LEONE

based on the work of

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MAP 2/1

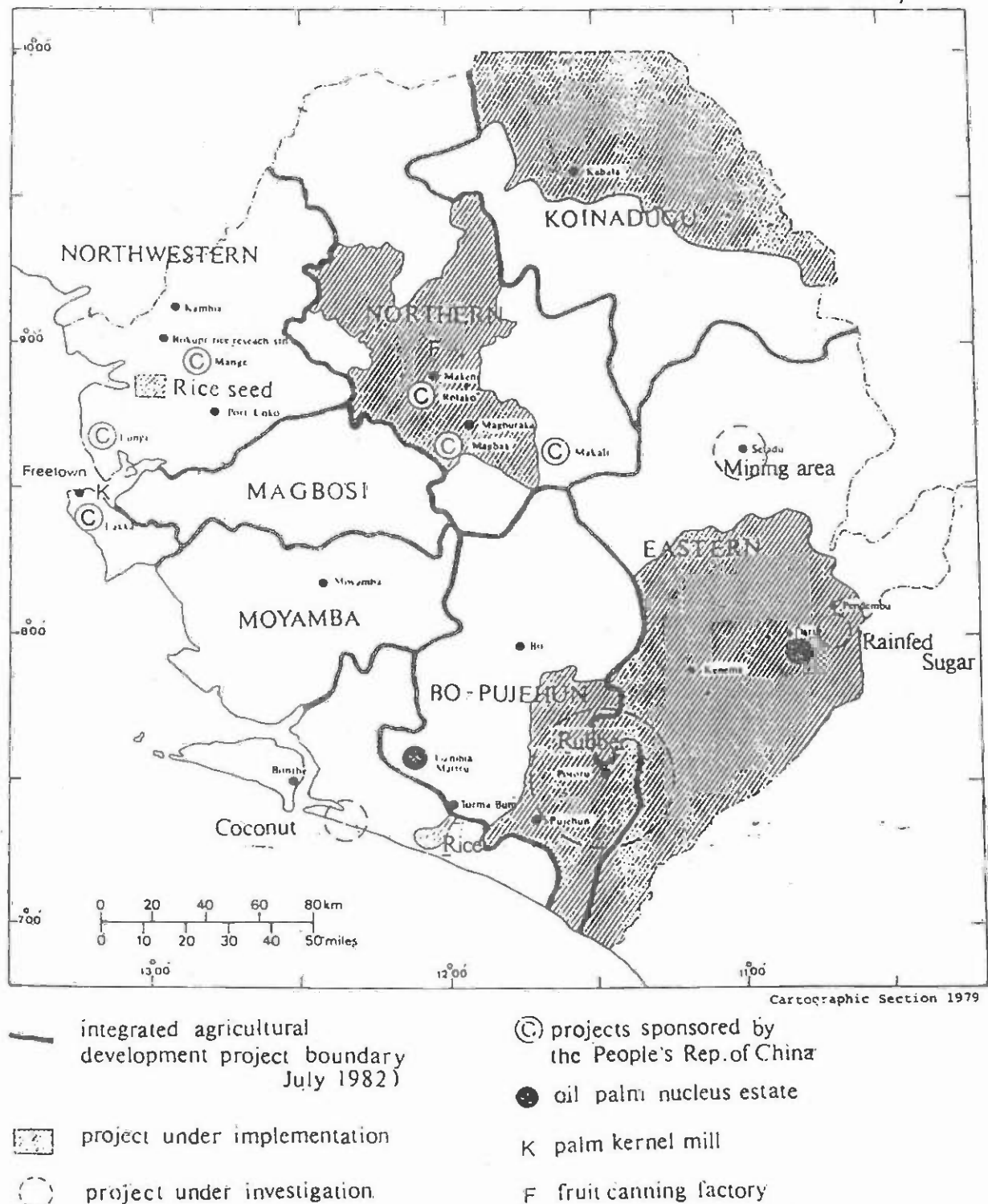


Figure 2/1. Sierra Leone, showing the principal agricultural development projects (after FAO/UNDP, 1979a).

INTEGRATED
RURAL DEVELOPMENT PROJECT
EASTERN PROVINCE, SIERRA LEONE

1. Physical and Socio-Economic Environment

The area concerned in this project covers about 11 000 km² in southeastern Sierra Leone, between 6°58' and 8°22' North latitude and 10°37' and 11°53' West longitude. Administratively, it comprises 23 chiefdoms in Eastern Province (on which the bulk of this report will be concentrated) and 9 in Southern Province.

Physiographically the project area in Eastern Province consists of three regions: the major part belongs to the coastal plains, which are locally dissected by hill ranges, while in the north and northeast the area belongs to the plateau region. The undulating plains at 100-300 m altitude consist of granite and acid gneiss and are locally intersected by hill ranges of granite. Local remnant ridges of basic and ultrabasic rocks also occur (e.g. the Kambui hills). A major river, the Moa, drains the plateau in a southwesterly direction. Another important geological feature is the local presence of diamonds, which are primarily mined in Kono and Kenema districts.

The soils which developed in the region are primarily gravelly ferralitic soils (orthic ferralsols associated with humic or ferric acrisols and ferralic cambisols). The normal texture is sandy loam to sandy clay loam with a high gravel content. The soil pH is generally around 5.0. The soils are usually well-drained, with about 2-3% organic C in the topsoil and a low nutrient status (cation exchange capacity 8-9 meq 0/00, base saturation about 25%). In the numerous swamps in the valleys, undifferentiated hydromorphic soils are present. On the hill ranges of basic rocks, shallow and very gravelly ferralitic soils (humic or ferric acrisols and orthic or humic ferralsols) have developed;

they consist of loam to clay loam, are well-drained, with a pH of about 5.5. Their carbon content is low (about 1.5% organic C in the topsoil), and they have a somewhat better nutrient status than the plateau soils (CEC 12 o/oo, base saturation 29%).

The average annual rainfall in the area varies from 2500 to 3000 mm; most rainfall is concentrated in the May-December rainy season. Annual evaporation is normally about 1300 mm; on average, water deficits occur from January to March, with an average deficit of about 460 mm.

The average annual temperature is 26-27° C, with only minor monthly variations; maxima occur in February-April, and minima in July-August. Annual averages at Daru meteorological station are minimum: 21.2°; mean: 26.9°; maximum: 31.9°. The relative humidity is high, often reaching 70-90%; only in the dry season, and especially during the northerly harmattan winds, may it fall to the 50-80% range.

The natural vegetation is characterized by a typical association of several types, resulting from the dominant agricultural system of shifting cultivation, which has led to an intricate mosaic of annual crops, grassland, thicket and regrowth forest, with localized areas of closed forest. Several stages of dense forest regrowth dominate; these farm bushes, of varying ages, are the first stage of forest recovery after removal of the high forest and agricultural use. Typically they consist of small trees (up to 10 m tall) and shrubs of fast-growing, and often relatively fire-resistant, species, such as Parkia biglobosa, Elaeis guineensis, Antiaris africana and Chlorophora regia, while thicket species such as Lantana camara, Cissus afzelli, Abrus precatorius, Clematis grandiflora and Scleria bovinii are also prevalent.

Closed high forest and secondary forest with trees 10-30 m tall and more are generally found only in the hills

and the forest reserves. Typical species in the evergreen to semi-deciduous high forest are Afzelia africana, Lophira alata, Heritiera utilis, Erythrophleum ivorensis and Piptadeniastrum africanum, and in the secondary forest Musanga cecropioides, Carapa procera and Myrianthus arboreus. The secondary forest species are often associated with such tree crops as coffee and cocoa, which are cultivated under their shade.

About 10% of the land consists of narrow, flat-bottomed inland valley swamps, typically flooded during 3-6 months of the year; they average 8 ha in size, although some may reach 80 ha. Their natural, generally dense, vegetation is dominated by sedge grasses and raphia palm, and this has resulted in a relatively fertile soil with a thick humic topsoil, although the subsoils are generally less fertile. Part of the swamps have been cleared for swamp rice cultivation, and rice is also the most important crop in upland cultivation, often together with cassava, groundnut, maize and other cereals and vegetables.

Land use data published by IDA (1975) reflect the agricultural system prevalent in Eastern Province: of a total area of 19 244 km², 7% were under forest reserves or protected forest, 5.9% under upland annual crops, 1.2% under swamp cultivation, 5.7% under tree crops, and 80.2% under fallow, etc.

The average population density in Eastern Province was 50 persons/km² in 1974; in the project area itself it was 43 persons/km². Population in the province increased by 43% from 1963 to 1974, much of the increase being reflected in urban migration: the population of Koidu, the main town in Kono district, increased by 428%, as young men in particular migrated to the mining areas. For the province as a whole, 78% of the farmers have agriculture as their sole activity, while 22% have additional part-time off-farm activities.

Normally, farm sizes vary between 0.8 and 4.5 ha, with an average, in Eastern Province, of about 2.1 ha, of which 0.8-1.2 ha are under upland rice cultivation. Between 30 and 40% of the farms include swamp rice plots of 0.4 to 1.2 ha, and the total land area, including fallows, available to the average farmer is 16.4 ha (IDA, 1975).

Generally speaking, areas planted in coffee and cocoa exceed those planted in rice; in one village of 880 inhabitants whose total land covered 804 ha, Hammons (1974) reports 135 ha of coffee and cocoa against 78 ha of upland rice and 56 ha of swamp rice. The median size of coffee plots was 11.8 ha and of cocoa plots 1.0 ha.

In recent years there has been a general trend to increase farm sizes, under the combined effect of increased dependency ratios, increased plantings of commercial crops, especially tree crops, and greater compulsory contributions of food gifts for social occasions as large families break up into smaller households. The effect of population growth on increased farm size has however been limited, owing to migration (Johnny, 1979; Binns, 1982). There are local differences in land availability: Hammons (1974) reports no vacant land available in his study area, while Binns (1982) found in his district that farmers could still obtain sufficient land to expand cultivation.

Agricultural land is usually owned by extended families or the community and is allocated by the local headman. Normally, land cannot be sold, since it is conceived as belonging to all members of the community, even the unborn. Permanent cultivation rights are however recognized to family members who habitually cultivate particular swamp areas, or for land under tree crops. Persons without blood relations within the extended family can "beg" a piece of land, and be granted it in return for a small token payment, in cash or in kind, as acknowledgement of the the family's ownership rights, but such grants are generally for short

terms and cannot be inherited, except that when authorization has been granted to plant tree crops, ownership rights thereto may be inherited. At times, holders of land may pledge usufruct as security for cash loans, and the government is encouraging the privatization of land as a means of allowing farmers to obtain assets for mortgage purposes (Johnny, 1979).

Tribal secret societies are the focus of much community, economic, political and social decision-making, and their ceremonies form an integral part of the calendar of farm activities (Johnny, 1979). Another cultural feature affecting land use is the fact that members of a community are restricted to the village area after nightfall, so that the land effectively available to the village is that within one day's walking distance from the village (Hammons, 1974).

Local cooperative savings groups offering interest-free loans and facilitating savings for old age have developed in certain areas (Johnny, 1979), but money-lenders are generally large farmers with additional cash earnings from off-farm employment: trade, blacksmithing, diamond mining, etc.

2. Former Traditional Agricultural System

Before the inception of the project, the prevalent agricultural system consisted of sedentary shifting cultivation (1), with upland rice as the main crop. For most farmers, the upland rice plot is the most important unit of his farm: 64% of all farmers grow the rice, on plots averaging 1.3 ha. For a total average labour input of about 210

(1) Locally, the term "bush fallow" is used, but since the average cropping period is 1.65 year and the average fallow period 8.8 years, it is better to characterize the system as shifting cultivation than as a fallow system, as the terms are defined by Ruthenberg (1980).

man-days/ha, 157 are provided by family labour, 6 by cooperative labour and 47 by hired labour (Johnny, 1979).

New sites to be cropped are selected soon after the preceding harvest; the age of the bush is the most important criterion. While in one survey of 138 farms the length of fallow ranged from 3 to 15 years, on 81 the range was 5-7 years (FAO/UNDP, 1980).

In clearing the site, most trees and shrubs are cut at about 1 m above the ground; large trees and economically useful species providing fruit, twine or building material (e.g. oil palm, Ceiba pentandra, etc.) are preserved, and stumps are left to assist regeneration during the fallow. Three to four weeks after cutting, the vegetation has dried sufficiently to be fired; this is normally done in common, adjacent plots being fired simultaneously. Where there is a market for fuelwood, unburned wood may be sold.

Seeds are generally saved from the preceding year, but for important crops such as rice, some may also be purchased. Cassava is often the first crop planted, because it can withstand a dry period after planting. Following this, short- and long- duration rice varieties are sown broadcast, the seeds usually being mixed with smaller amounts of other cereals: sorghum, millet or maize, and vegetables: okra, peppers, cucumber, tomatoes, pumpkin, etc. The soil is then hoed lightly to cover the seeds, and additional crops, likely otherwise to be disturbed by hoeing (yams, beans, etc.) may also be planted. Thus, on the upland rice fields, from 6 to as many as 20 secondary food crops may also be present.

Little weeding is reported necessary if fallow periods have been sufficiently long and cropping is mixed, but as the fallow period tends to become shorter, the weed problem is becoming more acute. According to Johnny (1979), farmers report a crop loss of 40% if no weeding has taken place.

and 10% if it has been late.

Some pest control is necessary, the principal pests being rats, birds and monkeys. Fences are built against rats, while children are used to frighten birds away. Damage by monkeys has increased recently, with the disappearance of mature forests containing food trees for the animals.

In general, phased planting and the use of crop varieties with different maturity periods serve to prolong the harvesting period and to alleviate the labour shortage during this crucial period, but hired labour is still an important input during the operation.

Traditionally, fields were cropped for only one year, but cultivation is being extended gradually into a second year: it was recently reported (FAO/UNDP, 1980) that only 28% of the farmers still used only one cropping season. Cassava was the main second-year crop, followed by groundnut and tree crops; rice was cultivated by only 2% of farmers during a second year.

Swamp rice cultivation takes only second place to the cultivation of upland rice, owing to a number of factors: difficulties in the initial clearing of swamp vegetation, consumer preference for upland rice, unhealthy working conditions in the swamps, and the social value attached to upland farming (FAO/UNDP, 1979a; Johnny, 1979). However, decreased land availability, combined with government pressure to increase swamp rice production, cultivation has gradually expanded, especially in swamp areas easily reclaimed by hand methods. About 37% of farmers are engaged in swamp rice cultivation; plot sizes average 0.56 ha.

Under traditional cultivation methods, swamps are partially cleared, and one year of cultivation is followed by 1-2 years of fallow. Normally, one or two crops are grown, in monoculture, depending on the degree of flooding

and drainage. In some areas, the rice crop may be followed by a short-cycle cash crop, such as groundnut, sweet potatoes or vegetables. Inputs are limited to labour, and only rudimentary water-control measures are applied. Even under these conditions, however, swamp rice cultivation is more labour-intensive than upland rice, requiring an average of 405 man-days/ha as against 210 for upland rice (Johnny, 1979).

In some districts, more than 50% of the farmers grow coffee, generally as a cash crop. On slopes, coffee has replaced cocoa, because of its less exacting soil requirements. Average coffee plot size is about 1.65 ha. Usually, coffee is planted only after a fallow period of at least 15 years, allowing for proper physical and chemical conditions of the soil as well as the presence of large secondary tree species to provide shade. Robusta bushes are generally not regularly spaced; mixed cropping is the rule, and over 20 crops may be used. Some plantations are reported to suffer from excessive shade, while vines and creepers occasionally cover trees. Little attention is paid to such cultivation techniques as brushing, pruning and fertilizing. On fields with scattered trees, only about 37% are of bearing age. Harvesting and processing techniques are also reported to be very simple and not geared toward obtaining a good-quality product (Gunawardene, 1970; Hammons, 1974).

Cocoa is also produced on individually-owned small-holdings with an average size of 1.9 ha. Its higher soil requirements limit its potential growth area in eastern Sierra Leone to about 46 000 ha; about 21% of the farmers in the area grow cocoa.

Like coffee, cocoa is planted on soils previously covered by high or secondary forest. The trees are usually cut in March or April, some tall trees being preserved for shade. After burning, cocoa is planted with the onset of the July-September rains; the soil is loosened with cut-

lasses, and the plants are seeded directly at a spacing of 1.20-1.80 m. Often two or three seeds are planted together, and since only little pruning and training take place, this results in over-stocked stands, especially when more than one seed in a hole germinates. On over 50% of the holdings, cocoa is mixed with such other plantation crops as coffee or kola. Shade is often rather dense. Underbrushing may be carried out once or twice, if family labour is available. Such techniques as fertilization, weeding and pest and disease control are rarely applied; stand density and absence of disease control often lead to outbreaks of such diseases as black pod (Gunawardene, 1970).

Oil palm may occur in fallow lands at a density of 25-50 trees/ha. In addition to yielding kernels for export, the tree also provides several locally-used products: palm oil (a primary item in the diet) and palm wine; its wood and timber may also be used (Hammons, 1974).

The raffia palm, which grows in swamps, is sometimes harvested by stripping its trunk. Other tree crops commonly grown near homesteads include kola, citrus and bananas; these crops cover about 3.6% of the total farming area. Rubber is cultivated on a limited scale in one district.

In the country as a whole, about 285 000 ha of forest are constituted reserves under the protection and control of the Forest Administration: another 34 000 ha are proposed for incorporation into the reserve, and a further 14 000 ha are protected forest on chieftom lands administered by the authorities. During the period 1976-1980, the deforestation rate was about 4 000 ha/year, while 1 400 ha of unproductive swamp and mangrove forest was cleared for official swamp cultivation projects (Kerhan, 1980).

Forest plantations, whose establishment began in 1930-1940, generally take the form of protective strips of 100-200 m along forest reserves. Their total area is 3 770 ha,

and they consist mainly of Gmelina arborea, Terminalia spp., Tectona grandis, Cassia siamea and Pinus caribea. The taungya system was often adopted during establishment, as a means of reducing costs. Between the young trees, spaced at 2.5 x 2.5 to 4.5 x 4.5 m, rice was usually intercropped, together with such crops as maize, guinea corn and cassava; agricultural cropping under taungya was usually authorized for two, and sometimes three, years.

The main produce of the reserved forests is construction and industrial wood, the former in particular being in short supply for the local population. Forests are less important as a source of fuelwood, which is usually obtained from the bush fallow areas in adequate quantities.

3. Description of the Project

The Integrated Agricultural Development Project originated in an FAO/UNDP project which published a 10-year agricultural development plan for Sierra Leone in 1970. The plan, incorporated into the country's first National Development Plan in 1974, placed primary emphasis on achieving self-sufficiency in staple food crops, especially rice, and a diversification of agriculture in general by expanding of production of export crops and import substitution, by strengthening the extension service, moving away from mechanical cultivation, creating a more effective system of agricultural input supply and initiating a series of integrated agricultural development projects (Binns, 1982).

The first of these projects, financed jointly by the International Development Association (IDA) and the government, was initiated in 1972, with the objective of improving the agricultural income of some 2500 farm families. Its basic premiss was that the agricultural activities with the best development potential were, in particular, oil palm, cocoa and swamp rice cultivation, and the main constraints to be overcome were the low level of technology

used by traditional farmers, the limited availability of key inputs (credit, fertilizers, pesticides and improved seeds), the low level of extension services and processing and marketing uncertainties (Binns, 1977; Airey, 1978). These constraints were to be overcome by providing an integrated package involving the introduction of new technologies, intensive extension services linked with farmer training and the integration of production with processing and marketing facilities. The basic components of the project were as follows:

- to provide smallholders with credit for costs of labour, pesticides, fertilizers and improved high-yielding varieties, to assist them in clearing 2 400 ha of inland swamp for rice production and to plant 300 ha of cocoa and 652 ha of oil palm;
- to train project farmers in efficient rice, cocoa and oil palm production techniques;
- to construct 20 small rice-mills;
- to complete the establishment of an 800-ha nucleus oil palm plantation by planting 204 ha and constructing a palm-oil mill to service the estate and associated smallholder plantations;
- to provide and supervise inputs and extension services at all stages;
- to improve feeder roads and bridges in the area, in order to facilitate access for extension officers, supplies of inputs and the transport of products for the market (ibid.).

In 1975, this first-stage project was followed by a second stage, whose activities were planned to include the following (IDA, 1975):

- the construction of 12 market centres, with housing, warehouses and offices;
- providing credit and extension to expand modern farming techniques to 2 400 ha of swamp rice cultivation and to improve upland rice farming on 1 400 ha;
- to establish 400 ha of cocoa and 640 ha of oil palm

plantations;

- to stimulate and improve development of seed multiplication farms;
- to establish a farm credit company for institutionalization of credit services;
- to establish a project evaluation and servicing unit.

Upland rice farming, excluded from the first stage, was included in the second, in recognition of the fact that it was the most important element in the entire farming system, representing tradition, security and a proved source of income, and of the fact that no effective rice programme aimed at meeting domestic demand could afford to neglect the situation that by far the largest share of cultivated land was devoted to upland rice production (IDA, 1975). While the principal activity proposed for upland rice production was the introduction of improved varieties, the appraisal of the second phase recognized that the constraints in this respect had been largely unresolved.

For swamp cultivation a much wider variety of measures was introduced in the second stage (IDA, 1975; Binns, 1977):

- encouragement of cooperative approaches to developing the swamps as a whole, to permit economies of scale in farm input supplies and credit administration;
- improved water control, providing adequate drainage systems, preventing flood damage and conserving water for irrigation. The techniques mainly employed were the establishment of irrigation channels and bunds, which have the additional advantage of reducing rodent attacks;
- use of wet nurseries to increase germination rates;
- introduction of new high-yielding varieties;
- providing fertilizers and spraying against attacks by stem-borers;
- stimulation of double-cropping through investigation of dry-season crop production.

The farmers to participate in these activities were selected by extension officers through the hierarchy of local chiefs to receive short-course training at demonstration farms. Selected farmers received further training to become agricultural demonstrators in their respective chiefdoms.

For improved tree-cropping, seedlings of new clones (e.g. dwarf oil palm varieties), raised in project-supervised nurseries, were distributed, together with fertilizers and pesticides. Participation in this scheme was limited to smallholders, who were authorized to plant a maximum of 4 ha. For oil palm, the government nucleus estate served as an example and market outlet.

To enable farmers to obtain funds for the necessary inputs, two types of credits were available: development loans, to cover land development and initial planting costs, and seasonal loans to cover current operating costs. Loans could be repaid in kind (Binns, 1977). For efficient marketing, use was to be made of the two existing national marketing organizations (for rice and tree crops respectively), while for the marketing of oil palm a new independent company was established. The stimulation of rice marketing through the creation of new rice mills was found unnecessary, in view of the existence of adequate private mills, and this proposed activity was therefore abandoned (Airey, 1978).

The performance of the projects in Eastern Province have been assessed by Binns (1977, 1982), Airey (1978) and Airey et al. (1979). Their analyses, based essentially on the outcome of the first phase, recognize generally that some considerable successes had been achieved and that the project had provided worthwhile basic guidelines and experience for subsequent integrated projects. Especially commendable (Binns, 1977) were the following aspects:

- a) The project's organization was based upon a good appreciation of the relationship between traditional food production systems and the ecological, economic and socio-cultural features of the area, collected by detailed feasibility studies. This knowledge made it possible to avoid the error of attempting to upset the balance of traditional food production by such means as forced resettlement.
- b) The project had encouraged simple, easily-adopted methods of swamp cultivation rather than mechanical techniques.
- c) A dedicated extension service had been created and had won the confidence of the local farmers.
- d) In general, the project had demonstrated that yields can be increased considerably through the supervised adoption of new cultivation techniques.

On the other hand, the assessments were more critical with regard to the over-all objectives of the project and the means employed with a view to attaining them (Airey, 1978; Airey et al., 1979; Binns, 1982).

- a) Despite farmer preference for upland farming, project emphasis, particularly in the first phase, had been mainly directed to swamp rice and tree crop cultivation. Emphasis on swamp cultivation was not only culturally, but also economically, inappropriate, labour input requirements being very high in the early stages and likely to cause difficulties for farmers desiring to continue upland farming while developing a swamp. Since conversion to swamp cultivation may be the only alternative where land availability creates problems, it might be worth while to limit efforts for swamp cultivation to areas which already have a perceived pressure on uplands (Airey, 1978).
- b) Emphasis on swamp rice cultivation had been justified partly on assumed yield differences between upland and swamp rice cultivation; recent and more reliable data

had provided much higher yield figures for upland rice. A further conceptual error in this respect lay in the fact that no heed had been paid to the much higher total yields of upland farming due to mixed cropping.

- c) Stimulating commercial oil palm cultivation in one of the more densely populated chiefdoms was a questionable approach, especially since the establishment of the nucleus estate had required the alienation of estate land, causing local discontent. Elsewhere, the establishment of outgrower plantations near the villages had created the need for considerably greater walking distances to the remaining upland rice fields (Airey, 1978). Finally, initial producer prices fixed for oil-palm bunches by the mill set up by the project had been too low, but this discrepancy had been overcome subsequently.
- d) At the farm level, the project provided technical assistance only for the "package" of project crops (especially oil palm, cocoa and swamp rice), and no attention had been paid to the two major existing cropping systems: multiple cropping on upland fields and coffee cultivation (Airey *et al.*, 1979).
- e) During the first four years of the project only 2609 farmers -- 1.5% of the total rural population -- were trained, and this limited result was inherent in the intensive nature of project activities. Thus, to be eligible to receive credit, farmers were required to possess guaranteed rights to at least 1.2 ha of swamp land and have adequate rights of use of the land for at least the period necessary to ensure repayment of the loan (Binns, 1977). This emphasis on clearly designated areas and elements excluded a large proportion of the farm population, especially newcomers. As other government institutions had not attained the high standards of the project, for these excluded farmers few opportunities for assistance were available. The gap between project performance and that of parallel organizations also raised the question of what would happen as

the project loses its independent status.

- f) In general, the level and depth of understanding of the rural communities in which the project was based was open to question. In particular, a real understanding of the dynamic nature of the existing agricultural systems and their management appeared to be lacking, and insufficient attention had been given to the possibility of relating project activities to the processes of spontaneous change (Binns, 1982).

