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UTILIZATION OF ERTS-1 IMAGERY IN CULTIVATION AND SETTLEMENT SITE IDENTIFICATION AND CARRYING CAPACITY ESTIMATES IN UPPER VOLTA AND NIGER

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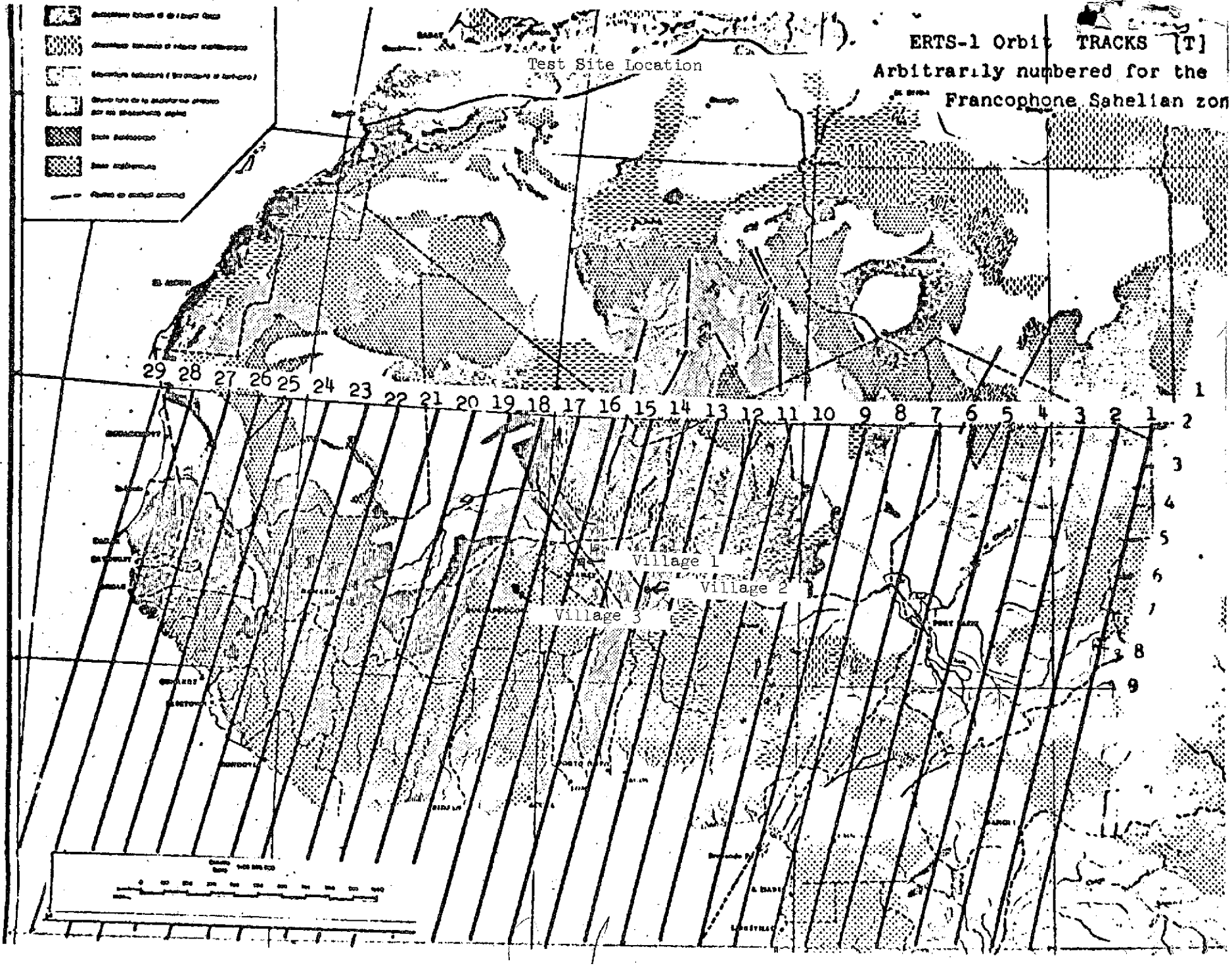

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INTRODUCTION

This study was designed in the spring of 1973 to support the aims of the Grain Stabilization Program in two of the ENTENTE States: Niger and Upper Volta. The goal of the program is to determine, design and implement the policies necessary to promote adequate cereal production for the food requirements of the population in these states, in both good times and bad. The severity of the long-term and short-term rainfall deficits clearly highlights the importance of these policies.

More specifically this study is designed to answer several questions at a preliminary level, e.g., can the new data source available in repetitive Earth Resources Technology Satellite - 1 coverage be productively utilized? Several hundred investigators are making application studies, using ERTS data, under these headings: agriculture, forestry and range resources, mineral resources, geological structure and land form surveys, environment, water resources and land use mapping, marine resources and ocean surveys (and interpretive techniques). The studies are designed to test the feasibility of ERTS data in solving the problems in making resource inventories and all of the theoretical problems involved in distribution studies. The imagery and computer compatible tapes (CCTS) used by all are, of course, the same; their interpretation varies according to discipline.

This report contains the results of an ERTS application study specifically designed to meet the problems of cereal production in the Sahel. Under these circumstances the study is primarily agricultural, although

water resources and soils are also especially relevant. As an application study in agriculture the work done under these auspices has been reported to the committee reviewing the ERTS studies results, at Goddard (November, 1973).

In the two countries of Niger and Upper Volta agriculture is horticulture, since the processes of planting, weeding and harvesting are done with hand held tools, and is practiced by indigenous persons whose crops, cropping regime, settlement patterns, tenure systems are differentiated primarily according to their cultural affiliation --- ethnic group --- as developed and adapted over a long-term period to the particular physical and climatic environment of the groups territory.

So, this is an ERTS application study of indigenous horticulture in the Sahel and the principal questions asked are what can be usefully, and demonstrably, distinguished, in the imagery of cultivations, or fields, and of settlements, because the two are inextricably linked under the conditions of hoe horticulture practiced by rural villagers. Within this context two questions become especially prominent:

1. Is there population pressure on the land resources and how can you tell with ERTS?

2. If there is population pressure is this leading to increasing desertification especially under conditions of increasing climatic aridity?

These questions are really questions about carrying capacity --- how many people can be accommodated in a given territory, and the question can be asked in an ascending scale --- the actual, the potential, the optimum carrying capacity or relationship between landand man, for a given group,

at a given level of technology, and in a given climatic regime.

Given the scope of ERTS scenes (180 kilometers on a side) and its already accepted capability in distinguishing soil classes and vegetation (Symposium: 1973), a carrying capacity approach emphasizing soils vegetation classes as the basic frame of reference was selected (Allan, 1965). This particular approach was, morever, designed to analyze indigenous systems of agriculture and was originally developed to evaluate African dry savanna regimes with exactly the same kinds of problems now being faced in the Sahel --- population pressure in a deteriorating habitat. Indigenous systems of agriculture are studied by ethnographers and the results are integral to carrying capacity estimates. Allan's work is well known to economists working in Africa and is thoughtfully recommended to administrators by McLoughlin (1965) as well as by others concerned with the same problems (Boserup, 1965; Spooner, 1972).

Most ERTS application studies involve a multi-stage approach: ERTS, aerial photography and field or ground observation. All these are in use although the aerial photographs were fortuitously obtained, are from 2 to 15 years old. Useful for "data base" purposes, they are of less direct use than would be simultaneous aerial coverage.

This report contains a summary of the findings on ERTS, on the carrying capacity results for nine different soil types, and on the carrying capacity results for three historically and geographically separate peoples: The Sonrai, Hausa and Mossi, as these are now understood on the basis of three short-term intensive field studies. Preliminary observations

on the socio-economic response to land constraint, observations on the methodology, and recommendations are also part of the summary.

Part II consists of the documentation to support the summary, and is divided into the three field studies. Included are reproductions of the ERTS imagery, aerial photographs and field photographs illustrating the findings.

Part III consists of the documentation on population densities in settlements, and on the population structure of the three villages, and the implications thereof.

Credits and Acknowledgements

During the field portion of this work, I reported to the RDO/Niamey, S. J. Littlefield and enjoyed the fullest cooperation and support from that office. Miss Littlefield and Mr. William Garvey made appropriate arrangements with senior Government of Niger officials for the conduct of the field studies. In Upper Volta Mr. Ambassador Easom very effectively made arrangements for the conduct of field studies and for discussions with appropriate government officials. The geographer Helga Prouty gave substantial help in soil analysis Koulbagou-Haoussa.

In Koulbagou-Haoussa, the Chef de village, Salefu Hamidou and his Deputy, Saidu Alidu, offered use of an available compound and supported the most useful assistance of villagers in discussion and field location work. A Sonrai: English interpreter, Hima Garba Kio literally made the collection of field data possible.

In Dogondoutchi the Sousprefect Hahaman Manon gave full permission for my stay and the work it entailed and recommended me to the Chef de Canton Sumana Gao and the Chef de Ville Bozari Koniage. Through the good

office of the Peace Corps in Niamey, it was possible for Abdullah Toure to serve as Hausa: English interpreter.

The Naba Zabre Naraogo of Nabadougou and Karentenga in Upper Volta gave not only his permission for the field work but also several days of his own time during a busy period. The More: English interpreter was Peter John Bamogo, a young but able person.

In Washington, I have reported to Martin H. Billings and under his guidance have had the useful support of his office.

ERTS-1 imagery, supplied by the Goddard Space Flight Center to the Drought Analysis Laboratory (DAL) was used throughout the study. Miss Rose Fanale has fulfilled the function of research assistant most ably. Aerial photographs of coverage distributed by the Institut Geographique National are reproduced with permission.

Drought Analysis Laboratory Facilities in Building 21 at Goddard Space Flight Center have been used in analytical work with the imagery and field observation data.

SUMMARY

ERTS-1 Imagery Analysis Results

Interpretation is based on these factors: location, shape or pattern, reflectance characteristics in MSS Band 4, 5, and 7, contrast boundaries, change especially between rainy and dry season or within rainy and dry season periods.

Soils and Vegetation Types

Some of these soils carry very little vegetation even in the rainy season and the exposed soil itself is reflected. Other soils are exposed during the dry season, or carry dormant vegetation, and are vegetated in the rainy season. Color refers to the appearance in color composites --- MSS 4-yellow, MSS-5 magenta, MSS-7 cyan.

1. Mineral soils (type 12), color is dark in all seasons, vegetation minimal or nil. No known carrying capacity. Immediately adjacent soils are bright all year. Easily distinguished.

2. Weakly developed lithosols in Upper Volta. High contrast with adjacent hydromorphic soils. It is soil type 22. Exposed soil with topsoil removed bright or light in all seasons, rainy season vegetation is dense on low elevations and distinguished only by shape and location from adjacent soils. Carrying capacity is 19 persons per square kilometer.

3. Weakly developed colluvial soils in Niger (type 27) is easily distinguished in all seasons, carries dormant brousse tigre vegetation in dry season which is then grayish in color, and with reddish tones in the rainy season. In most areas little or no evidence of cultivations and

hence no known human carrying capacity; animal carrying capacity is unknown.

4. Weakly developed regosols in Niger (type 28) is readily distinguished from adjacent soils by being very light or bright in reflectance in all seasons)of available imagery). The soil is exposed even in the rainy seasons; such vegetation as there is is in high contrast and bright red in color. The estimated carrying capacity is 11 persons per square kilometer.

5. Brown subarid soils in Niger (type 41) are difficult to distinguish from the tropical ferruginous soils with granites in the dry season. They are grayish brown in appearance, occur in longitudinal bands, and carry bright red vegetation especially adjacent to stream courses in the rainy season. Carrying capacity is 22 persons per square kilometer.

6. Tropical ferruginous soils on recent sands in Niger (type 51) can be readily distinguished from adjacent soils through boundary contrast, color, pattern of occurrence along the dallols, are a light pinkish brown in dry season and vegetated in the rainy season. Estimated carrying capacity is 16 persons per square kilometer.

7. Tropical ferruginous soils in Niger (type 54) can be distinguished from adjacent soils and vegetation (type 51) primarily because of higher density of vegetation which appears purplish in the dormant dry season state and rather dense vegetation in the rainy season, which is bright red when cultivated. Carrying capacity estimate is 12 persons per square kilometer. Old cultivations which do not regenerate vegetation in the rainy

season are bright or light all year and similar in appearance to soil type 28.

8. Tropical ferruginous soils with granites (type 58) in Niger are difficult to distinguish in the rainy season imagery from brown subarid soils but can be distinguished from adjacent hydromorphic soils, or together with the brown soils, are readily distinguished. They are light or light grayish in the dry season and support bright red cultivations, readily seen in the rainy season. Estimated carrying capacity is 38 persons per square kilometer.

9. Hydromorphic alluvial soils (type 91) in Niger are easily seen because of their location along the river with characteristic patterning, darkish gray tone in contrast during the dry season and very bright vegetation during the rainy season. The estimated carrying capacity is 40 persons per square kilometer.

10. Hydromorphic alluvial soils (type 95) in Upper Volta are also easily seen due to location and patterning, but appear to carry vegetation year-round light in tone during the dry season and very bright red in the rainy season due to cropping. The estimated carrying capacity is 80 persons per square kilometer.

Calculation of the total areas of these soils is possible because they can be distinguished and mapped and adjusted from the 1963 data base and is highly recommended for future work.

The cultivable percentage, the amount of land which is has been or could be put into cultivation can be calculated with ERTS imagery, with the proviso that care be taken not to include the problematical wasteland.

Cultivations

Cultivations or fields can be distinguished on these terms. They are circular in shape on all but the hydromorphic soils, where they are rectangular or ribbon shaped. Fields of ten plus hectares, cleared of vegetation in areas of homogenous bush (on brown subarid soils and tropical ferruginous soils) can be identified as cultivations, primarily through shape, contrast with surrounding vegetation and size. Most cultivated areas are in fields of this size or larger. Fields smaller than this are difficult to identify reliably on the tropical ferruginous and brown soils.

More contrast is present for fields in active cultivation relative to surroundings in the cropping cycle phases of clearing growth and harvest, but surprising variations occur for the same crop grown by the same people. Millet fields of the Sonrai on tropical ferruginous, brown subarid and hydromorphic soils can be seen in the dry season imagery for the first two and in the rainy season imagery for the hydromorphic. On the former the fields show only modest contrast in crop during the rainy season, on the latter they can be identified easily but only during the rainy season.

Fields in fallow or pasture or some stage of regeneration mimic the fields in active cultivation but in reduced contrast. Identification is through shape and location, e.g., near settlements and repetitive coverage is especially important.

Fields of previous cultivations, though technically in fallow may require assignment to true wasteland. Wasteland is defined here in the ecologic sense and not in the legal or land tenure sense of commons or pasture. Fields in Tera and Dogondoutchi arrondissments identified as such

on the basis of size, shape and location and contrast with surrounding dormant vegetation in the dry season imagery show no vegetation response in the current rainy season imagery even though they are on soil types which carry vegetation in the rainy season. The very light character of the fields in all season imagery suggests that the subsoil is showing and that normal regeneration is not likely. Comparison with the data base inherent in aerial old photographs would substantiate this interpreation. Measurement of area and continued monitoring of these former cultivations and their failure to carry vegetation is an important input for understanding desertification.

Crop, fallow and wasteland inventories are demonstrably possible with ERTS imagery.

Crops

Two classes of crops can be readily distinguished: rice and millets/sorghums. Rice is confined in cropping to hydromorphic soils by streams and is very dense and very bright red in the growing season. Millets/sorghums vary in contrast and are planted less densely than rice. Identification is aided by location and typical field shape.

Settlements

Permanent, year-round habitations or settlements whether villages, towns or cities can be seen in the imagery if they are greater in size than two hundred meters in diameter. Important to the identification is location (by water courses or water sources), density and surrounding cultivations or fields. If the village is occupied at high population

density (150 persons per hectare for the village as a whole), the imagery response in MSS Band 5 (year-round shade trees) and MSS Band 7 (roofs and moist compound floors) is also dense and the village well defined in contrast to surrounding lightly vegetated or non-vegetated areas. If the residential area consists of dispersed compounds at low population density for the village as a whole, they are difficult or impossible to identify reliably. Habitation can only be presumed on the basis of nearby cultivations.

Villages of moderate density can be identified if they are surrounded by an area of former cultivations, thus being in high contrast positions due to reflectance and shape or pattern.

In Niger, the use of ERTS for demographic purposes is definitely promising for the settled or arable portions of the country.

In Upper Volta, the use of ERTS for demographic purposes is promising only in that populated and unpopulated (onchocerciasis) areas are readily perceived. Making population estimates would be a complicated procedure.

Regional Land Use Patterns or Culture Areas

Settlement and cultivation patterns vary with different ethnic groups and can be seen in ERTS mosaics of more than one scene.

Carrying Capacity Estimates and Population Density Estimates

1. The estimated carrying capacity of the Sonrai village lands (Village 1) is 300 persons, or approximately 30 persons per square kilometer.

The percentage of compounds to total residential area is 82 percent, indicating a compact or nucleated settlement. The overall population density for village lands is 45 per square kilometer, significantly higher than the population density for Tillaberi Arrondissement as a whole, which is 8 persons per square kilometer.

The difference between the carrying capacity of 30 and the population density of 45 significantly suggests that land is a constraint. One third of the compound heads are absent and working elsewhere supporting the conclusion of land constraint and the need for an external source of support for villagers. Thirty-eight percent of the compound heads are without known cereal fields.

2. The estimated carrying capacity of the town Hausa sampled (Village 2) is 90 persons for the sample or approximately 13 persons per square kilometer. This is an estimate, derived as carefully as possible, but nonetheless an estimate. The overall population density for the Canton, including rural villages is 16 persons per square kilometer. The difference between the carrying capacity of 13 and the population density of 16 suggests that land is a constraint though not as markedly so as for the

Sonrai village. Because these are town folk, the occurrence of some (eight) compound heads without land is more understandable. Only three compound heads are absent, and eight of them are without fields.

3. The estimated carrying capacity of the Mossi village (Village 3) is 125 or approximately 22 persons per square kilometer. The percentage of compounds to total residential area is 1.5, indicating a very dispersed mode of settlement. The overall population density for village lands in 28 per square kilometer, somewhat lower than the population density for the Kaya Cercle, stated as 43 per square kilometer.

The difference between the carrying capacity and overall population density suggests here as well, that adequate arable land is a constraint. Notably in this village there is a striking lack of balance between the men present (35%) and women (present). Unlike the Sonrai village, compound heads are not absent, but rather other men who cannot be reliably expected to return.

Substantive Findings

In addition to the condition of landlessness or constraint on land which is a prominent finding of the carrying capacity estimates, there are several additional findings of note:

1. Millets are grown in every soil type so far examined, suggesting very strongly that they are especially adaptive in the Sahelian Zone. This finding is not true of any other plant.

2. Utilization of available hydromorphic soils is more thoroughly developed among the Sonrai, than among the Mossi, if variety of crops and amount of land under permanent or recurrent cultivation are criteria. Such present agricultural intensification is a potential for future development.

3. Village population densities vary in the villages of different ethnic groups.

Allan Methodology

1. The use of the soil-vegetation type as a frame of reference, a characteristic part of the Allan approach is empirically justified in the three village and cultivation sites studied in that:

a. The same group of people grow different crops on different soil types, or are selective in matching to crop to soils, in ways which are definitive for certain crops, so that an understanding of their cropping regime for a soil, can be converted into numerics. With ERTS the incidence of the soil type can be verified and the cropping regime studied. Repetitive is important.

b. The same group of people grow the same cereal crop on different soils, in ways which are not uniform, e.g., fallowing periods, field size, etc. vary with the different conditions.

2. The use of socio-cultural groups as a frame of reference is empirically justified in the three village and cultivation sites studied in that:

a. Settlement patterns, crop inventories and cropping regimes vary according to the identification of the group, or the group defines its settlement patterns, etc.

3. The carrying capacity estimates vary with the method used to calculate the area required per person. If the total population (of a village) is taken the resulting average acreage per head is usually in tenths of hectares. This can lead to an inflated figure for carrying capacity.

Recommendations

Short-term recommendations: (1) calculation of total areas of investigated soil types to yield estimate of regional carrying capacities, and (2) calculation of fields in crop on those soil types in September.

Long-term recommendations: (1) use of one or all three field studies for training sample purposes in conjunction with CCTS, (2) collection of detailed land use histories to determine crop, fallow and wasteland inventories, and habitation densities. The number of sites should meet statistical sampling minimum requirements. Selection should be based on perception in ERTS imagery and be illustrative (as well as typical of) regional land use patterns.

DOCUMENTATION

Basis of selection of villages

Three village and cultivation sites were selected for intensive short-term field work to provide comparative control over varying cultural, demographic, agroclimatic and soil/vegetation factors within the limits of the cereal producing areas of Niger and Upper Volta.

The variables are described and analyzed in detail in this report; briefly they are: Sonrai (Songhay), Hausa in Niger and Mossi in Upper Volta, representative of 3 major ethnic groups, relatively high density rural populations in each area, (Tweratha & Zelinsky) moister and drier single crop summer growth agroclimatic zones, (Bennett) and with a variety of soil types using the ORSTOM soil classification system.

The only change in the original plan of work was the elimination of low density rural areas for the following reasons:

In Niger the tops of sandstone formations cannot be used for cultivations and their distribution strongly influence rural population density patterns. In Upper Volta, the occurrence of onchocerciasis along certain river valleys is mutually exclusive with human habitation. The northerly limits of arable land in both countries coincides with declining rainfall. Therefore in consultation with the ADO/Nimaey,

the selection was adjusted to allow concentration on areas of high or relatively high population density. The brousse tigre vegetation in Niger occurs with soil type 27 and may be seen in Plates 1, 12, 13, and especially 18. The onchocerciasis incidence is implicit in the much higher density of vegetation seen especially well in ERTS scene ID # 1274-09552 in the listing on Table 3.

Sonrai, the Niger riverain people, the Hausa of southern Niger and the centrally located Mossi of Upper Volta are all alike in growing millets and sorghums as staple crops, in keeping and using a variety of domestic animals, in living in villages and in common subjection to the "savanna syndrome", the abrupt change from dry season to rain with its accompanying shift of activity. This year they are also subjected alike to the problems of coping with the cumulative rainfall deficit we call drought, though the harvest of the current rainy season crops cannot yet be assessed.

All the sites selected met these conditions and are bona fide examples of the several conditions specified--demographic, socio-cultural and environmental. Under statistical conditions where reliable bases for randomization are uncertain, a random sample was not considered possible at this stage. With the analysis presented here and ERTS mosaics of the Sahelian zone, future randomization using ERTS data and integrated with prior sources should lead to a more reliable basis of sampling.

Further consideration and constraints in the selection of actual village sites were: that they be visible in the imagery, and have aerial photographic coverage available for the multi-stage approach used in the field work. Because the time to be spent in each village was limited, villages thought to be modest in size were chosen in two instances (Mossi and Sonrai). In the third, the town of Dogondoutchi was selected and a sample only of the town population and their associated cultivations surveyed. The Sonrai village has a total population of 539, higher than anticipated and the Mossi village 167, lower than anticipated. The Hausa town sample comprises 167 people. In combination the villages have more women (52.6 per cent) than men (47.4 per cent). Because the villages are different, were chosen because they are different, nearly all data are analyzed village by village and not in consort.

The three village and cultivation sites selected for study are shown in Plates 3 and 7 for the Sonrai village of Koulbagou-Haoussa also referred to as Village 1. Plate 14 shows the Canton of Dogondoutchi a portion of which is seen in Plate 15 in the ERTS enlargement and the town in the aerial photography reproduced in Plate 17. The dominant population is Hausa and the study results are referred to as Village 2. Plate 25 shows the area of the Mossi Village of Nabadougou, also referred to as Village 3.

The village domains are those defined by the villagers as the area of jurisdiction of village authorities, within which villagers have principal rights for cultivations, in addition to residency.

However experience during the field work made it quite clear that several variables must be controlled if the carrying capacity estimates are to be accurately made. The village boundaries in all three instances comprise a variety of soil types and the villagers grow a variety of crops. Field work was confined to the village boundaries and their soil-vegetation types. Carrying capacity estimates are based on the area of the village domain. Extrapolation to other areas containing the same soil types (and within the same agroclimatic zone) is based on the occurrence of the same soil types as those empirically found in the three villages. However villagers fields intermingle with those of other villages and there appear to be no absolutely solid boundaries within which all the villagers fields are found. In each instance individual villagers were found to have acauired rights to field outside of the village domain. A clear distinction is made by villagers and repeated here between the village boundaries and individual villagers rights to cultivate beyond the village limits. The village, per se, is not thus extended. Therefore in all the calculations, a distinction was also made between those villagers who had fields outside of the village whether in whole or in part, and those whose fields lay entirely within the village domains.

A further consideration is that a number of villagers were absent from the village. Nearly all are adult men whose absence is a reflection of the "savanna syndrome"---the marked fluctuation in seasonal activity and requirements. Accordingly all villagers can be factored for present or absent.

In the course of the work many fields were measured directly, by using a compass and pacing, by tracing indicated boundary markers on transparency overlaying an aerial photo and by measuring known fields directly from the imagery. In somes cases estimates had to be made where crop and location were known and size relative to a standard were also known. Therefore a distinction is made between measured fields and estimated fields, and further provision is made for fields where neither estimates nor measures were available. Nearly all such cases are those of villagers whose fields lay beyond the village domain. For short term intensive field, easily the most satisfactory of all methods is tracing indicated field boundaries on a transparency overlaying recent 1:5,000 aerial photography, using repetitive ERTS coverage as a guide to large fields in different phases of cultivation.

Also implicit in the Allan approach is that the carrying capacity estimates are made in the context of a given level of technology; the customary land usage of the people becomes a given, a constant. At this stage, the estimates being made in this report also assume the present (1973) level of technology being practiced by the three groups in the villages studied.

More than one carrying capacity estimate could be made: (1) the actual land use equation at the present time, (2) the potential land use or carrying capacity, and (3) the optimum land use in terms of meeting a defined standard of nutrition for man and beast and conservation of soil and water resources. Fourthly, augmented (or diminished) carrying

Table 1. Methodology for estimating carrying capacity and population densities

Data Required according to Allan*	Data Source for Sahelian zone study			
	Literature	ERTS	Aerial	Field work
* 1. Soil map or land classification Vegetation map	FAO, Ahn ORSTOM IFAN	X	X	X (Prouty)
* 2. Customary land usage of people concerned: - components of husbandry - cropping cycle - tenure	Sonrai(Rouch) Hausa(Smith) Mossi(Hammond) (Skinner)	X		new field work with ERTS as guide
* 3. Estimate of proportion practicable for cultivation (empirically based)		1st 4th	2nd	3rd
* 4. Average acreage per head - acreage	Previous studies for comparison	X field	X location	X
- per capita				genealogical census of each compound
5. Population structure and type and distribution	Census	X village location	X	Age and sex composition with # 4.
6. Development cycle of domestic group: re amount of land in use and distribution of resources	Ethnographic			Compound data

capacity under increasing intensification of agrarian regimes in the sense in which Boserup (1965), Carneiro (1972), Spooner and others (1972) are using this term.

Allan's approach is designed to yield the second of these estimates.

From the outline in Table 1 of the methodology followed the integration of ERTS data with other sources is quite clear. Rapidly becoming a conventional approach to the use of ERTS imagery is the use of aerial photography as a midway link between the analytical interpretation of ERTS and the necessary observation on the ground, known also as "ground truth" and identified in this report as field work or field observation. The phrase covers more than the observations requisite to the analysis of imagery and further identifies the synthetic approach used.