4. Analysis

The project was one of the first test cases of an inductive approach to integrated rural development, typified by the following sequence of events (Airey, 1978):

- 1) Research and data collection on the rural environment to assess its readiness for change and development;
- 2) Identification of characteristics in the rural sector that either show signs of incipient development or appear to constrain the effectiveness of existing desirable trends;
- 3) Development of a comprehensive package of techniques and management expertise/skills designed to reinforce desired and inhibit undesirable changes.

The primary objective of the project, then, was not to develop alternatives to shifting cultivation as such, but rather to bring about general agricultural development as a means of stimulating rural development. As has been seen, the most promising systems with development potential were considered to be swamp rice cultivation and smallholder tree cropping, while improvements in upland cropping received little attention. Thus, two alternatives to shifting cultivation were implicit in the project: replacement of intermittent subsistence cultivation, mostly of annual crops, by permanent cultivation of perennial tree crops, and conversion to permanent annual cultivation on formerly uncultivated areas. However, these options were not specifically

put forward as alternatives to shifting cultivation but rather as a means of increasing agricultural production, and although the reports do not state the fact clearly, it would appear that these new cultivation practices most often took the form of additions to upland bush-fallow cultivation rather than of replacements for it.

The process of change was stimulated through various interventions, such as the introduction of improved cropping techniques, the supply of credit and other necessary inputs, and the establishment of an effective marketing system. However, changes in shifting cultivation took place not only as a result of these activities but also as a result of indigenous changes in agriculture, which also led to a gradual expansion of permanent cash-crop cultivation with trees but not to the expansion of swamp rice cultivation. This strategy arose from the gradual adaptation of the local farmers to the changed labour situation, increased needs for market products and increased opportunities for off-farm employment, providing cash for investment in agriculture.

The failure of swamp rice cultivation to expand spontaneously indicates the sensitive nature of the projected conversion from upland to swamp cultivation, and for that reason the differences between the two systems will be emphasized in the analysis below.

(a) Ecological stability. A number of features of the indigenous upland cultivation system act to ensure ecological stability:

- 1) Resilience to variable weather conditions is obtained by staggered planting, the use of rice varieties with differing maturing periods and by multiple cropping with crops having varying susceptibility to unfavourable conditions of climate. Thus, such crops as cassava, sweet potato and cocoyam are included as a possible emergency food supply, although they are not a basic staple food in the region (Johnny, 1979).

- 2) Resilience to pests, diseases and weeds is ensured by multiple cropping, since crops differ in their susceptibility to these threats: thus, birds and rats attack cereals, but not tubers.
- 3) The possibility of rapid development of a site-regenerating fallow vegetation is secured by suitable land preparation techniques, such as sparing useful natural trees and leaving high stumps for regeneration.

Multiple cropping also serves as protection against erosion (Cline-Cole, 1982), although under upland cultivation erosion can still be considerable. Interestingly, Johnny (1979) found that farmers preferred to cultivate steeper slopes, as producing higher yields; the difference has been attributed to the greater amounts of weatherable minerals on the steeper slopes.

Some favourable features gradually deteriorate as the result of apparently minor changes in the farming system. Thus, weeds became a greater problem as the fallow period was shortened, and damage by monkeys increased with the disappearance of natural forest. The decline of the length of fallow and the greater incidence of pests and weeds were three of the five principal constraints on upland farming perceived by the farmers (Johnny, 1979).

Swamp cultivation offers quite different attributes of ecological stability. Mono-cropping is dominant, and no phased planting is employed, but the geomorphological context of swamp areas is such that they are not highly susceptible to erosion. Flooding is an ecological hazard that can be controlled by proper water management techniques, which also reduce the drought hazard and provide protection against rodent attacks. Under mono-cropping, however, spraying against other pests and diseases is necessary.

The principal ecological constraint on swamp cultiva-

tion is related not to cultivation techniques but to the hazard to human health created by water-borne diseases. A secondary disadvantage is the loss of the varied diet ensured by the mixed cropping of vegetables with upland rice, impossible in swamp rice cultivation.

(b) Management resilience. For cultivation practices to be adopted, they must not be too impractical or complex, and they must be in a suitable relationship with other activities on the farm. In this regard, it must be noted that all the reports examined focussed not on the entire farming system but rather on specific aspects of cropping, so that the degree of combination of different techniques on individual farms is unclear.

In general, the farmers perceived the shortage of labour as their main management problem, especially during periods of peak activity, such as harvesting, although in traditional upland cultivation such peaks were to some extent levelled off through phased planting and the use of varieties with differing periods of maturity. The labour shortage has also led to several reactions such as cooperative labour arrangements and work groups and changes in the sex-related division of labour. The use of hired labour has also increased, especially near mining areas.

In swamp rice cultivation, labour is an even more severe constraint, especially during the first years, before the fields have been opened up and water control structures built. In addition, the labour calendar for swamp rice cultivation is more protracted, and phased planting is impossible, so that sharper labour peaks inevitably occur, especially for the harvest. In order to relieve some of the labour pressure during establishment, the project encouraged cooperative approaches.

Not only is modern swamp rice cultivation more labour-intensive, it also calls for an entire new set of management

techniques, which must be introduced from outside in the form of strong extension efforts and farmer training. Under the project, this effort was linked to the provision of credit facilities, with the result that only farmers with guaranteed cultivation rights were eligible. Only a selected group of farmers could be reached under this approach, because of the need for intensive supervision. The new management techniques were thus out of reach of most farmers, and only some of the techniques were gradually diffused.

(c) Production sustainability. No data are available to indicate whether yield levels were still being maintained under bush-fallow despite the gradual increase in cropping and the shortening fallow periods. Roberts (in FAO/UNDP, 1980) mentions upland rice yields of 780 kg/ha on lands lain fallow for more than 10 years falling to 540 kg/ha when fallow was reduced to 3-4 years; several reports indicate a critical period of 7-8 years, and on average this term is still respected. However, in the case under study, the development of alternatives to shifting cultivation appears to have taken place not in the context of the breakdown of this system, but of the perception of its inability to be improved in the service of rural development. Improved swamp rice production was perceived to be much more valuable in this regard, as with improved management techniques and high inputs, sustainable high production can be expected.

(d) Economic reliability. Data in IDA (1975) indicate that generally improved cultivation leads to increased returns both per unit area and per labour unit although, as noted above, these data are open to question: expected labour inputs and yields for upland cultivation seem very low in comparison with data collected in farm surveys, and no account is taken of hired labour, nor of yields of secondary crops. If these data are taken into account, returns per unit area and per labour unit are much higher for upland than for swamp cultivation, while if only rice yields are taken into account, swamp cultivation gives somewhat better

returns per unit area, but equal returns per labour unit. The results of these economic analyses differing, no final conclusion on the economic profitability of the different cultivation systems can be drawn, but the data do illustrate the great importance of the secondary crops in upland farming, often neglected in such analyses.

Capital inputs were low under traditional cultivation, and had to increase considerably under modern swamp cultivation. Traditionally, farmers had developed an extensive, rather than an intensive, cultivation system, since land was abundant and capital scarce, but as rural conditions are currently evolving, land is becoming scarcer, and the project endeavoured to assist by substituting capital for land through a credit scheme.

The need for few capital inputs under traditional cultivation results in a low economic risk for farmers. As greater capital inputs are required the economic risk increases, since the inputs are needed whether the crop succeeds or fails.

The position with regard to marketing is another important factor in judging the economic reliability of market-oriented improved cropping schemes, and marketing improvements can be a powerful stimulus for spontaneous adjustments in cropping systems. In recognition of this fact, the project stimulated marketing opportunities by improvements in communications (feeder roads) and the establishment of marketing organizations.

Importance of the tree component in the farming system

In traditional bush-fallow cultivation, trees played several roles: provision of products for subsistence and marketing, shade, site regeneration and energy production. In addition, construction wood for local requirements was often obtained from near-by protected forests.

Trees also had an important role to play in the alternative cropping systems introduced by the project, but the main emphasis in the tree-cropping schemes was directed at cash-crop production. Efforts were concentrated on oil palm and cocoa, and other useful species already used locally (coffee, cotton-tree, raffia palm, etc.) were neglected. Possible other roles of trees in the agricultural system, such as in environment management, were not considered, and their role in soil management was partially replaced by fertilizers. Nor does attention appear to have been paid to the possible role of trees in diversified subsistence production, including energy.

As stated above, it is not clear to what extent tree-crop production was intended to replace, or to supplement, bush-fallow cultivation. It is therefore difficult to assess the importance of having neglected the multi-purpose functions of trees. Under bush-fallow, fuelwood production is no problem, but this position may change when commercial crop cultivation is introduced, especially if no shade trees are maintained. Nor is it clear to what extent these tree plantations are still mixed with naturally-occurring useful tree species.

Once they reach full productivity, tree crops such as coffee and cocoa yield higher returns than rice cultivation, and farmer awareness of this fact is demonstrated by their spontaneous investment in tree crops of capital earned in mining. The credit provided by the project for tree-farming included only establishment costs, and not living costs during the non-productive period. No information is available as to whether intercropping with field crops during this period was permitted. If not, during the establishment phase, tree cropping must be supplemented by annual cultivation on other sites.

5. Conclusions

The Integrated Agricultural Development Project in the eastern part of Sierra Leone furnishes an example of outside intervention implying the gradual transformation of shifting cultivation into permanent annual and perennial cultivation. For annual cultivation, the main effort is directed to introducing new farming techniques on newly-opened swamplands, while perennial cultivation takes the form of tree cropping with modern techniques on the uplands. Some further efforts are also made to improve yields under the traditional bush-fallow system, but only by relatively limited means, primarily fertilization. This latter activity was undertaken because of the general importance of shifting cultivation, which not only covers the largest part of the country but is also closely related to the socio-cultural life style of the rural population.

The various project activities were based on extensive prior studies of the development constraints of traditional agriculture, to be overcome by an integrated package of services, such as extension and training of farmers in new farming techniques, supply of modern inputs and credit, and assistance in marketing. Little attention was given to the possible role of trees except in cash cropping.

One method of evaluating the suitability of these measures is to analyze the principal problems of farming as perceived by the farmers themselves and to relate project activities to processes of indigenous agricultural change. The main problems were the shortening fallow period, the incidence of pests and weeds, labour shortages and the lack of capital, coupled with high interest rates charged by traditional money-lenders; the main spontaneous agricultural change was the gradual development of the cash-cropping of vegetables and, later, tree crops. These processes could develop in response to relatively highly commercialized conditions near mining districts, where an expanding urban-

ized population needed farm products, improved marketing conditions and outlets in farming for the investment of off-farm income, all factors favouring cash-crop production. These developments ran parallel to the project's efforts to stimulate tree-crop production, provide ~~credit~~ and improve marketing facilities.

There was no specific project response to one of the major bottlenecks in traditional agriculture: the labour shortage.

Finally, it is questionable whether the development of swamp cultivation is appropriate under all conditions, or whether the effort should be concentrated in areas of relatively high population density exercising strong pressures on land availability.

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DEVELOPMENT
OF ECOLOGICAL METHODS
OF UPLAND FARMING
IN WEST USAMBARA MOUNTAINS,
TANZANIA

based on the work of

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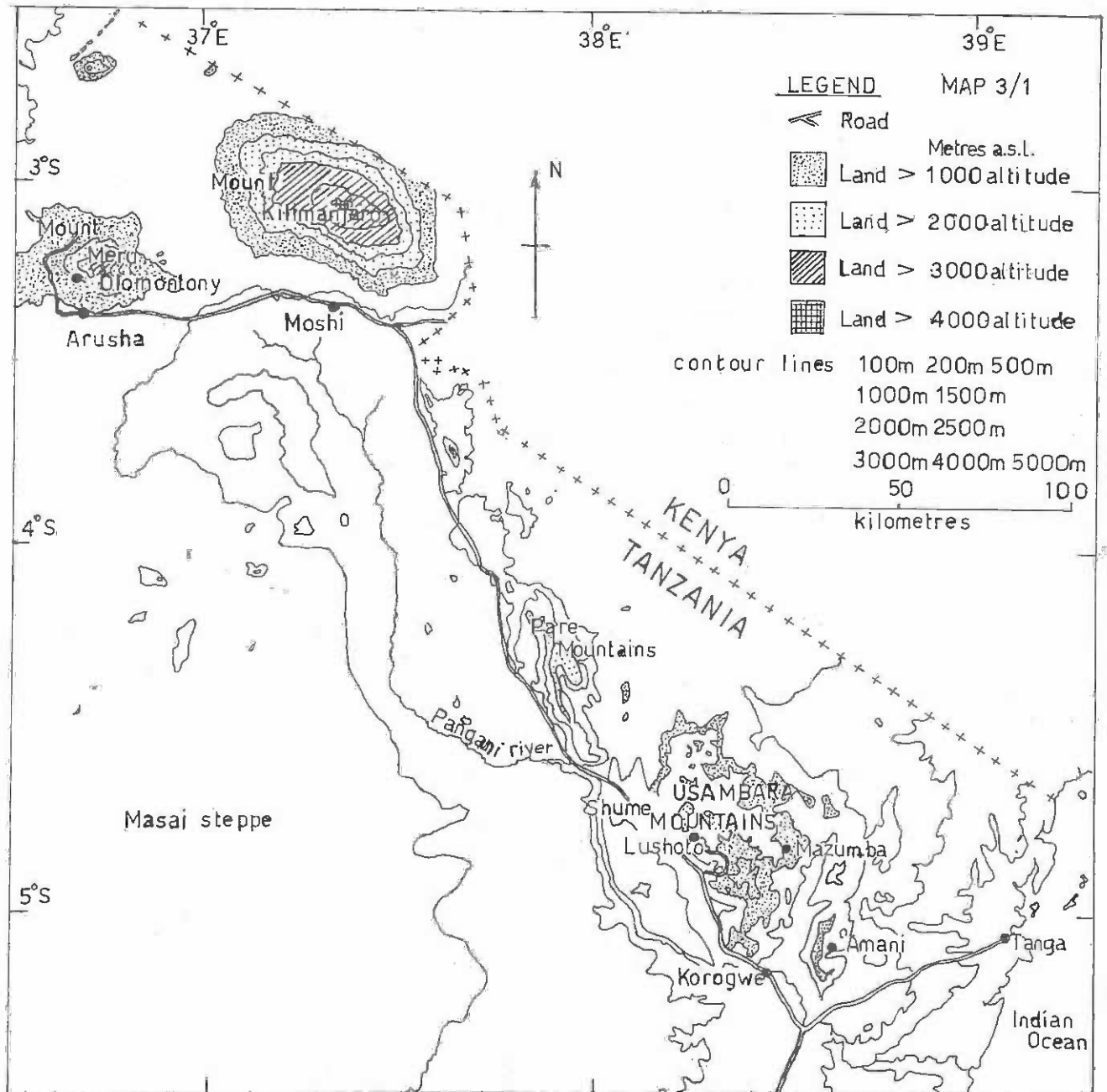


Figure 3/1. Northeastern Tanzania.

DEVELOPMENT OF ECOLOGICAL METHODS OF UPLAND FARMING IN WEST USAMBARA MOUNTAINS, TANZANIA

1. Physical and Socio-Economic Environment

The area discussed in this paper (see Fig. 3/1) is that of the West Usambara Mountains, the main block of the Usambaras, situated at about 5° South latitude and 38.5° East longitude in the Lushoto district of northeastern Tanzania. The West Usambaras consist of an uplifted block of highly folded, metamorphosed volcanic rocks, rising from the surrounding plains at approx. 600 m altitude; they have an irregular, eastward-sloping upper plateau at about 1300-1900 m, and a maximum altitude of 2300 m. Owing to the relatively recent uplift, there is considerable relief, with V-shaped valleys in fault-controlled troughs; the horst is bounded by steep escarpments. The principal rock types are gneisses, with varying amounts of pyroxene, hornblende and biotite.

The soils which developed from this parent material are generally latosols, humic ferralitic soils in the lower, wetter areas and humic ferrisols in the drier, cooler sectors; both are humic nitosols according to the FAO/UNESCO soil classification. They have a high clay and sand content but are low in silt; thanks to good aggregate formation, they are freely drained. Their colour is red to yellowish red, but the topsoil is darker, owing to the high organic-matter content of the original forest soils, which ensures a high cation exchange capacity but disintegrates quickly under cultivation. Under forest, the pH varies between 3 and 5, but under cultivation it may be higher. In the absence of organic matter, soil fertility is low.

The rainfall in the area generally exceeds 1000 mm per year, with a maximum of 2000 mm near the southern bor-

der of the area; rainfall diminishes toward the north and northeast. Important local variations occur, depending on exposure, as there are many rain-shadow areas on the northwest slopes. The area has a major rainy season in April-May, and a less distinct one in October-December; January-February and August-September are generally the driest months. The area usually has four months with a water surplus, which exceeds 300 mm; the deficit during the months when potential evaporation exceeds rainfall is less than 800 mm.

The mean annual temperature varies with altitude: at 500 m, it is in the 25-27° C range, while on the plateau at 1500-1800 m, the range is 17-18°.

The natural forest vegetation consisted of three main types: lowland forest below 750 m altitude, intermediate (submontane) evergreen forest -- the most luxuriant forest type of the region, with many endemic species -- from 750 to 1400 m, and highland evergreen forest above 1400 m. In the mountain area, which covers about 2000 km², this forest is currently restricted to about 340 km², parts of which have been transformed into industrial forest plantations, while another 160 km² are badly eroded. Consequently, only about 1500 km² are available for subsistence, commercial farming, grazing and settlements.

Based on environmental conditions and prevalent land use, five agro-economic zones can be distinguished:

- a highland area with maximal rainfall, where tea is gradually replacing coffee at altitudes above 1250 m, and the main food crops are maize, bananas and, to a lesser extent, cassava and beans;
- the west central zone, with irrigation in the valleys and high population density, where the main cash crops are coffee, vegetables and sometimes sugarcane, and the main food crop is maize;
- the high-altitude northwest zone, an area with poor infrastructure, where temperate fruits, vegetables and potatoes

are important cash crops but where subsistence farming of maize, cassava and beans is predominant;

- the most arid northeastern zone, where only subsistence farming of cassava, maize and beans, with some animal husbandry, is engaged in;

- the northwest central highland zone, with several forest reserves, relatively poor infrastructure, only local cultivation of fruits, potatoes, wattle and a little coffee as cash crops, accompanied by subsistence cropping of maize, beans, some cassava and a little banana.

In all zones, pastures, when available, are grazed intensively.

In 1900, the population of Lushoto district was estimated, perhaps too conservatively, at 15 000; by 1948, the figure had reached 127 500, implying a population growth rate in excess of 4.5%. (1) In the following decades, the growth rate has ranged from 2.1 to 3.2%, and the 1978 total population figure for the district was 286 000. Population density was 137 persons/km² in 1978; omitting forest reserves, steep escarpments, badly eroded land and other non-cultivable areas, the density attained 185 persons/km². These figures should be compared with the estimated "carrying capacity" of the district, established by Moore (in Heynen, 1974) at about 140 000. Understandably, there is heavy migration out of the district.

According to Attems (1967), the average farm size is 0.94 ha, but Heynen (1974) reports somewhat larger sizes and an average of 1.7 ha. Land is distributed unevenly, with about one third of the families owning two thirds of the land. On average, each farm is made up of three separate fields, about 35 minutes' walking distance from the house;

(1) Assuming a starting population of 30 000, population growth would have been a more reasonable 3% per year to reach the same figure.

it is considered advantageous to own as many separate plots as possible in order to distribute the risk of complete crop failure, resulting from having all the land on a single site. In addition to private plots, the farmers enjoy grazing rights on rather limited communal pastures.

In general, the road network in the mountains is reasonably satisfactory. There is one main all-weather road. Several minor roads cannot be used during prolonged rains, and in several mountain areas the roads are not sufficiently reliable to encourage the cultivation of perishable cash crops such as vegetables and tea, for which more dependable transport facilities are essential (Heynen, 1974).

2. Former Traditional Agricultural System

It is generally accepted that little shifting cultivation is left in Tanzania (Mnzava, 1980; Tiffen, 1982), although locally areas can be found where farmers still utilize fallow periods equal to or longer than the cropping period. In the past, however, shifting cultivation was a common technique of land use; it appears to have given way to semi-permanent cultivation around 1920, in response to a number of factors which will be discussed below. Indeed, little is known about how shifting cultivation in Tanzania actually operated, and it will therefore be more useful in the context of this study to examine the cropping practices of the Shambala, the principal tribe living in the Usambaras, whose agricultural system evolved out of shifting cultivation under outside pressures but with a minimum of outside intervention, and can therefore be considered an intermediate stage between traditional and modern.

The Shambala cultivate annual, biennial and permanent crops. The principal permanent crops are banana, coffee, tea above 1250 m, wattle trees (Acacia mearnsii), fruit trees and sugarcane, on about one third of their total cultivated area. Such field crops as maize, cassava, beans

and vegetables are grown on the remaining fields. Only 8% of the total farm area (12% of total arable land) is under a grass fallow of at least a year. Seasonal fallows are common during the short rainy season, but plots may also be cropped two or even three times a year; the average cropping intensity in the region is 134%.

Most traditional crops are cultivated under mixed-cropping systems, the most common of which are banana-coffee and maize-cassava; all the coffee and 62% of the maize are grown under such systems. Crop rotation is the rule: between cassava and maize, rotations and mixtures are systematically applied under which cassava serves to ensure the basis of nutrition, while the more uncertain yields of maize serve to maximize production. The exact system employed depends on the family's situation: cassava serves as the principal reserve crop, its importance increasing as holding sizes and family incomes decrease.

In contrast to the position in other parts of East Africa, the importance of the banana is declining in the Usambaras: only one third of the fields carry this crop, as against one half before 1918. This reduction is attributed to low yields resulting from the cool climate, low soil fertility, poor cultivation techniques and the preponderance of cooking varieties of bananas, less tasteful than maize or cassava (Attems, 1967).

Animal husbandry is no longer as important as in earlier years. According to Attems (1967), the average household owns 1.3 livestock units; Egger and Glaeser (1975) cite a figure about double that number. In addition to cattle, such smaller animals as goats, sheep and poultry are kept.

Farmers make use of local forests for collecting fuelwood in the form of dead branches and fallen trees. Fleuret and Fleuret (1978) report an average walking distance of one

hour's walk to collect fuelwood, and characterize this as relatively free access. The average fuelwood use of a small sample of households was 2.6 m³/person/year.

Traditionally, the timing of planting of the arable crops maize, beans and cassava is adjusted according to the alternating rainy seasons and the varying amounts of rain on different slopes. Once each year, the soils are cultivated deeply and thoroughly with hoes; after this, only superficial hoeing takes place, for weed control. Sowing or planting follows an irregular pattern. Mound cropping is used for sweet potato, but in general no ridging is applied for erosion control, perhaps (Attems, 1967) because of the unfavourable relation between the additional labour input and the short-term returns.

There is a well-defined order of priorities in cultivation: harvesting is given preference over planting, and planting over weeding. Consequently, weeding is performed only after harvesting and planting have been completed; this late weeding reduces yields, but on the other hand the weeds exercise a protective effect against erosion.

The techniques for growing vegetables (cabbage, onion, cauliflower, carrots, tomatoes, cucumber, etc.) are in sharp contrast with those for subsistence cropping. For vegetable growing, which started to expand in the 1950s, such techniques as terracing, fertilization with cow manure, clean-weeding, monoculture, raising of seedlings in nurseries and the use of commercial seeds are common practice, and irrigation is also often applied. It is significant that even when the same farmer grows cash and subsistence crops, he does not apply the modern techniques to the latter.

There are important variations in cropping patterns between villages. Heynen (1974) found that the ratio between food and cash crops increased from 1.8:1 to 4.5:1 depending on whether moisture availability was high, moderate or low,

while the percentage of cultivable land under maize and cassava rose respectively from 36 to 51% and from 11 to 20%.

Of the perennial crops, coffee is grown almost exclusively in mixed stands with banana, which are generally better cared for than pure banana stands. Coffee plants are usually mulched, bananas not. Coffee and tea plants are usually pruned poorly or not at all, and banana stems are rarely cut after the harvest. Consequently, single-stem cropping of coffee is the most common, and coffee stands are generally rather dense, with 1500 bushes/ha. The coffee suffers from "coffee berry disease", caused by a virus, making cultivation of this crop problematic (Egger and Glaeser, 1975).

Average yields of cassava and sweet potato are 6 t/ha, of maize 470-600 kg/ha, of beans 400-460 kg/ha, of banana 250 bunches/ha, and of coffee 250 kg/ha,

For the entire region, average gross income per household per year is 666 shillings (1) from cash crops, 846 from subsistence crops and 98 from animal husbandry, for a total average gross farm income of 1610 sh. (1630 sh./ha). Average inputs cost 65 sh./yr, and hired labour 50, leaving an average net farm income of 1490 sh, to which should be added an average of 385 sh. obtained from off-farm employment. As the degree of commercialization of agriculture is about 26%, the actual average net cash income per household is thus 968 sh. Important variations are however observed among households: 20% of families earn 50% of total family income and 60% only one fourth, differences due primarily to differences in the extent of cash cropping.

As can be inferred from the low degree of commercialization, most farm produce is consumed by the farm family

(1) US\$ 1 = 8.18 Tanzanian shillings (August 1980).

itself. A comparison of three villages published by Attems (1967) indicates clear differences in family calorie consumption related to the degree of commercialization and family income, but the trend is not an absolute one: where the cash cropping concerns coffee (a marginal crop in the area under current cultivation methods, the author points out), calorie intake decreases relatively to that obtained when vegetables constitute the primary cash crop. It thus appears that yields and proceeds from coffee are not high enough to enable the smallholders to purchase the necessary supplementary foodstuffs, whereas the higher-valued vegetable crops make this possible. For protein consumption, there are no noticeable differences among villages, vegetable protein being the essential source in all cases. Generally speaking, the nutrition situation in the area is far from satisfactory, and moderate malnutrition is common.

3. Description of the Project

As already stated, shifting cultivation in the Usambaras began to give way to semi-permanent and then to permanent cultivation around the turn of the century, in response to a number of factors. Primary among these was sharp growth in population, accompanied by an inevitable increase in demand for food for subsistence, leading to the introduction and generalization of cash cropping. At the same time, new and evolving government policies, whether of the earlier colonial powers or of governments of the newly-independent country, also profoundly influenced the traditional farming systems. In colonial times, lands were expropriated for the establishment of gazetted forests (some of which were placed under industrial forest plantations after 1950) and for coffee and tea plantations; this took place simultaneously with, or shortly before, infrastructural improvements facilitating trade and migration, and compulsory soil conservation programmes.

After Tanzania became independent, the so-called Arusha

declaration of 1967 defined a new land nationalization policy. Under this policy, the customary law of usufruct continued to apply in the villages, but the private ownership of land for speculative purposes was prohibited. No claim of private ownership could be put forward in respect of land not actively being used for production, and the communal exploitation of such land was encouraged.

In 1970 the government launched an extensive rural resettlement scheme, encouraging farmers to form communal ujamaa villages with a view to raising rural standards of living and agricultural production and developing local industries. This programme was accelerated in 1973, when about 200 small and medium farms were nationalized, but it had not yet had an important impact in the subject area at the time of the studies of the farming systems discussed in this paper.

Meanwhile, in 1964, the Max Planck Institute of the F.R.G. established a nutritional research institute in Lushoto, whose findings prompted the initiation of an experimental development programme in the area under the joint sponsorship of the Tanzanian government and the Kübel Foundation of the F.R.G. Because of its origins, the programme focussed to a great extent on health and nutritional services, but several non-medical activities were gradually developed when their importance was recognized; these included technical training and production improvement (metal and textile workshops, carpentry, etc.) and agricultural extension and marketing as well as such general rural development operations as improvement in the domestic water supply. This report will discuss only the agricultural activities of the programme, primarily on the basis of the description provided by Heynen (1974).

The Lushoto Integrated Development Project (LIDEP), in its agricultural aspects, placed its main emphasis on vegetable growing, for the following reasons:

- Vegetables were considered the crop best suited to develop a fundamental change in the utilization of the area's resource base, as it implies an intensive form of land use which can give high returns per unit of area and fairly good remuneration per unit of labour.
- With good management, year-round production of vegetables is possible in the area, providing producers a regular cash income throughout the year.
- The high profits obtained through vegetable production can encourage the farmers to improve their agricultural techniques in general, and further to intensify land use. It was pointed out that the areas of the Usambaras with the highest population densities were also the most prosperous, owing to the prevalence of vegetable growing in those areas.
- It was expected that vegetable growing would diversify and improve the local diet, as the population would consume at least that part of the produce which was unmarketable.

Activities under the vegetable scheme, initiated in 1969, consisted of the following:

- a) training of key farmers to become extension workers in modern production techniques, e.g. monoculture and the use of improved seeds, application of manure or artificial fertilizers and pesticides, and clean-weeding;
- b) gradual introduction of crop diversification;
- c) distribution of quality seeds;
- d) improvement of marketing facilities by collecting, grading and transporting produce to major markets outside the region. At the outset, the project called on local traders, but later it engaged in marketing directly;
- e) organization of these activities in cooperative production and marketing groups in order to obtain economies of scale in production and collection. In line with government policy, communal vegetable growing was encouraged; generally it was engaged in on a voluntary basis;

in a few cases in which communalization was stimulated by more forceful approaches, this had a negative effect; f) to a much lesser extent, attention was also given to terracing, strip-cropping and mulching, improvement of irrigation networks and improvement of animal husbandry, including stall-feeding.

Although the project met with a number of difficulties (temporary surpluses, transport breakdowns, competition from local traders, poor performance in some villages, marketing difficulties as production expanded, and increased marketing costs as the volume of sales increased, etc.), it was well received in general. In 1974 a total of 90 production groups, with a total membership of 3000, were participating, and producing about 150 t of vegetables per month. The project succeeded in raising production on existing fields and in increasing areas planted under vegetables: in a sample survey of 80 farmers, it was found that the area of vegetable cultivation had increased by 83% between 1967 and 1971, with the result that locally it was labour rather than land that became the limiting factor (Heynen, 1974). Further, the project stimulated general interest in vegetable growing in the area, and other individuals and (commercial) organizations followed the example it had set. Thus, LIDEP was directly responsible for only about 10% of the area's total vegetable production.

The general success of the project was such that in 1973 the government issued a directive making the project responsible, through its newly-formed Usambara Agricultural Cooperative, for the marketing of all vegetable production in the Lushoto district.

In 1974, Egger and Glaeser (1975) carried out an independent evaluation of the agricultural activities of LIDEP on behalf of the Kübel Foundation. Their study represents a critical evaluation of the modern, high-input technology adopted under the project, as related to traditional culti-

vation techniques. The principal arguments put forward in the report can be summarized as follows:

1. High-input agricultural practices such as those adopted for LIDEP are based on methods in use in the developed countries and are often unsuitable for application in developing areas. They create an increased dependence on market situations, in terms both of obtaining the necessary inputs and of selling produce. Under this form of agriculture, labour is replaced by capital, and this is frequently illogical in heavily populated regions lacking capital, and especially foreign exchange. Furthermore, the cultivation techniques called for are very likely to cause ecological deterioration of the land if the proper inputs are not used: selected high-yielding varieties grown in monoculture render the crops susceptible to pests and diseases, while clean-weeding increases the danger of erosion if no labour-consuming terraces are built. Finally, the fertility and physical characteristics of the soil may easily be degraded by the lack of sufficient organic inputs or improper fertilizer use.

2. The positive aspects of traditional cultivation techniques are often lost sight of in development projects. The current indigenous techniques of cultivation should not be regarded as a simple continuation of the original methods of shifting cultivation at a time when changing conditions have led to semi-permanent cultivation with subsequent low yields and site deterioration. Rather, they should be looked upon as a continuing improvement in, or adaptation of, the earlier shifting cultivation practices, adjusted to the requirements of semi-permanent cultivation without external help. These methods are based upon sound ecological principles: mixed cultures, providing many different types of products, thus spreading the risk of pests and diseases; maintenance of a humus layer by an almost permanent soil cover of weeds and by mulching; and the use of robust, resistant varieties. Valuable adaptations to

local conditions are also displayed by the exercise of care in selecting suitable plots and rainy seasons for cultivation, and the spreading of risk by differential rotations of maize and cassava. Some farmers are still attempting to maintain continuity in their adjustment of traditional systems, and this tendency should be encouraged.

Although the authors agree that vegetable growing was initially emphasized as a means of improving the local diet, the traditional subsistence farmers being unable to afford them, they recommend a change in the strategy of the project, so that more attention be given to ecological farming methods developed out of the traditional system. Under the prevalent conditions of limited land and capital, the thrust should be on supplementing, rather than replacing, subsistence farming with cash cropping, and this could be achieved by coordinating vegetable, fruit and animal production with subsistence cropping, and by improving irrigation. Such activities could well be integrated into the political objectives of the government: the ujamaa villages could play an essential role in these development efforts by facilitating land consolidation. This in turn would offer an economic advantage over the scattered plots, whose function as spreaders of risks would not be necessary if large communal holdings, which would also facilitate animal husbandry, were available. Finally, the execution of irrigation works and some necessary terracing could also be better implemented as a communal activity than by individual farmers.

In addition to this change of emphasis in agricultural activities, more attention should be paid to the need to create off-farm employment, for which the necessary capital might be obtained through cooperatives.

Based on the recommendations of Egger and Glaeser, a pilot project was initiated within LIDEP in 1975, with the following characteristics (Glaeser, 1977): shade trees in the fields; strips of deep-rooting Guatemala grass along

contours to provide fodder and protect against erosion; mixed cultivation to take advantage of differing ripening periods, plant heights and fertilizer requirements; crop rotation; mulching and composting; and reduced weeding. This project was turned over to the national authorities in 1976.

Two years later, a new German-assisted soil erosion control and afforestation project was initiated in the West Usambaras within the framework of the Tanga Integrated Rural Development Programme (TIRDEP); it became operational in 1981. Its over-all long-term objective is the improvement of both economic and ecological conditions; its main activities, as envisaged, are the following (GTZ, pers. comm.):

- a) Crop diversification through "ecofarming" techniques such as contour planting and the establishment of protective strips with grasses, legume bushes for fodder, and trees for fodder, fuelwood and timber; integration of animal husbandry and manure utilization; controlled weeding, and mulching of fields with crop residues and weeds; intercropping and crop rotation; and regular fallow periods.
- b) Introduction of tree-based farming systems on marginal and eroded lands, currently used in general for communal grazing. These systems involve planting mixed stands for fodder, wood production and soil conservation, and both pure and mixed stands for the two latter purposes.

4. Analysis

The trends in land use in the West Usambara Mountains as described above illustrate a long-term process of agricultural development, having as its starting point an original shifting cultivation system. The process took place under a double pressure:

- increased demand due to population growth led to indigenous adaptive strategies under which the farmers, over decades, gradually replaced shifting cultivation tech-

- niques by (semi-)permanent cultivation techniques;
- outside intervention through government programmes which, over roughly the same period, placed primary emphasis on, and sometimes enforced, erosion control measures, the development of cash-crop vegetable farming, and ecological cultivation methods integrating cash-crop and subsistence farming.

The process of change was directed not only toward cropping techniques but also toward such economic activities as increased off-farm employment, partly outside the area; planned migration to other areas; and encouragement of communal activities. The reports studied focussed little on the relationship between on-farm development and the creation of off-farm labour opportunities, although both the LIDEP and the TIRDEP programmes sought to develop both agricultural and off-farm activities.

(a) Ecological stability. In their descriptions of the indigenous cultivation systems which evolved out of shifting cultivation both Attems (1967) and Egger and Glaeser (1975) indicate various features ensuring ecological stability:

- Resilience to variable weather conditions was obtained by the differential cultivation of plots in different rainy seasons and by adapting the maize/cassava rotation to ensure a basic food supply. Moreover, irrigation was already a traditional practice before colonial times.
- Soil degradation was resisted through practices such as limiting ploughing (once only per crop), limiting weeding, and mulching (e.g. of coffee).
- Resilience and possible resistance to pests and diseases were related to multiple-cropping and rotation systems.

Contrasting with these observations are the comments of Attems (1967) and others (e.g. Lundgren, 1980) with regard to the process of soil degradation, which was already causing concern in the 1930s. It was generally attributed to the replacement of long-term tree fallows by short

grass fallows, lack of fertilization and extension of cultivation to steep slopes, all provoked by the rapid growth of the human and animal population. Although several reports describe visible soil damage, no clear information is provided on the lands on which erosion occurred, nor is it clear whether it arose out of cropping or over-grazing (1), whether the positive cultivation techniques described by Attems and by Egger and Glaeser were already applied at this period, or to what extent the population was practicing favourable cultivation techniques in optimal forms. The erosion that took place after parts of the Shume forest reserve were distributed for agricultural use shows either that not all farmers applied erosion-control techniques under all circumstances, or that the techniques were inadequate on the steep slopes, or both.

However, several trials have demonstrated that such methods as multi-storeyed cropping, limited weeding and mulching are useful in controlling erosion. In tests near Arusha, in northern Tanzania, erosion over a three-year period reached 22.4 m³/ha for clean-weeded coffee, against only 0.5 m³/ha for banana with trash mulch; erosion in maize plots with trash bunds was limited to 1.0 m³/ha, as compared with 12.0 m³/ha for maize plots without conservation measures (Temple, 1972). The positive effects of intercropping under scattered forest and fruit trees, using limited weeding, mulching and trash bunds are demonstrated by measurements of Lundgren (1980) in the Mazumbai region of the Usambaras. The annual soil loss under highland forest ranged between 3.7 and 7.5 g/m² depending on slope, under intermediate forest between 4.2 and 10.1 g/m², and on a well-managed traditionally cultivated agricultural plot, between 0.9 and 1.0 g/m²; although the plot had a slope of 10 to 20° and had been under cultivation for 50 years, no loss of productive capacity had taken place.

(1) Watson (1972) could find no substantive evidence of declining yields in published figures for the 1930s.

In commercial vegetable growing, with intensive ploughing, clean-weeding and monoculture, no such protection of the soil is provided, and erosion has to be controlled by terracing. Such terraces need proper lay-out and maintenance to be effective, and the risk of their collapse are relatively great. Too, the increased risk of pests and diseases in commercial vegetable growing have to be controlled by greater inputs of commercial pesticides and insecticides.

The description of the LIDEP project fails to indicate what efforts were made to offset the risk of unfavourable weather conditions affecting vegetable production; only passing references are made to improved irrigation. Egger and Glaeser (1975) suggest a further measure: the consolidation of scattered private parcels into large communal holdings, which would eliminate the disadvantages of scattered plots but still make it possible to adjust cultivation to highly variable rainfall conditions.

(b) Management resilience. The maintenance of ecological stability requires that the necessary management techniques be simple and practical enough to be applied. The relatively good adjustment of traditional management to ecological conditions has already been reported, but it appears that this adjustment failed to keep pace with the new conditions that emerged as a result of population growth.

- Owing to this increased population pressure, ever steeper slopes were cultivated. These areas often needed more intensive anti-erosion measures, but these were not taken because of the low short-term returns for the necessary extra labour inputs.
- Although under-employment prevailed over the year as a whole, hired labour was still needed in peak periods. Under subsistence farming, capital was often lacking, and consequently the potential of certain crops (e.g. sweet potatoes, highly labour-intensive) was not attained. It is significant in this regard that whereas communal activities are fairly frequent under subsistence ag-

riculture with shifting cultivation, in permanent farming hardly any communal or cooperative work takes place, especially where there is a high degree of commercialization; Ruthenberg (1964a) gives several Tanzanian examples, including from the West Usambaras.

- With increasing population densities, certain activities, such as building irrigation works or intensive terracing, cease to be practical on the basis of scattered individual plots. The prevalent individualistic approach to farming here hindered the execution of such agricultural development measures, which can only be realized on a cooperative basis.
- As more land was opened up to cultivation and as fallow periods shortened, pasture became scarce. It can therefore be assumed that after a period of growth in livestock numbers, a decrease in the number of head per family took place, resulting in a reduction in the available animal protein for human consumption and also in the available manure for soil fertilization.

In planning the vegetable-growing scheme, it was assumed that these management constraints could be overcome only by the introduction of high-return cash crops. It was hoped that by delivering an entire package of innovations, such as new crops and modern farming techniques, under the supervision of the staff of the scheme, ensuring high economic returns to the farmers, it would be possible to create a totally new attitude toward agricultural management. It appears that no analysis was made of whether such a radical change would be feasible for all the farmers of the area or whether it would be available only to certain categories, such as the somewhat more prosperous farmers who had relatively easy access to necessary capital resources or fertile valley lands near roads.

In their analysis of the vegetable project, Egger and Glaeser (1975) challenge this approach and suggest that a mix of traditional and modern techniques might be more

suitable for many farmers. They hope to stimulate agricultural production by supplementing the useful traditional management methods with new communal practices on consolidated fields, combining subsistence and cash cropping and making improved irrigation and animal production management possible.

(c) Production sustainability. Under traditional cultivation, the production of basic food crops was sustained by adapting management techniques to ecological conditions. As stated, differential cassava/maize rotation and the adjustment of different crops to differing plots and rainy seasons were of particular importance, but no production data over time are available to make it possible to ascertain how well these systems were adjusted for sustaining basic production. Extremely dry years still caused hardship in the northern part of the mountains (Heynen, 1974), while a drastic decrease in production has been documented for the lands removed from the Shume forest reserve. Egger and Glaeser (1975) suggest that the latter phenomenon was caused by steep slopes and by the inappropriate handling of settlement in the area.

Nor are long-term production data available for judging the sustainability and reliability of vegetable growing. Heynen (1974) notes that in some regions, production was occasionally affected in exceptionally harsh years. In cash cropping, however, the risk-avoidance strategy is directed not toward providing basic food crops, as in subsistence agriculture, but toward minimizing economic risks. For such farmers, economic reliability is of greater importance.

(d) Economic reliability. Glaeser (1977) analyzes the costs of and returns from various subsistence and cash crops under traditional cultivation, with minor improvements in cultivation (primarily increased labour inputs), and with further (capital-intensive) inputs. From his data, a number of conclusions can be drawn:

- Generally improved cultivation techniques yield an increased return per unit of land, but the returns per unit of labour are practically unchanged. Total labour requirements rise considerably, although it is not clear whether the increase is well distributed over the year or whether it is concentrated at certain periods. Under ideal conditions, optimal profits are yielded by the cash crops coffee and tea.
- Under traditional management systems, coffee is an attractive cash crop, requiring relatively little labour and therefore leaving time for subsistence cropping. However, the application of modern agricultural methods increases capital requirements by a factor of 10, and to obtain this capital, farmers are often forced to resort to credit.
- The more capital-intensive the technology applied, the greater the economic risk, because inputs must be paid for whether the crop succeeds or fails. In this respect, maize, tea and coffee involve serious risks, because the decrease in profitability when prices fall are much higher under improved techniques than under traditional methods, while the price elasticity of cassava and banana changes less under different technologies.

No similar data have been published which make it possible to analyze the economics of vegetable growing in the West Usambaras. For these cash crops another economic factor is of major relevance: dependance on good transport facilities and market outlets. Especially for these perishable products is a well-organized collection and marketing service essential if the potential profits are to be realized: it is less critical for less perishable products such as coffee. In the LIDEP vegetable-growing scheme, most of the effort was dedicated to organizing such a service, and a number of constraints had to be overcome: finding new outlets for expanding production, temporary over-production during certain seasons (particularly critical in that marketing was targeted at high-price targets such as tourist ho-

tels, whose requirements were often unrelated to seasonal production fluctuations), high wastage and increasing overhead costs (Heynen, 1974). Essential to securing sustained production in quantities sufficient for economic collection was the amalgamation of farmers into voluntary production groups.

Importance of the tree component in the farming systems

During the change from shifting cultivation to (semi-) permanent cultivation the role of trees in the farming systems gradually decreased, but it did not disappear. Unfortunately, neither Attems (1967) nor Heynen (1974) concentrated particularly on the role of trees in the indigenous farming systems, although the local integration of both fruit and wattle trees in the systems is evident from their data. For this reason it is not known, for example, where and how Acacia mearnsii was cultivated and to what extent it was used other than for its bark (e.g. for mulching material or fuelwood). During the colonial period the private expansion of the cultivation of this tree had been discussed, but as it was considered to compete with subsistence farming, no action was taken on the proposal (Watson, 1972).

The authors of the farming-system studies appear to have assumed that modern agriculture requires strict disassociation between trees and forests on the one hand and agricultural production on the other, and this in fact reflected the general attitude. The view was further reinforced by examples of the breakdown of the taungya system when no new afforestation areas became available and farmers were reluctant to leave the forest land. Further, the distribution of forest land for cultivation resulted in the rapid disappearance of all trees.

More recently, however, a renewed interest in combining crop-growing and tree cultivation can be discerned. Egger and Glaeser (1975) pointed out several possibilities of us-

ing trees in farming systems, such as the exploitation of unoccupied space, providing both subsistence (green manure, mulch, fuelwood) and cash crops (e.g. fruit), and for soil regeneration; they recommended that more attention be paid to the cultivation of fruit trees, which can be underplanted with subsistence crops, and the use of trees in anti-erosion strips.

Further, the growing realization of the negative effects of the disappearance of trees for the supply of essential fuelwood has stimulated interest in the integration of trees and agriculture, as is demonstrated by the incorporation of such techniques into the TIRDEP programme, which foresees not only the use of trees on agricultural land but also the cultivation of such cash crops as cardamom under forest shade.

5. Conclusion

In many tropical areas, population growth results in the illegal cultivation of gazetted forests, often characterized by the lack of investment for proper soil management resulting in serious soil depletion and erosion. The consequent declining productive capacity of the land then forces the squatter-cultivator to shift his cultivation to a new forest area. Although land use practices in such circumstances are very different from those of traditional shifting cultivation, such squatter cultivation is often perceived as a form of pioneer shifting cultivation. This process is clearly demonstrated in several areas of the Tanzanian uplands.

A growing population needs not only additional land to cultivate: it needs increased amounts of wood for fuel and construction, and this growing need is reflected in increased exploitation of the existing wood resources both on agricultural lands and in the adjacent forest. The problem of wood resource management to meet local needs thus of-

ten becomes critical when alternatives to shifting cultivation are being sought for.

Changing shifting cultivation through the introduction of farming techniques requiring high inputs of labour and other resources has often been proposed and attempted. It is currently understood that such high-input systems are often economically unfeasible, and that low-input systems may be more promising, especially for the management of marginal lands.

Many development projects have concentrated insufficiently on the possibility of using, as examples of alternatives to shifting cultivation, the manner in which traditional land-use systems have evolved. The present case study well demonstrates the applicability of this approach. Traditional shifting cultivation has been absent from the West Usambaras for several decades, and in the interval a number of efforts have been made to adjust farming systems to the evolving socio-economic situation. Under relatively favourable conditions of climate and soil, the local population gradually adapted their techniques to (semi-)permanent cultivation, mainly of subsistence crops, but including some cash crops as well. Although these indigenous strategies displayed some remarkable adaptations to ecological conditions, they were still insufficient to provide for sustained agricultural growth keeping pace with population growth, and a gradual process of land deterioration therefore took place.

As a first response, the colonial administration sought to improve agriculture on a wide front, with the main (and often forceful) emphasis on the establishment of physical structures to protect against erosion. For reasons more political and psychological than technical, however, these efforts failed.

After Tanzania became independent, it was suggested that

the introduction of especially profitable innovations would be needed to induce the "tradition-bound" farming community to accept modern, commercial land-management techniques, considered essential for development because the commercialization of production would have a positive effect on standards of living, nutrition and health. This approach led to local successes, but gradually its limitations -- differential acceptance by various categories of farmers, and increased dependence on outside economic forces -- became apparent. A new approach has therefore been advocated, incorporating the positive features of both traditional and modern techniques and combining subsistence and cash cropping. Mixed cropping is an essential element of this approach, and extends not only to field crops but also to trees.

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SMALLHOLDER
PLANTATION AGRICULTURE
OF IMMIGRANT BAOULÉ FARMERS
IN SOUTHWESTERN IVORY COAST

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Figure 4/1. Ivory Coast, showing the southwestern area studied and the original Baoulé region (after Schwartz, 1979).

SMALLHOLDER
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1. Physical and Socio-Economic Environment

The area reported on here (see Fig. 4/1) consists of about 30 000 km² in southwestern Ivory Coast, lying between 4.5° and 6° North latitude and between 6° and 7.5° West longitude. It is bounded on the east by the Sassandra River and on the west by the Cavally River, which constitutes the border between the Ivory Coast and Liberia. Although the area lies near the Gulf of Guinea, it is separated from the sea by a narrow coastal strip which has different characteristics and is not covered in this study. No notable geographical features mark its northern boundary, which is established arbitrarily. For administrative purposes, the area consists of all or most of seven sub-districts (sous-préfectures).

The geomorphology of the area is characterized by an undulating peneplain at 0-300 m altitude. It belongs to two orogenetic complexes: in the southeast and northwest, formations from the Eburnean cycle occur, the mother material in the southeast consisting primarily of granites and granodiorites, while in the northwest metamorphic rocks, mostly schists, predominate. From southwest to northeast occurs a second formation from the Liberian cycle, consisting mainly of gneiss and magmatite. In addition to the Sassandra, flowing roughly northwest-southeast, and the Cavally, flowing north-south, a few smaller rivers are present in the southern part of the area.

The soils which developed in the region form a typical catena, consisting primarily of ferric acrisols associated with orthic acrisols and dystic nitosols. Normally the texture is coarse to medium. Owing to their long period of development, these soils are poor in weatherable minerals,

they consist for the greater part of quartzes and kaolinites with a high sesquioxide (Fe, Al) content. Their cation exchange capacity is low (generally less than 1 meq/g), and their fertility depends largely on the organic matter content of the topsoil. Their base saturation is less than 20%, and their pH is about 5.5. The high clay content (55-70%) and the low silt content of these well-drained soils render them relatively immune to erosion.

The area's average annual rainfall varies between 1600 and 2400 mm, decreasing from southwest to northeast. Four seasons can be distinguished: a long rainy season (April to mid-July), a short dry season (mid-July to mid-September), a short rainy season (mid-September to November) and a long dry season (December to March). Potential evaporation exceeds precipitation for about 3 months in the southeast and 4-5 months in the northwest, the annual deficit ranging from 100 to 300 mm.

The average annual temperature is about 26° C, with a monthly variation of about 3°. Maximum temperatures are recorded during the December-March dry season, and minima in the rainy season that follows.

The natural vegetation in the area consists of ever-green tropical lowland rain-forest. The primary forest type is characterized by the prevalence of Eremosphata macrocarpa and Diospyros mannii, while stands on soils with a higher water retention capacity are characterized by Diospyros spp. and Mapania spp. Until a few decades ago, this natural vegetation had hardly been disturbed, the area being very sparsely populated. Traditional shifting cultivation gave rise locally to the presence of secondary vegetation which up to an age of about 10 years was dominated by Macaranga hurifolia, Harungana madagascarensis and Musanga cecropioides, while in older stands such species as Alibizzia zygia, Canarium schweinfurthii, Fagara macrophylla, Samanea dinklagei and Terminalia spp. may predominate. Coffee and cocoa

cultivation was introduced in about 1920 but became significant only in the 1960s.

Land use in the region is currently dominated by the following main features:

- In the north, the Tai National Park, with an area of 330 000 ha (of which about 200 000 ha under primary forest), is to be preserved as the only remaining reserve of the natural West African rain-forest and has been declared an "International Biosphere Reserve". Farther south, the Haute Dodo Forest Reserve has been designated for sustained forest production.
- In the remaining area, cash-crop cultivation has developed in the form of both small-scale private and large-scale state plantations. Several agro-industrial projects are planned, including 32 000 ha of oil and coconut palm, 13 500 ha of rubber and 350 000 ha of pulpwood. The development of smallholder coffee and cocoa plantations is also being encouraged.

The indigenous population of the southwestern Ivory Coast forms part of the Kru cultural group. The principal tribes in the area are the Kru in the south, the Bakwé in the north and east, occupying the greater part of the area, and the Oubi in the west. Prior to 1970, population density was very low: in 1972, the indigenous population on one tract of 18 000 km² consisted of only 20 000 persons, or 1.1 person/km² (Massing, 1979), while in other areas it was as low as 0.5 person/km² (Schwartz, 1979).