ERTS is a new source of data, already repetitive, and fortunately, a continuing source of data at the time of writing. The methodology and results presented here are a first attempt at the use of ERTS in any of the Sahleian zone countries for the purposes of making explicit evaluations of the man: land, ratios, which is one way of phrasing the human carrying capacity formula. Throughout the work, it need be emphasized that ERTS data enlarges and expands our available information on the Sahelian zone (in the three areas studied), but that it is by no means a self-sufficient data source, and is most rewardingly used in conjunction with every other relevant data source--in the literature broadly conceived--and through additional field work. The present report, in addition to substantive findings, is conceived of as a primer for an operational methodology lending itself to repetitive extensions in the Sahel or elsewhere.

A critique of the problems and utility of using ERTS is included in this report.

In the Sahelian zone countries where data resources are modest, uneven or incomplete, the extension and updating of existing sources of information may be the most significant use of ERTS information.

Data

ERTS-1 imagery, supplied by the Goddard Space Flight Center to the Drought Analysis Laboratory (DAL) was used throughout the study. The dates, ID numbers and country location follow. Please note the repetitive coverage.

Table 2. ERTS-1 imagery used in conjunction with Grain Stabilization

Study Date	ID #	Country Location	DAL Orbit and Frame #
20 April 1973	1271-09365*	Mail and Niger	Track 14 Frame 5
20 April 1973	1271-09372*	Niger	Track 14 Frame 6
07 February 1973	1199 09373	Niger and Nigeria	Track 14 Frame 7
20 April 1973	1271-09374*	Niger and Nigeria	Track 14 Frame 7
13 June 1973	1325-09371	Niger and Nigeria	Track 14 Frame 7
21 April 1973	1272-09430*	Mali and Niger	Track 15 Frame 5
21 April 1973	1272-09430*	Mali and Niger	Track 15 Frame 6
7 August 1973	1380-09415	Mali and Niger	Track 15 Frame 6
21 April 1973	1272-09433*	Niger and Upper Volta	Track 15 Frame 7
20 July 1973	1363-09423	Niger and Upper Volta	Track 15 Frame 7
22 April 1973	1273-09482*	Mali and Niger	Track 16 Frame 5
22 April 1973	1273-09485*	Niger and Upper Volta	Track 16 Frame 6
3 July 1973	1345-09480	Niger and Upper Volta	Track 16 Frame 6
26 August 1973	1399-09472	Mali and Niger	Track 16 Frame 6
13 September 1973	1417-09470	Mali and Niger	Track 16 Frame 6
22 April 1973	1273-09491*	Niger and Upper Volta	Track 16 Frame 7
23 April 1973	1274-09541*	Mali and Upper Volta	Track 17 Frame 5
23 April 1973	1274-09543*	Upper Volta	Track 17 Frame 6
7 October 1972	1076-09540	Upper Volta	Track 17 Frame 7
25 October 1972	1094-09542	Upper Volta	Track 17 Frame 7
12 November 1972	1112-09544	Upper Volta	Track 17 Frame 7
23 January 1973	1184-09542	Upper Volta	Track 17 Frame 7
23 April 1973	1274-09550*	Upper Volta	Track 17 Frame 7
4 July 1973	1346-09541	Upper Volta	Track 17 Frame 7
23 April 1973	1274-09552	Upper Volta	Track 17 Frame 8

* Constituent in Mosaic.

The format of all of the imagery of all four bands (MSS 4, 5, 6, 7) of each scene or frame available in use is 9 x 9 positive transparencies. The transparencies were prepared at the DAL at Goddard in color composites with bands 4 rendered as yellow, 5 in magenta and 7 in cyan with the use of a diazo machine. Analysis is accomplished with light tables at Goddard or elsewhere and a single scene portable light table was used during the summer in Niger and Upper Volta. Various means of magnification are used especially a Bausch and Lomb magnifier rule. A Zoom Transfer Scope at Goddard is used for superimposing the imagery over or with a second data source and adjusting the scale of the one to that of the other.

The imagery reproduced in this report is for illustrative purposes and cannot and should not be equated with the much better quality of the original imagery, where every effort has been made to use it under optimum analytical conditions. An exception are the three unretouched enlargements to the 1:50,000 scale (approximately) from MSS Band 5 judged to be the best for showing vegetative conditions, in which the enlargements have the merit of ease of work despite the blurring inherent in enlargement to this scale. The enlargements are seen in Plates 4, 15 and 26.

No computer compatible tapes (CCTS) of the scenes identified in Table 2 are available as yet, but requests are being made for

tapes of scenes suitable from the 1973 rainy season where cropping areas are perceptible in the imagery.

Aerial photographs of coverage distributed by the Institute Geographique National are listed below.

Table 3. Aerial photographs used in conjunction with Grain Stabilization Study.

Number	Country Location	Scale
72-NIG-012/75-IR	051 Niger	1:7,500.
72-NIG-012/75-IR	054 Niger	1:7,500.
AOF-034-150	001 Niger	1:15,000.
AOF-034-150	002 Niger	1:15,000.
AOF-034-150	003 Niger	1:15,000.
AOF-034-150	004 Niger	1:15,000.
AOF-034-150	005 Niger	1:15,000.
ND-30-X1	482 Upper Volta	1:50,000.
ND-30-X1	487 Upper Volta	1:50,000.
ND-30-X1	489 Upper Volta	1:50,000.

Conventional published and printed sources are noted when appropriate throughout the text and full citations appear in References Cited.

Thirty five mm. slides taken with a wide angle lens mounted on a Leica camera number approximately 500. Like the other sources, illustrative use is made of this resource in the report and with the remainder form a most useful source of information for analytical pursposes.

The socio-economic data derived during each one site village study are analyzed with the aid of a software program SIFT II Statistics by Interaction with Files from the Terminal II available at the Catholic University of America for use with their PDP?10 computer. Some additional programming was necessary to meet the requirements of methodology. The complete code appears in Appendix 1, and it can easily be seen that major emphasis is on soil type and component of husbandry information, together with the usual means of identifying persons such as age, sex, residential affiliation and actual place of residence. The data are in several files, compound heads and property owners distinguished from the other members of their compounds, and are stored on a DEC tape for potential comparative work. With the adaptations made additional studies could be entered into the system with greater economy of time, and money, than the initial set of studies which are the

subject of this report. Considerations of economy, time and accuracy lead to the direct use of portions of the printout.

Soils and Soils Classification

> "Tropical soils are light in texture, often sandy, usually low in organic matter, freely drained, and partially or wholly leached. The leaching produces the reddish color which varies from pink to brown. The soluble minerals percolate out, leaving principally iron and aluminum hydroxides. Being largely leached of line carbonate, the soils are of acid reaction." (Prouty: 1973)

A two digit coding of the soil classification prepared by Commission for Technical Cooperation in Africa, and used by ORSTOM, is employed in this report. (Ahn: 213-4). The first digit is assigned to the ten sub-Saharan soil groups and the second digit differentiates within the group,following the ORSTOM legend. The first digits have these referents:

0 Eutrophic brown soils of tropical regions

1 Raw mineral soils (rock and rock debris and desert detritus)

2 Weakly developed soils

3 Calcimorphic soils

4 Brown and reddish-brown soils of arid and semi-arid regions

5 Ferrugenious tropical soils

6 Ferrisols

7 Ferrallitic soils

8 Halomorphic (saline) soils

Although the soil types in the three village areas are different, the first digit numeral is significant and the relationship among the several soil types is easily seen.

Soils and Crops

Table 4 showing numbers of compound heads and property onwners having fields, and categorized according to soil type and crop is inserted at this place because it applies to all three study sites. The village area are implicit in the coding and therefore the village designations are included.

Table 4. Numbers of compound heads and property owners having fields, categorized according to soil type, crop and residential area. Villages are indicated.

1 VARIABLE 1 = DATA 23 = Residencial Area

VALUE:	FREQUENCY:	PERCENTAGE	Soil type description	Village
0	16	13,79	None	
22	17	14,66	Weakly developed regosols - Upper Volta	# 3
27	19	16,38	Weakly developed colluvials - Niger	# 2
91	63	54,31	Hydromorphic alluvial soils - Niger	# 1
99	1	0,86	No data	
TOTAL:	116			

1 VARIABLE 2 = DATA 25 = Rice

VALUE:	FREQUENCY:	PERCENTAGE		
0	71	61,21	None	
91	31	26,72	Hydromorphic alluvial soils - Niger	# 1
95	14	12,07	Hydromorphic with pseudo-gley - Upper Volta	#
TOTAL:	116			

1 VARIABLE 3 = DATA 29 Manioc-sorgho parcs

VALUE:	FREQUENCY,	PERCENTAGE		
0	89	76,72	None	
91	27	23,28	Hydromorphic alluvial soils - Niger	# 1
TOTAL:	116			

1 VARIABLE 4 = DATA 33 = Mango-Guava trees

VALUE:	FREQUENCY,	PERCENTAGE		
0	84	72,41	None	
27	1	0,86	Weakly developed colluvials - Niger	# 2
91	31	26.72	Hydromorphic alluvial soils - Niger	# 1
TOTAL:	116			

1 VARIABLE 5 = DATA 38 = Millet

VALUE:	FREQUENCY,	PERCENTAGE		
0	54	46,55	None	
22	15	12,93	Weakly developed regosols - Upper Volta	# 3
27	1	0,86	Weakly developed colluvials - Niger	# 2
28	3	2,59	Weakly developed regosols - Niger	# 2
→ 41	17	14,66	Brown subarid soils - Niger	# 1
51	5	4,31	Tropical ferruginous soils - Niger	# 2
58	9	7,76	Tropical ferruginous soils,-with granites - Nig	# 1
91	3	2,59	Hydromorphic alluvial soils - Niger	# 1
99	9	7,76	No data	
TOTAL:	116			

Table 4 continued

VARIABLE 6 + DATA 42 = Sorghum

VALUE:	FREQUENCY:	PERCENTAGE	Village
			Sorghum
0	95	81,90	None
22	10	8,62	Weakly developed regosols - Upper Volta # 3
41	1	2,86	Brown subarid soils - Niger # 1
58	2	1,72	Tropical ferruginous soils, with granites # 1
91	8	6,90	Hydromorphic alluvial soils - Niger # 1
TOTAL:	116		

1 VARIABLE 7 = DATA 46 Millet-sorghum

VALUE:	FREQUENCY:	PERCENTAGE	
0	94	81,03	None
28	2	1,72	Weakly developed regosols - Niger # 2
41	4	3,45	Brown subarid soils - Niger # 1
54	2	1,72	Tropical ferruginous soils - Niger # 2
58	6	5,17	Tropical ferruginous soils, with granites Nige
91	3	2,59	Hydromorphic alluvial soils - Niger # 1
99	5	4,31	No data
TOTAL:	116		

1 VARIABLE 8 = DATA 50 Peanuts

VALUE:	FREQUENCY:	PERCENTAGE	
0	106	91,38	None
22	9	7,76	Weakly developed regosols - Upper Volta # 3
99	1	0,86	No data
TOTAL:	116		

1 VARIABLE 9 = DATA 54 Bambara nuts

VALUE:	FREQUENCY:	PERCENTAGE	
0	104	89,66	None
20	1	0,86	Error
22	11	9,48	Weakly developed regosols - Upper Volta # 3
TOTAL:	116		

1 VARIABLE 10 = DATA 58 Kitchen gardens

VALUE:	FREQUENCY:	PERCENTAGE	
0	107	92,24	None
41	3	2,59	Brown subarid soils - Niger # 1
58	1	0,86	Tropical ferruginous soils with granites - Nige
91	3	2,59	Hydromorphic alluvial soils # 1
99	2	1,72	No data
TOTAL:	116		

Sonrai of Koulbagou-Haoussa, Village 1

Koulbagou-Haoussa (the Haoussa refers to lower and carries no ethnic connotation) is inhabited by a people speaking Sonrai-Dzerma considering themselves to be Kado, a variant of Sonrai. The village is properly riverain, in the rainy season the river rises to within 100 meters of the village, flooding the rice fields and watering the manioc parcs. Village lands stretch inland away from the river in a slightly curved band, approximately the width of the river frontage. Observation by air, road, in the imagery and on maps suggests that this is typical siting.

A "manure gradient" runs inland from the river and animal products contribute to daily diet and the use of donkeys and horses for transportation gives access to more distant fields. The combination of manure and soils of granitic origin (see below) together probably contribute to the apparently continuous use of near village fields.

Perhaps the most unexpected finding is that the area selected for bush fields is based or centered on a minor tributary of the Niger, the Tamtala, which reproduces almost in miniature some of the riverain features of the Niger including a ribbon of hydromorphic soil and is a rainy season water source as well, (91 in the Plate 3 overlay). A significant portion--one third-- of the millet and sorghum fields border the Tamtala and vary between five and six kms

from the river and main village. According to Rouch (1954), the distant bush fields are started when the closer fields fail and it may well be that the wasteland area which now intervenes between the village and its Tamtala fields represents just such an area. The lithosols buttes (soil type 12) accentuate the problems of reduced fertility.

Villagers smove into rainy season dispersed homesteads of very small scale which are not occupied through the year.

1. Soils-vegetation-climate

In a five kilometer radius of Koulbagou (lat.13° 50' N, long. 1° 35' E), the tropical soils are composed od aeolian sands (dune soils) and hydromorphic soils. The morphology of these soils is adapted to the fluvial terrace regime. The wide floodplain of the braided mainstream, and major tributary Tabati, is bordered by low sandstone buttes at a distance of more than five kilometers from Koulbagou. An intricate network of temporary water courses emerges on the upper terraces in the wet sean (June - September). The degree of slope is less than ten percent.

Soil type 91 - Hydromorphic alluvial soils

Soil Characteristics: Highly water-retentive montmorillonite clay soils with restricted permeability. Structurally a result of mechanical action, these soils are marked in the dry period by striae, cracks, and prisms. A rich mineral composition is common to both

vertisols and gleys. All hydromorphic soils are seasonally or permanently inundated (gleys). Pseudogleys tend to be wet for at least eight months, vertisols for at least four months of the year. Vertisols tend to evolve where gypsum is associated with clay; a bluish/green color is characteristic of these hydromorphic soils.

Classification: Alluvium

Following ORSTOM usage and the results of superimposing the ORSTOM soil map on the 21 April imagery, soil type 91 also includes sandy and loamy soils with a relatively high clay content in an area immediately adjacent to rice field soils just described. The latter soil is illustrated in Plate 9 taken on the land side of the village.

Soil type 58 - Ferruginous tropical soils.

Loamy and sandy-clay formations, corase granitic soil particles from weathered granite outcrops in this segment, and laterites from the first terrace parent material (soil type 12) (Prouty: 1973). ORSTOM groups these soils with those of little or no leaching, etc.

Soils are in the group of little or no leaching and under this, in the grouping comprising soils with some migration of iron oxide. This particular soil is on aeolian sands which contain elements derived from weathering of granite. The soils has a well-developed profile, which may have an ironstone horizon resulting from the past accumulation of iron oxides. Leaching has occured so that the ratio of sesquioxides to silica is quite high; silica has been leached out faster than the sesquioxides.

"The Sols Ferrugineux Tropicaux are associated mainly with the savanna areas of W. Africa. They are rich in iron (and sometimes manganese) oxides, but have no free aluminum. The clay fraction is mainly kaolin mixed with illite and hydrous oxides. The silt content can be quite high and the base saturation is at least 40%." (Ahn 1970:210).

Soil type 12 - Mineral soils, lithosols on diverse rocks.

Soils of this type are just beyond the village boundaries. In fact the village boundary is so drawn to exclude soils of this type, which nevertheless influence the lower lying soils of the other types in the gradient down to the river. These soils support very little vegetation and are indistinguishable in the dry season imagery from fields; only their location makes it possible to identify the one as a scree slope and the other as field. These appear in Plate 12 as irregular dark patches, and are significant, in a negative fashion, for the amount of arable land.

These soils do not have a well-developed profile, and have not been subject to climatic factors in their development as much as they depend on the rocks on which they lie. This particular soil is a lithosol with topsoil directly over the weathered substratum. Rock is relatively near the surface.

The Koulbagou-Haoussa area is in the region of wooded steppe with abundant Acacia and Commiphora, according to Keay and Aubreville (1959). Their annotation includes this information:

> 25. Wooded Steppe with abundant Acacia and Commiphora
>
> Vegetation classified under this heading covers large tracts between the desert and subdesert types on the one side and moister woodland types on the other.
>
> The appearance of the vegetation depends on the relative abundance of the trees and shrubs. In some places the trees, mostly species of Acacia and Commiphora, form open or closed woodland or thickets; in other places the trees are widely scattered. Most of the trees are deciduous, fine-leaved, and thorny.
>
> The grasses, usually less than 1 m. high, include such species as Chrysopogon aucheri, Aristida stipoides, Cenchrus ciliaris, Sporobolus variegatus, and Schoenfeldia gracilis; in S. Africa and in some lower montane areas Themeda triandra is abundant.
>
> In the wider river valleys there is much Acacia savanna with tall grass (e.g. Beckeropsis and Hyparrhenia). Keay and Aubreville 1959:10)

The boundary between soil types 91 and 58 can be seen in the aerial photograph reproduced in Plate 6. In the imagery, the brown subarid soils (4) can be readily distinguished, in part because they carry more abundant vegetation, whereas in the other two village soil types there is little vegetation outside of shade trees in the village and a few purposefully left, or the mango and guava trees maintained as cultigens. Fields can be identified in the imagery in the brown subarid soils because the vegetation has been removed and the field pattern is clearly distinguishable in the dry season imagery. Other soil types--where the

vegetation has been removed-- do not provide this contrast. In the latter cases the rainy season imagery provides the appropriate information - even for the same crop.

Rainfall. Koulbagou-Houssa lies between Niamey and Tillaberi, the two closest rainfall reporting stations. The long term annual mean for Niamey is 643 mm. and 552 for Tillaberi; the 1951-60 average is 636 and 510 respectively. An annual mean for Koulbagou-Haoussa probably is in the vicinity of 600 mm.

The pattern is for a single maximum peaking in August, with the rains normally beginning in June and virtually ceasing by October with the months of November, December, January and February being extremely dry. (World Weather Records: 1967 and Fromshon: 1973).

The rains started in Koulbagou-Haoussa on the 23rd of June with a moderate rain, followed by a heavy rain on the 24th. Planting began early on the morning of the 25th. Rainfall totals for the 1973 season are unknown; John becker has a detailed analysis of the trend 1967-72.

According to the ORSTOM publication of 1973, the Niamey rainfall in 1972 was 343 mm (compared with their normal of 534 mm) and the days of actively growing vegetation only 15 as compared with a normal of 75. The vegetation seen in the imagery of Plate 1 is properly viewed as the resulting from the normal dry season and cumulative rainfall deficit.

Koulbagou-Haoussa lies within the area designated as drier single crop summer growth by Bennett (1962:205). Distribution and amount are equally important in his analysis.

> (4) The symbol (-), appearing generally in areas lying between the rain-deficient zone and the moister single-crop summer-growth zone, represents in all instances stations where less than 25 inches of rain falls within any five successive months of the year. On the other hand, all stations receive at least 10 inches of annual rainfall, and most of them receive more than 15 inches of rain concentrated within a period of three months, being thus differentiated from stations lying within the rain-deficient zone. It will be recalled, however, that in delimitation of that rain-deficient zone, a considerable number of stations were excluded from it, although they experienced less than 15 inches of rain concentrated within three months, if they either lay at elevations above 4,000 feet or received more than 25 inches of rain within the calendar year; this was done in order to allow for the favorable effects, upon capacity to produce a starch crop, of lower temperatures due to elevation, and larger supply of soil moisture where a low level of seasonal rainfall is somewhat protracted. The zone where the symbol (-) tends to prevail may be called the "drier single-crop summer-growth zone." On account of the generally low level of seasonal rainfall, it is probably, among the four rain-sufficient zones, the zone of relatively highest risk of starch-crop failure by reason of drought.

2. Customary land usage of the people.

Cereal crops are cultivated by the Sonrai in an agrarian regime which includes other crops and animals and outside wage labor. Cereal cultivation is best understood, then, in the context of these other components on which the Sonrai also rely.

Sonrai have, keep, or grow deomestic fowl and animals, annual rainy and cold season crops, tree crops, some wild foods and also utilize the valuable source of protein in fish from the river. Most, but not all, of these components appear in Tables 5 and 6. Those not appearing are some of the cold season crops (grown in part with the help of the cold season crue, in October through May) such as maize, potatoes, onion, tomatoes, and according to Rouch, wheat. These crops are grown close to the village. Also not tabulated but contributing to the village economy are exchanges with Peul and Bela of animal products, including manure, for grain.

Components of Husbandry

Rice

Rice (Oryza sativa Sonrai = mo) is grown in fields with controlled flooding during the rainy season and used both for subsistence and to pay taxes. The soils are heavier grey colored and clayish and during the dry season are worked or "plowed" and left in large lumps. Rice fields show distinctively in the aerial photo in Plate 6 and the individual field demarcations are shown in Plate 5 and marked as such on the overlay. In the oblique aerial photo the line limiting the rice fields can be seen on the river margin of the village. In the ERTS imagery of April the line of rice fields cannot be distinguished. In the ERTS imagery of 7 August 1973, the fields contribute to a vivid band of vegetation between the river and the village. The imagery of 7 August 1973 is not reproduced here due to limitations of space.

The villagers own 33 rice fields with a total area of 6.6 hectars all lying in soils type 91. Only one person has 2 fields and one man's fields were unmeasured. No rice fields are held outside the village.

A different kind of rice is planted later in the rainy season along the Tamtala, seen in Plate 7. The Sonrai word is Gourmamoyna though this has not been identified as Hungry rice, (Digitaria exilis) nor as upland rice. These and subsequent botanical designations are from Irvine (1969).

Manioc parcs

Manioc parcs are relatively small, enclosed fields sited on elevated land just along the river channel. The parcs are used as well for sweet sorgho and a variety of catch crops; it is here that the cold season crops are planted, although this could not be observed in the rainy season period. The crops are manioc (Manihot utilissima) for which the Sonrai word is logo, and the sweet sorgho which may be either S. millitum or S. nigricans according to Irvine (1969: 140).

The parcs are enclosed with thornbush fences and these fences make the boundaries, and size, readily apparent in the aerial photo in Plate 6 with the parcs identified as such on the overlay in Plate 5. The compound owners numbers are not reproduced.

Twenty seven men have manioc parcs with a total acreage of 6.9 hectars, and they all lie within the village lands.

These small gardens further add to the intensification of agriculture practiced by the Sonrai.

Mango and guava trees

Mango (Mangifera indica) - Sonrai mangu, and guava (Psidium guajava) Sonrai guaybu are also enclosed in parcs, that is, given protection from animals with thornbush fencing which serves as well to demarcate the property line. These small parcs lie beyond the residential area in the vicinity of the village.

Sixty five trees are owned by 31 compound heads or property owners.

The mangoes ripen near the end of the dry season, adding a valuable source of food at that time.

The mango and guava trees are readily identified in Plate 6 but the circumferences are too tiny to be separate on the overlay. Table 9 contains the particulars.

Millet

Millet (Pennisetum spp), Sonrai heni or hayni, is the staple food crop of the Sonrai villagers. Rouch reports a number of different varieties, gros mil and petit mil, and sub-varieties, but the Koulbagou Haoussa Sonrai referred to the millet they were planting as heni, which is both the generic word for millet and the principal sub-variety of petit mil (1954).

Millet is grown in all three of the vegetation-soil types comprising village lands. The work is done almost entirely by men.

Fortunately it was possible to observe the planting season, since the field work occurred during the last week of the dry season and the first week of the rainy (planting) season. No pre-planting preparation is done in this village. However, in the most distant fields (soil type 41, seen in the overlay on Plate 3 and the imagery on Plate 4), the fields are barren of vegetation but surrounded by a light bush and tree cover suggesting that this vegetation must have been removed at some prior period, before their being incorporated as fields. Planting started on June 25, following a heavy soaking rain (and a return trip to Niamey in the late afternoon of that day made possible the observation that the entire region was planted on that day). An enzyme on the seed covering prevents germination unless the soil is well soaked (Cox: 1973). Sample counts of the number of seeds

placed in each hole varied from 20-35, with some of the seeds not appearing to be whole grains. Planting is accomplished with two men working in a team, the leader making a hole two-three inches deep with a diameter of about 10 inches, using a long handled hoe swung from side to side. The second man carries the seed, drops them in, covers them and steps firmly on the newly planted seed hole. Holes are approximately one meter apart, the lines quite regular and often following natural contours. Five days after planting, the new plants were three inches out of the ground, and in this village the germination appeared to be excellent in that each seed germinated hole had sprouting plants. The number germinated, on a quite limited number of sample countrs, ranged from ten to twenty. Careful inspection of Plate 10 will show the newly sprouted plants as quite small, dark clumps. The villager, in his own field, is standing midway between two such plant clumps, on Day 5 after planting. Weeding done in this area two to three weeks after planting, removes the weak plants leaving six to eight (assuming the techniques are the same as those observed in Dogondoutchi). The weeding demarcates fields seen in Plate 8, as geometrically sided darker areas (one prominent one is on the left margin of the plate). This photograph was taken on July 13, from an altitude of approximately 1,000 feet. The growing plants did not create a perceptible green field in this village at this date. These villagers are very much aware of the value of manure, run their own animals on their own fields at appropriate times in the year, carry manure from the village to nearby fields and arrange for manuring of Peul or Bela animals if they do not themselves own cattle. Further growth and harvesting has not been observed. The stalks from last season's fields can be seen in Plate 9.

The Chef de Village estimated the village seed stocks at 300 kilos, inadequate in his opinion for their requirements. Most, if not all, seed stocks were used in the late June planting and the observation is that seed stocks are now exhausted with the 1973 planting season and must be replenished from their own or other sources from this year's harvest.

The number of compound heads or property owners or lineage heads with identified fields is twenty nine, with a total number of reported fields as sixty-nine, ten of which are outside of the villages. Two of the outside fields were measured, the remaining eight entered as no data. Some compound heads farm with their lineage head and these data are discussed below. Only three millet fields are close to the village, seen in Plate 5 overlay, in the hydromorphic-alluvial soils. The average acreage is 2.3 hectares. Nine compound heads have identified fields in soil type 58, within the village boundaries for an average of 4.7 hectares and 17 compound heads have average fields of 13.5 hectares --- much the largest average size.

How these data figure in the average acreages is discussed below in Section 4.

The field boundary markers are stones, shrubs, and trees with a discernible linear element which can be seen by comparing the overlay with the aerial photograph in Plates 5 and 6.

The ERTS-1 dry season scene (21 April) has been repeatedly viewed for field identification purposes. Fields, either individually owned or in contiguous sets, can be seen in the dry season imagery under these conditions: (1) if the field is barren of vegetation and is surrounded by

contrasting light (or heavy) bush, (2) shape --- fields are irregularly bounded but tend to be roughly circular or square in shape, and appear circular in the imagery, (3) are in the vicinity of discernible habitations/settlements, i.e., in a range of 10 kilometers. Fields cannot be seen in the dry season imagery if they lie in an area equally barren of vegetation. Rainy season coverage (7 August 1973) provides contrast of a different and positive kind. In soil type 91, fields having had a growth period of six full weeks, display a bright, concentrated, red (in the diazochrome rendered magenta of MSS BAND 5) in contrast with the sparser non-cultivated surrounding vegetation which also grows in response to the rains --- but which also serves as pasturage for animals. Fields are contiguous and areas of 10-20 hectares can be seen in the imagery in this soil type. Only field work can allocate such fields to an individual or sets of owners.

The 7 August 1973 imagery of the largest set of contiguous fields, 135 hectares --- the most distant from the village in Plates 3 and 4 --- is not reproduced here. Analysis indicates that not all of the fields in the set have a strong stand of millet. Only part of the area appears to have good response in MSS Band 5. The villagers, including the Deputy Chef de Village, owning this set of fields explained that the entire area would be planted --- and indeed much had been planted by 1 July and some weeded by 13 July. A reduction in the acreage cropped here would reduce the overall average, however, some intra-village fields were reported by villagers and not identified, and addition of an average acreage for these compound heads would probably offset the reduction.