Immigration to this forest region by other tribes from the much more densely populated savanna to the north and east began in about 1960. During a first phase, the gradual development of the region's infrastructures (essentially the construction of primary roads) led to a modest degree of immigration, but the process was at first a slow one; by 1972, only 5600 immigrants were living in the region (Massing, 1979). During a second phase, however, several

additional factors contributed to a rapid increase in immigration: the construction of a bridge over the Sassandra at Soubré, the positive results of cash-crop farming by the first immigrants, creating a new labour market; several years of drought on the savanna; a growing awareness of the suitability of the forest areas for coffee and cocoa cultivation; and, finally, government efforts to stimulate migration into the area in order to create a new growth nucleus in the southwest to counterbalance the rapid growth of the Abidjan region in the southeast. As a result, by 1975 there were 10 000 immigrants living in the Bakwé district alone, the majority consisting of Baoulé (56%), followed by Mossi from the Upper Volta (15.5%) and other immigrants from Mali (Schwartz, 1979). The total population density in the southwest increased from 1.4 persons/km² in 1972 to over 3 in 1976; in 1975, Massing (1979) found an average population density of 4.4 persons/km² for 10 villages covering 210 km². These are over-all density figures, unrelated to the land areas actually available to the farmers: on one tract, the over-all figure of 3 persons/km² increased to 3.5 or even 5, after subtraction of the area of classified forests and of all planned agro-industrial projects, respectively.

Land availability under the traditional shifting cultivation system of the indigenous population was practically unlimited. On the 210-km² tract studied by Massing (1979), only 256 ha of the total land area were under cultivation in 1975, and the average cultivated area was 0.28 ha/person. This does not mean, however, that the remaining land was not used: traditionally, shifting cultivation was combined with hunting and gathering of forest products, so that the economic sphere of a Bakwé village stretched for tens of kilometres from the village base. The individual clans were considered as holding inalienable rights over these lands; a clan member could obtain usufruct rights to cultivation of a specific area, and clan heads could also grant temporary rights to outsiders (Lena et al., 1977).

These tribal rights over land and forest were not recognized after the Ivory Coast became independent in 1960. A new land ownership act of 1963 nationalized all land to which no title of private ownership existed (Massing, 1979), but outside forest reserves, local officials were empowered to grant land rights to persons actually cultivating the land, preferably those originating in the Ivory Coast (Ruf, 1982). This power of distribution has been exercised very liberally, on the grounds that the land belongs to those who work it.

Thus, on application to the local clan head, the first immigrants to the district were usually granted relatively large areas, against a token payment. Traditionally, these rights were not hereditary, and only arable crops were to be cultivated, but soon coffee and cocoa planting came to be accepted as well. Later immigrants, often members of the family or clan of the original ones, frequently limited themselves to requesting land rights from the latter only (Schwartz, 1979). Consequently, the Baoulé farmers who arrived first have been gradually replacing the indigenous population as masters of the land. Large areas are reserved by a strategy of spreading out in lines: from the existing villages, new tracks are laid out under the control of the chiefs, and new arrivals are installed at the ends of these tracks, far from the preceding camps, so as to reserve the intervening areas for occupation by even later arrivals (Lena *et al.*, 1977).

Where the indigenous population preserved their land distribution rights (e.g. the most recent immigration target in the Oubi lands), fields granted to immigrants are becoming smaller, from the original 1-2 km² to as little as 2-3 ha, as the original occupants act to protect their land rights (de Rouw, 1979; Ruf, 1982a). Land is preempted by spreading out the village population into many camps, preferably at the crossing of tracks (Sautter and Mondjannagni, 1978).

Currently, many immigrants are receiving fields located in blocks designated by the government for smallholder plantations; here and elsewhere, the land is being gradually privatized and may be sold (Ruf, 1982a).

Population growth due primarily to immigration, the extension of cultivated areas and the exclusion of lands for smallholders have led in several places to land saturation, and this situation is spreading from east to west. According to Ruf (1982a), it is characterized in particular by the following features:

- The land is the property of individuals, and each fallow area has a single owner;
- The natural high forest has been almost completely eliminated;
- There has been a shift from the sale of fallow lands to the sale of plantations;
- The establishment of new areas of cultivation is prohibited except as the result of the sale of plantations;
- The land is gradually being commercialized, at increasing prices.
- There has been a shift from the grant of ownership to the grant of other land exploitation rights, e.g. rights of usufruct on old, or sometimes recent, plantations;
- Special working arrangements have been developed among individual farmers.

Government-sponsored development schemes include official resettlement schemes designed particularly for Baoulé farmers (Pillet-Schwartz, 1979) and the distribution of land in unpopulated reserve blocks for the development of cooperative smallholder plantations, farms of 3-20 ha being granted for 99 years; often these blocks were reserved without traditional tribal rights having been taken into account (Schwartz, 1979). Finally, improved cultivation techniques are being stimulated through the Société d'assistance technique pour la modernisation de l'agriculture de la Côte d'Ivoire (SATMACI), the government agricultural service.

2. Former Traditional Agricultural Systems

Traditionally, the basic agricultural system applied by the indigenous farmers was shifting cultivation, upland rice being the principal crop. For one zone in which no changes had yet occurred, Massing (1979) reported an average cultivation cycle of 17.6 years, one year under crops and the remainder under fallow. In only one of the villages studied was cropping extended into a second year.

In selecting sites for cultivation, indigenous farmers take account both of existing vegetation and of soil conditions. While fields may be established on lands bearing prior mature forest, fallows bearing trees of a relatively small diameter are generally preferred, as being easier to clear. Eight years is considered the minimum age for cutting the secondary vegetation, but older fallows, of 15-20 years, are preferred. Younger fallows may be reopened if the farmer is reluctant to clear. In addition, some mature forests are opened up every few years in order to extend the farmers' cultivated area and to enable them to take advantage of more favourable soil conditions. Well-drained, clayey soils are preferred; sandy or imperfectly-drained soils are not cultivated. When planting perennial crops, indigenous farmers choose fields relatively near the village if possible.

In clearing the land, the indigenous farmer first eliminates the undergrowth and small trees with a machete and then fells the larger trees with a heavier machete or an axe; after felling, the debris is burned. In general, one or two large trees per hectare are allowed to stand, either because they are too difficult to fell (e.g. because of their hard wood), or because they provide useful products (e.g. oil palm, Coula edulis, etc.), or for their shade. Some trees are also saved for environmental reasons, such as their usefulness in forest succession or in preventing the formation of savanna.

Maize and rice are the first crops sown, immediately after the first rains; they are planted in small dibble holes, with no further land preparation. When the rice has reached a height of about 20 cm, tuberous crops (cassava, yam, taro) and secondary crops (vegetables, eggplant, okra, bananas, etc.) may be planted; peppers (Capiscum frutescens) may occur spontaneously. Coffee and cocoa are interplanted in June/July, after the rice harvest. Traditionally, the cash crops were seeded directly, but the new varieties introduced by SATMACI are nursery-raised for about 6 months.

If arable crops are planted on plots previously under mature forest, no weeding is usually needed; the contrary is true of fields previously under fallow. In general, arable crops are weeded only once, but cocoa may be weeded twice.

Maize is the first crop harvested, followed by rice. Some rice resprouts after harvesting, and a second crop may be obtained. Cassava, less appreciated than rice, is used as a reserve crop that can be harvested as the need arises, between 3 and 10 months after planting. The harvesting period for the other secondary crops varies with their maturity, and may be extended into the second year. Traditional cocoa varieties started yielding after three years, but the new varieties begin to yield 17-18 months after transplanting; the main harvest takes place in June. The fastest-growing coffee variety gives a first harvest after two years, but other varieties are slower; the main coffee harvest coincides with that of rice.

Historically, as mentioned above, cultivation lasted only one year, after which secondary vegetation took over. With the acceptance of coffee and cocoa cultivation, some secondary trees have still been allowed to develop in order to provide shade for the cash crops (which may be interplanted with bananas, pineapple or taro), the remaining large trees not providing sufficient shade for the proper

growth of the young plants. The shorter life-span of these secondary trees ensures a gradual decrease in shade as the plants grow, an important additional advantage. Some shade trees may still be maintained in mature plantations, however, particularly for coffee. Although shade trees help suppress weeds, some weeding is needed once or twice yearly.

3. Description of the New System

The main differences between the agricultural techniques of the Baoulé and those of the indigenous population are the greater use of fire in land preparation, the use of yams instead of rice as the primary staple crop, the universal inclusion of cash crops, and above all the virtual elimination of shifting cultivation in favour of the latter, especially coffee and cocoa. Baoulé farming techniques are relatively labour-intensive, but the Baoulé can obtain adequate labour through their practice of drawing on the human resources available in their native area.

Generally speaking, the Baoulé farmer enjoys no freedom of choice of his land, but must accept the piece of mature forest land assigned to him; the area he can work depends further on his ability to recruit labour. He may try to accumulate as much land as possible by planting as large an area as he can, neglecting planting quality and field maintenance; in this way, he may occupy larger areas for the future use of arriving family or clan members.

As the first step in land clearing, the Baoulé farmer in the southwest cuts shrubs and small trees with a machete. Then, unused to the axe, he clears the heavier growth by burning. During a first burn, the entire area is fired; areas with vegetation remaining are burned over a second time, all the cut material being piled around the trunks. Most large trees are killed in this way, and their branches and trunks generally fall after a few years. After burning, the land is cleared of any remaining debris, and yam plant-

ing is prepared by building mounds about 35 cm high and 1 m² in area, spaced at 1.5-2 m.

As already reported, yams are the main staple crop. They are preferred to cassava and taro, whose suitability for harvesting over a prolonged period nevertheless makes them very appropriate as reserve crops which may also be sold. Two yam species are used: Dioscorea cayenensis (var. Lokra), planted in June, and D. alata (var. Bété-Bété), planted in April after the first rains, and capable of being replanted in October/November. On mound or plot borders, such secondary crops as cassava, eggplant, tomato, okra, peppers, onions, groundnut, pineapple, avocado and cashew are grown. After the main rains have arrived, some rice may be sown by broadcasting and covering the seed by a light hoeing. The perennial crops are planted between the yam mounds, together with banana, in April/May, after having been raised in a nursery since the preceding December. In the second year some vegetables may still be intercropped, but normally no tubers are cultivated with the cash crops.

The yam mounds having been carefully cleared, only one weeding is normally needed; it also benefits the cash crops. Older plantations are weeded twice a year and frequently receive pesticide treatment. A few secondary trees are allowed to develop for shade between the coffee and cocoa, and although it is believed that ripe cash crops do not need shade, some medium trees are usually kept on the older plantations.

The Lokra yams are harvested in August, the Bété-Bété in December; the harvested yams are stored in the fields to be transported as needed. Cocoa can usually be harvested in July/September, and coffee in September/November.

All the land the Baoulé farmer clears is finally planted in coffee and cocoa; he no longer uses fallow. Further, he clears more land than does the indigenous farmer: Lena

et al. (1977) found that in 1976, in the area studied, the Baoulé cleared an average of 2.9 ha, against the 1.9 ha of the indigenous Bakwé. These figures should be viewed in the light of the need for food crops: the Oubi consider that about 2 ha of rice are needed to produce enough food for an average family, whereas for the Baoulé, 0.5 ha of yam suffice (de Rouw, 1979). However, because the Baoulé establish cash-crop plantations more systematically, their average total area cultivated was 19.1 ha, much greater than the 4.8 ha average for the indigenous farmers.

Baoulé farming could expand rapidly in the southwest because they had access to both capital and labour. Lena et al. (1977) report that most of the Baoulé in the area studied already owned plantations in their native area, and consequently had enough tools and capital to invest in reclaiming new land. Although their farming is more labour-intensive than that of the locals, they rarely suffer from labour shortages because, as already seen, they can tap the labour force of their native area, one major reason for their dynamic agricultural expansion (Schwartz, 1979; Chaveau, 1979a; Ruf, 1982a). This expansion is however losing impetus, as the new plots they can obtain decrease in size. In some areas, all available land is already farmed, and a further decrease in land availability, especially for immigrants, is to be foreseen. A drop in food production may result, most of the new land being planted in cash crops.

This situation has already arisen in the central western zone of the Ivory Coast, Baoulé farming techniques have evolved to counter the trend. In order of relative importance, the following adaptations are found (Ruf, 1982b):

- Arrangements under which immigrants clear the land of indigenous farmers and plant them in cash crops, and in return are allowed to grow food crops on the land thus brought under cultivation;
- Cultivation of ill-drained, formerly uncultivated, valley

land; currently, 80% of all lowland farming is in the hands of Baoulé farmers;

- Purchase or annual lease of land under secondary fallow;
- Extension of intercropping in plantations (e.g. maize and vegetable planting may be continued into the third year);
- Replacement of old plantations by new plantations intercropped with food crops.

While firm data on the extent to which the Baoulé have to purchase their food are lacking, it appears that in general they still depend on their own production.

As already stated, the government is promoting small-holder plantations through SATMACI, which seeks inter alia to encourage the formation of farm-production cooperatives by establishing blocks of reserved land to be distributed for the development of new plantations, and by introducing improved farming techniques, including the following (Lena et al., 1977; de Rouw, 1979; Ruf, 1980):

- Planting new tree-crop varieties for quicker and faster yields, the seedlings being raised in nurseries;
- Good plantation maintenance by three weeding per year, fertilization and spraying. Growing tubers in plantations is discouraged, because the roots of the plantation crops may be damaged during the harvest;
- Providing light shade by maintaining a few large trees, recruitment of secondary trees, or intercropping banana on young cocoa plantations at a density of 660/ha. For optimal shade, banana should be planted before cocoa; its yield can be used for subsistence and/or sale.

In general, the Baoulé have adopted the new techniques more widely than the indigenous farmers. Thus, Lena et al. (1977) found that 92% of the Baoulé in their study area were using pesticides, and also that the new techniques were more systematically applied within the SATMACI blocks, where the cultivation practices were regularly verified.

Ruf (1980) compares inputs/ha required for cocoa cultivation under traditional management and improved management based on SATMACI recommendations. He finds that over a three-year period, traditional farming requires a total of 186 man-days/ha and a capital investment (including labour costs) of 109 200 Fr CFA/ha (1), while compliance with SATMACI recommendations requires 328 man-days/ha and 136 200 Fr CFA/ha (not including nursery costs).

Yields of upland rice are between 1 and a maximum of 2 t/ha, while yam yields lie between 7 and 8 t/ha. Well-maintained coffee and cocoa plantations yield about 1000 kg/ha and 700 kg/ha respectively, but under less than optimal conditions yields are much lower. On the basis of an economic analysis by Ruf (1980), it can be said in general that given an equal level of management, cocoa yields better than coffee but has greater soil requirements. Productivity declines on plantations over 20 years old. Improved management leads to higher productivity on young plantations, but on old plantations, intensified cultivation does not raise production sufficiently to make it profitable.

4. Analysis

During recent decades, a dynamic process of land-use development has taken place in the southwestern Ivory Coast, under which the traditional shifting cultivation is gradually giving way to perennial tree-crop cultivation. This trend has resulted from the effect of adoptive land-use strategies of the native population and of spontaneous immigrants, combined with government interventions (Lena et al., 1977; Sautter and Mondjannagni, 1978).

The indigenous population originally employed an open-resource strategy consisting of forest gathering, hunting, and subsistence shifting cultivation, utilizing very large

(1) 100 francs CFA = 2 French francs = approx. US\$ 0.40.

areas at a very low intensity. Consequently, although large tracts of unpopulated forest were usually under the control of local tribes, the natural environment was little affected (Lena *et al.*, 1977). At the outset, land under this strategy was readily granted to newcomers, but as the influx of increasing numbers of immigrants was perceived to result in dispossession of the land, a land-blockage strategy gradually developed. An additional gradual change from subsistence to commercial agriculture is taking place through the inclusion of tree crops on land cleared for food crops, but this practice is not yet systematically adopted, and the plantations are not usually very well managed.

The traditional resource strategy of the Baoulé in their native area was directed toward the production of both subsistence and cash crops, by taking advantage of a wide range of natural conditions in differing ecological zones. For traditional cultivation, only small amounts of such natural resources as land were needed, but with the reorientation of the Baoulé trading economy to commercial tree-crop production, an expanding resource base became necessary. This led to a wave of Baoulé migration to the Southwest, under the attraction of a natural environment favourable to coffee- and cocoa-growing, combined with severe underpopulation. In their new area, the Baoulé developed a land-control strategy aimed at securing as much land as possible. The family-plantation economy thus became very wasteful of land, since even in areas only part of which were suitable for obtaining good tree-crop yields, all the land was occupied and cultivated so as to discourage competing claims (Sautter and Mondjannagni, 1978).

Government intervention was directed toward a land-use strategy aimed at increasing production by natural resource management in a strict time/space pattern designed to bring about a gradual change from commercial forest exploitation to agro-industrial complexes, the ultimate goal being the cultivation of high-yielding tree crops on selected sites.

Measures taken to implement this policy included infrastructural improvements, modifications in land-ownership rights, land-use planning and the extension of improved farming techniques.

The strategies of the indigenous population, the immigrants and the government were both complementary and contradictory (Lena, 1979). They complemented one another in that immigration assisted the government in achieving its aims of increased cash-crop and food production, establishment of a rural infrastructure, reclamation of forest lands by private resources, increased incomes, the broader distribution of development throughout the country, and reduction of land pressures in or near flood or drought areas. At the same time, however, several contradictions became apparent: the adoptive strategies of the indigenous population are costly in terms of land; the spontaneous spread of tree-crop farming may intrude into areas reserved for other agro-industrial projects or into forest and wildlife reserves; private land-reclamation prohibits the prior exploitation of valuable timber trees; and tensions mount between the indigenous population and the immigrants.

Although a gradual change in land use has taken place as shifting cultivation has yielded to tree cropping, it is thus questionable whether this process has resulted in a stabilized farming system. This problem will be examined below in the light of ecological stability, production sustainability, economic reliability and social changes.

(a) Ecological stability. The shifting cultivation techniques of the Bakwé/Oubi and the Baoulé discussed above included several features ensuring ecological stability:

- Resilience to variable weather conditions was achieved by adopting plant varieties with different maturity periods and susceptibilities to unfavourable climatic conditions, staggered planting and differential cultivation of plots in differing environments, as practiced by the Baoulé

in the savanna/forest contact zone. Both tribes grow such foods as cassava and yam as emergency crops, but not usually as staple foods.

- Resilience to pests, diseases and weeds is ensured by short cropping periods and long fallows as well as by multiple cropping. The weed problem is intensified as increasingly younger fallows are reclaimed.

- Sparing some natural trees and limited site-clearing, leaving the root-mat mostly undisturbed, are among the cultivation techniques adopted by the Oubi for rapid development of fallow for site regeneration. The Baoulé employ more intensive site-preparation techniques, but the general impression is that the latter are not very favourable for stimulating natural fallow (de Rouw, pers. comm.).

The cultivation techniques of the Bakwé and Oubi also provide effective protection against erosion, thanks to the permanent litter on the soil. In the natural forest, erosion consumes, on average, 100-150 kg/ha/yr (7% slope); in traditional swiddens the loss does not exceed 150-300 kg/ha/yr. Erosion is also minimal under secondary forest. Run-off in swiddens is however 2-3 times that observed in forest (Collinet and Valentin, 1979; Oliver, 1980). The Baoulé cultivation system is more vulnerable to erosion, owing to the more intensive soil preparation, including intensive burning and mounding. The mounds are ineffective for erosion control, since the unchecked run-off is rapidly canalized between them. In trials, the erosion on such fields was 7-48 times that on untilled fields, depending on soil conditions (Collinet and Valentin, 1979).

Generally speaking, the tree-crop plantations are ecologically less stable, even if they cannot be defined unstable. Most of the older plantations consist of monocrops mixed with some secondary trees, decreasing their resilience to varying weather conditions and increasing the pest and disease risk, although this is controlled by spraying. If well managed, so as to maintain a cover crop under the trees,

the erosion hazard in tree-crop plantations is still relatively slight, especially as compared with that involved in annual crop cultivation. Under plantation crops generally, soil fertility declines as related to forest soil, but after 15-20 years a new balance may be achieved at about 60-90% of the fertility level under natural forest (Olivin, 1980); artificial fertilizers can often offset the decrease.

The degree of ecological stability can be analyzed not only on the plot level but in a broader context. Indeed, the very rapid destruction of the natural forest under the advance of agriculture has caused much concern at the loss of the biological and ecological values of the region. In this respect, the negative effects of the extensive traditional shifting cultivation of the indigenous population were much slighter than the effect of the Baoulé tree-farming techniques, requiring much larger land areas, more intensive land preparation and the abandonment of fallow.

(b) Management resilience. In traditional subsistence agriculture, the extensive cultivation practices required only minimal time and effort to provide a basic food supply, so that time remained for social activities (Sautter and Mondjannagni, 1978). Constraints in the labour calendar were obviated by staggered planting of crops with differing maturity dates, making a long harvest period possible. With the conversion to tree cropping, more time has to be devoted to agriculture. Two factors affect the ability to ensure this additional labour input: the timing of the new activities with respect to the labour calendar and the possibility of access to an outside labour force. As already stated, the Baoulé were better able to expand tree cropping than the indigenous farmers because they had better access to outside labour as well as the ability to pay for it. Further, their yam cultivation techniques are better suited for combination with tree-crop cultivation than the rice-growing techniques of the Bakwé and Oubi (Ruf, 1980 and 1982b): the tree crops profit much more from late weeding of yam than from the

early weeding of rice; late weeding fits better into the labour calendar; and the possibility of storing yam on the fields after the harvest makes it practical to transport it during slack periods, or over a longer period in combination with other activities.

SATMACI's system of early planting of banana for intercropping with cocoa has not been generally adopted: it would create bottlenecks in the labour calendar, the bananas' providing shade to the cocoa is not widely accepted, and the tree is regarded only as a subsistence crop, not as an early-yielding cash crop. In several areas its marketing possibilities are limited: it is bulky and perishable, and nearby outlets are lacking (de Rouw, pers. comm.). Consequently, only a few bananas are planted after cocoa establishment (Ruf, 1980).

(c) Production sustainability. Historically, the ecological stability of the indigenous cultivation techniques ensured a sustained productivity of subsistence crops for the local population. With the influx of the Baoulé and the expansion of tree cropping, food-crop production increased at first, the tree crops being intercropped with food crops on the lands newly opened up. Although yam cultivation causes more site disturbance than upland-rice growing, tree-crop yields do not appear to have suffered considerably, the period of food cultivation being short. On the other hand, as already noted, increasing the total area of mature plantations decreases land availability; the emphasis on tree crops may thus compromise the sustainability of food-crop production, and new farming systems will have to be developed to counter this trend.

(d) Economic reliability. Studies of costs and returns for tree cropping under different management intensities lead to the following conclusions:

- Generally speaking, improving cultivation leads to increased returns for land and labour, for both cocoa

and the less profitable coffee, except that on old plantations whose productivity is declining, more intensive management is not remunerated.

- The improved techniques require considerable increases in hired labour and other capital inputs (although for the latter no precise data are available). These inputs being necessary irrespective of the success or failure of the crops, the economic risk is increased.
- An additional economic risk arises out of dependence on market prices, which the smallholders can hardly influence. Especially for coffee, changes in profit resulting from a 10% change in prices are very significant, but this price elasticity is less under good management techniques than under traditional management.

(e) Social changes. A new social stratification is appearing, which is due to the difference between the indigenous population and the old and new immigrants in access to land and labour. Differences between ethnic groups resulted from their different land-use strategies, while differences among individual Baoulé immigrants were determined by their time of arrival, the earliest arrivals controlling the larger areas of land. The resulting social environment has become fragmented into several small, homogeneous zones, each with its specific social production relations (Lena, 1979). Ruf (1980) distinguished, in the south central zone, four farming types, respectively of 1-5, 5-10, 10-20 and over 20 ha, each displaying different features with regard to production factors and cultivation techniques. Further government intervention to develop land use should take account of this social differentiation (Lena, 1979).

Importance of the tree component in the farming system

In the traditional shifting cultivation system, trees played several roles: provision of products for subsistence and marketing, energy production and amelioration of ecological production factors (site regeneration, weed control).

Although trees are evidently still dominant in the evolving tree-cropping systems, the importance of their multi-purpose function has decreased, and their main purpose currently is commercial plantation production. Some natural trees are still allowed to develop for shade to assist in the early development of the tree crops, but no information is available on the extent to which these secondary trees also continue to function in the management of other ecological production factors: suppression of weeds, nutrient cycling, etc. Some trees are kept for subsistence purposes, but it appears that little effort has been made to extend the cultivation of trees such as oil palm. The lack of success in combining banana and cocoa cultivation suggests that this neglect may be due both to the absence of a tradition of concentrating on cultivating such trees, and to the difficulty of fitting the necessary work into the labour calendar.

None of the writers examined focusses attention on the role of trees in providing fuelwood, but in the light of the abundance of trees that remain in this humid climate, fuelwood does not appear likely to become a major problem in the foreseeable future: it can be obtained not only from the prunings of the tree crops but also from the secondary trees mixed with these crops.

5. Conclusion

Shifting cultivation is often accused of being a major cause of the loss of valuable forest resources, and the need to stabilize it is emphasized in many discussions of forest-resource conservation. The present case study from the Ivory Coast suggests that not every agricultural system which includes the annual reclamation of a new area of forest land should be branded shifting cultivation. The creation of such a swidden may be a necessary step in the conversion of the natural vegetation into a more economic system of replacing forest with tree crops. Land preparation

for food crops assists in reducing competition between the natural vegetation and the development of the tree crops, and also provides farmers with a livelihood before the tree crops become productive.

Tree-crop cultivation has often been advocated as an alternative to shifting cultivation, in that it would ensure a more stable form of land use. The present case offers an example to show that this is not necessarily true. As tree-crop cultivation usually entails the commercialization of agriculture, its substitution for shifting cultivation brings about important changes in attitudes toward the production factors, such as privatization and competition for land. It must further be borne in mind that tree-crop cultivation may become an activity additional to, rather than alternative to, shifting cultivation. The data examined here suggest that under such circumstances, the introduction of tree cropping may increase, rather than decrease, pressures on forest resources. The strategy of the smallholder planters in the southwestern Ivory Coast is often one of extending planted areas, even if this entails neglecting crop maintenance to the point that cropping becomes a gathering activity. This strategy is diametrically the opposite of the intensive and careful growing of crops for high yields that is usually envisaged when tree cropping is proposed as an alternative to shifting cultivation (Sautter and Mondjannagni, 1978).