The weeding, which can be seen in the low altitude oblique aerial photo of July, probably reduces soil moisture but probably only influences the reflectance characteristics of the crop by retaining the bright sandy floor. In the opinion of Dr. Baumgardner (1973), the reflectance properties of these cereal crops is different from the properties of the same crops (especially sorghum), also grown in semi-arid or arid conditions where the plant density conceals the soil floor. (1973a and 1973b.)

Sorghum

Sorghum (Sorghum spp.), also called guinea corn, Sonrai bumbu, is a secondary but also important staple crop for the Sonrai. It is more restricted in distribution, being cultivated primarily close to the village and hence the main river channel, or close to the Tamtala and the subsidiary river channel, and both places can also be more readily manured because they are close to permanent or rainy season habitations.

Many of the observations just presented on millet, apply as well to sorghum, viz., method of planting, discernment in the imagery, etc. The immature plants are difficult to distinguish from millet for the non-indigenous observer, and identification of crop is made by villagers. Plate 11, close to the Tamtala, shows the characteristic clumps remaining from last year's harvest.

Eleven property owners and compound heads have sorghum fields, for a total number of 14 fields. Details appear in Tables 4, 5, and 10.

Millet-sorghum

Millet-sorghum are simply fields in which millet and sorghum are planted in alternate rows. Villagers said that cowpea (Vigna spp.) also called niebe, Sonrai dunguri, is planted in association, adding to both nutrition and soil quality (Irvine: 1969, 200 ff.). No separate acreage can be assigned to the cowpea for obvious reasons.

Fourteen property owners and compound heads interplant millet and sorghum. Details appear in Tables 4, 5, and 11.

Kitchen gardens

A portion of her husband's fields are used by wives as a kitchen garden in which she grows okra (Hibiscus spp.) Sonrai la, and sesame (Sesamum indicum) Sonrai lemti. The start is made after the cereal crops have been planted. No measurements were possible, but an indication is given of compounds in which food resources are supplemented with kitchen gardens. They are thirteen in number.

Cattle

Villagers have among them 275 cattle, a count which does not differentiate between bulls and cows, nor relative age so that herd structure information is lacking. Many of the animals were absent from the village in late June, being in the care of the village herder, a villager himself, who uses his own sons for assistance. Other young men of the village do not participate in the herding. (Nevertheless there were dozens of cattle in the village.) Ownership of animals is quite uneven with one man owning 200 and most men having no animals. Use of word "owner" is also loose, for

some animals are kept under trusteeship arrangements. Manure, milk are dominant in use, slaughter is negligible.

Animals are tethered in the compound of owner or trustee and given supplemental food in the evening, depending on availability --- millet gleanings, manioc stalks, specially gathered leaves. They are milked in the morning between 5:30 and 6:00, then sent out to pasture returning around 4:30. Calves are tethered in the compound all during the day and suckle first in the morning for about five minutes. Animals were thin in late June, because the "pasture" was virtually non-existent. Several men reported recent loss of cattle.

A cattle pass runs to the river through the pasture in Plate 5, used by Peul cattle as well as villagers own animals.

Sheep and Goats

Sheep are kept for slaughter or sale, though the former is rare and the latter primarily for emergency purposes. The number of 58 sheep is probably an underestimate and 22 goats even more so. They are let loose, often with no herd boy, during the day and tethered at night in the owner's compound. Their manure contributes to the manure gradient, and their grazing to the cleared cultivation zone around the village.

Chickens

Chickens and guinea fowl are kept by the Sonrai, but the chickens, in late June and early July, were prey to an unidentified disease and quite a few dead chickens were seen on the paths and rubbish heaps. The modest number of 55 chickens may well represent a survivor rate or even be too high under the circumstances. In more normal times chickens are used to

add to nutrition, but neither eggs nor chicken meat are fed to young children.

Horses and Donkeys

A few horses and donkeys are kept by these Sonrai villagers, the horses being used to ride to distant fields, for other errands and kept as status symbols. Donkeys are beasts of burden, and their owners certainly employ in the transportation of heavy loads, again to aid in the transfer of household goods from the permanent village to rainy season temporary compound, and undoubtedly used to carry harvest in from distant fields, either at harvest time or later as needed.

Granaries

Not all compound heads have granaries, since persons without fields have no need for them, but sixty four granaries are reported. Large granaries can be seen in Plate 6 (as black dots within the compound walls) and Plate 9 as the light thatched peaked roofs. A few men have granaries in the fields six kilometers away. Smaller granaries are used for rice and quite similar structures used for chicken coops. Many men reported have some food reserves in their granaries. A village by village breakdown is not available but fifteen percent of the compound heads reported empty granaries (in all three villages) and several demonstrated their point by showing me their completely empty granaries.

Tenure

The village domain consists of lands "rented" from Male, a neighboring village, under a long term agreement dating from one hundred and twenty three years ago. Land is owned, a process validated through recognition by

administrative authorities when the original settlers were willing to cultivate the distant fields despite the depredations of lion. The most distant parcel of land --- soil type 41 --- is owned by the village and the rented lands secured through the payment of a nominal rent, due at each harvest season. These arrangements are for the village as a whole, and land apparently comes within village jurisdiction either way.

Within the village juristiction, individual compound heads, property owners or lineage heads may have secured rights through inheritance, allocation, rent or purchase. The last is quite clearly recent and testimony to the relative value of riverain lands. Inheritance goes from a man to his primary heir (to the practical exclusion of other sons), nor strictly through primogeniture although most compound heads are in fact the oldest of known brothers still in the village. If a man dies when his children are still small, his elder widow can become the compound head and two such are in this village. More importantly, a man can inherit land through his mother, and at least one man owns land in another village through these means. A striking fact is that many of the wives in this village were born in the village. It is certainly possible, if not probable, that through contracting marriages within the village, possible fragmentation of village lands is avoided, since the families of both man and wife will then have the same interest in keeping the village lands intact.

Allocation can take two forms --- temporary usufruct to a brother --- or sharing with a lineage mate. Absent compound heads have allocated use of their land to a brother, an arrangement which enables the primary heir-compound head to return to his natal village either when he retires after

years of work abroad, or after some shorter period --- when the brother also stays on. The primary heir retains his rights indefinitely under this arrangement and has his wife's family to buttress his claim if need be.

The smaller lineages in this village, tend to consolidate their holdings as a unit --- that is the compound heads agreed that they do not hold land rights severally but farm together and then the head of the lineage or someone else specifically designated as the person in charge of lineage lands, allocates fields. Such a system allows flexibility from one year to the next for those men in good standing with their lineage mates.

Rent is the mode used by men who do not or cannot acquire sufficient land for their needs within the village domain, and go outside of the village to make individual arrangements. Ten men are in this category. Millet/sorghum fields are the only type of land rented in this fashion. In making the carrying capacity calculation, adjustment is made for these men and their families.

Cropping cycle

By cropping cycle is meant the number of years in fallow and in crop as well as crop sequence. Planting and harvesting times can be included as well.

Rice, manioc and sweet sorgho parcs, mango and guava trees and kitchen gardens are all cultivated without regard to fallowing; cropping occurs sequentially in each rainy season on the same plot. Renewal of soil

fertility is secured through the flooding of rains or crue, and manuring.

The millet and sorghum fields are a different matter. According to Rouch, fields are cultivated for as many as ten years in a row and then left to long term fallow, from ten to twenty years. (1954:19.) According to the Koulbagou-Haoussa villagers the close-in fields are cultivated in each rainy season without fallowing, although some fields are not in crop in the 1973 season and other "fields" are left as pasture. These are put into the lands potentially capable of cultivation. Whether planned or not, it is empirically the equivalent of fallow, but most land is in cultivation close to the village. In land farther from the village, where the crops are confined to millet or millet interplanted with sorghum, quite a lot of the land looks to be in some form of resting or fallow --- with very modest vegetation cover ---even though this is not stipulated as being in fallow, as such. The calculations appear below.

3. Estimate of proportion practicable for cultivation for each soil type. The cultivable percentage is the amount of land, within any one soil type, which is, has been or potentially could be put into cultivation. It excludes wasteland, non-arable soils, etc. Making the estimate therefore involves specific information on current cropping and equally specific determinations of the amount of land in some stage of fallow, whether rotational or naturally regenerative fallow.

These data on acreages are categorized by crop, by soil type and by whether the fields lie within or beyond the village domain and tables appear

in Section 2. For the hydromorphic alluvial soil type, the data in the three areas were derived by outlining field boundaries on a transparency overlaying the aerial photographs enlarged to a scale of 1:5,000 (and reduced for purposes of reproduction to a scale of 1:10,000); measurements of the fields is done with a planimeter. Fields are assigned to compound head or property owner with rights of cultivation. For the other two soil types measurement is accomplished through field mapping, planimetry and measurement directly from the imagery with a magnifying rule and similarly assigned to owners on the basis of information given in the field areas. Plate 3 shows individual field boundaries in soil type 91 and part of soil type 58. The hatched area in Plate 5 shows areas in crop.

The problems of deriving the cultivable percentage are considered by Allan to be the most intractable aspect of his methodology. (1965:24.) Here,ERTS imagery is especially useful, even unique in providing the data for fields in varying stages of cultivation-fallow. Repetitive coverage is especially important.

Table 13 summarizes the data.

These data are necessary for the calculation of carrying capacity. Several significant observations can be made at this stage. The hydromorphic soils carry the greatest variety of crops and are most intensively used. The millets and sorghums are grown in all the soil types used by the villagers while the specialized grops are confined to the hydromorphic soils. The millets are adapted to the greatest variety of soils and conditions.

1 ERTS-1 scene including Niamey, and Village 1 indicated in square.

Plate 2. Copy of ONC K - 2 corresponding to ERTS - 1 scene in Plate 1.

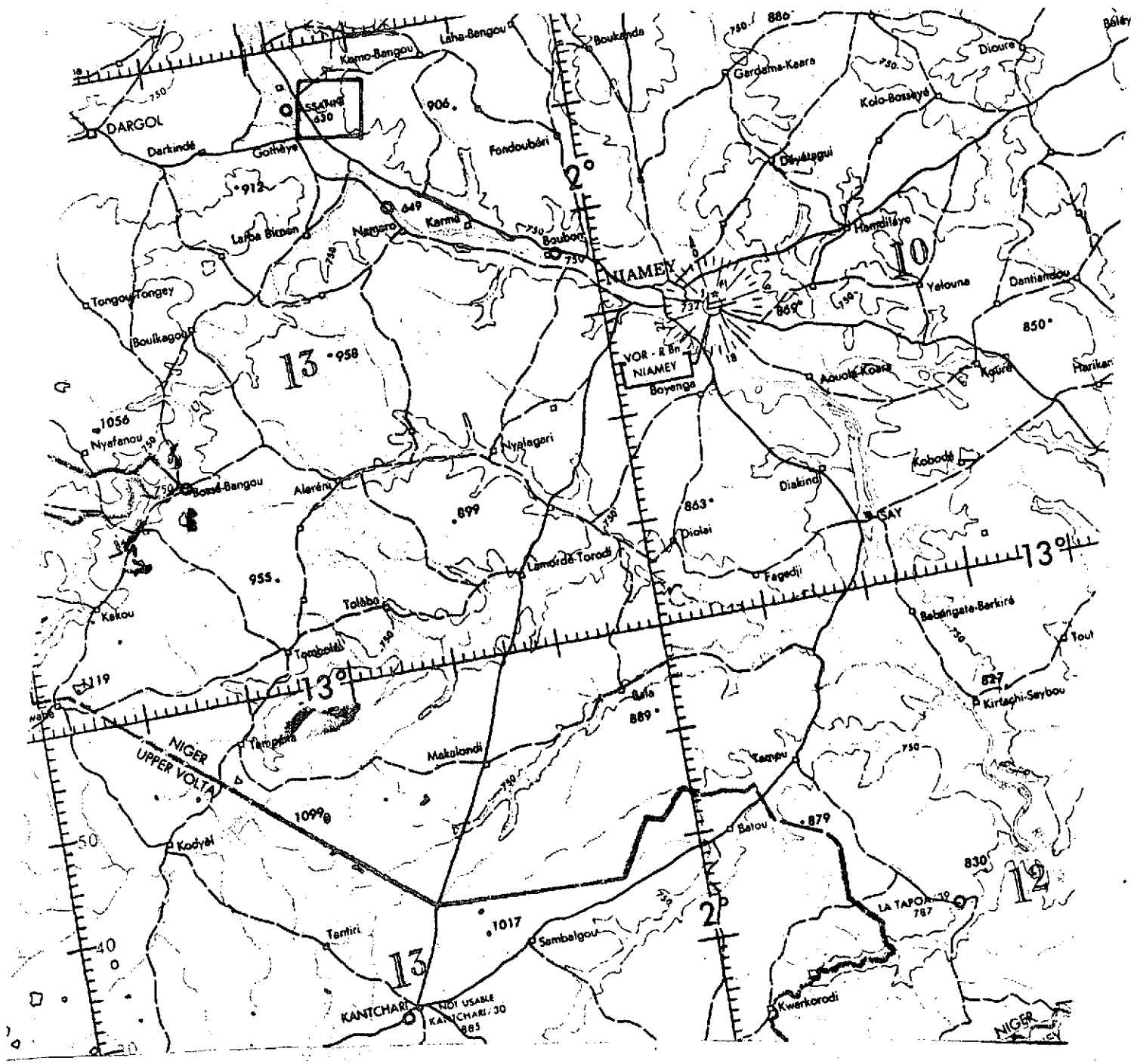

Plate 4. ERTS-1 enlargement to scale of 1:50,000 of domain of Village 1.

1 cm = 500 m.

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Plate 6. Aerial Photograph of Village 1, at 1:10,000 Scale.

Plate 7. Copy of Portion of Carte de l'Afrique de l'Ouest au 1:50,000 Gotheye 4 c, showing the boundaries of Village 1.

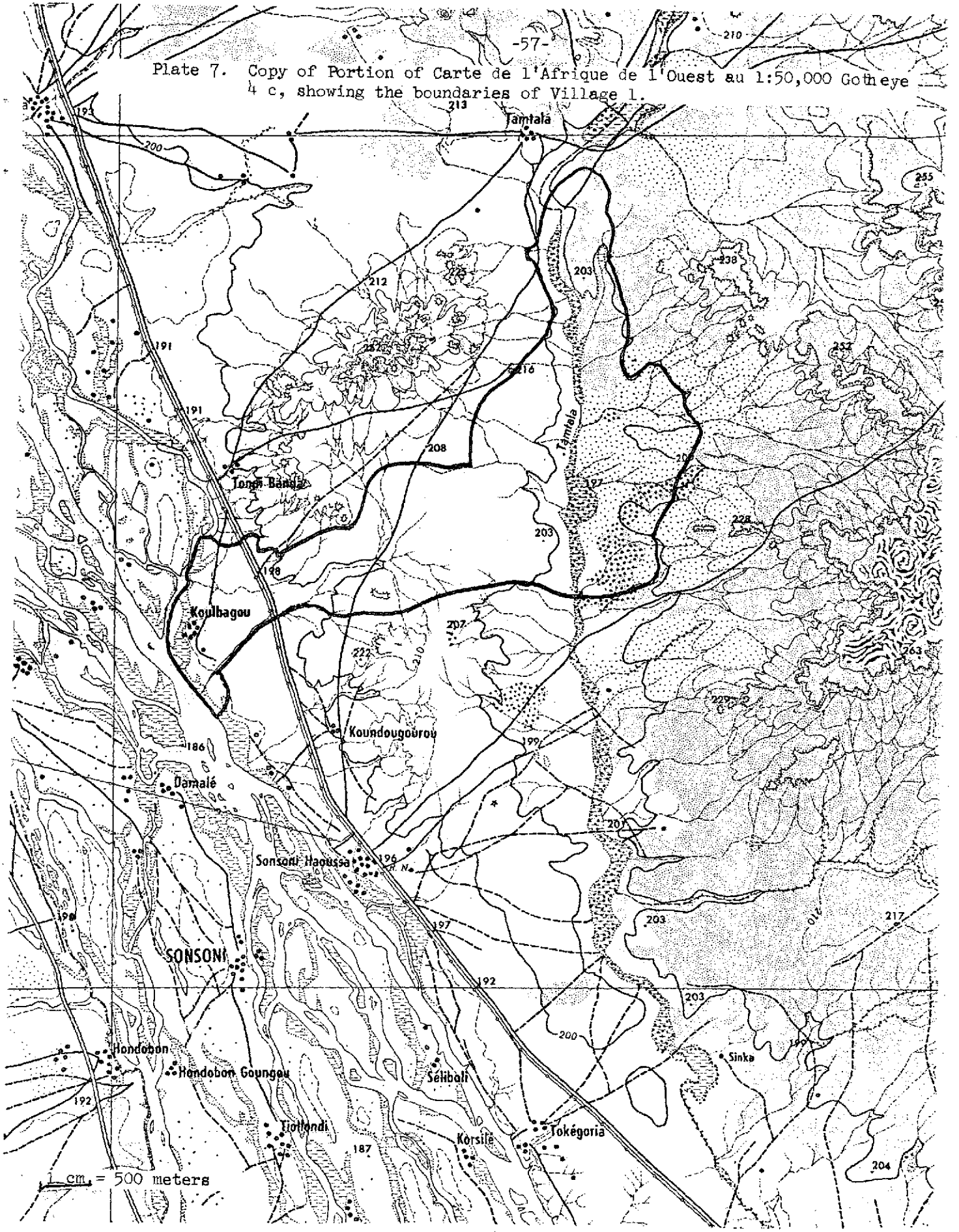


Plate 8. Low altitude aerial photo taken July 1973 showing Village 1 and environs.

Plate 9. Village 1 and soil type 91 (hydromorphic), ground view.

Plate 10. Newly planted millet field in soil type 58 (tropical ferruginous).

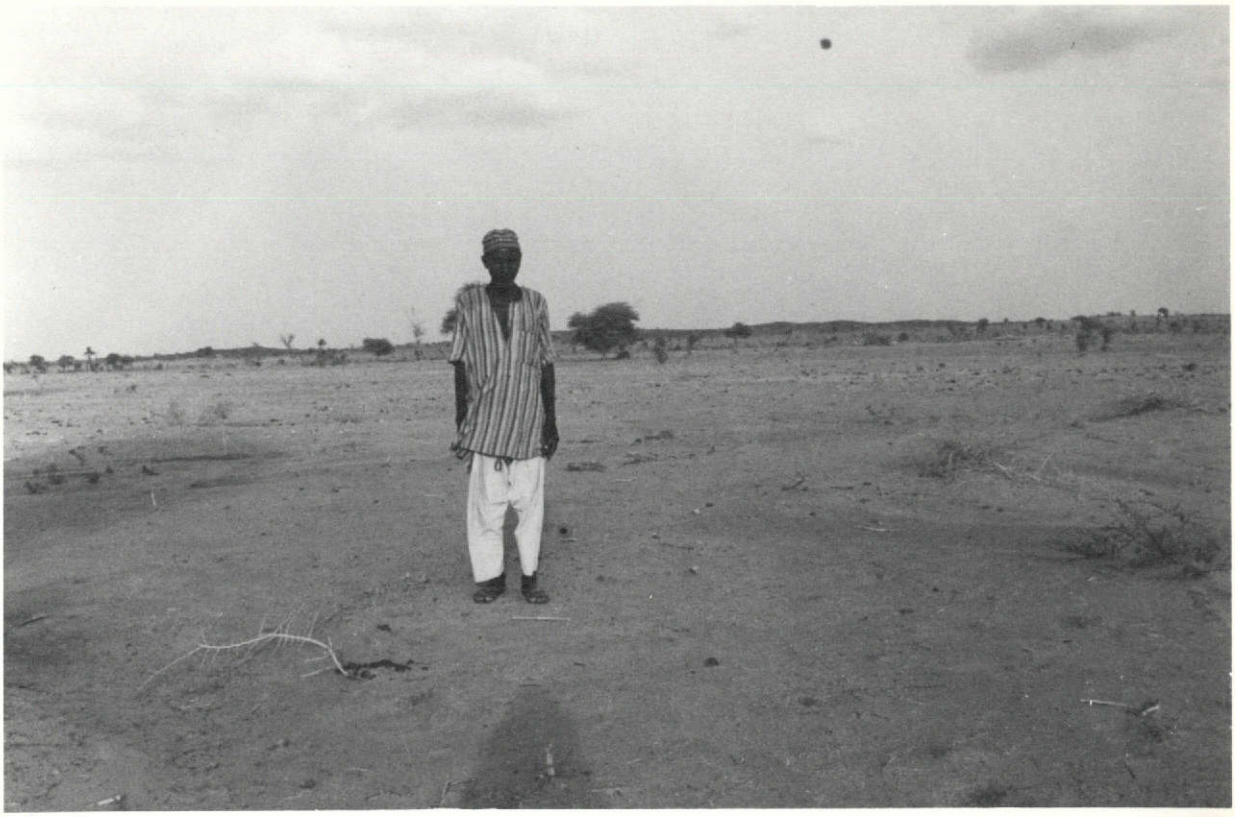


Plate 11. Sorghum field next to Tamtala.

Table 5. Numbers of fields and animals in Village 1.

CASES LOOKED AT: 116
CASES FOUND: 78

VAR	DATA	N	TOTALS	SD	HIGH	LOW	COMPONENTS OF HUSBANDRY: CATEGORY
1	62	78	275,00	11,33	98,0	0,0	Cows
2	63	78	56,00	3,65	30,0	0,0	Sheep
3	64	78	22,00	1,20	7,0	0,0	Goats
4	65	78	55,00	3,76	25,0	0,0	Chickens
5	19	78	144,00	1,51	7,0	0,0	Houses
6	26	78	33,00	0,55	2,0	0,0	Rice fields
7	37	78	69,00	1,32	6,0	0,0	Millet fields
8	41	78	14,00	0,50	3,0	0,0	Sorghum fields
9	45	78	25,00	0,63	2,0	0,0	Millet sorghum fields
1	61	78	11,00	0,45	2,0	0,0	Horses
2	66	78	9,00	0,48	3,0	0,0	Donkeys
3	67	78	1,00	0,11	1,0	0,0	Other property
4	21	78	64,00	0,75	3,0	0,0	Granaries
5	30	78	69,00	0,48	1,0	0,0	Manioc/sorgho
6	34	78	65,00	1,62	8,0	0,0	Mango trees
7	49	78	0,00	0,00	0,0	0,0	Peanut fields
8	53	78	0,00	0,00	0,0	0,0	Bambara fields
9	57	78	13,00	0,49	3,0	0,0	Kitchen garden

Table 6. Areas of fields in Village 1.

VAR	DATA	N	TOTALS	SD	HIGH	LOW	CATEGORY
1	27	77	4,00	0,36	3,0	0,0	Rice fields
2	28	78	62,00	1,30	6,0	0,0	Rice fields
3	31	76	4,00	0,32	2,0	0,0	Sorgho-manioc parcs
4	32	78	65,00	1,69	7,0	0,0	Sorgho-manioc
5	35	78	15,00	0,76	6,0	0,0	Mango-guava
6	36	78	48,00	1,49	8,0	0,0	Mango-guava orchards
7	39	67	0,00	0,00	0,0	0,0	Millet fields
8	40	78	2836,00	70,43	290,0	0,0	Millet
9	43	77	0,00	0,00	0,0	0,0	Sorghum
10	44	78	159,00	7,93	50,0	0,0	Sorghum
11	47	71	0,00	0,00	0,0	0,0	Millet-sorghum
12	48	77	939,00	39,02	230,0	0,0	Millet + sorghum
13	51	78	0,00	0,00	0,0	0,0	Peanuts
14	52	78	0,00	0,00	0,0	0,0	Peanuts
15	55	78	0,00	0,00	0,0	0,0	Bambara
16	56	78	0,00	0,00	0,0	0,0	Bambara
17	59	68	0,00	0,00	0,0	0,0	Kitchen garden
18	60	78	0,00	0,00	0,0	0,0	Kitchen garden

Table 7. Acreages of rice in Village 1, categorized by soil type and villagers rights in fields within and outside of village.

GROUP NUMBER = 1 NUMBER OF PEOPLE = 20

GROUPING COLUMN = 25	VALUE = 0	Soil type rice none		
GROUPING COLUMN = 24	VALUE = 0	Fields out/in village - none		
GROUPING COLUMN = 1	VALUE = 1	Village		
DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
27	0	0,00	20	0,00 Estimated area rice
28	0	0,00	20	0,00 Measured area rice

GROUP NUMBER = 10 NUMBER OF PEOPLE = 2

GROUPING COLUMN = 25	VALUE = 91	Hydromorphic-alluvial soils		
GROUPING COLUMN = 24	VALUE = 0	Fields out/in village - none		
GROUPING COLUMN = 1	VALUE = 1	Village 1		
DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
27	0	0,00	2	0,00 Estimated arearice
28	5	2,50	2	2,50 Measured area rice

GROUP NUMBER = 14 NUMBER OF PEOPLE = 2

GROUPING COLUMN = 25	VALUE = 0	Soil type rice - none		
GROUPING COLUMN = 24	VALUE = 1	Fields outside village		
GROUPING COLUMN = 1	VALUE = 1	Village 1		
DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
27	0	0,00	2	0,00
28	0	0,00	2	0,00

GROUP NUMBER = 27 NUMBER OF PEOPLE = 23

GROUPING COLUMN = 25	VALUE = 0	Soil type rice - none		
GROUPING COLUMN = 24	VALUE = 2	Fields inside village		
GROUPING COLUMN = 1	VALUE = 1	Village 1		
DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
27	0	0,00	23	0,00
28	0	0,00	23	0,00

GROUP NUMBER = 36 NUMBER OF PEOPLE = 21

GROUPING COLUMN = 25	VALUE = 91	Soil type hydromorphic-alluvial		
GROUPING COLUMN = 24	VALUE = 2	Fields inside village		
GROUPING COLUMN = 1	VALUE = 1	Village 1 (Sanrai)		
DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
27	4	0,20	20	0,19 Estimated area rice
28	43	2,05	21	2,05 Measured area rice

Table 7 continued.

GROUP NUMBER = 48 NUMBER OF PEOPLE = 2

GROUPING COLUMN =	25	VALUE =	0	Soil type rice - none
GROUPING COLUMN =	24	VALUE =	3	Fields both out and in village
GROUPING COLUMN =	1	VALUE =	1	Village 1 (Sonrai).

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)	
27	0	0,00	2	0,00	Estimated - none
28	0	0,00	2	0,00	Measured - none

GROUP NUMBER = 49 NUMBER OF PEOPLE = 8

GROUPING COLUMN =	25	VALUE =	91	Soil type rice - hydromorphic
GROUPING COLUMN =	24	VALUE =	3	Fields both out and in village
GROUPING COLUMN =	1	VALUE =	1	Village 1 (Sonrai)

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)	
27	0	0,00	8	0,00	Estimated- none
28	14	1,75	8	1,75	Measured

TOTAL

Table 8. Acreages of manioc parcs in Village 1, categorized by soil type and villagers rights in fields within and outside of the village.