Finally, this case study illustrates the ambiguity of the term "stabilization of shifting cultivation". The original shifting cultivation system had been stable for several decades, during which very low population densities were maintained and large forest tracts were left undisturbed. Pressure on forest resources began to grow only when the government sponsored the opening up of the area for commercial exploitation, leading to the rapid development of a pioneer front subject to radical changes in land use. Although in several areas this led to the stabilization

of temporary into permanent cultivation, it resulted neither in a spatial stabilization of land use nor in the stabilization of all interacting characteristics of the farming system. Instead, cultivation spread rapidly, with the result that important transformations in social production relations are taking place.

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ALTERNATIVES
AND IMPROVEMENTS
TO SHIFTING CULTIVATION
ON THE EAST COAST
OF MADAGASCAR

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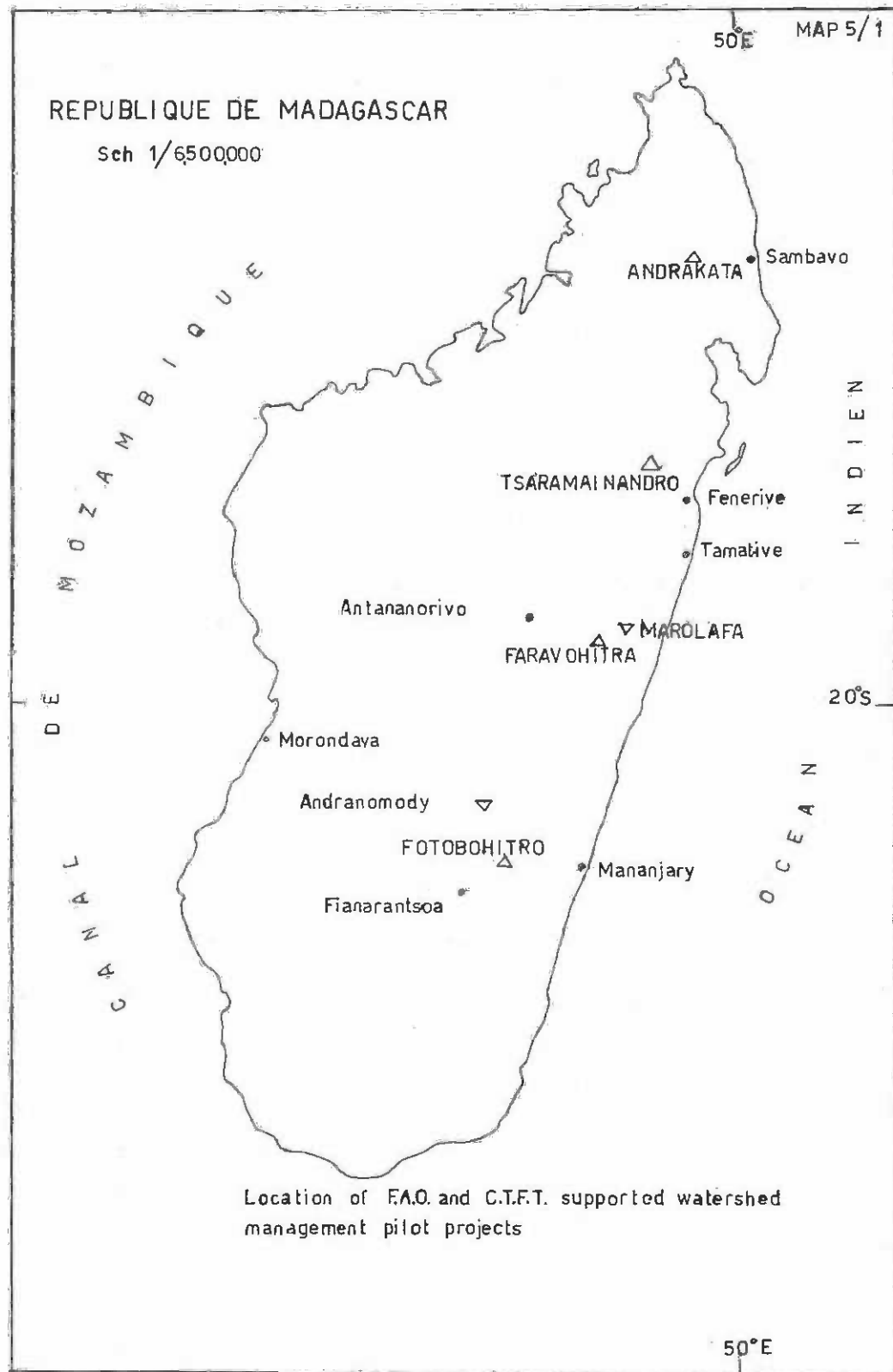


Figure 5/1. Madagascar showing FAO- and CTFT-supported watershed management pilot projects

ALTERNATIVES AND IMPROVEMENTS TO SHIFTING CULTIVATION ON THE EAST COAST OF MADAGASCAR

1. Physical and Socio-Economic Environment

The area with which the bulk of this report will deal (see Fig. 5/1) is the village of Tsaramainandro, in Toamasina (Tamatave) Province, some 7 km west of the larger village of Vavatenina, at approx. 17°30' South latitude and 49°20' East longitude. Its altitude is 300 m, although nearby hills rise considerably higher.

The area has a humid lowland tropical climate; the mean average temperature can be estimated at 22° C. Local topography causes wide variations in rainfall, but the total annual precipitation probably exceeds 3000 mm; the rainfall tends to increase at higher altitudes. There is no distinct dry season: at the nearest meteorological stations, 100 km northwest and 80 km south of Tsaramainandra, October, the driest month, still has a mean rainfall of 60 and 90 mm respectively. The relative humidity is high.

Parkan (1978: 26) describes the soils in the area as poor, leached ferralitic soils, with a marked deficit in basic elements, and very acid. Under the World Soil Map classification, the soils are orthic ferralsols (Fo 80-2 ab, Fo 81-2 ab).

The total population of the area is 545, of whom 439 live in the village. According to Parkan (1978: 27), the population density of the administrative area in which the village is situated is 83 persons/km². This figure is far in excess of population densities normally associated with shifting cultivation, and lends support to the suggestion that as practiced by the villagers, the system is a marginal form, since fallows are being reduced from 6 to 3 years,

following a cultivation period of 1 to 2 years: it would be more accurate to call this a fallow system, or a rotation system with fallow. Nor can the people of Tsaramainandro properly be described as shifting cultivators, since most of their income is derived from permanent cash-crop cultivation, and at least some of them produce only enough rice to satisfy their food requirements for about 3 months in the year; moreover, part of this rice is produced under irrigation, and its production therefore falls into the category of permanent cultivation.

With regard to land tenure, all of the land within easy walking distance of the village is divided, as in most parts of Madagascar, into privately-owned plots. Where land belonging to people in the village ends, land belonging to people from other villages begins: there is no 'spare' land, and access to land is by purchase or, more commonly, by inheritance.

Villagers say that the available land is not enough to meet production needs, and that they feel 'squeezed'. They add that this is nothing new: the situation began when such cash crops as cloves and coffee were introduced to the region, and planted over wide areas, some 50 years ago. This resulted in great increases in cultivated areas, since food crops still had to be cultivated in addition to the cash crops.

As elsewhere in Madagascar, difficulty of access to land has accentuated the inequality of land ownership. This inequality is manifested in terms of inherited status (descendants of free-born villagers tend to own more land than descendants of their former slaves), in terms of age (the older people own more land than the younger who, because of the land shortage, are having to wait longer and longer until they can inherit), and in terms of gender (men tend to own more land than women). Thus, in Tsaramainandro, 7 households (12%) occupy 75 ha (42% of the total land), while

49 households (88%) occupy 101 ha (58% of the total land). Of the latter group, 3 households are totally landless, and have to rely on paid employment in the fields for their income (SEMCO, 1980: para. 5.12). This unequal distribution of land is not uncommon in Madagascar as a whole. For example, a detailed study carried out in 1971-73 in the village of Ambohitravoko, some 50 km southeast of Antananarivo on the central plateau, showed that the heads of 9 households owned 62% of the village land (an average of 3.27 ha per family), whereas the remaining 38% were distributed among 20 heads of household (an average of 0.88 ha per family) (Pavageau, 1981: 96).

This inequality of access to land, and especially the fact that a significant proportion of households do not have enough land to ensure their subsistence while another group have more land than they can exploit with their own labour alone, gives rise to certain forms of exploitation:

- paid agricultural labour, at a daily rate of about 300 MG (1). This item represents the most important farming expense, at 80% of total farming expenses, and also the village's largest expenditure including farming and other expenses, at 69% of total expenses (SEMCO, 1980: para. 6.3). Tasks executed by paid labour include ploughing, clearing, planting, harvesting, etc.
- tenant farming under a variety of arrangements. In some cases, land is rented yearly for a fixed sum, while in others the arrangement is a semi-permanent share-cropping agreement under which the tenant gives the land-owner between one third and two thirds of the crop; very often, payment is partly in cash and partly in kind. Under still another arrangement, the tenant farmer plants and tends a given number of clove saplings for the land-owner (e.g. 200 saplings on 2 ha of land), and in return is authorized to use the remainder of the land for his own food-crop cultivation. In most cases, combinations of these

(1) US\$ 1 = 350 Malagasy francs (MG) (March 1983).

or other arrangements prevail: true share-cropping concerns only 3 of the 56 households in Tsaramainandro, and leased farms 4 of them (SEMCO, 1980: table 9).

The heads of household who own only small areas of land therefore spend much of their time -- and labour -- working the land of other people, often that of their older relatives. Within the household, wives spend, on average, more time on agricultural work than their husbands, and this is particularly true of tenant farmers and daily workers who, in practice, are generally the same people. While there is a sexual division of labour, the men performing the heavier tasks such as land clearing for upland rice, and the women most of the sowing, weeding and transplanting, there is no distinction between men's and women's crops: women can and do cultivate all the cash crops on their own land. Children also provide agricultural labour, particularly frightening birds away from ripening crops.

Many of the villagers engage in off-farm paid labour such as house-building or cutting firewood. Some travel away from the village (but rarely outside the region) for work of all kinds. According to SEMCO (1980: para. 6.22), 29 households (51%) derive income from on- and off-farm paid labour; for 5 it is the only source of cash income, and for many it is the major source.

All the households in Tsaramainandro except one cultivate rice; 86% grow upland rice and 38% rice under irrigation (SEMCO, 1980: para. 5.1.1). Rice is never sold, although there would be a good local market for it: as already mentioned, the average household produces enough rice for its own subsistence needs for only 3 months of the year. Only four or five of the wealthiest land-owners grow enough rice for their own year-round needs. Imported rice, when it is available, is bought in the neighbouring village of Vavatenina (ordinary quality: 140 MG/kg; de luxe quality: 300 MG/kg). It is paid for from the proceeds of the sale

of cash crops: cloves, coffee, cinnamon, bananas, sugarcane. The harvest is often sold "green" (i.e. before it is ripe) to the local trader, who pays a lower price under these circumstances, but who at least assures the household of a regular supply of goods from his store (soap, kerosene, salt, clothing, tools, etc.) and a certain amount of credit during the difficult time before the following harvest.

When their rice supply is exhausted, the villagers are obliged to rely on their other crops: maize, cassava and, as a last resort, bananas. There is little malnutrition, but in periods of rice scarcity the villagers feel that their meals are incomplete without rice.

2. Former Traditional Agricultural System

A number of Malagasy terms are used in any discussion of shifting cultivation in Madagascar, and it will be useful to set out their meanings and implications at the beginning of this review. Two of these words, tavy and savoka, are particularly common, and their meanings sometimes lack precision; the following definitions were arrived at after many discussions with Malagasy speakers.

Tavy is an agricultural technique, commonly practised on hill slopes along the east coast of Madagascar, of clearing vegetation (primary forest or secondary formations) by slashing and burning, and of subsequent cultivation of the land, especially under upland rice, for a period generally limited to 1-3 years. The hill slopes are called tanety and the rice grown on them is tanety rice.

Savoka is the vegetation growing on land lying fallow (for at least one year, more characteristically from three to six years, and sometimes even more) after the practice of tavy. The vegetation is herbaceous and/or woody depending on its age, the nature of the soil, the length of the cultivation period, the rainfall, the altitude, the surrounding

vegetation, etc. The term savoka can be qualified according to the dominant species: e.g. bamboo savoka, ravenala ("traveler's tree") savoka, etc.

Taking the expression "shifting cultivation" to mean an agricultural system characterized by relatively short periods of cultivation followed by longer periods of fallow during which the soil is given the opportunity to restore its fertility, it can be said that tavy followed by a certain period of savoka constitutes a cycle of shifting cultivation. On the other hand, the fallow period can be much reduced, and in this case the tavy + savoka cycle can better be described as "accelerated shifting cultivation". Thus, a cycle of two years of rain-fed rice cultivation followed by two years of fallow, practised at some places on the east coast of Madagascar where pressure on land has become acute, could be more accurately described as "land rotation with fallow" than as "shifting cultivation".

It should also be borne in mind that in Madagascar, settlements are always permanent or semi-permanent: temporary shelters may be constructed near the rice fields, but families do not move there. In many cases, villagers have to walk long distances between their homes and their different fields; in Tsaramainandro, a farmer's upland rice fields may be as much as 11 km from his swamp rice fields. In the context of Madagascar, then, the term "shifting" should not be taken to refer to settlements but only to the fields on which crops are grown.

Finally, it must be remembered that forest may be burned for a variety of reasons other than rain-fed rice cultivation: it may be burned and cleared by farmers for the permanent cultivation of cash crops; by hunters, to trap animals; by herders, to destroy parasites and encourage the regrowth of new grass; by charcoal-burners; and even as a well-established form of political protest. None of the foregoing motivations is necessarily related to the practice

of shifting cultivation, and it is necessary to be cautious of assertions which place all blame for deforestation in Madagascar on that system.

Deforestation has certainly taken place, however, and even pre-colonial governments attempted to check the practice on the central plateau. A text (in Uhart, 1962: 106) dating from the period 1787-1810, specifies that "it is prohibited to set fire to the forest and burn its wood, except for producing charcoal for blacksmithing. This prohibition, imposed in your own interest, is intended to avoid the complete and irremediable disappearance of the forest. Therefore, when you wish to make charcoal, go to the edge of the forest and not within it." Again, the code of laws promulgated in 1881 provides, "The forest may not be cleared by fire with a view to establishing fields of rice, maize or other crops; only those parts which have already been cleared and burnt over may be cultivated; any person making new clearings by fire or extending those already existing shall be punished by imprisonment for five years." (In Uhart, 1962: 108.)

These measures may have delayed the process of deforestation, but they did not put a stop to it, since the plateau area has long been emptied of its trees, with the exception of small pockets consisting mainly of exotic species such as pines and eucalypts, which were planted subsequently. As the first quotation above indicates, an important cause of deforestation other than shifting cultivation and indiscriminate burning was the cutting of wood for blacksmithing charcoal.

At a later stage, the colonial government attempted to slow down deforestation along the east coast, but not to prevent it, because the east coast was one of the most suitable areas in Madagascar, from the point of view of climate and access, for cash-crop production, which was one of the regime's first development priorities. Farmers

could not be expected to produce cash crops in addition to their own food crops without increasing proportionately the amount of land they had under cultivation. Tavy were either authorized by the administration for political or other reasons, or they were carried out clandestinely. It was estimated that in 1959, 400 000 ha of forest vegetation, of which 25% was primary forest and the remainder secondary forest, were destroyed in the eastern and western parts of the country (Uhart, 1962: 117), but it is not clear to what extent this forest was destroyed for permanent cash-crop production and to what extent for subsistence cropping under tavy.

Quantitative information on forest depletion during the post-colonial period is lacking. Based on projections of officially authorized deforestation in the east and west only, and on an exceptionally low rate of rural population increase of 1.5% per year, FAO (1981: 297) estimated the rate of deforestation at 100 000 ha in 1980, but the actual figure may well be much higher.

The Tsaramainandro villagers practice three principal cropping systems: irrigated rice fields, shifting cultivation with annual crops, and cultivation of perennial crops.

At the bottom of the narrow valley, irrigated rice fields are maintained. There are some terracing and water management works in the form of small canals and water conduits making use of split bamboo.

Tavy is widely applied on the mountain slopes surrounding the village. The natural forest has completely disappeared except for a small clump on one mountain peak. Thus, only secondary vegetation (savoka) is actually cut for shifting cultivation. The vegetation is cut from September to November, the older savoka having to be cleared relatively early because it requires more time to dry. The cut-over

area is burnt between mid-November and December: farmers are required to obtain permission for burning from the Forest Service and to maintain a fire-break of 1.5-2 m surrounding the area.

The principal crop grown under shifting cultivation is rice, often mixed with some maize; cassava is sometimes planted as a second crop. Many of the hill slopes surrounding the village will have been under rice cultivation at some time in the past; currently, cultivation takes place in general on the middle and upper, often steep, slopes. No measures appear to be taken against erosion.

Planting begins soon after the fields have been burnt over. The technique is exceedingly simple: a hole is made with a stick, and a few grains of rice are placed in the hole. Often some maize is planted simultaneously. Fields are weeded 2-3 months after planting; from mid-March until the harvest, birds and other predators are frightened away from the fields. The rice is harvested from mid-April to May, the maize somewhat earlier.

After the harvest, the field remains untended. Frequently cattle enter the field and pasture on it for some time. Cultivation is followed by a fallow of 4-5 years, sometimes reduced to 3. (A 6-year fallow is said to have been applied formerly.) Rice cultivation may be followed, as already stated, by cassava cultivation during the second year; when this occurs, the fallow is extended to 5-6 years. Fallows tend to be reduced on the more attractive sites, i.e., those nearest the village.

The vegetation that springs up during the fallow soon forms a dense cover. One or more of the following species usually dominate: Lantana camara, Gramineae, "bamboo" (i.e. Ochlandra capitata?), Harungana madagascariensis, Ravenala madagascariensis, and Zingiberaceae (mainly on relatively moist, rich soils).

Cultivation of perennials may take place in several different manners. More or less pure clove plantations are planted on the middle and upper, often steep, slopes; some mixed coffee and clove plantations are found on the lower slopes. These constitute the primary, if not the only, cash crops of the villagers. Surrounding part of the village, and on the lower slopes bordering the irrigated rice fields, are tree plantations, mainly for subsistence: jack-fruit, litchi, breadfruit, mango, guava, citrus, banana and papaya are all found, and always interplanted with coffee and/or cloves. At times, in open spaces in these plantations, relatively short-lived species are also interplanted: pineapple, taro, cassava and sugarcane. Some pure plantations are also to be observed: banana, in narrow zones along creeks and bordering irrigated rice; bamboo, in large, isolated clumps bordering irrigated rice and on some lower slopes; and a very little sugarcane on the lower slopes.

Conversion of one cropping system to another, e.g. from annual to perennial plantations, may occur. In this event, rice cultivation during the first year may be followed, in the second, by planting of cloves and/or coffee, interplanted with rice; if space permits, rice is grown in the third year as well.

3. Description of the Projects

A. The C.T.F.T. Project at Marolafa (1)

In the 1960s, it was found that the measures taken by the Malagasy Forest Service to control the practice of tavy -- prohibition, attempts to distinguish between farming zones and forest reserves, and extension and improvement of irrigated rice cultivation in the valleys -- had been ineffective, and as an alternative approach the Centre technique forestier tropical (C.T.F.T.) undertook pilot projects

(1) Source for this section: Benoît de Coignac et al. (1973).

in two test villages. One of these was Marolafa, lying on the Antananrivo-Toamasina road, about mid-way between the two towns, at an altitude of 550 m. Annual rainfall is about 2000 mm; there is no dry season.

A land-use inquiry was held in 1967, and a strategy for land development was defined, encompassing improvement of the village's irrigated rice cultivation, conservation management of the areas under dry cultivation, livestock improvement and the production of fodder crops, and the reafforestation of denuded slopes.

As a first step, in 1969, the Forest Service ceased issuing authorizations for tavy. As a substitute for dry rice cultivation, the following programme was set up:

- irrigated rice: irrigation and drainage improvement, soil preparation by plough, transplanting in rows, introduction of a short-cycle variety;
- hill-slope cultivation: cutting and uprooting of existing vegetation, concentration of debris in rows following the contours, and planting the rows with bananas or fodder crops. For the strips between the rows, the following rotation was established: cassava (2 years), maize (1 year), legume crops (1 year), grassland (3 years);
- stabulation of cattle, and manure collection;
- propagation of tree crops (coffee, citrus);
- reafforestation of steep slopes.

Burning was thus to be abandoned, and shifting cultivation was to be replaced by a system of permanent cropping which involved rotation between various agricultural crops in monoculture and grassland. Rice cultivation was to be limited to the irrigated valleys, and tree cash crops were to be encouraged. Demonstration plots were maintained by a "Technical Support Centre" (Centre d'appui technique), and monthly meetings were held with farmers to communicate extension advice.

Clearly, the introduction of such a programme meant

a radical change in the villagers' agricultural practices. At the end of 1973, the results of the experiment to date were analyzed, and progress was said to have been achieved in many areas. Even the most reticent farmers were said to have adhered to the programme, and new ideas and techniques were said to have begun to spread to neighbouring villages. However, at the same time the activities at Marolafa began to be phased out for a number of political and administrative reasons, and a few years later the experiment proved to be an almost complete failure. The farmers had shown no interest in the new methods of hill-slope cultivation, because of the heavy labour input required, the low yields, the prevalence of pests, etc., and the prohibition of the traditional tavy must have influenced their attitudes toward the new technologies. Only the cultivation of irrigated rice appeared at the time to have been successful,

The socio-economic causes of this failure, in which purely agricultural factors appear to have played little or no role, will be analyzed in detail in Chapter 4 below. Parkan (1978: 9) saw as possible reasons a system of salaried work which gave the farmers the idea of easy and permanent support; too abrupt change, resulting from the simultaneous introduction of many innovations; and the short duration of the project. By 1983 even the valley bottom, formerly used for wet rice, was being left fallow except for a small area near the technical centre.

B. The FAO/UNDP Project at Tsaramainandro

At the request of the Malagasy government, FAO in 1978 formulated a proposal for a watershed management project, whose main purpose was to combat the progressive deterioration of the natural land and forest resources caused by the ever-extending practice of tavy on the east coast of Madagascar. The principal over-all objectives of the project were as follows (Parkan, 1978):

a) introduction of conservation farming techniques in four

pilot villages under different socio-economic, ethnic and ecological conditions;

- b) stabilization of agricultural land use in areas suitable for cultivation by introducing more appropriate cultivation techniques and more productive crops;
- c) improvement and diversification of animal husbandry and cultivation of industrial crops, fruits and vegetables, as well as the creation of communal forests to provide fuel and construction wood;
- d) creation of a forest protection system to safeguard its potential for producing valuable timber, and reafforestation of steep, denuded and eroding slopes;
- e) promotion of integrated rural development, based on the needs of the local people;
- f) testing the efficiency of new agricultural techniques and determining their effect on the socio-economic situation.

The immediate aims of the first phase of the project were to select the pilot villages and to build project infrastructure there, to train national staff, to survey the area by aerial photography and prepare base maps from the photographs obtained, and to improve agriculture and land use, especially by eliminating the practice of tavy. This phase, originally foreseen to cover one year, finally required two years for its completion: an FAO expert arrived on the site in October 1979 and departed in November 1981.

Although plans for Phase II had been discussed in 1981, by April 1983 it had not yet begun. In the meantime, for a number of financial, administrative and political reasons, the continuity of the project had been seriously compromised, and several of its positive accomplishments had been cancelled by lack of support. But nothing had been done to discourage tavy nor to improve the savoka, and it seems indeed that the farmers had not been informed of these major objectives of the project.

4. Analysis

In the following analysis of both the Marolafa and the Tsaramainandro projects, primary focus is brought on the socio-economic factors which determined the appropriateness of the newly-introduced alternatives to, and improvements of, tavy cultivation. For organizational reasons, neither project developed as originally planned, and major setbacks independent of the agricultural context proper caused important delays in, or curtailment of, project activities before the latter could attain the stage of self-sustaining development. Accordingly, only organizational and social reasons can be given for the failure of several activities. This is all the more so that very few data are available concerning the technical feasibility, the productive capacity and the environmental protection of the cultivation techniques that it was planned to develop. Finally, the current organizational status of the projects limits the possibility of a fuller analysis of the suitability of the planned interventions.

A. The Marolafa Project

When this project became operational in 1969-70, there was an effective presence of the C.T.F.T. in the area, in the form of technical advisers, materials, and agricultural and technical inputs; there were also some 30 local salaried workers on the site. Political and administrative changes in the country in 1972 and 1975, and their aftermath, led to a dramatic alteration in this position: the C.T.F.T. was reduced to a few technical advisers based in the capital of the country, and by 1983 there were only 5 salaried workers in the project area, including the local project manager. The negative psychological and material effect of these developments on the project beneficiaries, who witnessed the scaling down of activities, and especially the delivery of inputs and help by extension workers, cannot be overestimated.

Another psychological error made at the start of the project probably also played a major role in its failure. The project beneficiaries were 12 heads of household who were all related and formed part of the same extended family; together they owned all the project land. This explains the lack of impact of the project in the area, despite attempts at extension work among other local farmers: everyone saw that one particular family was being favoured, and, rather than setting a good example, as the C.T.F.T. had possibly hoped, this situation caused a certain amount of resentment on the part of the other farmers. Further, it rendered the project highly vulnerable to shifts in the political winds, and may have exercised some influence on the decision to scale it down -- or abandon it.

Although irrigated rice was presented as the principal alternative to upland rice and the practice of tavy, all the easily irrigable land near the village was already privately owned; even if it may not all have been under cultivation, the important fact was that no one except the owner could have access to it. Irrigable land was available farther away from the village, but villagers did not like to leave the women working in remote places while the men went off to do their work elsewhere, because of escalating problems of insecurity in rural areas. If, on the other hand, they had moved their homes to create another village near the available land, they would also have had to remove themselves from the centre of project activities: the road, the school, the doctor, the suppliers, etc.