GROUP NUMBER = 23 NUMBER OF PEOPLE = 1

GROUPING COLUMN = 29 VALUE = 91
GROUPING COLUMN = 24 VALUE = 1
GROUPING COLUMN = 1 VALUE = 1

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
31	0	0,00	1	0,00
32	1	1,00	1	1,00

GROUP NUMBER = 36 NUMBER OF PEOPLE = 21

GROUPING COLUMN = 29 VALUE = 91
GROUPING COLUMN = 24 VALUE = 2
GROUPING COLUMN = 1 VALUE = 1

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
31	4	0,21	19	0,19
32	51	2,43	21	2,43

GROUP NUMBER = 49 NUMBER OF PEOPLE = 5

GROUPING COLUMN = 29 VALUE = 91
GROUPING COLUMN = 24 VALUE = 3
GROUPING COLUMN = 1 VALUE = 1

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
31	0	0,00	5	0,00
32	13	2,60	5	2,60

TOTAL

Table 9. Acreages of mango-guava enclosures in Village 1, categorized by soil type and villagers rights in fields within and outside of the village

ROUP NUMBER = 10 NUMBER OF PEOPLE = 3

GROUPING COLUMN =	33	VALUE =	91	Hydromorphic alluvial soils
GROUPING COLUMN =	24	VALUE =	0	Field status unknown
GROUPING COLUMN =	1	VALUE =	1	Village 1

DATA POS.	TOTAL	MEAN	# CTS	MEAN(ALL)
35	0	0.00	3	0.00
36	10	3.33	3	3.33

GROUP NUMBER = 27 NUMBER OF PEOPLE = 22

GROUPING COLUMN =	33	VALUE =	0	No data on soil type
GROUPING COLUMN =	24	VALUE =	2	Fields inside village
GROUPING COLUMN =	1	VALUE =	1	Village 1

DATA POS.	TOTAL	MEAN	# CTS	MEAN(ALL)
35	0	0.00	22	0.00
36	1	0.05	22	0.05

GROUP NUMBER = 36 NUMBER OF PEOPLE = 22

GROUPING COLUMN =	33	VALUE =	91	Hydromorphic Alluvial soils
GROUPING COLUMN =	24	VALUE =	2	Fields inside
GROUPING COLUMN =	1	VALUE =	1	Village 1

DATA POS.	TOTAL	MEAN	# CTS	MEAN(ALL)
35	13	0.59	22	0.59
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

GROUP NUMBER = 49 NUMBER OF PEOPLE = 6

GROUPING COLUMN =	33	VALUE =	91	Hydromorphic Alluvial Soils
GROUPING COLUMN =	24	VALUE =	3	Fields both inside and outside
GROUPING COLUMN =	1	VALUE =	1	Village 1

DATA POS.	TOTAL	MEAN	# CTS	MEAN(ALL)
35	2	0.33	6	0.33
36	4	0.67	6	0.67

Table 10 Acreages of millet fields in Village 1, categorized by soil type and villagers rights in fields within and outside of the village.

GROUP NUMBER = 13 NUMBER OF PEOPLE = 4

GROUPING COLUMN =	38	VALUE =	41 Brown subarid soils
GROUPING COLUMN =	24	VALUE =	0 Field status unknown
GROUPING COLUMN =	1	VALUE =	1 Village 1

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
39	0	0,00	4	0,00
40	640	160,00	4	160,00

GROUP NUMBER = 48 NUMBER OF PEOPLE = 1

GROUPING COLUMN =	38	VALUE =	58 Tropical Ferruginous soils-granite
GROUPING COLUMN =	24	VALUE =	3 Fields both inside and outside
GROUPING COLUMN =	1	VALUE =	1 Village 1

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
39	0	0,00	1	0,00
40	25	25,00	1	25,00

GROUP NUMBER = 51 NUMBER OF PEOPLE = 1

GROUPING COLUMN =	38	VALUE =	99 No data on soil type
GROUPING COLUMN =	24	VALUE =	3 Fields both inside and outside
GROUPING COLUMN =	1	VALUE =	1 Village 1

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
39	0	0,00	0	0,00
40	0	0,00	1	0,00

GROUP NUMBER = 52 NUMBER OF PEOPLE = 3

GROUPING COLUMN =	38	VALUE =	41 Brown subarid soils
GROUPING COLUMN =	24	VALUE =	3 Fields both inside and outside
GROUPING COLUMN =	1	VALUE =	1 Village 1

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
39	0	0,00	3	0,00
40	375	125,00	3	125,00

Table 11 Acreages of sorghum fields in Village 1, categorized by soil type and villagers rights in fields within and outside of the village.

0GROUP NUMBER - 18 NUMBER OF PEOPLE - 2

GROUPING COLUMN - 42 VALUE - 31 Hydromorphic alluvial soils
GROUPING COLUMN - 24 VALUE - 0 Field status unknown
GROUPING COLUMN - 1 VALUE - 1 Village 1

0 DATA POS.	TOTAL	MEAN	# CTS	MEAN(ALL)
44	72	36.00	2	36.00
0TOTALS	72	36.00		36.00

0GROUP NUMBER - 33 NUMBER OF PEOPLE - 1

GROUPING COLUMN - 42 VALUE - 38 Tropical ferruginous soils-granite
GROUPING COLUMN - 24 VALUE - 2 Fields inside village
GROUPING COLUMN - 1 VALUE - 1 Village 1

0 DATA POS.	TOTAL	MEAN	# CTS	MEAN(ALL)
44	41	41.00	1	41.00
0TOTALS	41	41.00		41.00

0GROUP NUMBER - 36 NUMBER OF PEOPLE - 5

GROUPING COLUMN - 42 VALUE - 31 Hydromorphic alluvial soils
GROUPING COLUMN - 24 VALUE - 2 Fields inside village
GROUPING COLUMN - 1 VALUE - 1 Village 1

0 DATA POS.	TOTAL	MEAN	# CTS	MEAN(ALL)
44	36	7.20	5	7.20
0TOTALS	36	7.20		7.20

0GROUP NUMBER - 46 NUMBER OF PEOPLE - 1

GROUPING COLUMN - 42 VALUE - 38 Tropical ferruginous soils-granite
GROUPING COLUMN - 24 VALUE - 3 Fields both inside and outside
GROUPING COLUMN - 1 VALUE - 1 Village 1

0 DATA POS.	TOTAL	MEAN	# CTS	MEAN(ALL)
44	8	8.00	1	8.00
0TOTALS	8	8.00		8.00

0GROUP NUMBER - 49 NUMBER OF PEOPLE - 1

GROUPING COLUMN - 42 VALUE - 31 Hydromorphic Alluvial Soils
GROUPING COLUMN - 24 VALUE - 3 Fields both inside and outside
GROUPING COLUMN - 1 VALUE - 1 Village 1

0 DATA POS.	TOTAL	MEAN	# CTS	MEAN(ALL)
44	2	2.00	1	2.00
0TOTALS	2	2.00		2.00

Table 10 continued.

GROUP NUMBER = 35 NUMBER OF PEOPLE = 8

GROUPING COLUMN = 38	VALUE = 58	Tropical ferruginous soils granite	
GROUPING COLUMN = 24	VALUE = 2	Fields inside village	
GROUPING COLUMN = 1	VALUE = 1	Village 1	

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
39	0	0,00	7	0,00
40	412	51,50	8	51,50

GROUP NUMBER = 36 NUMBER OF PEOPLE = 3

GROUPING COLUMN = 38	VALUE = 91	Hydromorphic alluvial soils	
GROUPING COLUMN = 24	VALUE = 2	Fields inside village	
GROUPING COLUMN = 1	VALUE = 1	Village 1	

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
39	0	0,00	3	0,00
40	69	23,00	3	23,00

GROUP NUMBER = 38 NUMBER OF PEOPLE = 5

GROUPING COLUMN = 38	VALUE = 99	No data on soil type	
GROUPING COLUMN = 24	VALUE = 2	Fields inside village	
GROUPING COLUMN = 1	VALUE = 1	Village 1	

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
39	0	0,00	0	0,00
40	0	0,00	5	0,00

GROUP NUMBER = 39 NUMBER OF PEOPLE = 10

GROUPING COLUMN = 38	VALUE = 41	Brown subarid soils	
GROUPING COLUMN = 24	VALUE = 2	Fields inside village	
GROUPING COLUMN = 1	VALUE = 1	Village 1	

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
39	0	0,00	8	0,00
40	1315	131,50	10	131,50

Table 12 Acreages of millet-sorghum in Village 1, categorized by soil type and villagers rightss in fields within and outside of the village.

GROUP NUMBER = 35 NUMBER OF PEOPLE = 5

GROUPING COLUMN = 46 VALUE = 58 Tropical ferruginous soils
GROUPING COLUMN = 24 VALUE = 2 Fields inside
GROUPING COLUMN = 1 VALUE = 1 Village 1

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
47	0	0,00	5	0,00
48	398	79,60	5	79,60

GROUP NUMBER = 36 NUMBER OF PEOPLE = 3

GROUPING COLUMN = 46 VALUE = 91 Hydromorphic alluvial soils
GROUPING COLUMN = 24 VALUE = 2 Fields inside
GROUPING COLUMN = 1 VALUE = 1 Village 1

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
47	0	0,00	2	0,00
48	127	42,33	3	42,33

GROUP NUMBER = 39 NUMBER OF PEOPLE = 3

GROUPING COLUMN = 46 VALUE = 41 Brown subarid soils
GROUPING COLUMN = 24 VALUE = 2 Fields inside
GROUPING COLUMN = 1 VALUE = 1 Village 1

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
47	0	0,00	2	0,00
48	350	116,67	3	116,67

GROUP NUMBER = 48 NUMBER OF PEOPLE = 1

GROUPING COLUMN = 46 VALUE = 58 Tropical ferruginous soils
GROUPING COLUMN = 24 VALUE = 3 Fields both inside and outside
GROUPING COLUMN = 1 VALUE = 1 Village 1

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
47	0	0,00	1	0,00
48	31	31,00	1	31,00

GROUP NUMBER = 52 NUMBER OF PEOPLE = 1

GROUPING COLUMN =	46	VALUE =	41	Hydromorphic alluvial soils
GROUPING COLUMN =	24	VALUE =	3	Fields both inside and outside
GROUPING COLUMN =	1	VALUE =	1	Village 1

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
47	0	0,00	1	0,00
48	33	33,00	1	33,00

Table 13. Estimate of cultivable percentage of each soil type in Village 1.

Soil Types	Acreages in hectares		
	Hydromorphic - 91	Tropical Ferruginous - 58	Brown sub-arid 41
Crops			
- rice	6.6		
- manioc	6.9		
- mango-guava	6.3		
- millet	6.9	41.2	229.5
- sorghum	11.0	4.7	3.2
- millet-sorghum	12.7	42.9	35.3
- kitchen gardens	*	*	
Total Acreage Crops	50.4	88.8	267.7
Other			
- Pasture Wasteland	13.8		
- Fallow		21	275
Total	64.2	110	543
Total Acreage Soil Type	90	210	795
Cultivable Percentage	71%	52%	69%

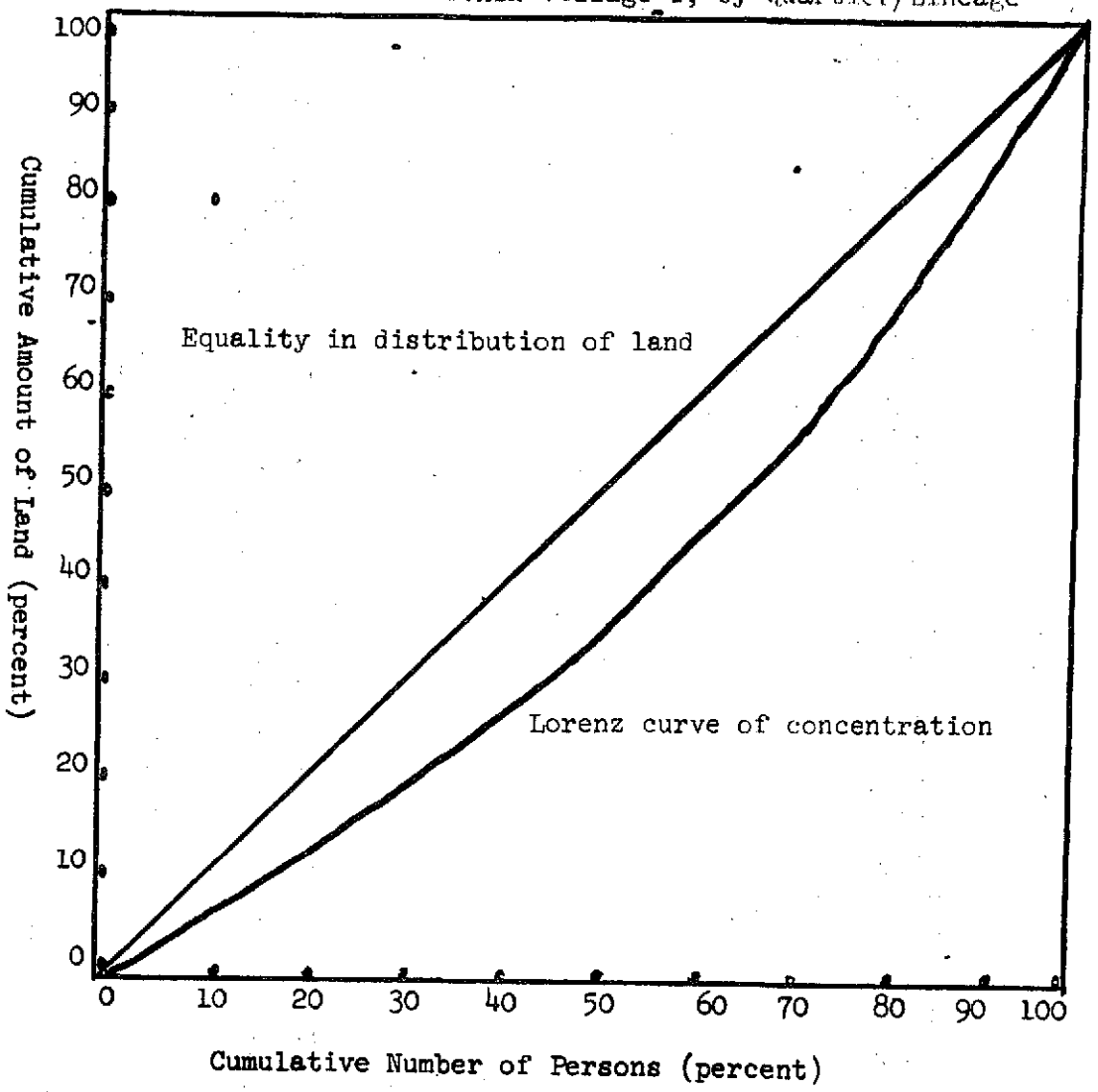
* Kitchen gardens could not be measured.

The village lands, selected from among the resources available in this area exclude the least desirable soil and vegetation types, therefore the overall cultivable percentage is relatively higher than it would be if all soil types are taken into consideration, but the cultural adaptation to particular soil types becomes one prime factor influencing population distribution, and the rate of use can be empirically derived through this methodology.

4. Average acreage per head = cultivation factor

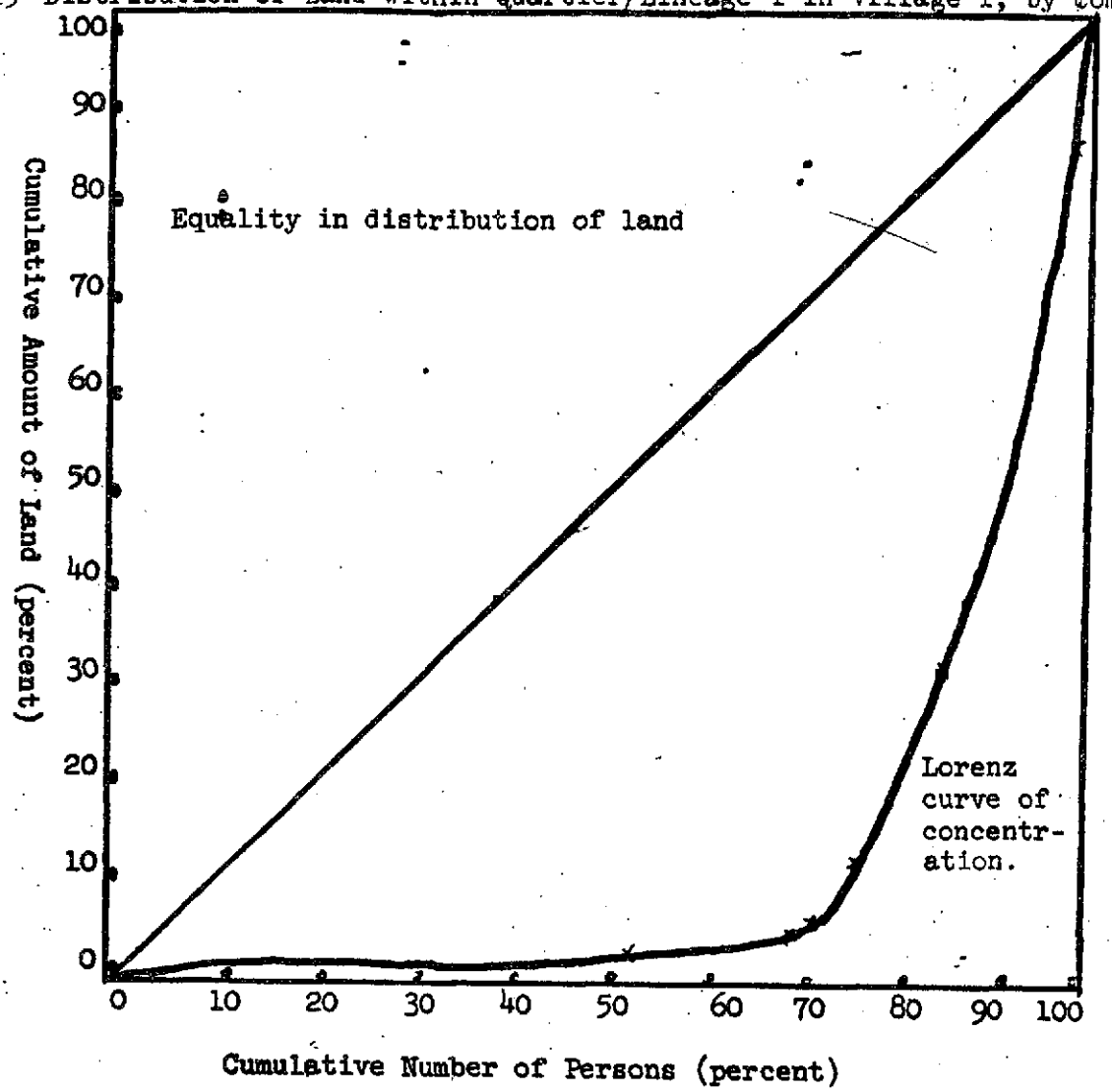
The total number of people present in Village 1 is 486 and with those having a claim to residence in the village but absent at the time of the study, 538. Two compound heads whose fields were measured outside of the village have 6 and 8 members in their families, but also have land inside the village equal in acreage to that rented. The other men who rent or own fields outside also have land inside the village; in soil types 91 and 58 their families number another 54 people. For calculations involving soil type 41, the village population is reduced by 34, to account for those relying on extra-village field resources to equal 478. Because many of the absent were expected to return for the rainy season, half of them are added for the average acreage per capita, to equal 512 persons. For soil type 91, then, the average acreage in crop is .1 hectare. Because additional land is used for pasturage, for village animals, that land carries an average acreage of .03 hectare per person. Together this is .13 hectares per person. For soil type 58, the acreage in crop is

Table 14 Distribution of Land within Village 1, by Quartier/Lineage



hect/person	Lineage	# persons	cum # persons	%	# hectares	Cum # hects.	%
.542	3	108	108	20.1	58.5	58.5	14.1
.675	1	204	312	58.2	137.9	196.4	47.9
.907	5	103	415	77.4	93.4	289.8	70.6
.924	2	75	490	91.4	69.3	359.1	87.4
1.12	4	46	436	100.0	51.6	410.7	100.0

Table 15 Distribution of Land within Quartier/Lineage 1 in Village 1, by Compound



Hect/person	# of persons	Cum # of persons	%	# hectares	Cum # Hect.	%
0.0-0.09	124	120	57.7	2.9	2.9	2.1
0.1-0.19	25	145	69.7	4.0	6.9	5.0
0.2-0.39	3	148	71.1	0.7	7.6	5.5
0.3-0.39	0	148	71.1	0	7.6	5.5
0.4-0.49	0	148	71.1	0	7.6	5.5
0.5-0.59	2	150	72.1	1.0	8.6	6.2
0.6-0.69	0	150	72.1	0	8.6	6.2
0.7-0.79	1	151	72.6	0.7	9.3	6.7
0.8-0.89	8	159	76.4	7.1	16.4	11.9
0.9-0.99	0	159	76.4	0	16.4	11.9
1.0-2.0	20	179	86.0	27.3	43.7	31.7
2.0-3.0	19	198	92.3	47.4	91.1	66.1
3.0-4.0	9	207	99.5	29.5	120.6	87.4
4.0	1	208	100	17.3	137.9	100.0

88.8 hectares, equaling .17 hectares per person. For soil type 41, the amount of land in crop is 268 hectares (though this may be reduced) for .56 hectares in acreage for the 478 people for whom this applies.

These data appear in the carrying capacity calculations which follow the discussion on the distribution of land resources.

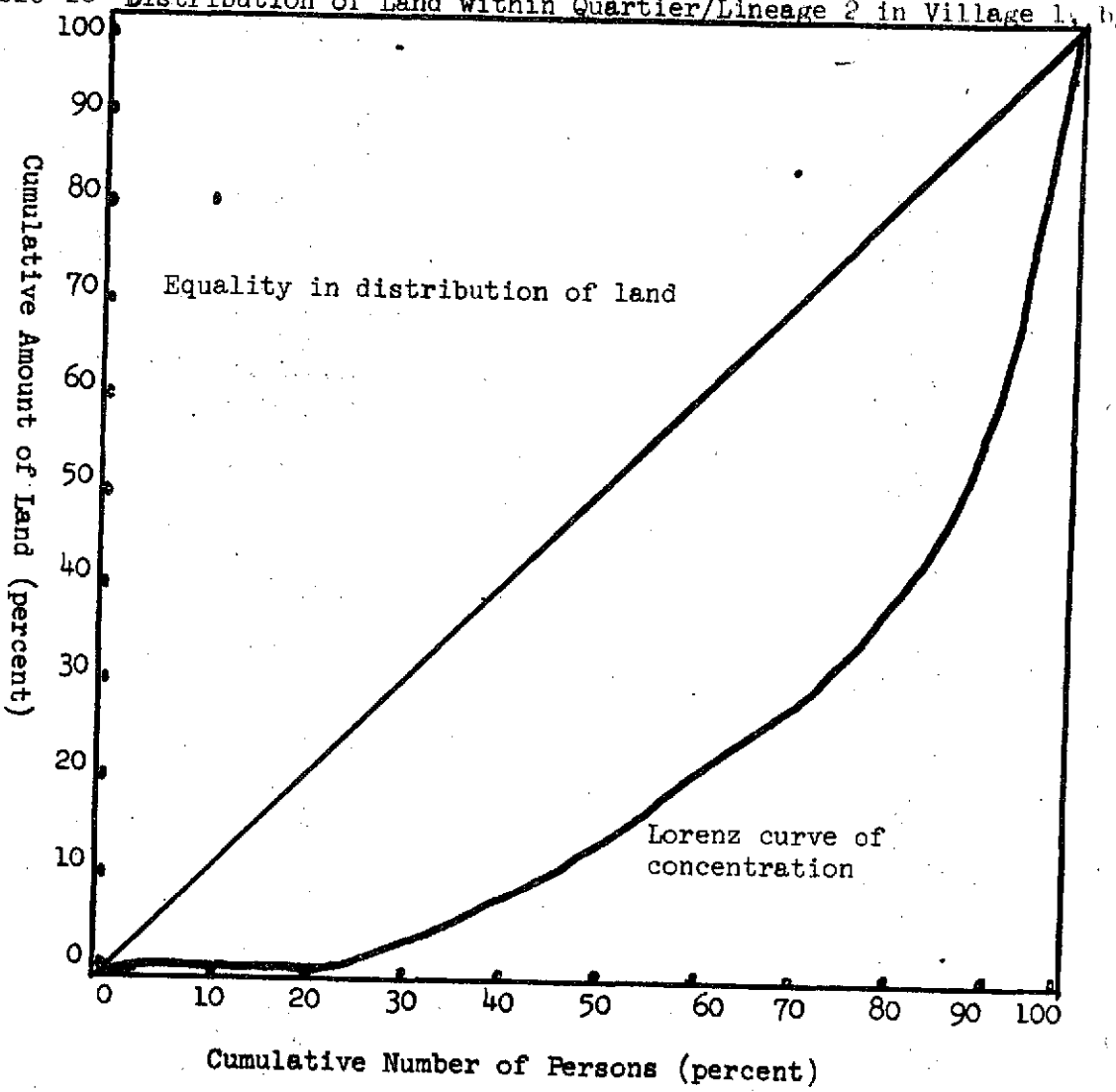
Although the mean is necessary for carrying capacity calculations, the mean also conceals quite interesting and relevant variations in the distribution of land resources. In order to elicit the relationship between land resources, taken here as all crop land available to each compound head, and the number of people within the compound dependent on those resources, a program was run to summarize crop holdings by compound, with lineage/quartier affiliation also indicated. These results are displayed by means of a Lorenz curve of concentration in Table 14, for the village as a whole, where all of the land owned by members of the lineage are pooled together with all of the persons belonging to that quartier/lineage. Included are those absent as well as present. Table 14 displays in graph c and tabular form, the fact that land is not distributed evenly on a per capita basis within any one lineage nor between lineages. The largest lineage, number one, is displayed separately in Table 15, where truly substantial variation in land holdings show up --- all, however, within relatively modest terms, even the largest holdings being no more than 4 hectares per person, while some have no land at all. One possible explanation or analytical approach is presented in Section 6, where the family type is seen as influencing property holdings.

Table 16 shows the distribution of land lineage 2.

Perhaps the clearest finding here is that relative amount of land held within the lineage is much more evenly distributed than when single compounds are considered, a measure of the significance of lineage allocation in the distribution of land.

The procedure for computing the Lorenz curve of concentration is taken from Nicholson (1969: 281-285).

Table 16 Distribution of Land within Quartier/Lineage 2 in Village 1, by Compound



Hect/person	compd #	# persons	cum # persons	%	# hectares	cum # hect.	%
0	204	6	6	8.0	0.0	0.0	0
0	206	10	16	213	0.0	0.0	0
0	208	5	21	28.0	0.0	0.0	0
0.2	207	4	25	33.3	0.8	0.8	1.2
70.752	203	23	48	64.0	17.3	18.1	26.1
0.886	202	14	62	82.7	12.4	30.5	44.0
1.725	201	8	70	93.3	13.8	44.3	63.9
5.0	205	5	75	100.0	25	69.3	100.0

Carrying Capacity Estimate

Two different ways of calculating Allan's carrying capacity formula present themselves with quite different results, shown in Tables 17 and 18. The variable is the method of calculating "area required". In his table on page 86 (Allan: 1965), the "area required" is derived by multiplying the proportion of the cultivable percentage (relative to a base of 100) by the Land Use Factor. Calculated by this means, the results for Village 1 appear in Table 17. The alternate way of calculating the area required is presented by Allan on his page 89, with a formula for computing that factor: 100 LU x C/P. Using this formula the Cultivation Factor is computed as the average acreage under cultivation per head of population at any one time. For the Lamba system, Allan assumes the Cultivation Factor to be one acre. However, when the Village 1 data are used in calculating the Cultivation Factor, the average, in tenths of hectares, is much smaller than one acre. This then results in a lower figure for area required and an inflated figure for carrying capacity, shown in Table 18. The first alternative in Table 17 is seen by this author as the potential carrying capacity since it includes both the amount of land in crop and a measure of the land required for continued cropping, and is presented here as the more accurate result. Two findings from the analysis of the socio-economic data substantiate this conclusion: (1) that men with larger families rend land outside of the village --- presumably because of constraints of land availability within the village, and (2) that absent compound heads also with larger families find their working absences a means necessary to supplement village resources.

Table 17. Human carrying capacity for Village 1, Estimate 1.

Soil 1/ Type	Total Area in h.	Years of Cultivation	C.P. 2/	L.U. 3/	Area 4/ Required in h.	Carrying Capacity
91	90	Recultivation + 3 in 1	71	1.75	1.4 x 1.75 = 2.45	36
58	210	4 in 1	52	1.3	1.3 x 2 = 2.6	81
41	795	10 in 20	68	3	3 x 1.5 = 4.5	176
	1095					293

1/ Soil type is the soil type and vegetation class.