Perhaps exceptionally, in the rural world, the younger generation of Marolafa appears to have preferred paid work to farming their own land. By 1983, none of the 12 land-owners was cultivating wet rice at Marolafa; the only person to be doing so was the local project manager. It emerged that the young households had left Marolafa for more thriving farming areas, in search of paid jobs; in fact, only the old head of the family and his wife remained in Marolafa.

The younger family members had not, however, abandoned their claim on land at Marolafa -- quite the contrary. Because of the visibility of the construction work associated with irrigated rice, the ownership of such land could not be disputed, even if the land went unexploited, nor would anyone dare to farm it without the authorization of the owner, especially when the head of the family was living near by. The situation with regard to land under savoka is different, especially since 1975, when the government began to encourage farmers to make use of land which had been lying fallow for some time and did not appear to be used by the owner. In Marolafa, in 1983, tavy was therefore being practiced in a cycle of 1-2 years of cultivation followed by 2 years of savoka, not so much to maximize yields (since everyone was aware that yields would fall with such short fallow periods, and that the minimum period of savoka for good yields was 5 years) as to establish and confirm the owner's right to the land, so that third parties could not lay claim to it, and so that it would thus be available for family members who might need it in the future. Paradoxically, therefore, the owners' preoccupation with the possible future land needs of their family, i.e. the security of land tenure, led to considerable decreases in yields.

Family preoccupations appear also to have been at the root of another difficulty of the Marolafa project. While there are no oxen in the region, seven had been given to the community by the project. At some time after the political changes which affected C.T.F.T.'s involvement in the project, these oxen were apparently 'eaten' -- or sold. The farmers appreciated the value of oxen for ploughing, and the probability of increased yields if the manure were used as fertilizer, but it seems that none of the farmers had been willing to take responsibility for any of the animals. While it may be relevant to note that a tax on oxen was introduced at about this time, Pavageau (1981:169) discusses a case that may shed a somewhat different light upon

the matter. He reports on a village in which, in 1975, there had been much discussion about the usefulness of the plough which the administration had given to the villagers in 1972. Only the few families with oxen could make use of it, and this was accentuating the social stratification of the village by allowing those few -- already the more prosperous group -- to become even richer. The villagers without oxen proposed to sell the plough and divide the proceeds among all the villagers, and this was duly done, in order not to destroy harmony among kinfolk. It is by no means impossible that similar considerations led to the disappearance of the Marolafa oxen.

B. The Tsaramainandro Project

Phase I of the Tsarmainandro project was conceived as being essentially preparatory, and for this reason the agricultural activities proper carried out by the project were necessarily of limited scope and only marginally successful. The accomplishments of the project with regard to infrastructure can be summarized rapidly:

- A socio-economic survey of the area (SEMCO, 1980) was completed; it includes invaluable agricultural and other data.
- While the programme of aerial photography was not executed as planned, a rough topographical map of the area was prepared.
- A construction programme made it possible to build a house for the local project manager, offices, a warehouse and accommodation for visitors.
- 20 men were given two years' training as masons, carpenters, and agricultural and forestry monitors. All but one of these were however dismissed in December 1982.
- Agricultural monitors collected and recorded information on individual farmers in the project area with regard to land use, inputs required and obtained, etc.
- One village pump was installed, and a small dam was built for rice irrigation.

- One school building was built and furnished with desks and chairs; a teacher started working with the children in January 1983.

The agricultural activities of the project were carried out on a wide front:

- 30-40 000 eucalyptus seedlings, and some pines, were raised in the nursery by farmers, who planted them out in their own fields; they were distributed without cost to the farmers who had assisted in the nursery, and at a small charge to the others.
- 10 small fish-ponds were built by farmers on their own land; in 1983, some had been stocked, while others were waiting for fish.
- Improved chicken varieties were distributed to farmers and vaccinated. Subsequently, however, no vaccine was available at the time of a disease outbreak, and the birds all died.
- Tree crops were sprayed when insecticides were available. In 1983, ants were doing considerable damage to the coffee trees, but insecticide supplies were exhausted.
- The use of improved agricultural tools had been demonstrated; a list of tools required by farmers had been drawn up and the tools ordered, but they had not been delivered.

As already mentioned, the farmers on the project had not been informed that principal aim of the project was to replace tavy by other agricultural systems. It will be noted however that the thrust of all the agricultural activities listed above was directed toward such a replacement, even if this purpose was not explicitly defined as such. The beginnings of a reafforestation programme can be perceived in the relatively large-scale seedling operation; aquaculture as a valuable source of protein in the diet can make an important contribution to living standards, as can poultry improvement; encouraging tree cropping is a useful method of promoting the stabilization of shifting

cultivation; and the use of improved tools is a powerful stimulant to the application of improved cropping methods. From this point of view, the psychological and pedagogical approach of the project had much to be said for it: persuading farmers to abandon a centuries-old practice is more difficult, and less effective, than showing them a better way to do things.

In the context of Tsaramainandro, there are four possible major alternatives to shifting cultivation: irrigated rice cultivation, cash-crop cultivation, an agro-forestry system with simultaneous annual and tree cropping, and reafforestation.

Wet rice production, although not the most common technique, is not new to Tsaramainandro, where it has been practiced on suitable lands for the last 50 years at least. The practice has gained in popularity with increasing pressure on the land, and among the 38% of households engaged in it are to be found both large and small land-owners, although plot sizes vary widely. Some owners trace their origins back to other parts of Madagascar where, for historical or topographical reasons, swamp-rice technology is more widespread; the technology traditionally associated with formerly forested hillside areas is, of course, tavy.

The villagers transplant irrigated rice, but usually not in straight lines. They do not generally weed it, and they use no fertilizers: chemical fertilizers, while used in the past by some villagers, especially for cash crops, are currently too expensive and rarely available. There were 5 head of cattle in the village in 1980 (SEMCO, 1980), but their owners use them for ploughing only, making no use of their manure. They realize the value of the manure, but say that they do not want to spend the time necessary for collecting and spreading it. It is possible, however, that considerations similar to those observed in the case of the Marofala oxen apply here as well.

Local extension workers have been attempting to introduce and disseminate transplanting in straight lines, rotary weeding, ploughing with oxen and the use of manure, but they have been encountering serious resistance. The farmers argue that these practices entail extra work, especially during the first years, when they are still unfamiliar, that equipment and paid labour are costly, and that therefore only wealthy people can afford these activities, even if it is recognized that they can produce better yields per unit of area.

In any case, farmers are at least as much concerned with yields per unit of labour as with per unit of area. Their argument, supported by some local agricultural officers, is that under local conditions and adopting local practices, a given quantity of rice can be produced with less labour on the hills than under irrigation, even though the area required is greater. Under the local sexual division of labour, men's involvement in upland rice cultivation is limited to land clearing, which they can combine with cash-crop production, salaried work on other farms or off-farm, or such other cash-earning activities as charcoal-burning or timber production. The women are responsible for planting, weeding and harvesting, but these activities leave them partly free for other farm work as well: the cultivation of cash crops, other cereals, vegetables and fruit. Frightening birds away from the ripening crop is the children's job.

Irrigated rice, on the contrary, requires constant work at every stage: land preparation, planting, transplanting, weeding, bird-frightening, harvesting and, above all, maintenance of canals and dams to prevent silting and flooding. The maintenance tasks are considered particularly laborious because of the unsuitability of the terrain, which consists only of small valleys between steep hills. Further, farmers are handicapped by the lack of help and advice from extension workers, unable for want of transport to reach

zones where their services are needed. The constant work required limits the farmers' ability to engage in other profitable activities, and this fact has to be weighed against the higher yields that growing rice under irrigation can produce. What is more, some of the improved techniques, in particular rotary weeding, upset the sexual division of labour, insofar as they are taught to the men, whereas weeding is the women's responsibility.

There are also other grounds for resistance. Upland rice is normally intercropped with maize and beans, while this is obviously impossible with irrigated rice. Some farmers find working with their feet in the mud objectionable. Finally, consumer preferences tend to go to upland rice as opposed to irrigated rice.

Some farmers, despite these objections, would still like to cultivate irrigated rice but have no access to irrigated land. For them it is out of the question to find suitable unoccupied land, and probably impossible to irrigate the most suitable of their own land without capital expenditures beyond their means. If the land were more suitable, farmers might be able to group together to reduce the initial costs of building an irrigation network, but this is not the case in Tsaramainandro, where stream diversions would make it possible to irrigate only small surfaces. The construction of such a diversion is currently contemplated, but a considerable amount of work would make it possible to irrigate only 5 ha. Meanwhile, because of inequalities in land distribution and tenure, what suitable land does exist remains under-exploited: its owners produce only one wet-rice harvest a year, whereas two could be obtained.

Cash crops have been grown on a large scale in the area since they were introduced about 50 years ago; as observed above, it was at this time that the local population became conscious of the land shortage. The colonial authorities encouraged the use of the best agricultural land for

such crops as coffee, cloves, bananas and sugarcane, to the detriment of food crops, and since then Tsaramainandro, like other areas of Madagascar that produce cash crops, has become less and less self-sufficient in rice, while nearly every household produces cloves, coffee and bananas (SEMCO, 1980: Table 7).

Under ideal conditions, cash-crop production is a suitable alternative to upland rice production, since the earnings from the cash crops can be used to buy rice for family consumption and thus compensate for the farm's reduced production of rice. In the event, however, the yield of the main cash crop, cloves, has proved to be very uncertain, and during recent years has been very low indeed; the coffee shrubs have been suffering from attacks of ants destroying the unripe berries; and at the same time the local demand for bananas is inadequate to cover the supply, even if the prevailing transport difficulties could be overcome. These problems, compounded by the difficulty of obtaining rice during periods of shortage, have led the villagers to concentrate increasingly on rice production for their own subsistence.

All of the wealthier villagers produce enough rice for their own needs; only the less prosperous have to buy rice or do without it. Cash-crop production thus represents a desirable alternative to rice production (and thence to shifting cultivation) only when the family's subsistence needs for rice are satisfied. Meanwhile, the principal constraint on the other villagers' ability to satisfy their subsistence needs for rice is the lack of access to suitable land. Irrigable land is the most desirable, followed by hillside land near the village and land that has been under savoka for a prolonged period; failing these, relatively remote hillside land or land under short periods of fallow can be used; no one prefers such land, but some villagers have no choice but to farm it.

Clearly, then, future efforts to encourage cash-crop production should take into account that it can play only a role supplementary to subsistence rice farming. For reasons of location and transport difficulties, preference should be given to non-perishable, low-bulk products. Mixed cropping is preferable to monoculture, in that it minimizes risks of total crop losses through pests and diseases and allows for a regular production cycle throughout the year, while it also renders possible the inclusion of certain subsistence crops, such as fruit and taro.

Agro-forestry offers several possibilities in the improvement of, or finding alternatives to, shifting cultivation. Although little evidence is available to substantiate the view, it is likely that some planted fallows are more efficient in restoring soil fertility than natural fallows; certainly they can permit the production of a modest wood crop for fuel and small poles. The local project manager at Tsaramainandro has experimented with planting Grevillea in savoka on his own land near the village; the trees grew in the fallow for three years, and were cut for fuelwood when the savoka was cleared for rice cultivation. He reports better rice yields on these plots than on others left in fallow for three years without Grevillea.

Multi-storeyed cropping techniques such as those experimented in Tanzania (see p. 72 above) also offer promising possibilities.

Planting live fences along contours can do much to reduce erosion, organic material and sediment accumulating above the planted row. This system also improves water infiltration and contributes to soil improvement if suitable nitrogen-fixing species are used, prevents further losses in fertility and produces wood and leaves to be used as fuel, mulch and/or fodder. The soil is prepared 40 cm deep in a 60-cm strip following the contour; a small ridge down slope will enhance water infiltration in the prepared zone.

Nitrogen-fixing, easily coppiced species (e.g. Gliricidia, Leuceana, Calliandra) are planted in a dense row, at intervals of about 30 cm. The only management requirement is that the fence should be cut back every 2-4 years.

In alley-cropping, rows of trees or shrubs are planted in strips between rows of cultivated crops such as rice and maize. This technique serves the same purposes as planting live fences, and the planting techniques are also the same except that the interval between plants is 3-5 m. The planted rows should be cut back more frequently, from 2 to 6 times a year.

The people of Madagascar are highly conservation-conscious, and this attitude was reflected in the policies of pre-colonial governments quoted above. It is precisely because successive governments have laid emphasis on protecting the country's forests that setting forest fires has come to represent an essential form of political protest. Villagers with enough land, and security of tenure, have long engaged in tree planting, especially in areas where wood for charcoal is scarce. However, they distinguish clearly between tree-planting for themselves and reafforestation for the Forestry Department, which often neglects the former practice. Reafforestation on behalf of the Forest Department is considered not only unrewarding -- because the trees planted are the property of the Department and may not be exploited by the villagers -- but even a form of punishment, since in colonial times persons found clearing areas in protected forests were imprisoned and obliged to plant trees for the authorities. Reversing this attitude is likely to be very difficult indeed.

One of the main accomplishments of Phase I of the FAO project at Tsaramainandro was the planting of eucalyptus, and the more prosperous villagers needed little encouragement to plant when they were provided with inexpensive saplings. Only a small minority of the villagers, however,

have enough land to spare, and access to enough labour, to be able to plant a eucalyptus grove. Some villagers plant a few trees only, widely dispersed among their food crops. Others do not plant at all: these are the smallholders, who need all their space for food and cash crops, and the tenant farmers, who have no interest in planting, on their leased land, trees which would in any event be the property of their landlords. As one observer of the Tsaramainandro operation put it, "Only the rich can afford to plant trees."

Under any reafforestation project envisaged, therefore, it should be made perfectly clear at the outset that the beneficiaries of the work will be the owners concerned, and not the authorities. Even if this will mean that only the more prosperous farmers will be interested in the operation, it is to be encouraged, with priority given to the agro-forestry practices outlined above.

It was not possible, under Phase I of the Tsaramainandro project, to collect data on the land and water conservation characteristics of the land use practices currently applied or introduced by the project. However, the options proposed under the project were derived largely from research by Bailly *et al.* (1974) on erosion in Madagascar under traditional and modern cultivation techniques. This had shown that over a 9-year period, erosion under secondary forest amounted to only 0.2 t/ha, against 15.6 t/ha under a cycle of 2 years of tavy + 7 years of savoka; in the latter cycle, some 83% of the total loss took place in the first year. Under old savoka, erosion is negligible, probably similar to that under mature forest, whereas under tavy + young savoka, erosion increases greatly. Conservation farming techniques succeeded in lowering the erosion level to 6.6 t/ha, but this amount is still appreciably higher than that observed under undisturbed forest conditions.

No further local data having been collected under the appropriate environmental conditions of the east coast of

the island, it is difficult to assess the real local potential of the various possible land-use techniques with any degree of certainty. Data from other areas, however, indicate that several of these techniques are promising indeed.

5. Conclusion

Tavy being a technique of upland rice production, any alternative to it must foresee an alternative means of producing or purchasing rice, the staple food of Madagascar. No alternatives introduced by the Marolafa and Tsaramainandro projects were new to the local farmers, who indeed were already practicing them all, especially irrigation. It can be said that the main achievement of both projects was to have improved irrigation locally through the construction of dams and canals.

Despite the views of many foreigners, the main constraint to increased reliance on irrigated rice as opposed to upland rice is neither the Malagasy farmers' ignorance nor their innate conservatism: all know that, under the right conditions, rice under irrigation yields more than upland rice per unit area. The principal constraints are other, and the most important is the problem of access to suitable land, particularly in the densely populated, hilly region of the east coast, exacerbated by inequality in land distribution. The Malagasy government has drawn up plans for land reform, but they are very difficult of execution, and in the meanwhile it is better to have access to land as a tenant farmer than to have no access to it at all. Landlords, on the other hand, are aware that if leases are too disadvantageous for the tenants, the latter will desert the land for salaried jobs; a certain balance is thus ensured.

Another constraint is the low official price of rice which, although doubled in 1972, has not since then been raised sufficiently to motivate surplus rice production.

This situation is rendered still more serious by the lack of consumer goods that can be purchased with the proceeds of the sale of any surplus rice that might otherwise be produced: imports are severely restricted, and local manufacturers face acute distribution difficulties. These problems of motivation help explain why such a small proportion of the irrigated land is actually exploited -- as little as 20%, according to one impartial observer --, and why, in general, only one crop a year is grown when two would be technically possible. Meanwhile, greater numbers of the population, especially of the younger generation, are leaving rural areas in search of salaried jobs, rather than pay landlords anywhere between one third and two thirds of their harvest as rent.

Other constraints also exist, limiting the possibility of improving irrigation. For example, essential materials such as cement are unavailable. Finally, particularly in the remoter rural areas, technical advice is lacking, because extension workers without means of transport cannot reach a large sector of the population which needs them most.

Given these constraints on the principal alternative to tavy, much can be done toward improving it so that its effect can be less ecologically degrading. In particular, a renewed effort in the direction of tree planting, above all in the savoka, and the encouragement of agro-forestry techniques, could only have a beneficial effect.

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THE MODIFICATIONS
TO TRADITIONAL
SHIFTING CULTIVATION
BROUGHT ABOUT BY THE
FOREST DEVELOPMENT PROJECT
IN THE HADO AREA, KONDOA,
TANZANIA

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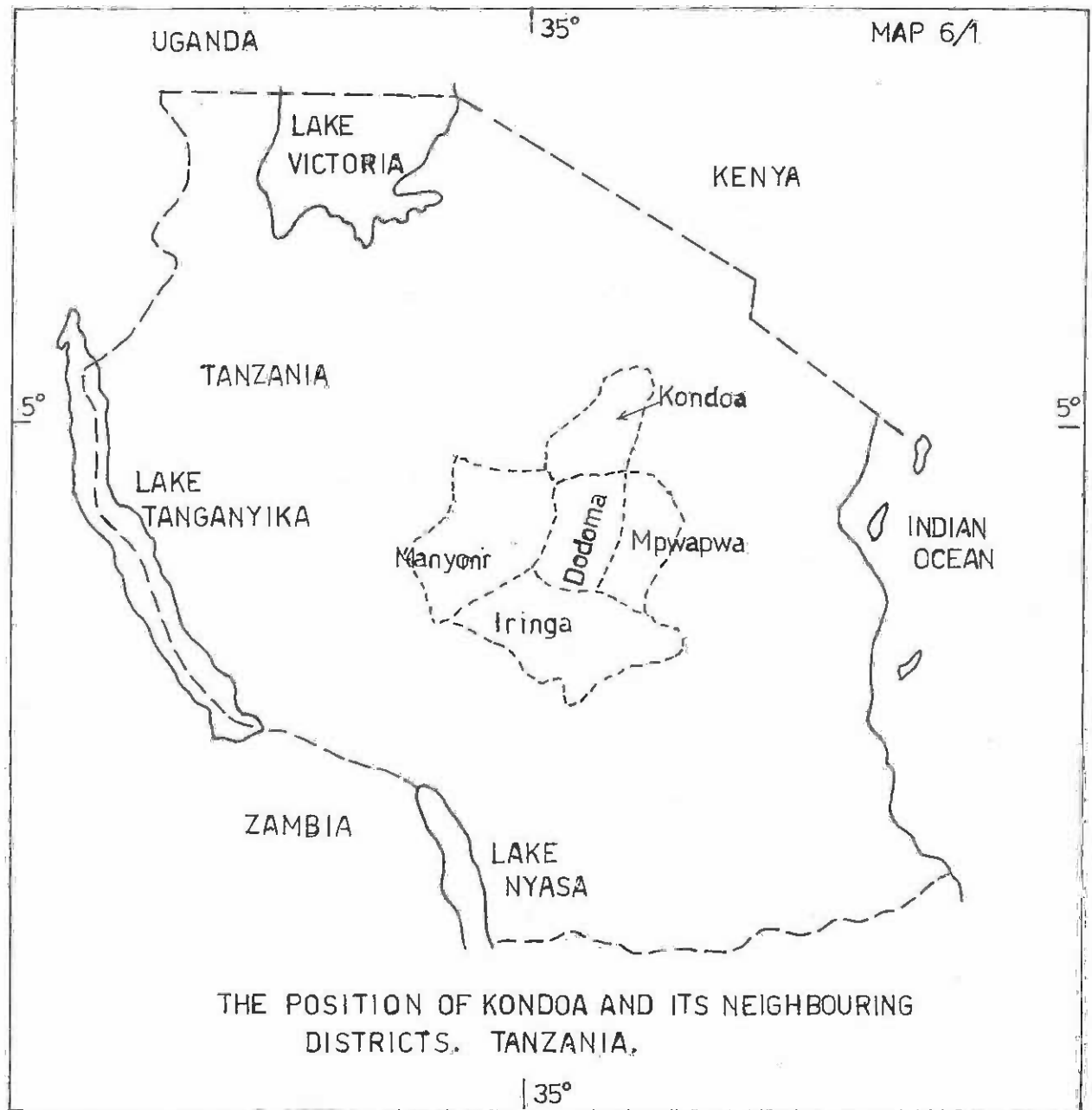


Fig. 6/1. Tanzania, showing Kondo District and neighbouring districts.

THE MODIFICATIONS TO TRADITIONAL SHIFTING CULTIVATION BROUGHT ABOUT BY THE FOREST DEVELOPMENT PROJECT IN THE HADO AREA, KONDOA, TANZANIA

1. Physical and Socio-Economic Environment

The HADO (Hifadhi Ardhi Dodoma) area covers some 1256 km² in Kondoa District, in central Tanzania, lying between 4° 10' and 5° 44' South latitude and 34° 54' and 36° 28' East longitude, at an altitude between 1300 and 1800 m.

Banyikwa et al. (1979) distinguish six geomorphological features in the area: inselbergs, escarpments, pediments, alluvial flats and flood-plains, lakes and other drainage basins. Inselbergs are the most common topographical feature of the Kondoa highland, indicating the geological erosion of the area and exemplified by the hills separating the Mkuku and Kondoa river flood-plains. Where the vegetation is sparse or has been completely removed, granitic rock is exposed. Escarpments, associated with the Central Rift Zone, are cut by ephemeral streams separating the outstanding hills, which rise to about 1800 m. Eroded pediments are characteristic of all foot-slopes along the inselbergs and the dissected escarpments, where gradients lie between 4° and 15°. Below these, and above the flood-plains, are colluvium-laden pediments, generally of gradients less than 6°. The colluvial material consists of loose rock pebbles and some sand; the vegetation cover is made up primarily of short grass with scattered shrubs or scrub. Both eroded and colluvium-laden pediments are associated with ephemeral rivulets and streams. Alluvial flats and flood-plains are developed over most of the low-lying areas or along river valleys, most occurring along the Kondoa and Mkuku river valleys in the western part of the district. The flats are a visual demonstration of the erosion-sedimentation process;

they offer good farmland because of their abundant supply of plant nutrients, and for this reason the main settlements of several tribes are located along the flats. Lakes Bicha and Haubi, the two lakes in the area, are generally shallow because of the vast amounts of eroded material from the surrounding area that are deposited in them. The river basins, including that of the Chiri River, the most important, are drained internally, and their water is therefore salty. The drainage of Kondoa District is dendritic, with streams and rivers branching off from the Kondoa, Mkuku and Dalai river basins, which are aligned in a generally north-south direction.

Detailed information concerning the soils of Kondoa District is scanty. D'Hoor gives a general classification and observes that ferruginous tropical soils are commonly found. FAO/UNESCO (1967) and Baker (1970) provide further classifications, but the descriptions given by the latter do not correlate well with simple, direct field observations (Tosi et al., 1982). Conyers (1971) divides the district into agro-economic zones, thus offering what is perhaps the most practical classification of those available:

- 1) In the northeast, the dry Masai steppe, undulating and infested with tsetse fly. The soils are dark brown silty loams in the north, dark reddish-brown loams in the south, and black clay in the depressions.
- 2) In the north-northeast, dry, fairly fertile, undulating lowland, some isolated hills, and large swamps. The tsetse fly is present.
- 3) In the north, the Bereko highlands, the highest and wettest part of the district, rolling to hilly, reaching above 1800 m. The soils are deep dark reddish-brown clay loams, with black clays in the depressions.
- 4) In the central part of the district, around Kondoa, are the central highlands, hilly and dissected by a northeast fault, with scarps and numerous streams. Cultivated areas are severely reduced by erosion. The soils are dark, reddish-brown, coarse sandy loams and dark

yellowish-brown loams.

- 5) In the remaining central zone, the land is flat in the west and undulating to hilly in the central and eastern areas. Some tsetse fly is present near the Songa Forest Reserve. The primary agricultural activity is animal husbandry; crop production is of little importance. The soils are very variable.

There is even less information on the chemical properties of the soils in the district. Only Anderson (1969) has published an analysis of one site in the HADO area. He reports an mean pH of 5.8 (range: 4.4-7.0), and a cation exchange capacity of 15.9 meq/g (range: 10.3-20.1); this low figure suggests that soil fertility may be exhausted by continuous cultivation without the use of fertilizers.

Rainfall in Kondoa is almost invariably concentrated in a November-April rainy season, with most precipitation being recorded in December-January. Rain falls in heavy storms, causing rapid, strong surface run-off and flash-floods in streams and rivers. Over a period which however did not exceed 10 years, the average rainfall at nine stations in the Kondoa eroded area was 682 mm, with a range of 879-524 mm among stations; the area is therefore properly classified as semi-arid.

The maximum and minimum mean annual temperatures are 29° and 16° C respectively; annual relative humidity varies between 60 and 70%. Owing to the incompleteness of the data, it is not possible to calculate potential evapo-transpiration directly, but from the fragmentary data available it appears that climatic conditions are unfavourable for plant growth from July to November.