2/ C.P. = Cultivable Percentage. These percentages are given in Table 3.

3/ L.U. = Land Use Factor. The length of time in crop, length of time in fallow, expressed as a ratio.

4/ Area required. For a single vegetation-soil type, the area of land required is the proportion of the C.P. to a base of 100 multiplied by the L.U. Factor.

Allan doesn't say so but this is close to real carrying capacity.

Table 18. Human carrying capacity for Village 1, Estimate 2.

ST-V# 1/	Total Area in h.	Years of Cultivation	C.P. 2/	L.U. 3/	Area Required 4/	Carrying Capacity
91	90	Recultivation + 1 in 4	71	1.75	.24	222
58	210	Recultivation + 1 in 4	52	1.3	.43	488
41	795	1 in 3 10 in 30	68	3	2.4	331
	1095					1041

1/ ST-V#. Soil type-vegetation class #.

2/ C.P. = Cultivable Percentage. These percentages are given in Table 13.

3/ L.U. = Land Use Factor. The length of time in crop, length of time in fallow. Expressed as a ratio.

4/ Area Required. For a single vegetation-soil type, the area of land required per head of population may be expressed by the formula: 100 L.U. x C/P. L.U. is the land use factor. C = the Cultivation Factor: an average acreage (in hectares) under cultivation per head of population at any one time.
P = Cultivable Percentage.

Allan This is the correct formula but the system has collapsed.

Soil Types, Agroclimatic Zones and Sonrai Territory in Tillaberi and Tera Arrondissements

The basis for extrapolation of carrying capacity estimates can be seen in Plates 12a and 12b. The outlines of Tilaberi and Tera Arrondissements are superimposed on the maps depicting the soil types investigated in the two Niger villages. Tropical ferruginous soils and brown subarid soils are restricted in Tillaberi. Alluvial riverain soils, by definition, are most limited in distribution. The undesignated areas in the map represent brouse tigre vegetation on top of sandstone buttes (type 27) and the black areas are lithosols (type 122) neither of which can be used for cultivation.

In Tera Arrondissement the distribution of brown subarid soils and tropical ferruginous ones is substantially greater in extent and the sandstones buttes do not occur. Accurate measurement of the areas of these soil types is a new order of business.

The overall population density figure of 8 persons per square kilometer in Tillaberi quite properly reflects the relative lack of arable and in that arrondissement. A high incidence of the arable soils is readily seen in Tera Arrondissement, an incidence which supports Sonrai expansion into this area. Except for this area (and the Inland Delta) the Ronrai are confined to the immediate environs of the main channel of the Niger River. Other soil types, not yet investigated do carry cultivation marks in Tera. Tera 1970 area and population data are lacking so that relative population density comparison cannot be made.

In the ERTS imagery of 3 July (DAL Track 16, Frame 6), the two soil types --- tropical ferruginous (58) and brown subarid (41) are readily

distinguished from other soils; they are difficult to distinguish one from the other. It is too early in the cropping season to see vegetative response to the rains, for the new crop or other vegetation.

Preliminary viewing of imagery (26 August 1973 ID# 1399-09472, and 13 September ID# 1417-09470, both DAL Track 16, Frame 6) shows that the brown subarid and tropical ferruginous distinctions can be made in the later rainy season imagery. The brown subarid soils are all traversed by now prominent water courses and fields adjacent to the water courses can be seen, in addition to gallery like vegetation. Fields between streams are modest or negligible in extent and other vegetation is also sparse.

The tropical ferruginous soils (soil type 58) are more heavily cultivated.

Soil type 12 is not found in Village 1 domain. In the dry season imagery the vegetation cover is very sparse --- virtually non-existent. In the current rainy season, clear evidence is now available of Sonrai present and previous fields, almost surely referable to current crop and fallow. Other vegetation is also very prominent. Field observation for proper identification is mandatory. An understanding of the Sonrai agrarian system will be incomplete without analysis of their use of these soils, and the almost dramatic difference between dry and rainy season vegetation.

The August 1951-60 climatological mean of 200 mm (Fromshon 1973) coincides with the line used by Bennett to mark the northernmost limit of his "drier single crop summer growth," and that boundary in turn defines rain sufficiency (to the south) and rain deficiency (to the north). (Bennett; 1962: 201). The boundary is indicated on Plates 12a and 12b. The boundary also coincides with the northern boundary of Sonrai expansion.

Plate 12a Soil types, rainfall boundary in Tillaberi Arrondissement.

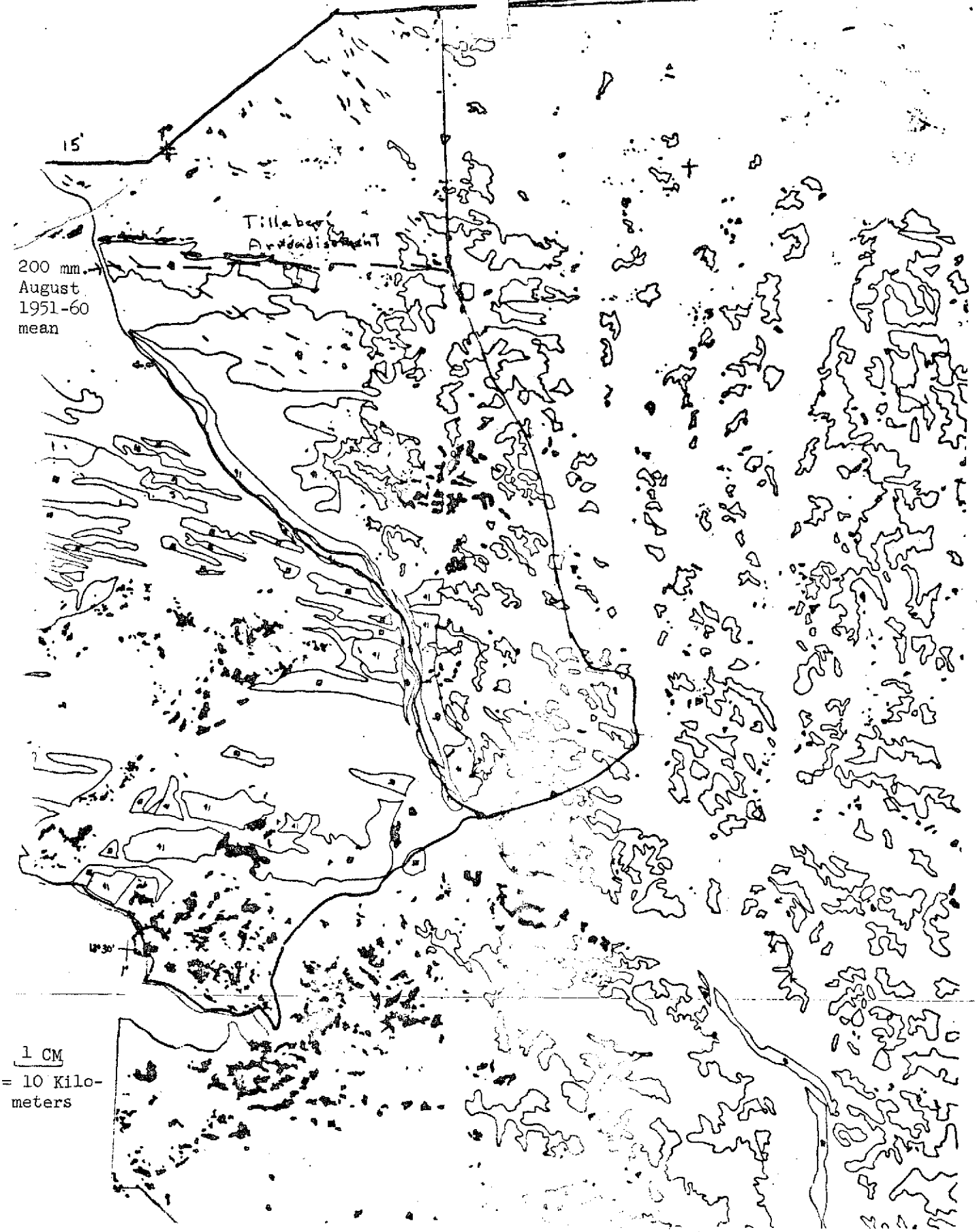
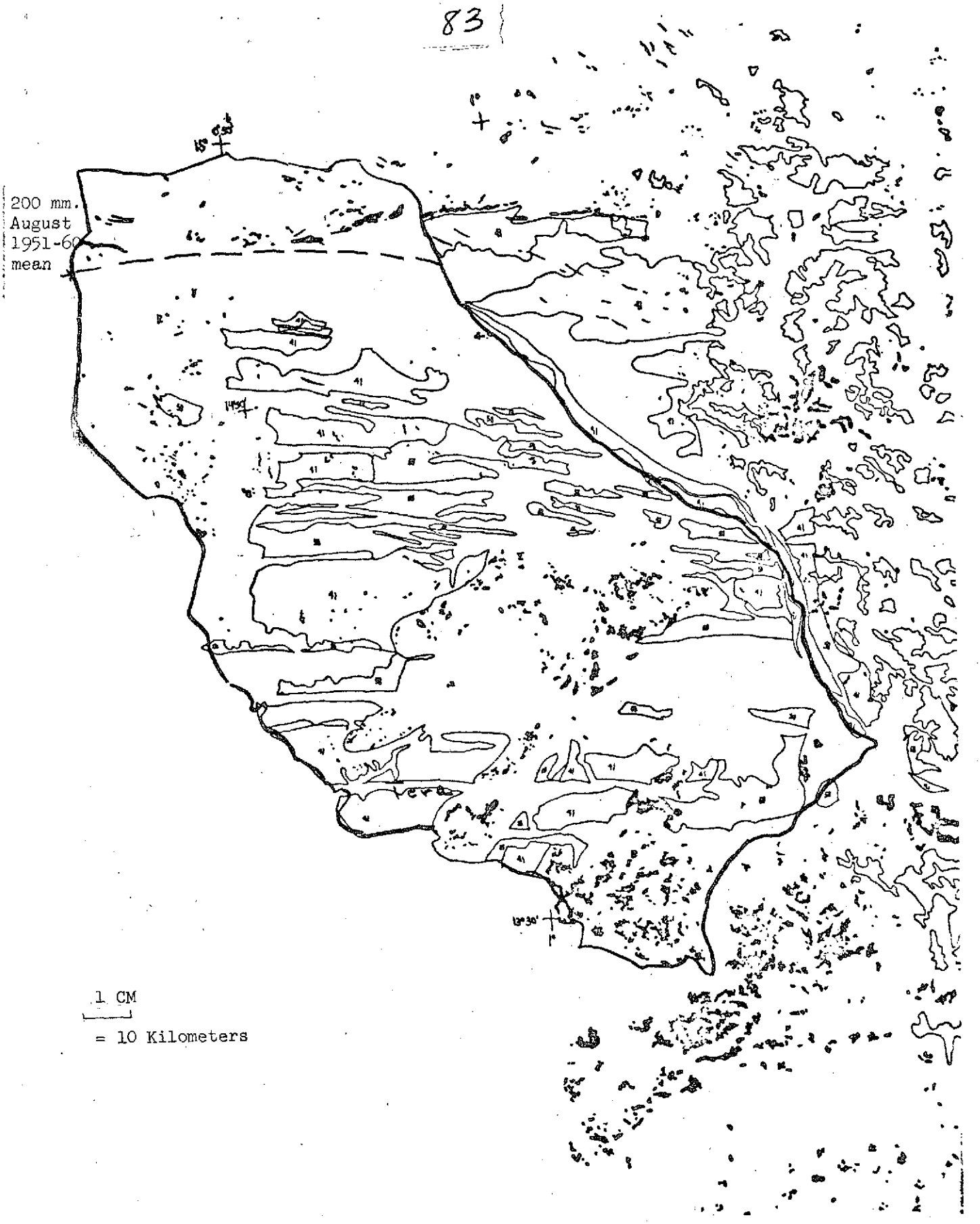


Plate 12b Soil types, rainfall boundary in Tera Arrondissement:



Hausa of Dogondoutchi, a sample of the town, Village 2.

The Hausa (Haoussa) in Niger are very closely related to the Hausa in Nigeria. In discussion with the ADO, Niamey, and with the availability of serial photographs for the area it was decided to study a sample of the town rather than rural Hausa village (which nevertheless should be done at some future time). Because Dogondoutchi has an estimated population of 10,000, a sample was selected, indicated in Plate 16, to give an idea of the involvement of town Hausa in crop cultivation and animal husbandry.

The sample was selected by marking off the town overlay in 1 cm. squares and making a random choice of 3 squares.

The Chef de Canton in a most cooperative manner agreed to discuss the particulars of family size and property holdings. Because his household numbers 75 persons and his property equivalent in size, these data are separate from the other in the tabulations.

The Hausa in Dogondouthchi live in compounds although rural Hausa villages consist of a cluster of compounds with open ground between each compound. The Dogondoutchi town Hausa relie also on millet or sorghum cultivation as a staple crop, do relatively little intensive agriculture and make extensive use of animals: donkeys, horses, cattle, sheep, and camel- for burden carrying, food, etc. Goats appear to be a real exception in that they are numerous (ca. 5,000 in a town of 10,000 people) with an equal number estimated in outlying areas and totally barren land in the immediate vicinity of Dogondoutchi may result from their food demands. Goats are said to be a form of wealth, self-increasing, and readily negotiable in tax time.

Dogondoutchi farmers leapfrog small intermediate villages and travel

as much as 20 km for cultivation and like the Sonrai, fields as large as 10 hectares-are sown by a single owner- though not by a single man. Even more strikingly then with Sonrai the town Hausa men and women appear to have a strict division of labor which puts the man into cropping activity and the woman into food preparation, child and compound care, water carrying, etc.

Notably the town Housa also appears to have greater occupational diversity.

Seed stocks were said by Dogondoutchi Hausa families to be quite adequate (except for the normally marginal) for this cropping season and food supplies also (this particular area having had a reasonable crop last season) but all were equally convinced that a good rainy season and a good harvest this year were mandatory for normal life to continue. At the time of field work, the crop was three weeks old and highly variable in germination/growth. The Dogondoutchi Hausa cultivate almost exclusively into the Dallol Maouri to the west of the town; artesian wells apparently with abundant water are sited along the Dallol wall, which is further accentuated by buttes. Hausa also crop the same area repeatedly and their loose sandy soils require no preparation prior to planting, but do require weeding after planting.

1. Soils-vegetation-climate

Beyond the town limits the soils of Dogondoutchi are very loose and sandy and support rather sparse vegetation. Gao trees are protected and large ones are in evidence. Within the town are several areas denuded of top soil, between and old town and commercial and administrative center, visible in the aerial photo and as lighter areas in the ERTS enlargement.

The soil types are:

Soil type 27- Weakly Developed Soil- Regosol

These are similar to the above but are weakly developed for a different reason. Erosion has removed most of the soil nutrient. The term regosol refers to thin soils mostly composed of rock or a rocky profile but which are soft and penetrable as a result of root action. Here the soil is on Tertiary sandstone and is a ferruginous clay sand with colluvial mixing. It is probably associated with old ferruginous crusts.

Soil type 28- Weakly Developed Soil- Colluvial

These soils are little developed due to their recency and are different from the average soil of this climatic zone. Recent colluvial sand deposits intergraded with ferruginous deposits or a mixed layering of colluvium form the basis of this soil. They are well-drained.

Soil type 51 - Ferruginous Tropical Soils on Recent Sands

This particular soil is on recent sands but is otherwise comparable to the soil type at K.-H.

Soil type 54- Tropical ferruginous soils on middle Niger sands

These soils are similar to the others of its group and differ in being formed on the middle Niger.

Soil type 55- Reddish tropical ferruginous soils on middle Niger sands

These soils differ in being reddish and occurring on a plateau.

The boundaries of the soil types can be seen in Plate 22 and are visible in the Plates of ERTS scenes. The soil type numbers are shown in Plate 22 and an inset shows the soil boundaries derived from the same ERTS scene as Plate 13. Soil samples from the recent tropical ferruginous soils of the plateau above the town (soil type 28) and from the buttes (situated

at the edge of the plateau) are being examined for their reflectance characteristics at Goddard Space Flight Center by Dr. Lambros.

Dogondoutchi lies just on the northern margin of Keay vegetation type 20. This vegetation is in response to somewhat moister conditions. The full annotation appears below. Keay (1959: 9).

> 20. *Undifferentiated: relatively dry types*
>
> A considerable range of floristic types is included here. Climatically most of them come between the moister types of Woodlands (types 16–19) and the Wooded Steppe with abundant *Acacia* and *Commiphora* (type 25). In east tropical Africa type 20 and in south tropical Africa types 20 and 22 are particularly well developed in the big river valleys and even occupy many small valleys within areas of types 16–19.
>
> The savanna types are in general more extensive than the steppe, and although acacias are often frequent, there are many broad-leaved trees such as species of *Combretum* and *Terminalia*; *Adansonia digitata* and *Sclerocarya* are particularly abundant in this type.
>
> Also included here are alluvial savannas of tall grass with certain species of *Acacia*, notably *A. polyacantha* subsp. *campylacantha* and *A. sieberiana*. These communities of *Acacia* with tall grass are very different ecologically from the steppe communities (e.g. type 25) in which other species of *Acacia* are dominant.

The vegetation called brousse tigre, seen in its dormant state in Plate 18, is typically found on the surface of the Tertiary sandstones and much of the darkest gray tone on Plate 13 can be attributed to the buttes and their associated begetation. Very little cultivation is done on these soils. The bright areas in the ERTS- 1 are those of fields or stream beds where little vegetation remains in this advanced dry season.

of twenty plus hectares, trebled with the field of the Chef de Canton.

Peanut

One cultivator reported a peanut field, but it was not seen and the soil type unknown.

Cows

Only seventeen cattle are reported by the Dogondoutchi town Hausa, and these were then being herded elsewhere.

Sheep and Goats

These Hausa value sheep for food and for sale. The number reported, one hundred, is possibly an underestimate. More likely to be an underestimate is the number of goats reported, one hundred eighty, for each compound has its complement. Goats are valued as animals, and their principal use is their negotiable quality in the market. Hausa here do not eat goat and their numbers seem relatively great. The animals are herded by a single man, and are trained to find their own compounds in the evening. In July they were being herded on the plateau east of and beyond the town, but obviously they are also frequently herded on the Dallol, for droppings are very much in evidence in these soils. Like the typical nomadic goat they are not milked (French:1970). The estimated number for the town as a whole is ca. ten thousand animals.

Chickens

Chickens and their eggs are valued in Dogondoutchi, and the eggs eaten. The number is probably an underestimate, at twenty five.

Horses and Donkeys

Horses and donkeys are a distinctive feature of this town, with donkeys being both ridden and serving as beasts of burden and horses very

very highly valued and their being used for transportation to fields a fairly common sight. Not all men own horses or donkeys and these data in Table 19 are thoughtto be quite accurate.

Granaries

Large clay granaries, almost the size of houses, are to be seen in the millet fields. The harvest is customarily placed there and transported as required for domestic use. The number of twenty one reflects the fact that each compound owner with fields has at least one granary, and several more than one.

Other Property

The Chef de Canton owns camels and a Land Rover and other camels are also owned here. Adequate camel pasturage has been hard to find however in this vicinity.

Tenure

According to the townspeople, land rights can be inherited and land can be allocated or rented, or loaned. If fields cannot be used and are unfarmed, they become abandoned, in effect, and can be taken over by someone else. These observations support the statement of Smith in discussing the Hausa of Zazzau among whom "rights of use and occupancy now have priority over other rights of ownership." (1960:2).

Cropping Cycle

The timing in the planting of millets is coordinated with the onset of the rainy season and took place in mid June in this seventy three season. Neither sorghum nor the cowpea had yet been planted.

Dogondoutchi town and Canton lie well north of the line separating moister from drier single crop summer growth. An approximation of this boundary from Bennett is shown on Plate 22. The drier single crop summer growth definition has already appeared in the Village 1 discussion. However, the 200 mm August annual mean isohyet is still farther north so that this area is adequately within the rain sufficient zone of normal years.

2. Customary Land Usage of the People.

The average Hausa household in Dogondoutchi town lives in a walled compound has rights to fields located at some distance away in the Dallol, keeps sheep and goats, herded separately by a master herder, and expects to supplement their subsistence cropping with an occupation, or in the case of elderly or incapacitated people with almsseeking. Although the components are present for mixed husbandry, the individual farmer does not practice an integrated agrarian regime. Rural Hausa, whose villages have been fleetingly observed almost surely are able to integrate animal keeping and cropping more effectively.

The Dogondoutchi townspeople nonethless consider themselves to be primarily farmers and their crops center on the millets and sorghums, but few have access to the kitchen gardens (called fadama or garka) in which potatoes, rice, onions, vegetables, data palms cotton and bananas can be grown according to Morgan and Pugh (1973: 365). One such garden space surrounded by thornbush fence can be seen in the foreground of Plate 19. Peanuts are a well known crop in this area, but only one of the farmers sampled owned a peanut field.

Millet

(Pennisetum spp.)

Millet is grown out on the Dallol Maori in a large area of contiguous fields. The Dallol floor is flat and nearly shrubless. Small, low mounds, covered in July with a succulent plant, are utilized in the planting of sorghum in amongst the millet fields. No separate acreages estimates are possible. Villagers fields can be up to twenty kilometers from town, and by pass several small villages.

In the second week of July the millet plants were well out of the ground, having been planted on three weeks previously, and weeding was underway. In the loose soils, the weeding is done with a long handled eskate-like instrument which loosens the weeks just below surface. The tool is pushed along parallel to the surface and does not dig down into the ground. The condition of the crop can be seen in Plate 21. Growth or germination appeared to be quite uneven in all of the millet fields seen, with only an exceptional field having even, full stands.

In the Canton of Dogondoutchi are five soil types, indicated in the Plate 22 inset and the sampled cultivators grow millets in two of them. The total number of cultivators is 8, growing 65 hectares of millet in 12 different fields. With the Chef de Canton the acreage almost doubles to 115 hectars. These data are shown in Table 21.

Sorghum

No pure stands are grown by the sampled cultivators.

Millet Sorghum

Millet and sorghum, and again cowpea, are interplanted in the manner described above. Four men cultivators have these fields for a total acreage

The crop is expected to ripen in October. The full cropping calendar for this area could not be observed and that reported by other authors to the south is almost surely influenced by the earlier onset of rains and their duration to a later time.

Fallowing is a subject inadequately understood but of considerable importance. In talking with Dogonodoutchi cultivators the main point being made was that little fallowing is practiced in the fields within walking or riding distance of the town itself. Manuring and interplanting are relied upon for support fertility. Thus the three year cropping and six year fallowing reported by Nicolas could not be substantiated--nor conclusively disallowed, (1960). Observation led to an understanding of some empirical fallowing, i.e., some land not in use which appeared to have been cropped, even if it did not fall into a crop:fallow cycle.

Plate 13. ERTS-1 Scene Including Village 2 Site of Dogondoutchi.

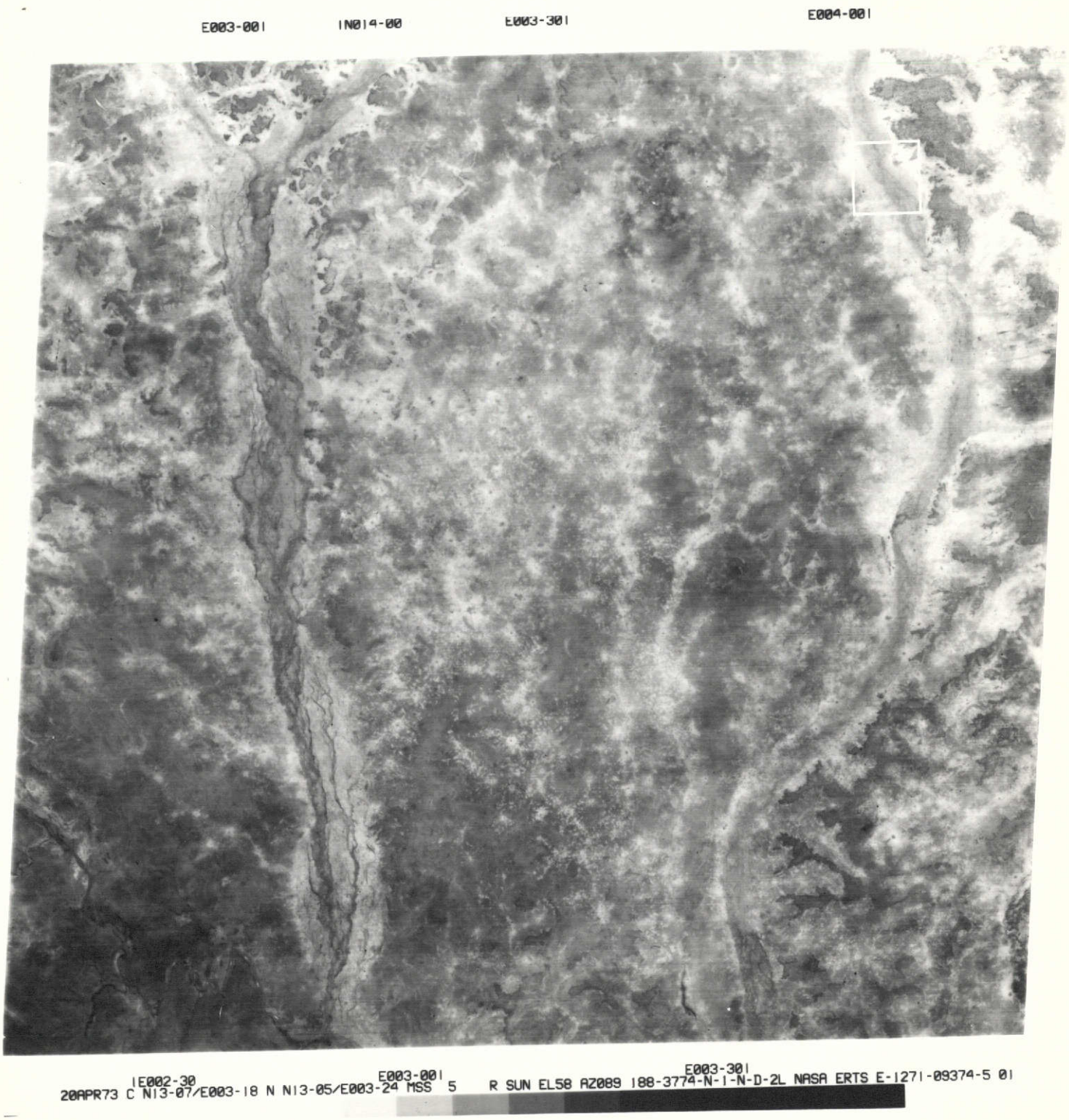


Plate 14. Copy of ONC K-2 corresponding to ERTS - 1 scene in Plate 13.

1 CM

= 10 Kilometers

Plate 15a. 1972 Cropping areas in three soil types adjacent to Dogondoutchi, from ERTS imagery.