On the basis of aerial photographs taken in 1976, Ban-yikwa et al. (1979) distinguish 10 types of vegetation in the HADO area, varying widely according to the prevailing type of land use in the particular sectors. Cassia singuana

was dominant (80%) in the sector of Kelema and Kondoa town, with Acacia seyal, Cassia abbreviate, Maerua spp. and Strophanthus kombe also present; dominant grass species were Aristida adensonsionis, Dicanthium spp., Evagrostis spp., Chloris spp. and Rhynchretum spp. In another sector, the Lake Bicha - Mondo area, four different types of vegetation could be defined, which were related to the manner in which the land had been grazed: in one part of the sector, trees were almost completely absent and most grasses had been grazed beyond identification; the remaining trees were Dodonea viscosa (40%), Acacia seyal, A. tortilis, Cassia singuayana and Markhamia obtusifolia; in another, reclaimed, part, Cassia singuayana (29%) and Xeroderris stulmannii (29%) were dominant, the grasses consisting mostly of Aristida spp. Two neighbouring sub-sectors around Impaka, one unprotected from grazing and the other protected for two years, showed sharp differences in vegetation. The unprotected sub-sector was bare of grasses, while the tree cover remained relatively dense, with Acacia tortilis dominant (42%), followed by Markhamia obtusifolia, Dichrostachys cinerea, Maerus spp. and Schreberera spp. In the protected sub-sector, on the contrary, the tree cover was less dense, Cassia singuayana (39%) and Leucaena cencocephala (39%) being dominant, but a wide variety of grasses was observed.

These data suggest that grazing may tend to induce a type of vegetation different from that which is induced by complete protection; prolonged protection from grazing in the HADO area may introduce a different type of vegetation altogether. The experience of the last two sub-sectors also suggests that care must be exercised in deciding on what reclamation measures should be taken, and where: it is apparent that once gullies become too deep, the situation may be out of hand and call for special measures not covered in general "blanket" recommendations. In other words, different reclamation measures are needed to deal with differing degrees of erosion, as may be indicated by the total densities of the tree cover.

From the ecological point of view, most of Kondoa District is classified as tropical premontane dry forest, the highlands falling into the category of tropical lower montane dry forest. Historical documents and remnant trees indicate that the district was originally covered by miombo woodland, but a long history of occupation by farmers, deforestation for tsetse control, and high human and livestock populations has led to the serious degradation of the environment and resources of the highlands. Where natural vegetation survives, it is usually fire-resistant and only 2-4 m tall. The five forest reserves in the district cover a total of 49 607 ha of the district area of 13 210 km².

The population of Kondoa District, 146 000 (12 persons/km²) in 1948, had risen by 88% to 275 000 (21 persons/km²) in 1978, an annual rate of increase of 2.9%. The population density of the HADO sector is far higher than the average for the district: according to the 1978 census, the HADO area included some 15 300 households for a total population of 73 467, or 59 persons/km², but taking into account the large land areas in the sector that are unsuitable for agriculture, the density per km² of arable land is appreciably higher still.

Almost 95% of the district's population depend on agriculture for their livelihood, but agricultural production is largely at the subsistence level. Crops marketed include food-crop surpluses (millet, maize, etc.) and cash crops (sunflower, groundnut, castor, etc.). The annual per caput crop-growing income for the region as a whole in 1973/74 was 82 Tanzanian shillings (1), the range among the different regions of the country being from 389 to 80 T.Sh. (CIDA, 1975). At least 98% of farm incomes are derived from sedentary, as opposed to classical shifting, cultivation.

Ethnically, the southern part of the district and the

(1) US\$ 1 = 8.18 T. Sh. (August 1980).

central highlands are occupied by Bantu tribes, respectively engaging in pastoral and agricultural/pastoral activities; the Bandwe in the southwest are occupied primarily with honey-collecting and agriculture; in the northwest are several Nilotic tribes, engaging in hunting and honey-collecting; Hamites, primarily pastoralists, occupy the north, and pastoral/agricultural Burungas are in the southeast. About 65% of the population is under 24 years of age. Average family sizes in the HADO sector range from 5.57 to 7.31, according to the degree of erosion of the land occupied; the average for other villages in the district, but outside the HADO area, is 7.70, possibly indicating the extent of migration from the area in October 1979; at that time, the area was completely destocked of bovines, whose density was 69/km² in 1975.

2. Former Traditional Agricultural Systems (1)

Three types of shifting cultivation are practiced in Kondoa District, although to differing degrees. The simplest form, under which farmers clear, burn over, and cultivate plots in virgin forest, bush or grassland until crop yields fall below the subsistence level and force the farmers to move to another area, is currently estimated to be practiced by only 1-2% of the population of Kondoa. It was formerly common among several tribes; when it fell out of favour could not be established, but it is possible that interest in the system gradually declined at the turn of the century. It is certain in any case that the practice had become rare before the initiation of the HADO project.

In another type of shifting cultivation observed, prac-

(1) A large part of the data in this and the following sections of this paper are based on a sociological survey of the farmers in the HADO area. The subjectivity of responses cannot be ruled out, and the validity of the material should be assessed with this fact borne in mind.

ticed by less than 10% of the respondents interviewed, a group of permanent homesteads is surrounded by permanent fields which may be rotated in natural fallow, depending on weather and land and labour availability.

Under the most common type of shifting cultivation practiced in the area, still closer to permanent cultivation (31% of responses to interviews), the farmers live permanently on one site but have other plots that may be left under fallow, again depending on weather and land and labour availability. Farm sizes vary between 1 and 3 ha, and farms of comparable sizes could be found within walking distance.

About 60% of the respondents to interviews were practicing true sedentary agriculture, i.e., continuous cropping of farmlands with crop rotation.

Among farmers practicing some form of shifting cultivation, the normal cycle consists of 4-6 years of cultivation followed by 1-3 years of natural fallow, the very limited land availability precluding longer periods of soil regeneration. Under these circumstances, the natural vegetation never reverts back to grassland/woodland. The fallow system may therefore be described as continuous, accelerated savanna/woodland fallow 5/2 (FAO, 1976: 29). The survey showed that the proportion of farmers practicing a fallow system was somewhat higher on less eroded than on moderately or severely eroded land, but the difference was only marginally significant.

The land preferred for clearing is normally savanna woodland, with a proportion of trees varying from 10 to 40%. Virgin forest was formerly preferred, but relatively recent legislation prohibits clearing virgin forest and limits clearing to areas formerly used communally for grazing and to fields kept under fallow. The preferred soils are deep sandy soils with a grass vegetation other than Aristida spp., which is an indicator of low soil fertility.

Other ephemerals, such as Bidens spp. and Datura spp., may also be used as indicators of good soil fertility. In some areas, trees are deliberately maintained when the bush is being cleared, the species generally preferred being Acacia tortilis and A. albida; many interviewees correlated positively crop yields under these trees as compared to yields at a considerable distance from an A. albida, while A. tortilis is probably used for shade.

The slash on newly-cleared plots is heaped and burned to enrich the soil. The crops planted are usually maize or millet, often interplanted with beans and peas. When a reduced yield indicates a drop in fertility, or when there is danger of drought, less demanding crops, such as sweet potatoes and cassava, are planted.

Planting generally takes place in December. Information on planting densities is not available, because agricultural recommendations are only beginning to be respected. Yield figures published for Dodoma region by CIDA (1975) indicate levels far below those for mainland Tanzania as a whole, but it is not clear whether planting densities are a major factor in this lower productivity.

Stalks standing after the harvest are burned when the fields are being prepared for the following crop. Fire appears to be a key tool in land preparation in the HADO area, and it is interesting to note considerable differences in attitudes among farmers on less eroded land on the one hand (62.5% against the use of fire), moderately eroded land (45% against), and severely eroded land (32.5%). It is quite probable that the nutrients released by burning the slash are washed away by the rains; the use of fire in severely eroded areas, coupled with their limited adoption of agricultural innovations, places farmers in these areas at a considerable disadvantage.

Farmers may sell their produce privately, but govern-

ment corporations also exist to function as marketing services, purchasing prices being fixed annually on a regional basis. Farmers are free to sell any quantity they wish, but over-selling is discouraged as creating the risk of food shortages. Transport difficulties exercise a serious constraint on marketing.

Precise information on the effects of shifting cultivation in Kondoa District are lacking. Specifically, nothing is known concerning the practice's effects on soil fertility, structure, moisture regime and temperature, nor of what happens in the soil during cropping and fallow periods and as a result of clearing, accompanied or not by burning. The impossibility of making quantitative statements on these and other aspects of the question does not, however, alter the fact that modifications to the system can be valuable in that the land, perhaps the most important resource in these communities, needs protection against being laid waste by careless farming methods.

3. Description of the New System

Strategies introduced in Kondoa District in the 1950s to combat erosion included such measures as --

- compelling farmers to reduce herd sizes by imposing livestock taxes;
- requiring farmers to plant sisal around their farms;
- terracing, obtaining labour from farmers unable to pay poll taxes or from food-for-work programmes;
- transfers of human and animal populations from highlands to lower-lying areas;
- restricting grazing on eroded lands, especially during the rainy season;
- prohibiting grazing completely on lands of more than a specified slope.

For lack of adequate enforcement, however, land degradation continued, and by 1961 all the terraces constructed in the 1950s had been completely destroyed.

Against this background, the Kondoa District Council in 1968 adopted a more stringent law on soil-erosion control and soil conservation. Among other practices, it prohibited, with respect to certain lands, planting and cultivating crops of any kind, keeping, grazing or transiting livestock, felling any tree, or burning grass or trees. This law, too, proved ineffective, and after a survey of the eroded areas (mostly in the Irangi Highlands) in 1973-74, the HADO project was introduced with assistance from the Swedish International Development Agency (SIDA).

The objectives of the HADO project were essentially the same as those foreseen in the 1950s and 1960s, with one major difference: HADO was also required to rehabilitate the "bad-lands" in its area and to assist villages in tree planting. The strategies to be used for combatting erosion were as follows:

- Terracing, followed by the planting of trees for subsequent use as fuel;
- Establishing demonstration tree-cultivation plots;
- Providing advice on soil conservation, including warnings against indiscriminate clearing, clearing steep slopes, burning grass, etc.;
- Establishing tree nurseries, producing inter alia fruit trees for planting in villages;
- Planting grass, particularly in gullies, in order to check the erosive power of the water and the silting of nearby farms.

Shifting cultivators were not required to vacate land to make way for the project, but were encouraged to adopt agricultural methods consistent with the HADO objectives, such as making fire-lines around their farms to avoid the unintentional spread of fire during land preparation, and building terraces to check erosion. These initial attempts met with only modest success, because the livestock density in the area was still greater than the carrying capacity of the range-lands. For this reason, it was decided to de-

stock the highlands completely; some 85 000 animals being transferred to lower-lying areas. In addition, an undetermined number of the human population also migrated out of the highlands to accompany their livestock. This move between parts of the district had little effect however on the total population of the area; only the distribution within the area was affected. Draft animals are allowed to return to the area during the November-February ploughing season.

By the end of December 1982, four tree nurseries had been set up in the project area and some 7.1 million seedlings had been raised. Demonstration plots totalling 1690 ha had been installed at four villages, and 95 km² of the area had been terraced. Following the destocking operation, it was anticipated that about 50% of the HADO area would regenerate naturally.

Fuelwood is the forest product of primary interest to the inhabitants of the area, and assuming a consumption of about 1.65 m³/yr, it is estimated that about 28 400 ha of woodland are needed to cover the requirements of the population. By early 1983, some 10 000 ha of the HADO area had been reclaimed. When the reclamation process has been completed, and as the reclaimed areas revert to woodland, it can be expected that some 50 000 ha of forest will be available. The effect of this increase in forest land, coupled with an expected increase in the length of the growing season, as well as current reafforestation practices with exotic species, can be expected to offset the effect of population pressures on forest products.

In the severely eroded areas of the HADO project, 85% of respondents to the survey were engaging in tree planting; in moderately eroded areas the percentage rose to 93%. However, tending was not rigorously pursued. There were clear indications that interest in tending trees could be stimulated if multi-purpose species were used; where erosion was severe, 60% of interviewees expressed interest in agri-silvi-

culture, whereas the proportion fell to 35% among the inhabitants of the moderately- and little-eroded areas. Significantly, 75% of inhabitants in the severely-eroded areas reported a shortage of fuelwood, against only half this proportion among residents in the other areas.

4. Analysis

A clear comprehension of what happened and is happening to the soils of Kondoa District requires some understanding of the historical processes that came about in the last half-century or more. Documents from as early as the 1900s report that trypanosomiasis was rampant at that time among the human and animal populations of the Kondoa District. Anti-tsetse campaigns initiated in the late 1920s led to the wholesale clearing of vegetation, and this triggered off a chain reaction of factors whose end result was severe land degradation.

The high frequency of trypanosomiasis and the surviving remnants of large tree trunks indicate that at the outset, the vegetation of the area was mainly woodland. Clearing in the Irangi area appears to have begun in 1927, and the general practice was the indiscriminate clearing of the woodlands, especially Brachystegia woodlands such as those which were dominant in the area.(1) Indiscriminate clearing continued until 1949, when it was decided that future clearing programmes should be preceded by intensive surveys. But this decision came too late: by the time it was taken, most of the vegetation had been destroyed regardless of the topography of the area. By 1952, the tsetse fly had been almost completely eliminated from large areas of the district, and by 1958 a former broad band of Brachystegia woodland as well as the Acacia combretum and other plant communities had been cleared.

____ Post-clearing vegetation types were determined by the
(1) Discriminate clearing was attempted only to a limited extent in the Acacia combretum woodland communities.

human activities that took place after that time. Reports indicate that on cleared land that was not settled, annual regeneration was very rapid, and that the secondary vegetation was denser than the original. As a result, the regenerated vegetation had to be slashed and burnt every year, thus inhibiting the natural succession of the vegetation.

On the other hand, where clearings were effectively settled upon and grazed, the natural vegetation was obviously completely impaired. In point of fact, the original purpose of clearing was not only tsetse control but also to provide new land for occupation by emigrants from over-populated areas which had started to show signs of erosion, and this in turn was conducive to further erosion. In due course, then, the regeneration process was so modified that a permanent change took place in the structure of the vegetation, leaving the steep slopes almost bare and vulnerable to erosion. As a consequence, the "bad lands" that began to appear in Kondoa District as early as the 1930s became a typical feature of the landscape.

In the meantime, however, attention began to be focused on soil erosion problems as early as the 1920s. In 1931 a special committee set up to examine the problem concluded that, rather than extensive erosion-prevention or -control works, efforts should be concentrated on educating farmers in improved land-use methods (Rapp *et al.*, 1973). Owing in part to financial difficulties, no soil conservation service was set up until 1945, enabling major schemes to be launched and new approaches to be put to the test. An official review carried out in 1951/52 found however that the schemes had been poorly implemented, and that the authoritarian nature of some measures taken had created a high level of farmer resentment. This failure of soil conservation during the transitional period toward independence served a tacit warning that attempts at soil conservation after Tanzania became independent would -- justifiably or not -- be interpreted as manifestations of colonialism, and therefore that they

would encounter strong resistance and be doomed to failure (Banyikwa et al., 1979).

Two lessons can be drawn from this experience. On the one hand, it is clear that before any conservation measures can be adopted it is necessary to understand fully the historical antecedents of the current situation. For example, many observers in Kondoa District have blamed its soil erosion problem on shifting cultivation, while the actual root cause of the situation was the indiscriminate cutting of trees and burning of the regenerated saplings for tsetse control. The second lesson to be drawn from the Kondoa experience is that all measures adopted should be specific to the local conditions: a campaign of education, unaccompanied by substantial physical measures, at a time when the farmers were not yet sensitive to the acuteness of the problem that was developing, and in a rapidly-evolving socio-political context, could not reasonably be expected to be effective.

The scope and implementation of the HADO project indicate that these lessons had been well assimilated, but also that it was not always a simple matter to apply them. Thus, the 1979 decision to destock the entire area was inevitable if the aims of the project were to be attained: the only alternative was to transfer the entire human population out of the area. Nonetheless, the measure was unpopular, and probably contributed to creating an unfavourable image of the entire project among certain sectors of the inhabitants. Some interviewees complained that destocking had created meat and milk shortages, the true cause of which was an unsatisfactory price pattern. Others (or possibly the same) protested that the removal of the animals created a fertilizer problem, but it is significant that this objection was voiced primarily by farmers in the less severely eroded areas, who were not yet as sensitive to the entire problem as those whose subsistence had already been endangered by acute erosion.

Notwithstanding this, there can be little question but that the total net impact of the HADO project on the area's agriculture has been positive. In the first place, the reclamation process has led to an increase in cultivable areas, and with a 2.9% annual population increase, this is in itself an important development. Secondly, the luxuriant vegetation has increased soil fertility and water retention capacity by the accumulation of organic matter, and the vegetation itself has reduced wind speed and drying power. Floods and the silting of fields have decreased. The over-all effect of these factors has naturally been to increase crop yields, and farm incomes have risen correspondingly.

Somewhat offsetting this favourable result is the fact that destocking the area has deprived it of the manure that would otherwise have been used to enrich the soil. It is expected however that the use of compost, and the rational use of some inorganic fertilizers, will contribute to overcoming this problem.

The destocking operation is probably at the root of the ambivalent attitude of the farmers toward extension and extension workers on the one hand, and the HADO project itself on the other. Some replies are difficult indeed to reconcile. Thus, 52.5% of farmers in severely-eroded areas reported that they had frequent and good contacts with extension workers, but of the same group only 7.5% sought agricultural advice from them. The respective percentages for the moderately- and slightly-eroded areas totalled 25% and 21.3%. These figures appear to indicate -- although one must guard against hasty conclusions in attitude surveys -- that the extension workers concentrated most of their time and effort in the severely-eroded areas, where in fact they were most needed, but that they were more successful in "selling" themselves than in "selling" their services. When this indication is set against the fact that 35% of interviewees in the severely-eroded areas, and 25% in the other areas, made negative statements with regard to the HADO project in gene-

ral, the conclusion is inevitable that there was a breakdown in the educational infrastructure of the project, to the extent that one existed. Public support is a necessary ingredient of any development programme, and a single authoritarian action, such as the destocking operation, can do more to damage the project's image than many hours of briefings and discussions can do to reinforce it, and this is all the more true when the level of sophistication of the audience is lower.

With the benefit of hindsight, it is easy to say that the destocking operation should have been preceded by a more strenuous information campaign than that which was conducted, but it is not certain that time and resources were adequate for such a campaign to be effective, especially in the context that then prevailed. More recently, HADO officials have stated that the people within the project area show a greater degree of understanding than that which was current when the destocking seminars and campaign took place.

The increase in the project area under forest appears to have led to a reduction in run-off, although this cannot be quantified at the present stage. If this deduction, based on the reduced water discharge from a catchment originating in the Irangi highlands, is correct, it is of great significance. An increase in the soil moisture recharge increases the length of the growing season and, consequently, agricultural production as a whole, farm incomes and nutritional levels. The benefits of reafforestation have also made themselves felt in the greater availability of fuelwood and wood for poles, and this trend can be expected to continue as the project reaches completion.

Finally, it can be expected that forest conservation and regeneration measures will contribute to a further reduction in the proportion of shifting to sedentarized cultivators. The national "villagization" programme also reinforces this trend, as does the presence of small-scale industries

in a number of villages in the project area. The national land reform legislation, which provides that the land belongs to the individual or group of individuals who are actually using it, may on the other hand act to counter, to a limited extent, the trend toward sedentarization.

5. Conclusions

Indiscriminate clearing of vegetation in Kondoa District in central Tanzania, undertaken for tsetse control and to increase immediate land availability in the face of a rapid increase in population, led to serious soil erosion, manifested as advanced gully erosion. First attempts to remedy this situation met with only scanty success. In 1973/74 the Tanzanian government, with the assistance of the Swedish International Development Agency (SIDA) commissioned the HADO (Hifadhi Ardhi Dodoma) Project, designed to rehabilitate the eroded areas, particularly in the Irangi highlands, by planting trees and grass, terracing, etc. A number of modifications in the prevailing shifting cultivation system of the area were involved.

A survey made in early 1983 found that the project affected the micro-climate, especially as regards the water supply; that the availability of such forest products as fuelwood had increased; that removing all the livestock from the area had led to internal readjustments in population figures, although the over-all population of the district as a whole was little modified; that farmland availability had been increased; that the soil was becoming increasingly rich in organic matter; and that flooding and silting of farmers' fields had decreased. The low per caput availability of farmland was leading to a type of shifting cultivation closer to continuous accelerated savanna fallow, the land being cultivated on average for five years and left in fallow for two; even this type of cultivation was slowly giving way to sedentarization.

The local economy is based on subsistence farming and pastoralism for its food supply. The nature of cultivation appears to leave little room for the introduction of a tree-planting element, since there is always competition for good land. On the other hand, if trees are planted on marginal land, their growth rates may not suffice to convince the farmers that tree-planting can be lucrative. Furthermore, the time of tree planting coincides with that of land preparation for food crops, and farmers tend to devote all available labour to the latter. There is wide -- but by no means unanimous -- interest in agri-silviculture in the area, but a strong educational effort will be needed before the practice is widely and successfully adopted.

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FORESTRY
AND SOCIO-ECONOMIC ASPECTS
OF MODIFICATION OF TRADITIONAL
SHIFTING CULTIVATION
THROUGH THE TAUNGYA SYSTEM
IN THE SUBRI AREA, GHANA

based on the work of

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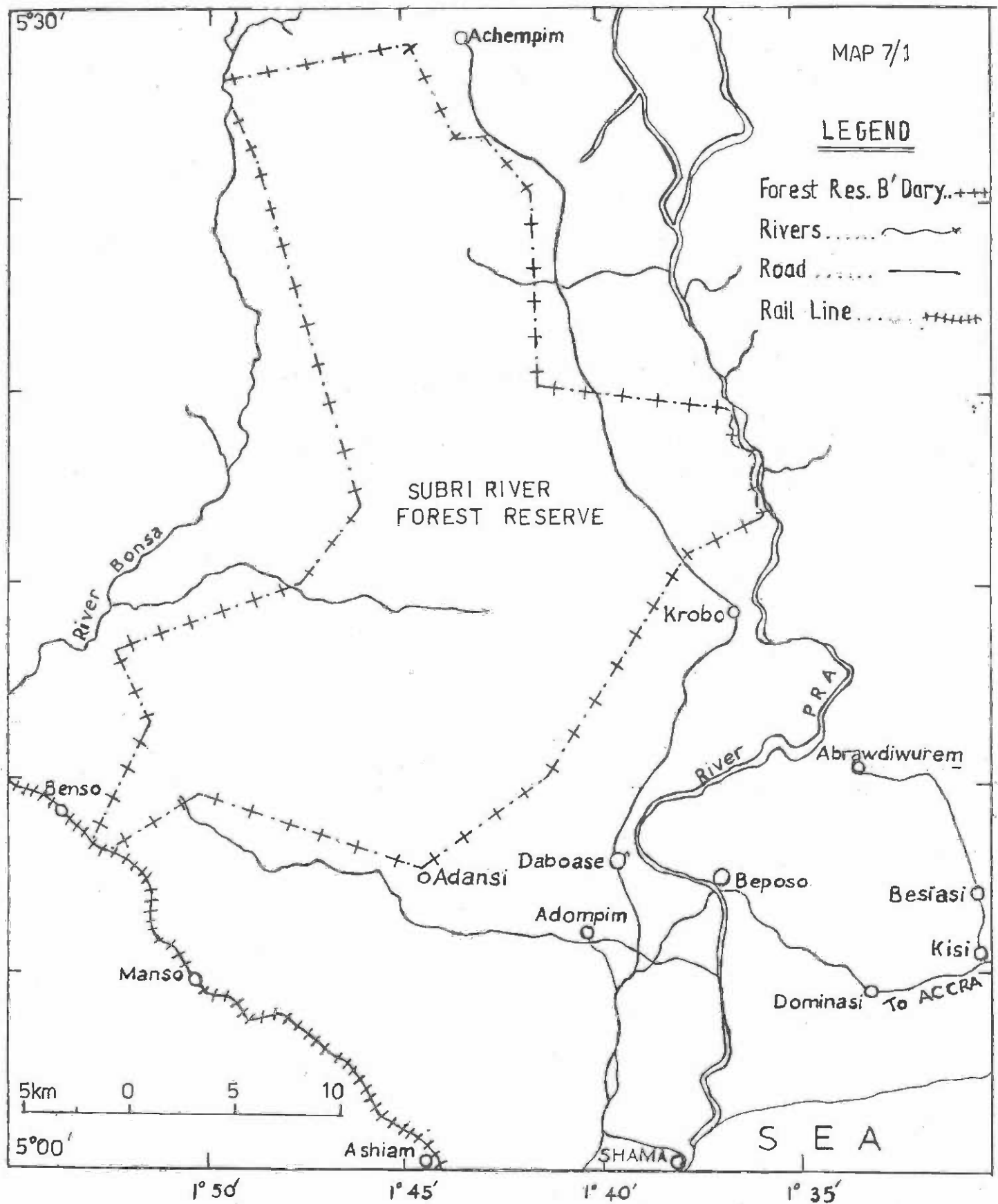


Figure 7/1. Southwestern Ghana, showing the Subri Forest Reserve.

FORESTRY
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1. Physical and Socio-Economic Environment

The Subri Project area (see Fig. 7/1) lies within the Tarkwa Forest District in the Western Region of Ghana, near the Gulf of Guinea, between 1° 30' and 1° 55' West longitude and 5° 00' and 5° 30' North latitude. It is bounded on the east by the Pra River and on the west by the Bonsa River and the Ashiam-Benso section of the Sekondi-Kumasi rail line; it surrounds the Subri Forest Reserve.

Topographically, the area is generally undulating, with altitudes ranging from 30 to 170 m. Clusters of very steep hills are found in the north, centre and southeast, while steep valleys, falling abruptly to flat swamps, are found throughout the area. These swamps, prevalent along the principal streams, are described in the Subri Forest Reserve working plan as "unworkable in the wet season and often in the dry season as well"; this may be taken to indicate their unsuitability for timber exploitation but not necessarily for such agricultural uses as wet rice cultivation.

Several streams in the area flow southwest to the Bonsa or southeast to the Pra, which is particularly important as the source of water for the Sekondi/Takoradi City Council area and as the site of a projected hydroelectric dam and pulp mill.

The rocks in the area are described in the geological map of Ghana as Middle Pre-Cambrian, mainly Upper Birrimian, of metamorphosed lava and pyroclastic rock -- granites and granodiorite. The soils have not been studied in detail, but according to the soil map of the country the predominant

soil types, under Charter's classification, are forest ochrosols and forest ochrosols-oxysol intergrades, with gleisols along the watercourses (Brammer, 1962); under the FAO/UNESCO (1968; 1970) classification, they are rhodic ferralsols, acrisols and dystic gleysols along the watercourses. Stal-janssens (1981) observes that the most widespread parent rock material is Birrimian phyllite, associated with mica schists, decomposing only to a slight extent and releasing relatively small quantities of nutrients on weathering. Younger granites, associated with granodiorites, constitute the second important parent material, decomposing to form gritty clay soils; as the granites vary widely in composition, soil fertility depends on the quality and proportions of feldspars and dark minerals present. Hornblende and biotite are quite common.

A typical catena has been described (Stal-janssens, 1981) as follows:

- Upland - Well-drained red and brown gravelly sedimentary clay soils
- Upper slopes - Red concretionary clay soil on steep slopes, or yellowish-brown (orange) gravelly soils
- Lower slopes - Yellow light colluvial clay soils with mottled subsoil, sometimes close to the surface
- Lowland - Yellow and grey sand or silty clay alluvial soil

The frequent changes in topographical features are thus associated with changes in soil types and, consequently, changes in site productivity.

The area lies within the relatively high rainfall zone of Ghana. Total annual precipitation ranges on average from 1500 mm in the east to 1875 mm in the west; it is characterized by a gradual rise from the December-January minimum to a major peak in May-June, followed by a lesser peak in September-October. Temperatures are high, reaching a peak of 31-32° C in March-April. Minima rarely fall below 19° C. Relative humidity is high and fairly constant.

In respect of its vegetation, the area lies within the moist semi-deciduous zone. Taylor (1960) recognizes two ecological associations: a Celtis-Triplochiton association to the north and east and a Lophira-Triplochiton association in the south. Smaller sub-types, due to edaphic conditions such as marshes and freshwater swamps, with Mitragyna citiata, raffia palms and calamus, are frequent throughout the area, particularly along the watercourses, as also are vast areas of serial communities, showing varied stages of closed forest development after shifting cultivation.

The climatic climax vegetation is represented only in reserved forests and in small scattered patches of unreserved forest. The rest of the area is covered by perennial cash crops (predominantly cocoa, rubber, oil palm, coconut palm and citrus), farms of staple food crops (cassava, maize, cocoyam and plantain) and abandoned food farms (bush fallow at various stages of reversion to closed forest).

The vegetation in the closed forest is a mixture of a large number of tree species: GFD (1967) records some 235. The tree crop is described as poor in economic timber species, even more so toward the south. The hills and slopes are generally better stocked than the swampy valleys, which rarely contain timber trees of value. This poor stocking, attributed in part to creaming of the southwestern Ghanaian forests for mahoganies in the early days, accounts for the Forestry Department's decision to convert the Subri Forest Reserve into a plantation.

The population density of the Tarkwa administrative district is 40.6/km², in line with that of the Western Region as a whole (40.7/km²) and somewhat below the national mean of 42.2/km². The figure is rather low as compared with that of other regions in the closed forest zone, 109.1 and 82.9/km² in the Central and Ashanti Regions respectively, the closed forest zone of Ghana being generally more densely populated than the savanna woodland zone.

The working population is largely engaged in agriculture. While employment figures for the study area proper are unavailable, the employed population of the Western Region as a whole (total population: 974 000) is estimated at 74.3%, of whom 55.3% engaged in agriculture. Other major employment markets include mining (gold, manganese, bauxite and some diamonds) and the timber industry.

The low population density suggests little pressure on land availability, and this is confirmed by interviews. Apart from the inhabitants of one village very near the Subri Forest Reserve, most villagers stated that they had adequate land for farming.(1)

The land tenure system prevalent in the area is that of the Akkans of Ghana: tribal ("stool") lands controlled by the head of the stool, or chief, for the benefit of the community. Individual ownership is generally restricted to usufructuary rights, continuing only as long as the land is put to productive use. In his discussion of tenures under customary law in Ghana, Pogucki (1962) establishes a relation between tenure and the economic evolution of the area. Thus, where land is under pressure, rights are linked permanently to defined parcels, while where land is abundant -- or subject to rapid deterioration --, rights consist of the power to use any piece of land within an area. This rather cumbersome system of land tenure influences the choice of the system of farming; in a way, it dictates the farmer's desire to evolve methods maintaining the productive status of the land, and the cultivation of tree crops such as cocoa, oil palm and citrus ensures him some permanence of his rights of use. As part of the government's over-all effort to improve agricultural production, it is seeking to streamline land tenure.

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- (1) It should be noted however that the sample size was rather small and excluded the eastern part of the study area, where villages are hemmed in between the Subri and Bonsa River Forest Reserves.

The practice of forestry is one of the major land uses of the area. Of the compact block of some 59 000 ha (41.2% of the area) occupied by the Subri Forest Reserve, individual farms and village lands made up only an insignificant total of 188 ha; the rest of the reserve was devoted to productive forestry. Under the expired 1961-71 forest plan, the objects of its management were as follows:

- to maintain the protective functions of the forest, bearing in mind particularly the maintenance of suitable climatic conditions for the agricultural crops in the neighbourhood;
- to manage the forest on the basis of maximum sustained yield and to furnish a steady revenue to the land-owners;
- to increase the proportion of economic species in the crop in the course of exploitation;
- to satisfy the reasonable demands of the local population for forest produce;
- to set aside an area for research work, with particular reference to studies in methods of conversion from natural selection to more regular forests.

While the objectives of management have not changed fundamentally, emphasis since 1971 has been on conversion of the natural forest to plantations of fast-growing species suitable for pulping.

Although, as noted above, the tree crop in the reserved forest is considered poor in respect of economic species, even in its depleted state the Subri Forest Reserve has been exploited for timber, yielding substantial revenues; it has also been a source of such minor products as bamboo, building poles, canes, raffia, rattan, binding materials, fruits, nuts, spices, meat and pharmaceuticals. Timber exploitation has not only furnished an employment market but has helped to open up the countryside with extraction routes, and the minor forest products have been a resource base for small-scale rural industries: carving and basket-weaving.

Forestry also plays an important ecological role in

the area. On the one hand it furnishes, as elsewhere, protection against erosion on the rugged terrain. Just as important is its role in preserving the humid environment needed for the growth and development of the perennial crops, particularly cocoa. The very severe drought and dry-season fires of 1982/83, which penetrated even the rain-forest, underscore the need for preserving this humid environment.

2. Former Traditional Agricultural Systems

It is difficult to identify a single farming system prevalent in the study area. The existing system may best be described as a mix of systems, and it is perhaps more appropriate to make a distinction based on the type of cultivated crops. On that basis, two main systems can be recognized: permanent agriculture for the permanent or semi-permanent cash crops (cocoa, rubber, oil palm, citrus and coconut palm, in that order) and shifting cultivation for the staple food crops (maize, cassava, plantain, cocoyam and spices). These staples are not only cultivated to meet the farm family's subsistence requirements but are considered by the farmer himself as important cash crops. Ready markets exist in the urban centres, and the current situation of almost chronic food shortage and consequent high prices for staples has made their cultivation more lucrative than the traditional cash crops.

As an alternative system of land use, permanent agriculture has an impact on the land available for shifting cultivation, and hence the length of the fallow period, while as a source of supplementary income it improves the farmer's financial position and enhances his ability to obtain the needed inputs, which may dictate the type of farming system he adopts. Further, in the early stages of establishment of his permanent crops, the farmer incorporates cultivation of the staples, which are maintained together with the perennials until they are excluded by canopy closure; to this extent, the system applied while forest-tree crops are being

established is very similar to taungya. Finally, in establishing his permanent crops, the farmer preserves some of the existing trees, either because they are deemed valuable to the community (fruit trees, medicinal plants or important timber species) or because of their favourable impact on the environment. Inasmuch as these trees do not interfere with the crop planted, the system has the characteristics of a form of agro-forestry.

The Subri farmer, like farmers elsewhere in Ghana, sees perennial crops as a security for loans, as insurance for his old age, and also as a status symbol. In the Tarkwa District, 10% of the total land area -- nearly 15% of the land available for agriculture -- is under cocoa; corresponding figures for the Western Region as a whole are 14% and 20%. Statistics for oil palm, coconut palm, citrus and rubber are not available.

For the purposes of the following discussion, the term "shifting cultivation" is taken in the definition of Tiffen (1982): "a technique for restoring soil fertility after a period of arable cultivation, (consisting of) relatively short periods of cultivation followed by long periods of fallow". This system, akin to "land rotation" (Ofori, 1974) or "recurrent cultivation" (Greenland, 1973), is adopted by the entire Subri farming community for staple food crops.

Normally, Subri shifting cultivation does not involve movement from one dwelling place to another. The dwelling places are permanent and in organized village communities, ensuring, in the view of the farmer, community life and access to such facilities as good drinking water, health clinics, schools and essential commodities. If a farmer operates farms concurrently in widely separated areas (in one case observed, his farms were some 40 km apart), he maintains more than one home, each of which he considers permanent. More often, the farm is fairly close to the settlement, usually within 10 km.

The Subri shifting cultivator is far from evoking the classical image of the poor peasant farmer who subsists by literally scratching at an impoverished site. In a survey, his social standing was found to be widely varied: he can be the local chief as well as an ordinary member of the tribe. In general he is little educated, but he appreciates the value of education and sends his children to school, even if this deprives him of their services on the farm during school sessions. In one extreme case encountered, the farmer had completed secondary school, had been a teacher and had worked in the Prime Minister's office for two years; he had five children in secondary school and considered their assistance on the farms as negligible.

An estimated 10 to 15% of the farmers had both permanent farms (mainly cocoa, oil and coconut palm, citrus and some rubber) and staple-crop farms under shifting cultivation. Farm sizes ranged from 2 to 8 ha under cocoa and from 2 to 6 ha under oil and coconut palm; the other crops occupied smaller plots. Depending on the case, the farm was either originally cleared and cultivated by the farmer himself, or inherited, or inherited and subsequently expanded. Farms were not always in compact blocks but could be scattered in several localities.

The average farmer appears to see in shifting cultivation the system that best earns him an income commensurate with his inputs. His choice is more influenced by physico-chemical factors, climatic and edaphic, than by questions of social status. The one feature that seems to be common to all is the lack of access to technological inputs (equipment and fertilizer), but this is not peculiar to the shifting cultivator.

Sites for clearance may be chosen in what remains of the primary forest or, after a period of fallow, in the secondary forest; primary forest is fairly scarce outside permanent forest estates. The farmer's choice of site is deter-

mined to a considerable extent by the tools available to him for clearing. In most cases these are limited to the axe, the machete, the traditional hoe and, occasionally, a hired chain-saw, and his ability to prepare the site intensively is limited correspondingly. In addition to the problem of obtaining adequate labour, this is often given as a reason for returning frequently to fallow plots.

Sites are prepared by slash-and-burn. The undergrowth is cleared, and climbers are cut, soon after the November-December rains; the over-wood is felled and the branches of the felled trees are lopped, to be burned when the debris is dry at the peak of the dry season, in late February-early March. A few farmers make an attempt to convert the woody debris to charcoal, but most of it is consumed in the fire. Large trunks remaining unburnt are left to rot with time.

The only tree specimens left standing are certain valuable species, as mentioned above, and a few trees considered too difficult to fell. A few species (e.g. Piptadenia africana and Tarrietia utilis) are considered injurious to the food crops and are felled, no matter how valuable they are and how difficult they are to remove.

Soil preparation is minimal, and fertilizer application is very rare. Government policy is to encourage the use of fertilizers, and they are furnished at subsidized prices, but supplies are very irregular.

Food crops are planted in patches (maize) or on small mounds (cassava, cocoyam, plantain and yams); crops are most frequently mixed. Two crops of maize may be raised in the same year, the first pure and the second inter-cropped with cassava and other food crops.

According to farmers' replies to the survey, the cropping period is generally two years, or occasionally three, followed by a fallow period of 3-5 years. A few farmers re-

ported observing declines in yields the second year, while one maintained that he had cropped the same plot for four consecutive years without decline. Although most farmers observed a three-year fallow period, most preferred longer periods, of five years or more. One maintained a one-year fallow period on some of his plots, explaining that this enabled him to observe longer periods on other plots in anticipation of higher yields. Several interviewees indicated that early returning to fallow plots was sometimes determined not by land scarcity but by the difficulty of clearing older, and consequently more densely wooded, fallows.

Farmers were generally reluctant to disclose their income, but all said they made a good living out of farming. One, who worked about 4 acres (= approx. 1.6 ha) reported 1982 earnings from sale of produce, excluding quantities consumed by his family, at the equivalent of US\$ 2760; another, farming 9 acres (= approx. 3.6 ha) reported earnings of US\$ 6000 from his staples and about US\$ 3500 from cocoa.

3. Description of the Project

Large-scale reafforestation was undertaken in Ghana in 1968, following a decision of the Forestry Department to convert reserves, or sections of reserves, poorly stocked with economic species, into plantations of fast-growing indigenous and exotic species to supplement future supplies from the natural forests. Work in the Subri Forest Reserve began in 1971; in view of the planned pulp and paper project, efforts were concentrated on establishing a crop of Gmelina arborea. Sites were prepared by clear-fell and burn, and the taungya system was applied. The programme fell behind, however, largely because of lack of inputs stemming from reduced financial support.

In 1974, CIDA and FAO/UNIDO missions recommended that considerable savings could be effected if, instead of burning the clear-felled forest, the wood were converted into char-

coal. A subsequent report, commenting positively on the proposal, suggested further that the project should incorporate social, silvicultural and management criteria in order to achieve maximum benefits. It pointed out that wood and labour were not limiting factors to charcoal production in Ghana, and suggested that higher economic and social returns might be obtained from labour-intensive rather than from capital-intensive schemes.

The preliminary phase of the project was initiated in 1976; a new document for the main phase, prepared in 1978, greatly emphasized effective forest management to maximize the output of renewable fuels without prejudice to the flow of other forest products or damage to the environment.

The project is situated in the Subri Forest Reserve. It is easily reached by an old logging road, now very much improved; there is a network of logging roads over much of the area, mostly in poor condition but capable of improvement at reasonable cost. The reserve is covered by various felling concessions and continues to be logged, but logging intensity has been declining, largely because of lack of equipment.

In addition to demands on the reserve for wood and fuel for private consumption (charcoal is shipped to the country's capital, some 230 km away), the production of a planned pulp and paper mill in the locality is estimated at 60 000 tonnes a year, and a projected iron and steel mill close by is estimated to create a demand of 120 000 t of charcoal. Other demands for forest products can also be expected, and an increased demand for food, and hence for arable land, is likely to arise.

The Subri conversion system aims at evolving the most appropriate and inexpensive methods of converting the tropical forest into a plantation of fast-growing tree crops. It seeks to maintain a forest environment during conversion operations as far as feasible; to select sites of high poten-

tial for plantation purposes; to select and preserve pole-sized, naturally regenerated, stems of economic timber species for sawn-wood production; to utilize as much as possible of the material felled during site preparation in a portable sawmill and in firewood and charcoal production; and, considering the existing demand for foodstuffs, to introduce an agri-silvicultural system of plantation establishment for producing raw material of uniform size, range and quality for future industrial use.

Variations in site productivity have been discussed above. Since there is more than sufficient land in the Subri Reserve for plantation demands (10 000 ha of 59 000 ha available), unsuitable sites can be easily avoided. Soils are surveyed and classified, and base maps are prepared to permit steep slopes, shallow and rocky soils, swampy areas and areas of special ecological interest to be identified and excluded from conversion, as are areas close to watercourses.

Site preparation consists of climber cutting, brushing the under-wood, selection of standards and, finally, felling. Due attention is given to the need to preserve the forest environment, minimize damage to the standards selected and make full use of the woody material, which under traditional slash-and-burn techniques was consumed by fire. Some 80 trees/ha -- more than is needed, to allow for felling damage -- are selected as standards; these, subsequently thinned down to 50-60/ha, constitute advance growth destined to form part of the future crop. Depending on its species and size and the technology available, the felled material is either sawn, sold as fuel-wood or transformed into charcoal. The output is estimated at about 250 m³/ha. From one sample plot of 3.3 ha, 234 m³ of charcoal and 13 m³ of commercial saw logs were obtained; 15 m³ of wood, mostly buttress pieces, were not utilized.

During the early years, carbonization by departmental labour was found uneconomic, and the trend is currently to

encourage charcoal production by private entrepreneurs.

The standards are selected from among the sapling- and pole-stage specimens of the current economic classes I and II species, under the Forestry Department classification. The planted crop consists predominantly of Gmelina arborea; other species on trial include Cassia siamea, Eucalyptus spp., Albizzia spp., Lencaena spp. and Sesbania spp., as well as certain indigenous "economic species": Entandrophragma, Khaya, Chlorophora, Terminalia and Triplochiton, some of which have not hitherto performed well in plantations.

In view of the short supply and high prices of food in the area, agri-silvicultural systems are adopted; the produce is sold to the staff on a ration basis and helps maintain the morale of the labour force (Mason, 1981). The proceeds are paid into the project fund and go to offset part of the establishment costs.

The taungya system was introduced in the Krobo section of the reserve in 1976-78; plot demarcations were 100 acres (= approx. 40 ha) for each of the three years. The farmers prepared the site, provided pegs and assisted with pegging and tending in exchange for use of the land. Results were not too satisfactory: some tree crops failed as a result of inadequate tending, and a relatively large area demarcated for 1979 could not be planted by the department; this led to the temporary abandonment of taungya. According to recent reports, the system is to be reintroduced.

The Subri conversion system, first tested in 1978, appears to have achieved its primary objectives: the establishment of stands of fast-growing species at economic costs, the maintenance of a forest environment and preservation of regeneration. The early stands look promising. The Gmelina arborea shows good growth; according to Mason (1981), primary measurements indicate that at the age of 7 years, mean annual increments range from 9 m³/ha on poor sites to 20 m³/ha on

good sites, a quite encouraging figure. The standards present the picture of a good mix, and with the undergrowth they have preserved the forest environment. It is however too soon to assess the silvicultural gains with respect to the growth and development of the economic species left as standards which have not been successfully established in plantations: the khayas and the entandrophragmas. It is still not clear whether these can be retained to exploitable girths at the present stocking of 40 trees/ha without prejudicing subsequent rotations of light-demanding Gmelina arborea.

The most significant achievement of the project appears to lie in the economics of the system. An analysis of costs and income (excluding planting, subsequent tending and derived income) indicates a credit balance, attained not by reducing operational costs but by generating income from what previously was wasted wood, and by employing a system of agro-forestry. It is also significant that in putting the existing vegetation to productive use, some community needs have been met and employment opportunities have been created in the effort to convert to sawn timber and charcoal.

Inter-cropping with staple food crops has remained primarily within the purview of the Forestry Department and has not offered the local population much opportunity to increase their food production through the taungya system, although food sales to forestry workers at reasonable prices have been most welcome.

4. Analysis

Shifting cultivation is widespread throughout the area studied, and aerial photographs indicate that about 80% of the tropical forest outside the reserved land has been degraded by it. Destruction of the tropical forest and consequent depletion of its resources in wood and minor products, together with the loss of intangible assets from the forest cover and environmental degradation may thus be seen as the

major impact of shifting cultivation in the area. The reserved forest is gradually becoming the area's only source of fuel-wood, and even in these rural areas, in the closed-forest zone, fuel-wood and charcoal have ceased to be "a free good" and have become expensive commodities: a 32-kg bag of charcoal cost the equivalent of US\$ 40 in a neighbouring village.

Despite the rugged nature of the terrain and the consequent variations in site discussed above, there appears to be no basic criterion for site selection for the various crops cultivated, or even for distinguishing between sites for permanent tree crops and for staple annuals. Steep slopes which should have been under tree crops have been cultivated for staples, and signs of erosion are already evident. Again, failure to plan future crops invites Eupatorium adoratum, an aggressive weed extremely difficult to eradicate, and problems are thus created when the fallow comes to be recultivated.

It cannot be said as yet that the arable land available to the farmers has reached a stage of irreversible degradation, reducing yields to an extent that would impoverish the farming community. This fortunate situation is largely due to the fact that population density is low and pressure on the land correspondingly light, rendering possible short cropping periods as compared with the length of fallow. This situation is however not likely to be permanent, and there is cause for concern for the future, in the light in particular of an annual population growth rate of 2.7%.

Increased production of staple food crops is currently a major national concern in the face of the acute food-deficit situation. Increasing the land under cultivation by encroaching on the permanent forest estate does not offer a panacea, and may have adverse consequences in a locality where almost the entire unreserved tropical forest has been replaced by secondary formations as a result of shifting

cultivation. Part of the answer lies in improved agricultural systems. Efforts should be made to evolve methods that will help maintain the nutrient status of the soil at an acceptable level for longer periods, and thus to reduce the ratio between fallow and cropping periods, the final aim being permanent or semi-permanent cultivation. This could be achieved by proper matching of crops to sites, the use of high-yielding crop varieties, crop rotation and mixed cropping with well-selected species, including inter-cropping with nitrogen-fixing leguminous tree species, an agro-forestry system.

Maintaining high crop yields by intensive soil-improvement and fertilizer application would call for investments in equipment and large quantities of fertilizer, possibly beyond the means of the shifting cultivator and of the national economy. A reasonable alternative would be to slow down the rate of soil degradation, checking erosion, soil compacting and surface run-off, by eliminating fire as a means of site preparation and debris disposal. The debris could be put to more productive use by carbonization into charcoal and by retaining branchlets and leaf litter as mulch and eventually as a source of green manure.

While the current food situation is focusing primary attention on staples production, sight must not be lost of the fact that Ghana is very dependent on its agricultural exports, particularly of cocoa, and that such tree crops as palm fruit, copra and rubber are needed as raw materials in her industrial plants. The project area lies in the oil palm and citrus belt; it is suitable for rubber, and the northern section falls within the best cocoa-producing zone of the country. The economic importance of these crops should therefore not be neglected. Some farmers, attracted by the current high prices of staples, are said to be contemplating replacing their cocoa by staples; this negative attitude is not in the best national interest, and the authorities should take the necessary economic measures to counter it.

Production from the Subri Forest Reserve may appear substantial, but it is inadequate in relation to its potential, largely because exploitation has been selective and biased in favour of a few "economic species", while a large proportion of the available yield of lesser-known species has gone unexploited. This was not necessarily wasteful: the trees remained available for exploitation at some later time, although they may have retarded regeneration of the forest and the growth of saplings and the pole crop. Wasteful management arrived with the conversion of the natural forest into plantations. The existing vegetation went largely unutilized, and large volumes of usable wood were burned during site preparation or left to rot. Efforts at carbonization were indeed made, but their effectiveness was limited by the lack of facilities and equipment.

The mode of site preparation adopted by the shifting cultivator is very similar to that, outlined above, used by the Forestry Department. Wastage, especially in secondary forests, may not be as great as is sometimes reported, but if the cultivator made greater efforts to utilize the existing vegetation he could certainly supplement his income. Maximum utilization could also generate small-scale rural industries: forest mills for on-site conversion of logs to lumber, manufacture of tool handles, rural carpentry shops for manufacture of inexpensive furniture, charcoal production, etc. This in turn could create avenues for employment, raise rural living standards and also, to some extent, reduce rural-urban drift.

The forest also has an important protective function, which the farmer appreciates even if periodically attempts are made to encroach upon the stands. His demand for land for agriculture stems not from his dislike for the forest but from his desire to exploit the intangible benefits of the forest in maintaining soil fertility. He accepts taungya in forest reserves not because no arable land is available to him outside the reserved forest but as an assertion of

his belief that land kept under forest cover for many years is likely to be more fertile than his fallowed plot. He is aware, too, that forest cover protects his water resources and his agricultural crop.

What the farmer in the Subri Forest Reserve really looks to is multiple-use forest management. The stage is set for the forester to exploit this situation, introducing the shifting cultivator to multiple land-use, agro-forestry, initially in the reserved forest while it is being converted into man-made forest, and then teaching him to extend the system onto his plots outside the reserved area as a means of improving shifting cultivation.

5. Conclusions

Alternatives to shifting cultivation should be geared to mitigating its adverse consequences: degradation of the environment, leading to low crop yields and impoverishment of the rural population. While site degradation, as stated above, has not reached the irreversible stage in the Subri area, signs of degradation are already evident and cause concern for the future.

Land must still be made available for food production, and what is needed is a proper balance between the share of land to be devoted to the cultivation of staples and that which should be maintained under forest cover in order to protect the environment and meet the forest products requirements of the community. This concept has been generally ignored by the shifting cultivator in the Subri area, who also makes very little effort to distinguish between sites suitable for cropping and fragile sites that can best be left under forest, or between those better suited for tree crops and those suitable for shifting cultivation. Proper site selection and species allocation should reduce soil degradation, as can the elimination of fire as a means of land clearing. The Subri conversion system, incorporating these con-

cepts, would for that reason alone be worthy of emulation.

It has been noted that the shifting cultivator leaves some trees standing when he clears his plot, and that he practices some mixed cropping. This practice could be carried out more systematically, and where necessary tree crops could be planted. A mere species mix would not however be enough. It would be more advantageous to develop sound agro-forestry systems, taking into account the impact of the crop mix on the individual crops, on the site, and on the value of the non-food crops, and thus the impact of the system on farm incomes.

Maximum utilization of the woody material obtained during site preparation as practiced under the Subri conversion system provides an opportunity for increased earnings. While the shifting cultivator cannot be expected to earn much from sawn timber, since he invariably cultivates the secondary forest, the potential for fuel-wood is high, and could be increased even further if the farmer introduces short-rotation crops into his system, with the dual purpose of rejuvenating his site and creating another saleable commodity.

An alternative to shifting cultivation as currently practiced in the Subri area should not only be such as to raise farm incomes but should also contribute to meeting the basic needs of the immediate community and, where possible, contribute to the national effort as well. The potential market for wood fuels reaches far beyond the immediate farm community, and in improving the wood-fuel situation the farmer is not only increasing his earnings but also helping to solve a major national problem.

Improvements in the system as a whole can however be achieved only if certain constraints in the socio-economic conditions in the area are removed. A system of land tenure that does not ensure permanent possession of the land must deprive the farmer of any incentive to enhance its productive

capacity in the long term. The lack of inputs such as equipment facilitating site preparation and the maximum utilization of the existing vegetation acts as a serious disincentive, as does the lack of access to credit.

While the Subri experience has demonstrated its potential, therefore, its acceptance by the shifting cultivator demands intensive extension work as well as continued support by the authorities.

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