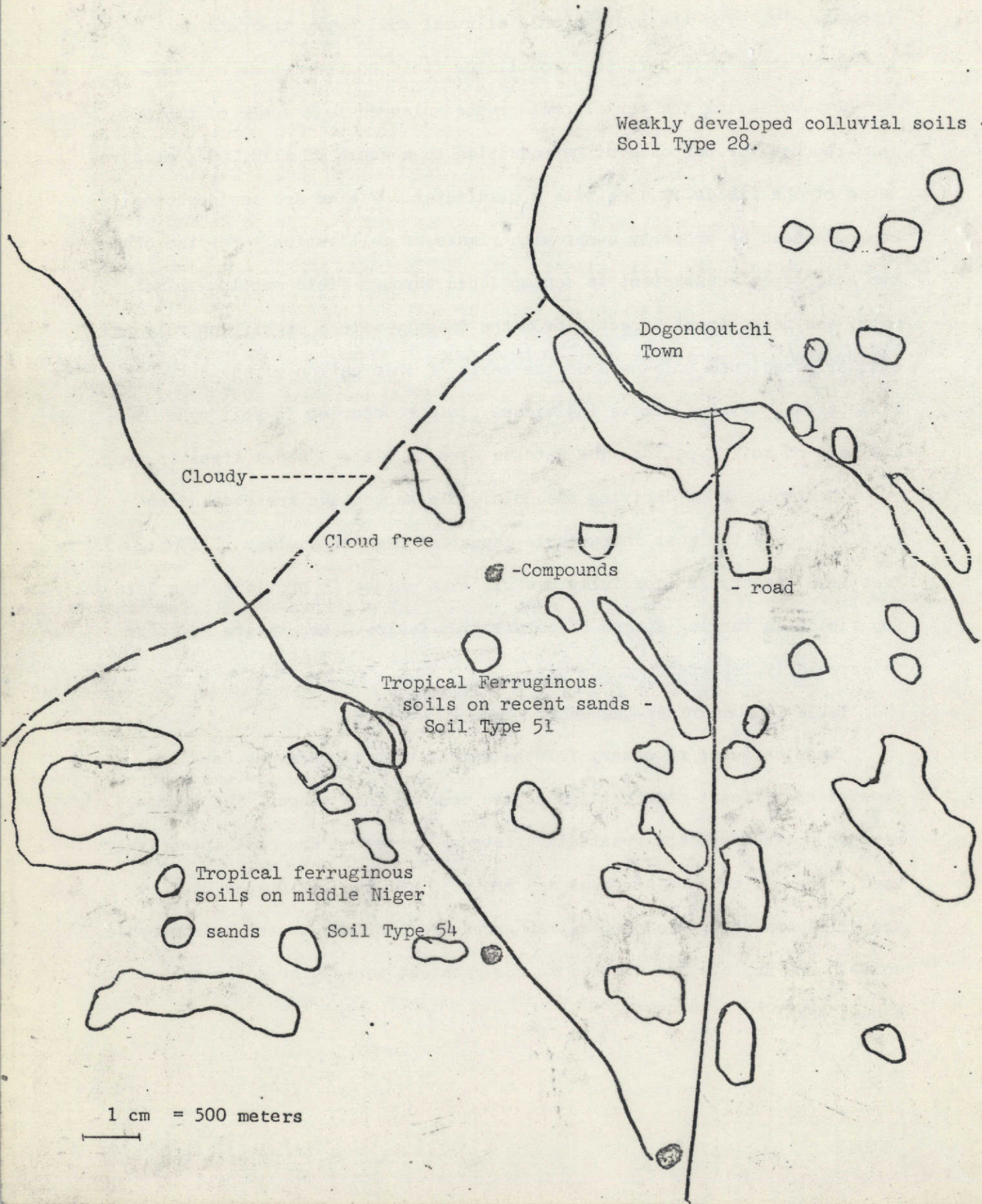


Plate 15b. ERTS-1 Enlargement to Scale of 1:50,000 of Dogondoutchi.

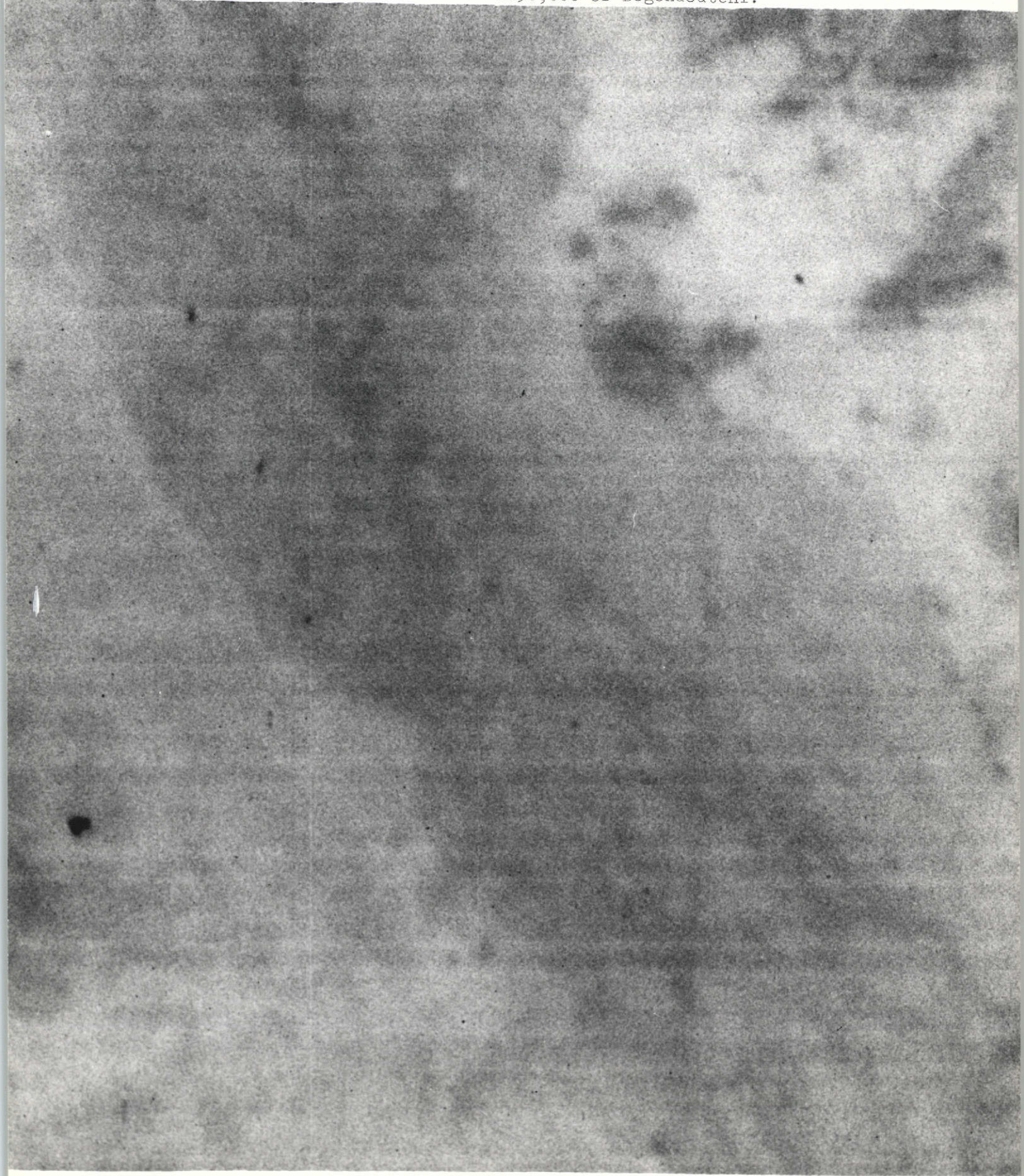


Plate 17. Aerial Photograph of Dogondoutchi at Scale of 1:15,000.

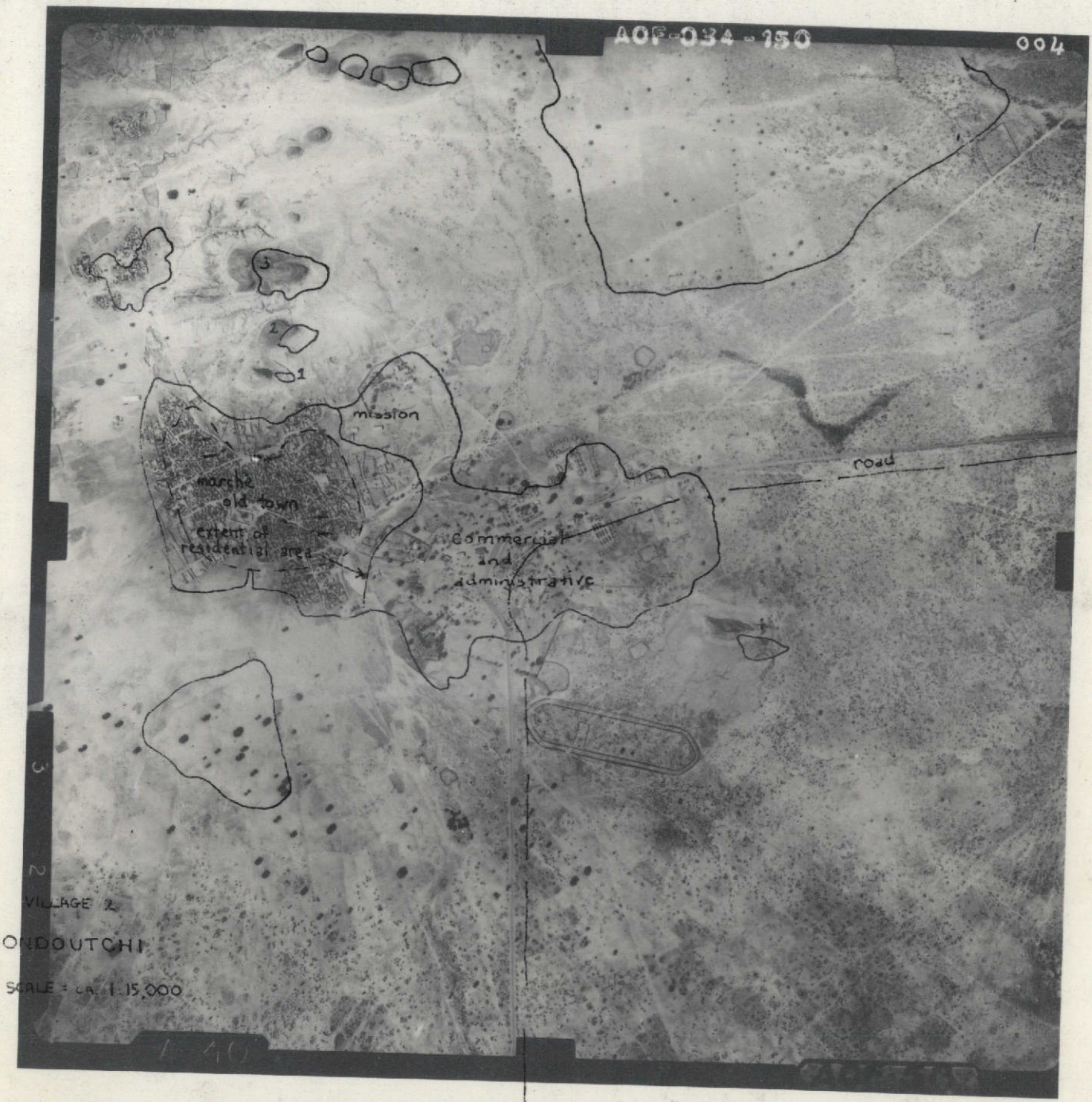


Plate 18. Brousse tigre vegetation on sandstone formation, near Dosso.

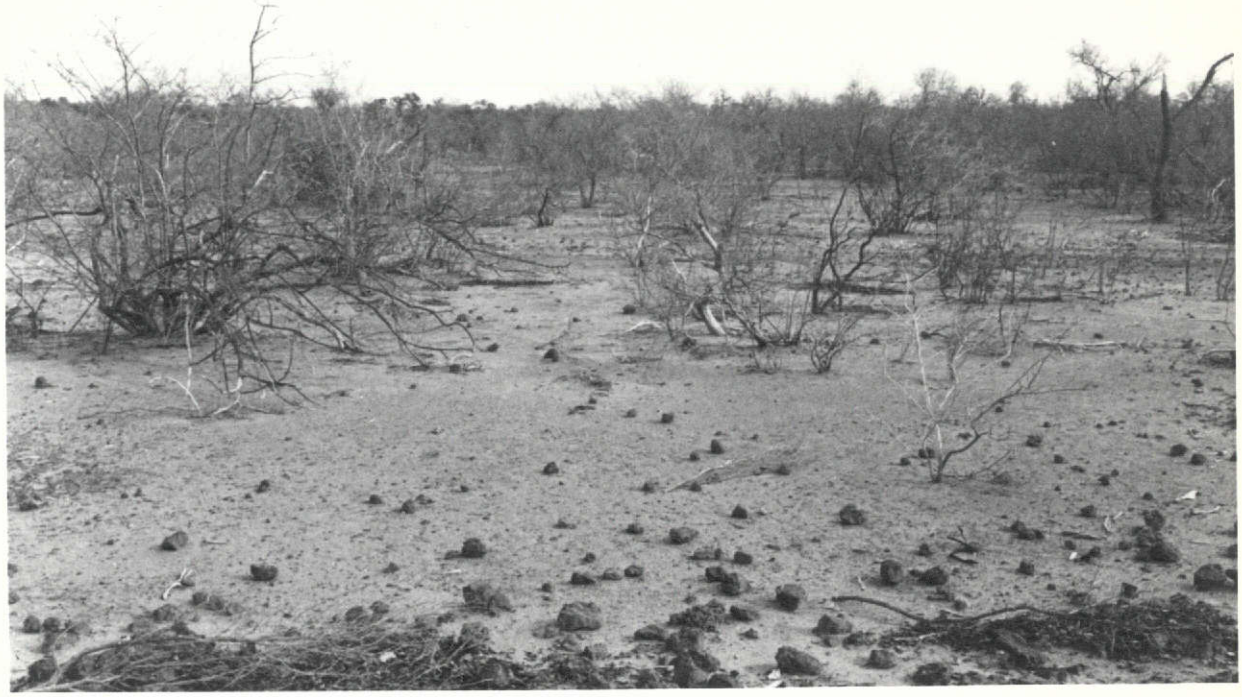


Plate 19. View of Dogondoutchi and the Dallol.

Plate 20. Dogondoutchi, showing well and new compounds.

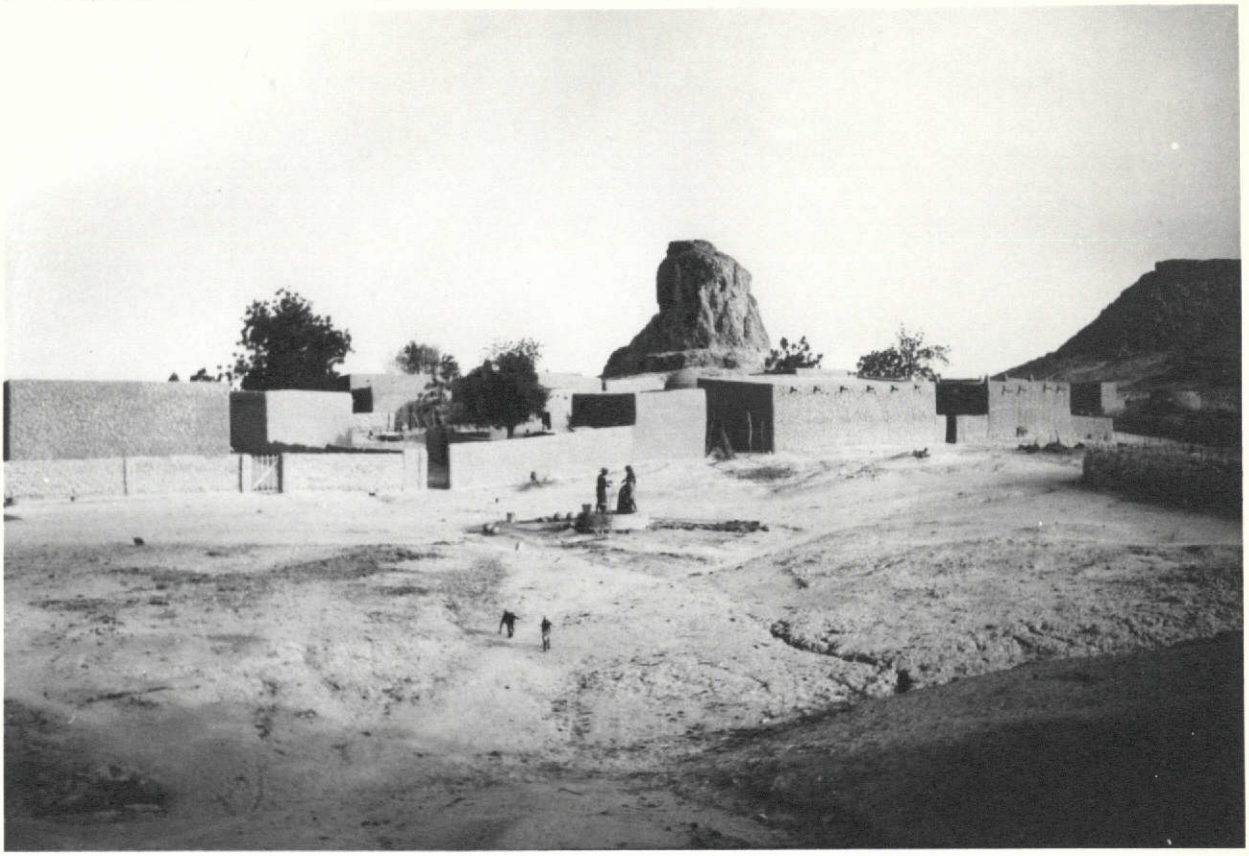


Plate 21. Millet field and gao tree.

Table 19. Number of fields and animals in Village 2.

CASES LOOKED AT: 115
CASES FOUND: 22

VAR	DATA	N	TOTALS	SD	HIGH	LOW	COMPONENTS OF HUSBANDRY: CATEGORY
1	62	20	17,20	3,36	15,0	0,0	Cows
2	63	20	124,00	17,07	75,0	0,0	Sheep
3	64	22	182,20	22,13	98,0	2,0	Goats
4	65	20	25,00	5,59	25,0	0,0	Chickens
5	19	20	67,21	3,23	12,0	1,0	Houses
6	26	20	0,00	0,00	0,0	0,0	Rice fields
7	37	20	12,00	0,52	3,0	2,0	Millet fields
8	41	20	0,00	0,00	0,0	0,0	Sorghum fields
9	45	20	0,20	0,92	4,0	0,0	Millet sorghum fields
1	61	21	22,00	2,36	8,0	0,0	Horses
2	66	21	11,00	0,81	3,0	0,0	Donkeys
3	67	21	11,00	1,83	8,0	0,0	Other property
4	21	21	21,00	1,18	4,0	0,0	Granaries
5	30	21	0,00	0,00	0,0	0,0	Manioc/sorgho parcs
6	34	20	0,00	0,00	0,0	0,0	Mango trees
7	49	21	1,00	0,22	1,0	0,0	Peanut fields
8	53	21	0,00	0,00	0,0	0,0	Bambara fields
9	57	21	0,00	0,00	0,0	0,0	Kitchen garden

Table 20. Areas of fields in Village 2.

CASES LOOKED AT: 115
CASES FOUND: 22

VAR	DATA	N	TOTALS MEANS	SD	HIGH	LOW	
1	27	22	0,00	0,22	2,0	0,0	
2	28	22	0,00	0,82	2,0	0,0	
3	31	22	0,00	0,82	2,0	0,0	
4	32	22	0,00	0,22	2,0	0,0	
5	35	22	0,20	0,20	2,0	0,0	
6	36	20	0,00	0,20	2,0	0,0	
7	39	22	43,20	9,62	43,0	0,0	Millet fields, Estimated
8	40	22	613,32	62,99	260,0	0,0	Millet fields, Measured
9	43	20	0,20	0,82	2,0	0,0	
10	44	20	0,00	0,00	0,0	0,0	
11	47	20	0,00	0,00	0,0	0,0	
12	48	20	259,00	38,33	129,0	0,0	Millet-sorghum, measured
13	51	19	0,00	0,00	0,0	0,0	
14	52	20	0,00	0,00	0,0	0,0	
15	55	20	0,00	0,00	0,0	0,0	
16	56	20	0,00	0,00	0,0	0,0	
17	59	20	0,00	0,00	0,0	0,0	
18	60	20	0,00	0,00	0,0	0,0	

Table 21. Acreages of millet fields in Village 2, categorized by soil type and villagers rights in fields within and outside of the village.

GROUPING COLUMN = 38 VALUE = 28 Weakly developed colluvial soil
GROUPING COLUMN = 24 VALUE = 2 Fields inside
GROUPING COLUMN = 1 VALUE = 2 Village 2

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
39	0	0,00	3	0,00
40	323	107,67	3	107,67

GROUP NUMBER = 84 NUMBER OF PEOPLE = 5

GROUPING COLUMN = 38 VALUE = 51 Recent tropical ferruginous soils
GROUPING COLUMN = 24 VALUE = 2 Fields inside
GROUPING COLUMN = 1 VALUE = 2 Village 2

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
39	43	8,60	5	8,60
40	264	52,80	5	52,80

GROUP NUMBER = 90 NUMBER OF PEOPLE = 1

GROUPING COLUMN = 38 VALUE = 99 No data on soil type
GROUPING COLUMN = 24 VALUE = 2 Fields inside
GROUPING COLUMN = 1 VALUE = 2 Village 2

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
39	0	0,00	1	0,00
40	26	26,00	1	26,00

Table 22. Acreages of millet sorghum fields in Village 2, categorized by soil type and villagers rights in fields within and outside of the village.

GROUPING COLUMN = 46 VALUE = 28 Weakly developed colluvial soil
GROUPING COLUMN = 24 VALUE = 2 Fields inside
GROUPING COLUMN = 1 VALUE = 2 Village 2

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
47	0	0,00	1	0,00
48	129	129,00	1	129,00

GROUP NUMBER = 85 NUMBER OF PEOPLE = 2

GROUPING COLUMN = 46 VALUE = 54 Tropical ferruginous sandy soils
GROUPING COLUMN = 24 VALUE = 2 Fields inside
GROUPING COLUMN = 1 VALUE = 2 Village 2

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
47	0	0,00	2	0,00
48	76	38,00	2	38,00

Table 23. Estimate of Cultivable Percentage of each Soil Type in Village 2.

Crops	Soil Types in Hectares								
	Soil Type 28 Weakly Developed Colluvial			Soil Type 51 Tropical Ferruginous with Sand			Soil Type 54 Tropical Ferruginous on mid-Niger sands		
	Without 824	With 824	Total	Without 824	With 824	Total	Without 824		Total
Millet	32.3	82.4		30.7	30.7		7.6		
Millet-Sorghum	12.9	12.9			39.0				
Peanut*									
	45.2	95.3		30.7	69.7		7.6		
Other									
- Pasture		[1]			[1]		[1]		
- Fallow		130.6			17.5		106.0		
TOTAL		196			87.2		113.0		
Total Acreage			10,000 [2]			9,000 [2]			22,000 [2]
Cultivable %			30%			50%			45%

* Peanut field unmeasured.

1-Estimate.

2-Total Acreage of Soil Type Drived by Planimetry of ERTS imagery.

3. The Cultivable Percentage

The cultivable percentage is the amount of land, within any one soil type, which is, has been or potentially could be put into cultivation. In the Canton of Dogondoutchi, the total acreage of each soil type has been measured by planimetry, using as boundaries these visible in the imagery and using the ORSTOM identification of the different soil types occurring within the Canton. Imagery available are three dry season frames from February, April and June on 1973 and one rainy season frame from the 1972 cropping season (August). Acreages in crop are known from the twenty-two compound heads sampled in Dogondoutchi town, but not for the entire population of the Canton. However, with the very useful comparison of 1972 cropping season imagery with the 1973 subsequent dry imagery, it is possible to make an estimate of the amount of land in crop in the three soil types.

The tropical ferruginous soils on recent sands (soil type 51), the soil type of the Dallol, appears to be extensively cultivated when driving through the Dallol on the road. On other trips into the Dallol within six kilometers of Dogondoutchi, the area also appears to be extensively cultivated and farmers said that they did little fallowing, lending credence to an estimate of as much as ninety percent of the Dallol being arable. However, a comparison of the 1972 and 1973 imagery (shown in Plate 15a) suggests that probably no more than fifty percent of the Dallol is arable at present and of that total only fifteen percent was in crop in 1972. The principal conclusion from this is that much more work needs to be done on the crop-fallow-waste ratios as they are observable both in the imagery and on the ground.

At this stage of the work, the cultivable percentage of the Dallol is given as fifty percent and the amount of land in crop (as of last year) is fifteen percent of the total, with the remainder assigned to fallow.

The tropical ferruginous soils in middle Niger sands which lie at an altitude above the Dallol and are readily distinguished in the imagery to the west of the Dallol in plate 15, appear to have been extensively cultivated (observation from the road) but with very little of it currently in crop. A further observation is that some of these former fields will require very long-term regeneration before they can be adequately recropped. Because the marks of cultivation are extensive (see plate 15), the cultivable percentage is estimated at forty-five percent. The normal crop fallow ratio is unknown, Nicolas' estimate three years in crop and six in fallow may not be an accurate guide at the present time. In the 1972 cropping season for the portion of the soil type visible in the ERTS frame of 29 August (most is obscured by cloud), fifteen percent of the land was in crop.

Weakly developed colluvial soils (soil type 28) in the immediate vicinity of Dogondoutchi are estimated as being cultivable at a relatively low rate -- no more than thirty percent. The figure is based on measurement of some current fields and observation. The aerial photographs show marks of cultivation in areas not now in crop. These areas are in long-term fallow, an allocation made with the reservation that in some places the top soil is no longer present. The 1958 aerial photos are a data base. Cropping in the 1972 season, based on ERTS imagery of 29 August is measured at 850 hectares (in an area of 8,500 ha., i.e., 10 percent was in crop last year). A portion of the area is observed by cloud. Close comparison of

the area visible in the aerial photographs show that most of that area which showed cultivation mark in 1958 was not in crop nor very heavily vegetated in 1972. The fallowing rate suggested by Nicolas of six years after three in crop would be consistent with these observations of a cultivable percentage of thirty percent and ten percent in crop.

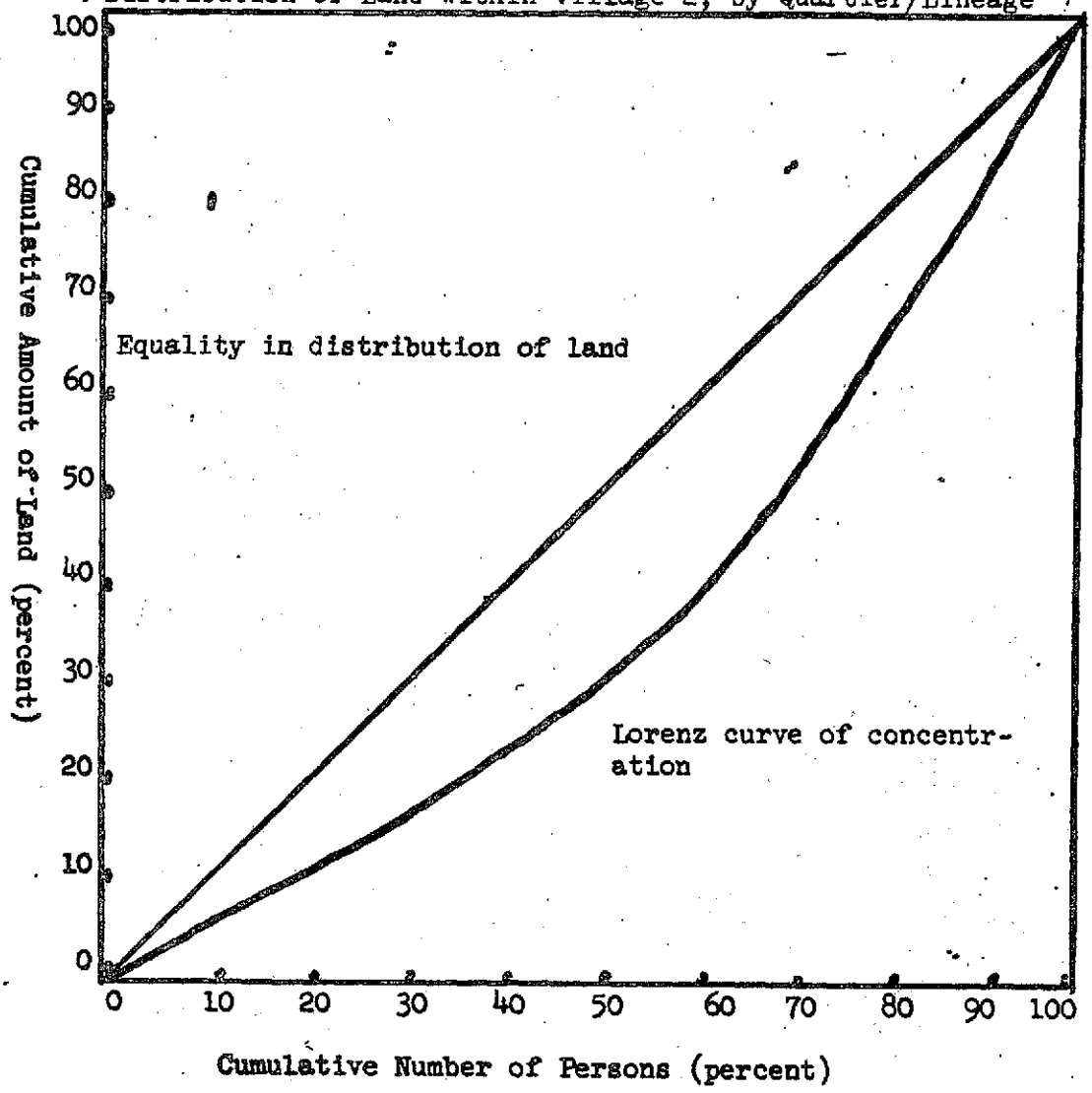
4. Average Acreage Per Head = Cultivation Factor

The total number of people in the sample taken in Village 2 is 233 including all compounds seen and 158 without that of the Chef de Canton (#824). No fields are outside of the Canton, and very few men are absent, although some men present did not have fields.

In the weakly developed colluvial soils, the average without #824 and his household is .29 hectares per person and with #824, .28 per person. In the Dallol soils, (soil type 51), the average hectarage per person is .19 and with #824, .3 hectares per person. The field in the third soil type is a single one and <u>not</u> thought a useful datam because it is such a tiny fragment of the total area of 22,000 hectares of that type within the Canton. However, the average is.05 hectares.

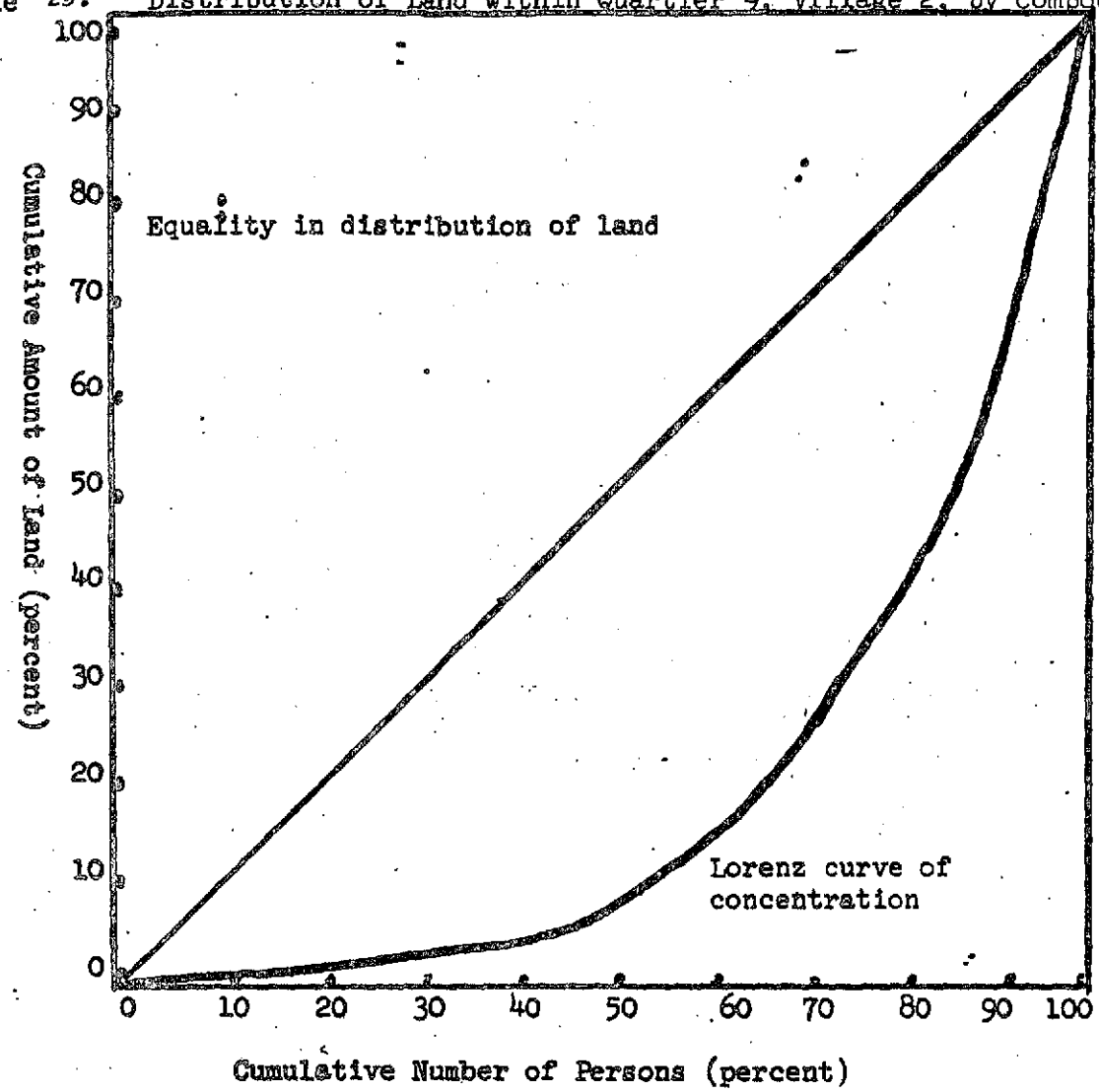
A Lorenz curve of concentration displaying variation in the distribution of land resources relative to compound population is shown in Table 24 and can be compared with Table 14 of Village 1 and Table of Village 3. The distribution resembles that of Village 1, but the inequality is somewhat more marked. Eight compound heads are entirely without land resources. The lineage /quartier of the Chef de Canton is included in the data of Table 14. In Table 15 can be seen distribution, compound-by-compound in one of the Dogondoutchi Quartier, that given the arbitrary number 9. Like the distribution within a single compound in Village 1, this distribution also shows very marked variation.

Table 24. Distribution of Land within Village 2, by Quartier/Lineage



Lineage	Hect/person	#persons	Cum # persons	%	# Hect.	Cum # Hect.	%
8	.432	62	62	27.2	26.8	26.8	15.6
9	.483	69	131	57.4	33.3	60.1	35.0
6	11.13	75	2066	90.3	85	145.1	84 5
7	1.18	22	228	100.0	26	171.7	100.0

Table 25. Distribution of Land within Quartier 9, Village 2, by Compound



Hect/person	Compd #	# persons	cum # persons	%	# hectares	cum # hcts.	%
0	902	6	6	8.7	0	0	0
	905	13	19	27.5	0	0	0
	906	1	20	28.9	0	0	0
	907	4	24	34.7	0	0	0
	911	1	25	36.2	0	0	0
0.371	910	7	322	46.4	2.6	2.6	7.8
0.406	909	16	48	10.0	6.5	9.1	27.3
0.65	908	4	522	75.4	2.6	11.7	35.1
0.716	904	6	58	84.0	4.3	16.0	48.0
1.43	903	3	61	88.4	4.3	20.3	61.0
1.62	901	8	69	100.0	13.0	33.3	100.00

Carrying Capacity Estimate

As is the case in the first village, the carrying capacity estimates vary with the different methods of calculating the area required per person. The figure of 90 is close to the actual number of people in the sample after the landless compound heads and their families are subtracted. If the carrying capacity estimate is calculated for the Chef de Canton with his large household and fields, (75 persons) and fields (80 hectares), the result is an estimate of 152 -- twice the number of his household -- and quite possibly a reasonable approximation of the surplus a man in his administrative position finds necessary to have.

Using the data we have derived with Allan's methodology by calculating the amount of arable land, the amount in crop, the amount in fallow, and the number of people, and Carneiro's formula: $\frac{W}{C(Y + R)/Y} = 1.65$ hectares for all three soil types. W = area of arable land, C = size of plot needed to provide an average person with food, Y = number of years of cultivation and R = number of years of fallow (1972:66)

By this calculation in the Canton of Dogondoutchi, the total amount of arable land is 16,500 acres, and the requirement 1.65 hectares, the carrying capacity is 10,000 persons. If the estimate of 13,000 persons for the Canton is correct, the present population is exceeding the carrying capacity.

Table 26. Human carrying capacity for Village 2, Sample of Canton, Estimate 1.

Soil 1/ Type	Total Area in h.	Years of Cultivation		C.P. 2/	L.U. 3/	Area 4/ Required in h.	Carrying Capacity
28	450*	3	6	30	3	3 x 3 = 9	50
51	206*	10	20	50	3	3 x 2 = 6	34
54	50*	3	6	45	3	3 x 3 = 9	6
							90

1/ Soil type is the soil type and vegetation class.

2/ C.P. = Cultivable Percentage. These percentages are given in Table 3.

3/ L.U. = Land Use Factor. The length of time in crop, length of time in fallow expressed as a ratio.

4/ Area required. For a single vegetation-soil type, the area of land required is the proportion of the C.P. to a base of 100 multiplied by the L.U. Factor.
*Estimate based on the known acreages multiplied by percentage in crop.

Table 27. Human carrying capacity for Village 2, Sample of Canton, Estimate 2.

Soil Type 1/	Total	Years of Cultivation		C.P. 2/	L.U. 3/	Area 4/ Required	Carrying Capacity
28	450*	3	6	30	3	3	150
51	206*	10	20	50	3	1.2	128
54	50*	3	6	45	3	.3	166

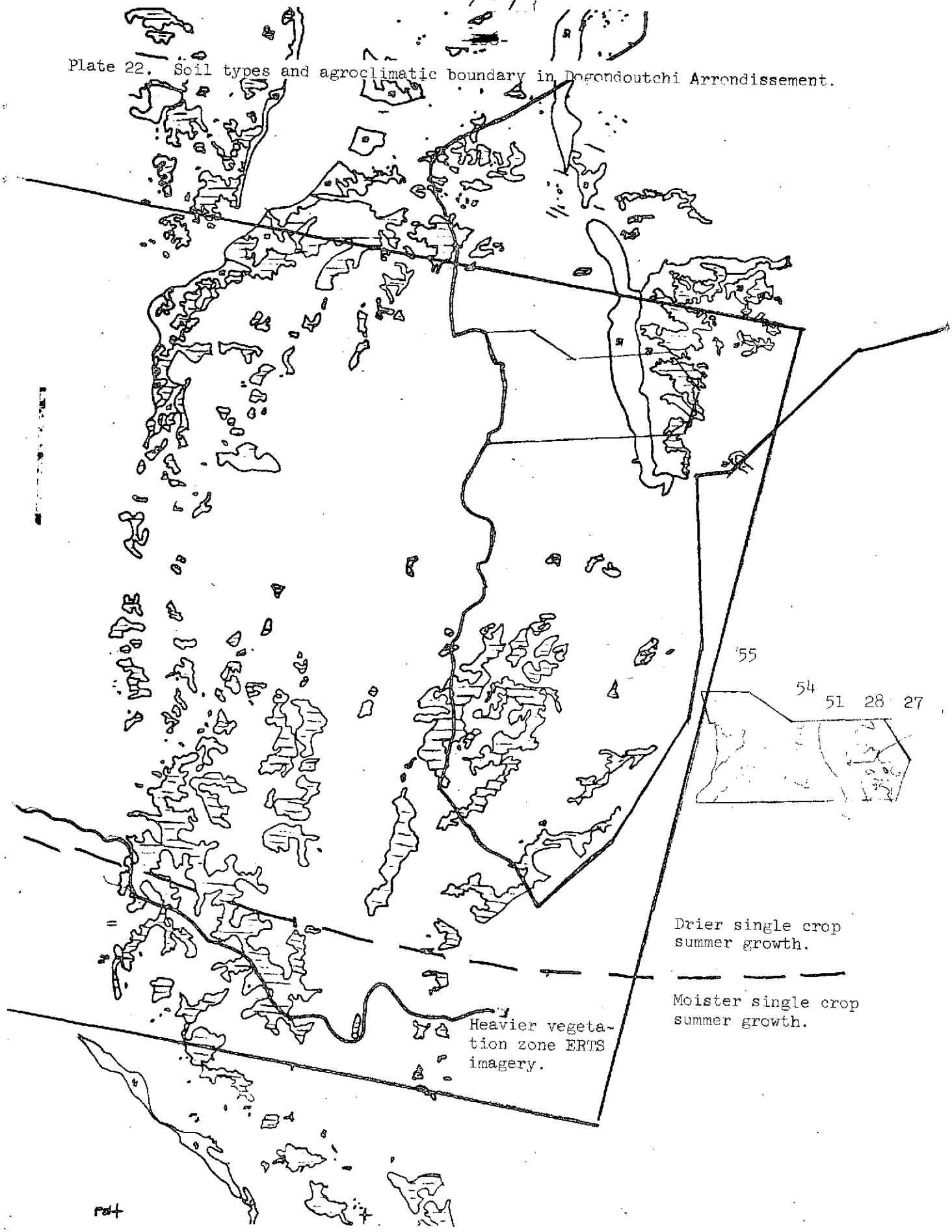
1/, 2/, and 3/ as above in Table 26.

4/ Area required. For a single vegetation-soil type, the area of land required per head of population may be expressed by the formula: 100 L.U. x C/P. L.U. is the land use factor. C = the Cultivation Factor: an average acreage (in hectares) under cultivation per head of population at any one time). P = Cultivable Percentage.

Occurrence of Soil Types in Dogondoutchi Arrondissement

The incidence of two soil types is shown in Plate 22: the Dallol soils and the weakly developed colluvial soils (soil type 28) adjacent to the Dallol. That Plate also shows an approximation of the boundary of the Arrondissement, taken from Carte Administrative Republique du Niger (Avril, 1965). In an inset the map also shows the incidence of several soil types --- using the code followed throughout this work --- taken from the dry season ERTS imagery. Also on Plate 22 are approximations of the Bennett agroclimatic boundary between drier and moister single crop summer growth zones and lastly, a boundary between light and denser vegetation taken from the same ERTS-1 dry season imagery. Both the Dallol soils and their adjacent colluvial soils are quite restricted in incidence.

Plate 22. Soil types and agroclimatic boundary in Dogondoutchi Arrondissement.



Mossi of Nabadougou, Village #3

The village is sited just north of the lake which has formed above the Louda barrage and is near Kaya town, about six kilometers away. The village consists of seventeen dispersed compounds, with most of them in two clusters separated by a small creek. Between them lies what is probably a site of a very large chief's compound for the transliteration of the name means place of the chief (Naba), and the probable site is a low mound composed of small pebbles, small pieces of pottery or sherds. The village site which appears as a well defined spot on the dry season imagery (23 April 1973) is found to consist of a cluster of ten compounds, the site and a restricted clump of trees on the creek, just where it joins the larger stream which feeds Louda barrage lake. These three features are immediately adjacent to each other ... and measure five hundred meters across. In the late rainy season imagery of 1972 (7 October) reproduced in Plates 23 and 26, the cluster of compounds can be discerned, once its location is known, but it is not sharply defined. The compound-site-vegetation combination also appears in band 7 of the same date. The remaining eight compounds in this village cannot be seen at all in the imagery and are even impossible to detect in the reproduction of the aerial photograph in Plate 28, although in the original they could be found. In the photograph of Plate 29, are three of the compounds. Their location is indicated on the overlays and the most economic perimeter, drawn to include them all, defines the village residential area.

Several conclusions follow: (1) the village site is correctly identified as a village, though most of its inhabitants have long since gone,(2) the cluster of compounds can be discerned but not very reliably, (3) approximately half of the population's habitations cannot be seen at all, (4) the measured area of the compound cluster at approximately two hundred and fifty meters is nearly the size of the Sonrai village. In comparison the Sonrai village has five hundred inhabitants compared with seventy-four in the compound cluster. The Sonrai village has a higher population density, and a greater density and clearer definition in the imagery. This comparison nonetheless makes urgent the observation that the village settlement of the same size, can carry, in different areas, very different population densities.

Although general village location is stable and each village maintains its traditional history, individual compounds can be and are abandoned so that over time, the compounds constituting the village are in different places. Very careful inspection of the aerial photographs of the fifties, with contemporary ones (not available) would be necessary to ascertain the rates of change in constituent compounds. In short, the village as a community is relatively stable, the village as a collection of physical compounds is subject to change.

These villagers people one of the many hundreds of Mossi villages in the Voltaic plateau whose political institutions (Skinner, 1964) and technology (Hammond, 1966) are well described by American authors and whose complex and detailed historical traditions are among one (Izard, 1965) of many other studies.

1. Soils-Vegetation-Climate

The soils of the Nabadougou village are much heavier and harder to work than the loose sandy soils in Niger and the Mossi must work them with a short handled hoe, stooping over to do so. See Plate 32. Donkey drawn cultivators are to be seen and are being promoted as a matter of ORD policy, and two men in this village are using such cultivators.

Soil type 22 - Weakly developed lithsols on ferruginous crusts and leached ferruginous soils.

According to Boulet (1968:53), these soils are usually uncultivated. Their natural vegetation consists of drought resistant plants and reflects the very unfavorable ecological conditions. Sometimes soils of similar morphology can be cultivated when they are also well watered. Even so the results are mediocre. The most common use is for range purposes and in the production of firewood.

In short the soils are not well suited for cultivation, but they are used in this village for millets and sorghums, peanuts and Bambara nuts.

Soil type 95 - Hydromorphic soils with pseudo-gley.

These soils are similar, though not identical with, the Niger River soils, and the Mossi, like the Sonrai use them for growing rice.

Mossi country is wetter on the average than the Sonrai and Hausa habitats, but they are plagued by irregularity in the rainfall even though the total reaches seven hundred millimeters. The variation

may be as much as thirty percent (as Morgan and Pugh point out 1973:350) and Mossi may plant more than once. It has been suggested that second or even third planting may account for the striking variation in height of crop clearly evident in Plates 29 and 30.

Continuing the use of Bennett's agroclimatic zones, Village 3 falls in the moister single crop summer growth area defined as follows:

> (3) The symbol (x), appearing in regions generally circumscribing those where the symbol (•) prevails, represents stations where, as in the potential successive-crops zone, there is rainfall totalling at least 25 inches concentrated within five consecutive months of the calendar year. But stations marked (x) also meet the criterion that during at least six other successive months of the year conditions are droughty, with less than 4 inches of rain in any month of the six. Some localities, while receiving 25 inches of rain within five months, may receive most of it within a period of three months and up to eight or nine months of the year may be droughty. They may indeed be nearly rainless. In other localities a great deal more than 25 inches of rain may fall within five months, but the onset and cessation of the rainy season may be so sharp and extreme that at least six months of drought follow the high seasonal rainfall level of the rainy season. The general characteristics of localities designated by the symbol (x) are that a fairly adequate to a fully adequate supply of rainfall is available for an unirrigated starch crop, while the duration of the rainy season is too short to permit production of more than a single crop from a given piece of land within the calendar year, or to permit a sequence of sowings and harvests protracted over several months. Here the requirements of the population for starch crops throughout the year must generally be met not partly from a succession of harvests without prolonged storage, but by almost year-long storage of a single harvest. The region where stations characterized by the symbol (x) prevail may conveniently be called the "moister single-crop summer-growth zone."
>
> Bennett: 204-5

The somewhat heavier rainfall is reflected in heavier tree growth and a grassy cover as can easily be seen in the several plates, even though this village is in th same general vegetation zone as is Dogondoutchi. The descriptive details appear in section 1 of that village.

2. Customary Land Usage of the People

The Mossi are savanna cultivators who also keep animals. The physical dispersal of the village's compounds means that each compound is surrounded by its own fields. Kitchen gardens and cereal cultivations both are near at hand. Such physical proximity promotes the dispersal of compound refuse and manure directly onto the fields. The same dispersal and easy proximity also means that Mossi women, who do much of the actual cultivation, in addition to compound work and child care, are able to combine their tasks more easily.

The fields are typically much smaller than the Sonrai or Hausa cereal fields. Boundaries though certainly known to compound owners and neighbors are irregularly demarcated and subject to change, according to Hammond (1966:73) and in observation this summer.

Each village with its collection of dispersed compounds is more or less autonomous and self-sufficient, economically, and has a variety of mechanisms for maximizing access to land resources and minimizing risk for any compound member. As we have seen in Section I under Soils, the soils are poor and the resultant productivity is usually low, according to Hammond who also sees the Mossi agrarian technology as well adapted to securing maximum benefit under these conditions.

Components of Husbandry

Rice. Rice fields under controlled irrigation are a new form of cropping for traditional Mossi cultivators. Opportunity for such cultivation is on the increase as a low level flight between Ouagadougou and Kaya town made quite clear. The villagers studied in Village 3, like many

others, are close to a barrage constructed across a stream bed. The resulting lake provides the water reservoir for the rice fields below the barrage. Village 3 residents can and do go outside of their village to rent paddy rice fields in the Louda barrage system and receive the crop in exchange for their labor minus a nominal payment. One such field system is extensive and serves many villages in addition to Nabadougou. These rice fields below the barrage are plainly evident in the ERTS imagery of 7 October 1972 and extend for 7.8 kilometers below the barrage.

Cultivators in Village 3 also grow rice in fields adjacent to the stream. Two such fields, being weeded are shown in Plate 32. These fields were inundated, rather to the villagers dismay, by a heavy rain on the day after the picture was taken. By their streamside location, the villagers anticipate having access to water for their rice fields, but in this particular instance the rainwater --- held back by the barrage --- flooded the area rather than watering it. Nonetheless these fields and the experience with the modern irrigated works downstream are a continuing source of innovation and potential intensification of agriculture.

Eleven compound heads hold 20 rice fields, estimated at .1 hectare each, and 3 compound heads hold 6 rice fields below the barrage, estimated also at .1 hectare each. All rice fields are in hydromorphic soils with pseudo-gley and are nearly clear of all other vegetation except for a few large trees as may be seen in Plates 31 and 32.

Millet. Millet (Pennisetum spp. More = ki), a staple crop for the Mossi, is grown immediately next to the rice fields and in other fields

usually at some little distance from the compounds. The crop in Plate 30 was identified as millet, planted in quite small fields here bordered by a legume as a boundary marker. In the middle distance in the left part of the photograph may be seen a much taller and thicker stand of millet, a response to small-circle burning of brush prior to planting. In the fields in this vicinity were several such circles --- but with a total acreage only a tiny fraction of the area planted.

In the overlay on Plate 27, the millet field area is identified.

The millet fields shown in Plate 30 were measured, but size, lack of suitable recent aerial photographs and irregular demarcations made it necessary to estimate the fields of single compound heads on the basis of the total area planted to millet. Fifteen compound heads own fields, which are allocated to their wives, for a total acreage of 22.7 hectares, all within the village domain.

Sorghum. Sorghum (Sorghum spp. More = ki) also a staple crop for the Mossi, is grown immediately around the compounds and this crop may be seen in Plate 29. Note that the More word is the same for both millet and sorghum. Due to location, sorghum benefits most from compound refuse and manure from animals tethered in the owners' compounds.

Ten men grow sorghum around their residential compounds. Total acreage is 18.5 hectares, all within the village domain.

Peanuts. Peanuts and Bambara nuts together are important Mossi crops. Peanuts or groundnuts (Arachis hypogea, More = soom kam) are planted in this Mossi village as single crops and not intermixed. Sandier parts of

the village soils are chosen for peanuts. Peanuts and Bambara nuts are used for sauces in normal cookery and count as subsistence crops, but they are also marketable as cash crops and the proximity of Kaya, a major market town, facilitates such disposal if that choice is made. Nine compound owners grow peanuts for a total acreage of 13.3 hectares divided into 20 fields.

Bambara Nuts

This West African domesticate (Voandzeia subterranea) has almost as much acreage as millet and sorghum combined. Bambara nuts were not found in other villages (Sonrai and Hausa), with lighter sandier soils and it may be that Bambara nuts will yield a crop with greater return for labor on these poor heavy soils. Bambara nuts are the crop of preference under similar conditions in East Africa. Twelve compound owners have a total acreage of 40.7 hectares divided into 26 fields. Some of these fields are under lease arrangements with Kaya townsmen or more specifically with women from Kaya. Since a portion of the crop will go to the compound owners whose land they till, this acreage is counted with the compound owners own. The arrangement is the obverse of that seen in Dogondoutchi town where townsmen go out into the countryside, including that of small villages, in search of cultivation sites.

Cattle. Nabadougou villagers, in classic fashion, make arrangements with Peul herdsmen for the care of their cattle. The Peul have two smallish kraals, just north of the village domain. The cattle enclosures (kraals) measures less than one hundred meters across and, in July were lightly and unevenly manured. These enclosures cannot be seen in the

imagery of 4 July, nor in the other imagery. In fact, however, reliable identification cannot be made in the aerial photograph, taken fifteen years earlier.

Peul women were regularly offering milk for sale in the village in July, from the herd of approximately fifty animals. According to village compound owners no more than fourteen animals are their property and this may be an underestimate. The animals are herded in village lands, and sometimes, villagers said, in among their cultivations. The Peul cattle are relatively large, humped, shorthorned, thin in July, but surviving.

Sheep and Goats. Sheep and goats are tethered in their owners compounds at night and grazed out during the day. Sheep are used for ritual purposes and goats may be eaten and are definitely marketable. The numbers in Table 28 are more likely an underestimate of total holdings though they represent the sum of figures given by householders. Manure droppings from these animals are evident in the fields and along paths and are sometimes composted for certain plants such as tomatoes.

Chickens. Mossi use chickens in conjunction with ceremonials, according to Hammond (1966), afterwards collected and cooked and thus add to total nutrition. The chicken census, about one chicken per person, is more likely an underestimate than an overestimate. Chickens are also used as gifts. These chickens appeared healthier and larger than did the fowl in the other two villages.

Donkeys. Two compound heads own donkeys and use them with cultivators, an innovation being pressed by ORD officials. Donkey drawn cultivators

are being used for breaking up the soil after a five-year fallow period and the fields were to be planted to Bambara nuts.

Houses. Each adult person, male and female, owns a dwelling-storage house where stores and other property can be kept, and for sleeping in rainy or cool weather. Food stores in very large earthen pots are kept inside. Houses are inherited following rank ordering in the group of male relatives, and then assigned to wives. If however, no near male relative lives in the compound, or village, the house and compound will be abandoned in whole or in part, as was seen in this village.

Granaries. Granaries, almost as large as individual houses are often seen just outside the compound walls, as may be seen to the right in Plate 29. Like houses, granaries are inherited by one male from his next older brother among a group of male relatives, and jurisdiction over their contents is maintained by the compound owner.

Tenure. Most land is held under individual ownership acquired through inheritance by the eldest son. Such land cannot be alienated through sale and is for the use of the man, his wives, and his brothers and their wives in the man's lifetime. Theoretically every Mossi man has a right to fields within the domain of his own village, but priority goes to the eldest son and his wives and lesser priority to younger brothers. If the family is prolific and no near male relatives have an over abudant supply, younger brothers may in fact be landless. These general conditions found elsewhere among Mossi, prevail at Nabadougou, Village 3, where no man had more than one brother in his compound and where only thirty-one percent of the adult

population is male and present and only six percent of adult population are absent men, noted as such. The twin facts of their absence and that they are not counted as absent, that is not expected to return strongly suggests that land is a major constraint for continued residence in the village and landlessness a major reason for the "rural push."

Land, that is rights in fields, is allocated by a compound head to his wives, for their use.

Within the village some land may also be held communally, among the members of a large compound, composed of a senior male, his brother and their sons. Such land is also worked communally, according to Hammond (1966:76), that is members of compound join each other in helping with planting, weeding, etc. The harvested crop is stored in the compound head's granary to be dispensed for cooking to the several wives.

In addition to acquiring land through inheritance, land may also be loaned by a compound head who has more than he can use or need keep in fallow to a needy relative or anyone else who contracts with him for the temporary transfer of land. As we have also seen Village 3 farmers rent rice fields and also lease Bambara fields on a short-term basis to unrelated townsmen.

Cropping Cycle. Mossi regulate cropping activities with a 28-day lunar calendar adjusted to the specific climatic variations of any one year and any single village. Normally the first phase is essentially a ceremonial recognition of the utter reliance Mossi have on subsistence cropping. The second phase is clearing and burning in April, a first planting of millets in late May, a planting of other crops in the

following month, weeding of millet in July as the fifth phase, followed by still more weeding the next month, and a final harvest phase in September-October. In July in Village 3 villagers were weeding millet and rice, and planting Bambara and peanuts. More than one seeding of millet is a possibility, or even a probability under conditions of late or inadequate rains. Information on the full cropping cycle comes from Hammond in his chapter on this subject.

3. Cultivable Percentage, Estimate of the Proportion Practicable for Cultivation in Each Soil Type

An important, but unsolved problem is the cultivation potential or land which has been cultivated, and is now abandoned with little or no topsoil remaining and very little natural regeneration of vegetation. Comparison of Plate 26, the ERTS enlargement (to a scale of 1:50,000 where 1 cm. equals 500 meters) with Plate 28, the aerial photograph of the same scale, taken approximately fifteen years earlier shows very light or bright patches in both plates. In the northern part of the village domain (toward the top of the plate), are old compound sites, now abandoned, and in the vicinity of these compounds are barren stony patches of ground. These still barren patches, which show the marks of cultivation fifteen years ago and were also light in reflectance at that time, were undoubtedly fields. Because the process of vegetative regeneration appears to be so slow, they are considered here as wasteland or no longer as land capable of cultivation. The cultivable percentage is thereby reduced. The wasteland inventory appears to be as important to understand and evaluate as the crop and fallow inventories.

Table 28 Number of fields and animals in Village 3:

CASES LOOKED AT: 116
CASES FOUND: 17

VAR	DATA	N	TOTALS	SD	HIGH	LOW	COMPONENTS OF HUSBANDRY: CATEGORY
1	62	17	14,00	1,07	4,0	0,0	Cows
2	63	17	44,00	2,83	8,0	0,0	Sheep
3	64	17	42,00	3,35	12,0	0,0	Goats
4	65	17	162,00	9,79	30,0	0,0	Chickens
5	19	17	96,00	4,31	20,0	1,0	Houses
6	26	17	20,00	1,01	3,0	0,0	Rice fields
7	37	17	34,00	1,70	7,0	0,0	Millet fields
8	41	17	15,00	0,93	3,0	0,0	Sorghum fields
9	45	17	0,00	0,00	0,0	0,0	Millet sorghum fields
1	61	17	1,00	0,24	1,0	0,0	Horses
2	66	17	2,00	0,33	1,0	0,0	Donkeys
3	67	17	23,00	2,40	8,0	0,0	Other property
4	21	17	18,00	0,90	3,0	0,0	Granaries
5	30	17	0,00	0,00	0,0	0,0	Manioc/sorgho parcs
6	34	17	0,00	0,00	0,0	0,0	Mango trees
7	49	17	20,00	1,47	5,0	0,0	Peanut trees
8	53	17	26,00	1,12	3,0	0,0	Bambara fields
9	57	17	0,00	0,00	0,0	0,0	Kitchen garden

Table 29 Areas of fields in Village 3:

VAR	DATA	N	~~MEANS~~	SD	HIGH	LOW	
1	27	17	26,00	1,01	3,0	0,0	
2	28	17	0,00	0,00	0,0	0,0	
3	31	17	0,00	0,00	0,0	0,0	
4	32	17	0,00	0,00	0,0	0,0	
5	35	17	0,00	0,00	0,0	0,0	
6	36	17	0,00	0,00	0,0	0,0	
7	39	17	199,00	28,18	120,0	0,0	Estimated area millet
8	40	17	28,00	6,79	28,0	0,0	Measured area millet
9	43	17	155,00	11,22	43,0	0,0	Estimated area sorghum
10	44	17	32,00	7,76	32,0	0,0	Measured area sorghum
11	47	17	0,00	0,00	0,0	0,0	
12	48	17	0,00	0,00	0,0	0,0	
13	51	17	124,00	11,64	40,0	0,0	Estimated area peanuts
14	52	17	15,00	2,49	10,0	0,0	Measured area peanuts
15	55	17	365,00	57,17	240,0	0,0	Estimated area Bambara
16	56	17	42,00	7,19	26,0	0,0	Measured area Bambara
17	59	17	0,00	0,00	0,0	0,0	
18	60	17	0,00	0,00	0,0	0,0	

Table 30 Acreages of rice in Village 3, categorized by soil type and villagers rights in fields within and outside of the village:

GROUP NUMBER = 105 NUMBER OF PEOPLE = 1

GROUPING COLUMN =	25	VALUE =	0 Soil type unknown
GROUPING COLUMN =	24	VALUE =	0 Fields out/in village, none
GROUPING COLUMN =	1	VALUE =	3. Village 3

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
27	0	0,00	1	0,00
28	0	0,00	1	0,00

GROUP NUMBER = 131 NUMBER OF PEOPLE = 2

GROUPING COLUMN =	25	VALUE =	0 Soil type unknown
GROUPING COLUMN =	24	VALUE =	2 Fields inside village
GROUPING COLUMN =	1	VALUE =	3 Village 3

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
27	0	0,00	2	0,00
28	0	0,00	2	0,00

GROUP NUMBER = 141 NUMBER OF PEOPLE = 11

GROUPING COLUMN =	25	VALUE =	95 Soil type hydromorphic with pseudo-
GROUPING COLUMN =	24	VALUE =	2 Fields inside village gley
GROUPING COLUMN =	1	VALUE =	3 Village 3

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
27	20	1,82	11	1,82
28	0	0,00	11	0,00

GROUP NUMBER = 154 NUMBER OF PEOPLE = 3

GROUPING COLUMN =	25	VALUE =	95. Soil type hydromorphic with pseudo-
GROUPING COLUMN =	24	VALUE =	3 Fields both inside/outside. gley
GROUPING COLUMN =	1	VALUE =	3 Village 3

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
27	6	2,00	3	2,00
28	0	0,00	3	0,00

Table 31 Acreages of millet fields in Village 3, categorized by soil type and villagers rights in fields within and outside of the village:

GROUPING COLUMN = 38 VALUE = 22 Weakly developed lithosols
GROUPING COLUMN = 24 VALUE = 2 Fields inside village
GROUPING COLUMN = 1 VALUE = 3 Village 3

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
39	181	15,08	12	15,08
40	0	0,00	12	0,00

GROUP NUMBER = 146 NUMBER OF PEOPLE = 3

GROUPING COLUMN = 38 VALUE = 22 Weakly developed lithosols
GROUPING COLUMN = 24 VALUE = 3 Fields both inside/outside
GROUPING COLUMN = 1 VALUE = 3 Village 3

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
39	18	6,00	3	6,00
40	28	9,33	3	9,33

Table 32 Acreages of sorghum fields in Village 3, categorized by soil type and villagers rights in fields within and outside of the village:

GROUP NUMBER - 133 NUMBER OF PEOPLE - 8

GROUPING COLUMN - 42 VALUE - 22 Weakly developed lithosols
GROUPING COLUMN - 24 VALUE - 2 Fields inside village
GROUPING COLUMN - 1 VALUE - 3 Village 3

G DATA POS.	TOTAL	MEAN	# CTS	MEAN(ALL)
43	137	17.12	8	17.12
GTOTALS	137	17.12		17.12

GROUP NUMBER - 144 NUMBER OF PEOPLE - 1

GROUPING COLUMN - 42 VALUE - 0 Soil type unknown
GROUPING COLUMN - 24 VALUE - 3 Fields both inside/outside
GROUPING COLUMN - 1 VALUE - 3 Village 3

GTOTALS	0	0.00		0.00

GROUP NUMBER - 146 NUMBER OF PEOPLE - 2

GROUPING COLUMN - 42 VALUE - 22 Weakly developed lithosols
GROUPING COLUMN - 24 VALUE - 3 Fields both inside/outside
GROUPING COLUMN - 1 VALUE - 3 Village 3

G DATA POS.	TOTAL	MEAN	# CTS	MEAN(ALL)
43	16	8.00	2	8.00
44	32	16.00	2	16.00
GTOTALS	48	24.00		24.00

Table 33 Acreages of peanut fields in Village 3, categorized by soil type and villagers rights in fields within and outside of the village:

GROUP NUMBER = 131 NUMBER OF PEOPLE = 7

GROUPING COLUMN = 50 VALUE = 0 Soil type unknown
GROUPING COLUMN = 24 VALUE = 2 Fields inside/outside village
GROUPING COLUMN = 1 VALUE = 3 Village 3

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
51	0	0,00	7	0,00
52	3	0,43	7	0,43

GROUP NUMBER = 133 NUMBER OF PEOPLE = 6

GROUPING COLUMN = 50 VALUE = 22 Weakly developed lithosols
GROUPING COLUMN = 24 VALUE = 2 Fields inside village
GROUPING COLUMN = 1 VALUE = 3 Village 3

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
51	88	14,67	6	14,67
52	0	0,00	6	0,00

GROUP NUMBER = 146 NUMBER OF PEOPLE = 3

GROUPING COLUMN = 50 VALUE = 22 Weakly developed lithosols
GROUPING COLUMN = 24 VALUE = 3 Fields inside/outside village
GROUPING COLUMN = 1 VALUE = 3 Village 3

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
51	32	10,67	3	10,67
52	10	3,33	3	3,33

Table 34 Acreages of Bambara fields in Village 3, categorized by soil type and villagers rights in fields within and outside of the village:

GROUP NUMBER = 133 NUMBER OF PEOPLE = 8

GROUPING COLUMN = 54 VALUE = 22 Weakly developed lithosols
GROUPING COLUMN = 24 VALUE = 2 Fields inside/outside village
GROUPING COLUMN = 1 VALUE = 3 Village 3

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
55	91	11,37	8	11,37
56	16	2,00	8	2,00

GROUP NUMBER = 146 NUMBER OF PEOPLE = 3

GROUPING COLUMN = 54 VALUE = 22 Weakly developed lithosols
GROUPING COLUMN = 24 VALUE = 3 Fields inside/outside village
GROUPING COLUMN = 1 VALUE = 3 Village 3

DATA POS,	TOTAL	MEAN	# CTS	MEAN(ALL)
55	34	11,33	3	11,33
56	26	8,67	3	8,67

Plate 23. ERTS-1 Scene Including Village 3 Site in the Vicinity of Kaya.

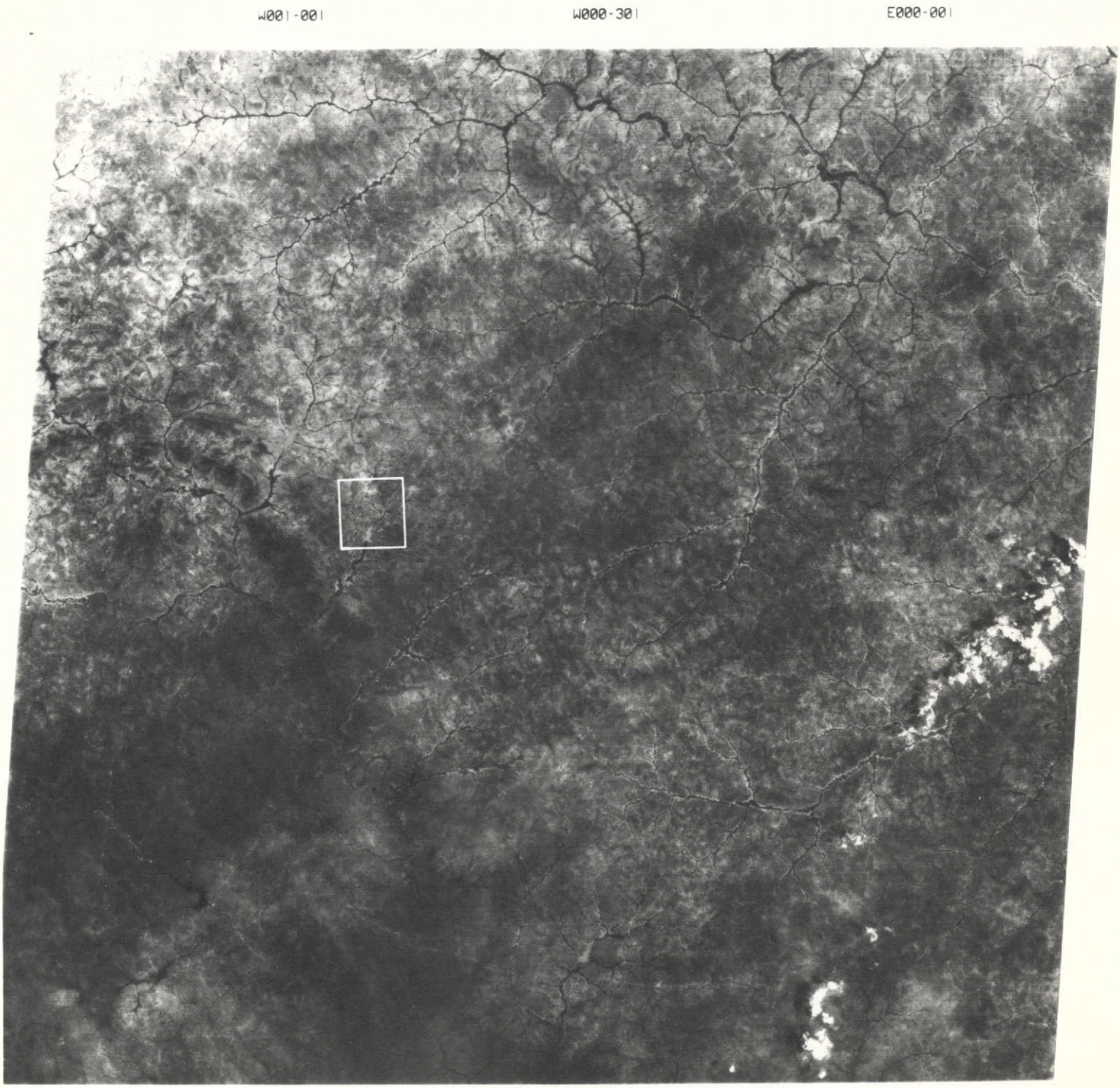


Plate 26. ERTS-1 Enlargement to Scale of 1:50,000.

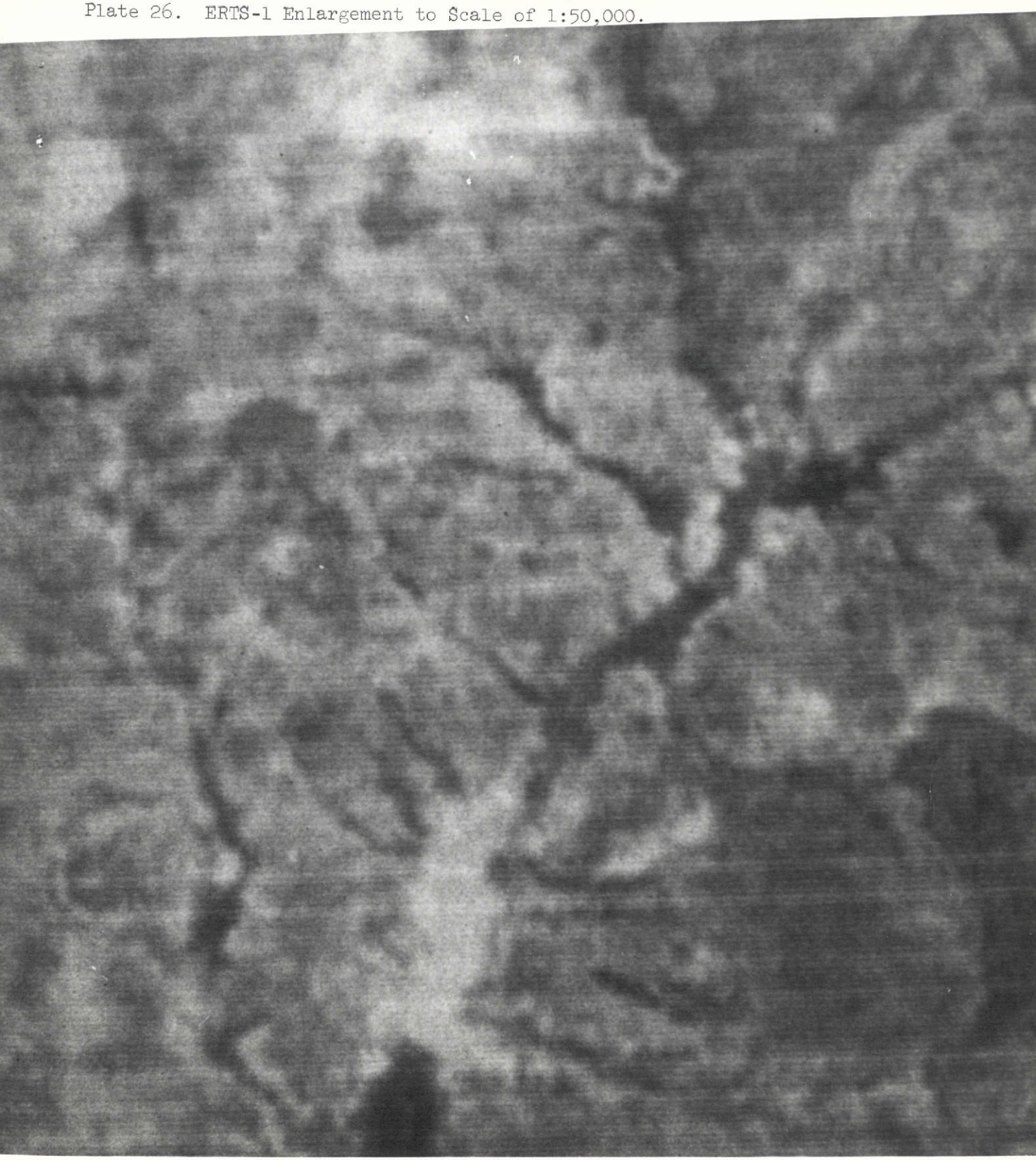


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Plate 28. Aerial Photograph of Village 3 and Environs.

Plate 29. Three compounds in Village 3.

Plate 30. Village 3 millet fields.

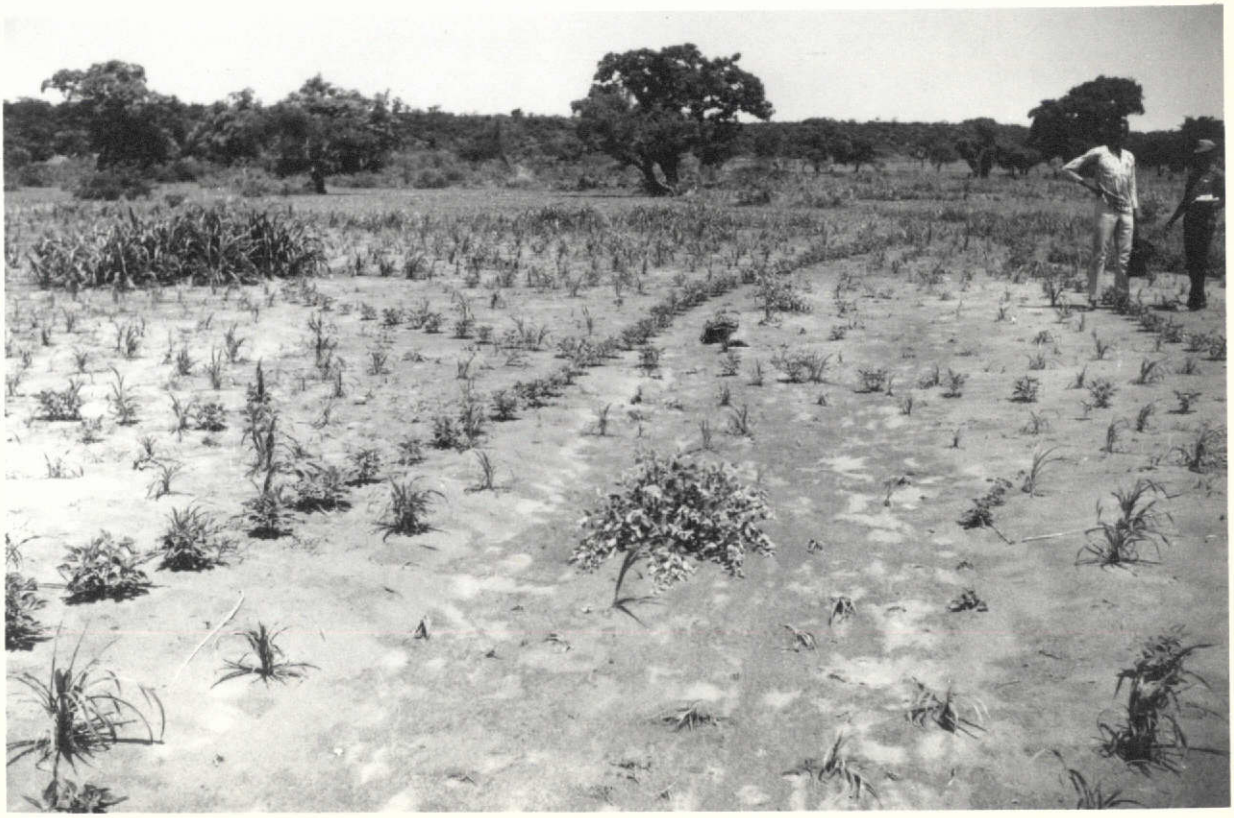


Plate 31. Rice field below Louda barrage.

Plate 32. Rice field in Villae 3.

Also appearing very bright in reflectance are the soils immediately adjacent to the streams, which are intermittently flooded.

Table 35. Estimate of Cultivable Percentage of Both Soil Types in Village 3.

	SOIL TYPES	ACREAGES IN HECTARES
	Hydromorphic - 95	Weakly Developed Lithosols - 22
Crops		
- rice	2.6	
- millet		22.7
- sorghum		18.5
- peanut		13.3
- Bambara		40.7
	2.6	95.2
Other		
- Fallow	18.6	317.0
- Wasteland	4.0	125.5
- Woods		15.0
Total Acreage	25.0	552.0
Cultivable Percentage	75.0	75.0

4. Average Acreage Per Head, the Cultivation Factor

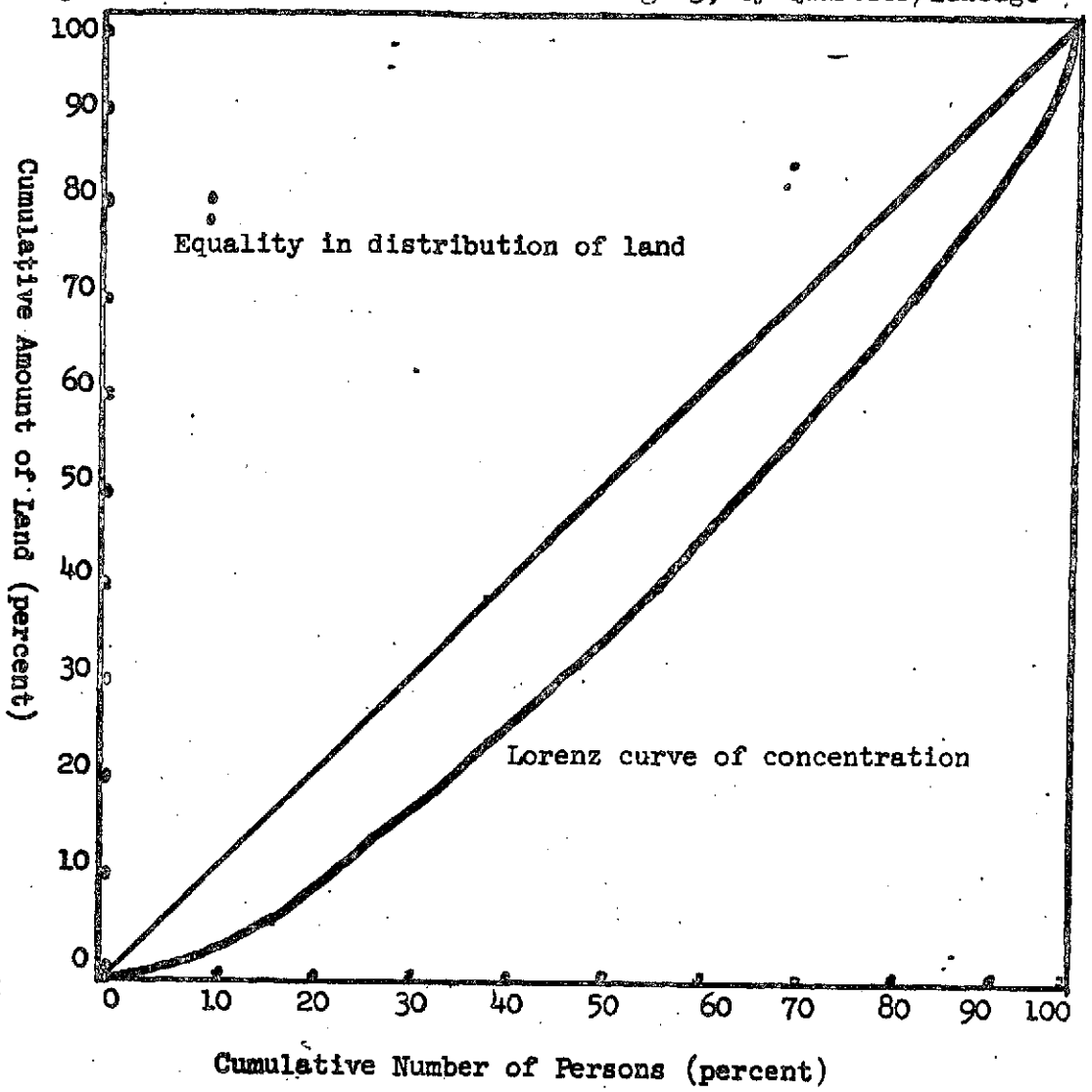
The total population of Village 3 is 167 persons, only 7 of whom are absent. In the hydromorphic soils in which rice is grown the amount of land in crop per person is estimated at .01 hectare. In the other soil type in the village where all the other crops are grown, the amount of land in crop per person is estimated .5 hectares.

In Table 36 can be seen the Lorenz curve of distribution of land according to the number of persons in each compound for each quartier or group of compounds whose heads acknowledge a close relationship. The curve demonstrates some inequality in distribution of land. It is, however, quite similar to the overall distribution of land resources found in the Sonrai village and Hausa sample. Hammond argues that the processes of redistribution and reciprocity maximize equality of distribution of resources by a flexible system of making adjustments each year to the needs of the compounds relative to the land resources within control of the village. That is compound heads who have need of more land can borrow land on loan, and compound heads who have land they do not need are prepared to lend it to those who do. The data from Village 1 does not radically dispute this argument, but it certainly suggests that Mossi land allocation processes result in a distribution pattern virtually identical with that found in the other two villages. The other two villages are examples of two other quite different peoples or ethnic groups. In the other two villages inequalities of distribution were found to be much greater within a quartier or lineage than within the village as a whole. There are insufficient data in Village 3 to test whether that is, or is not, the case here.

Carrying Capacity Estimate

The carrying capacity estimate for Village 3 appears in Table 37. Like the other villages the present population is in excess of the estimated carrying capacity.

Table 36 Distribution of Land within Village 3, by Quartier/Lineage



Lineage	Hect/person	# Persons	Cum # Persons	%	# Hect.	Cum # Hect	%
17	0	3	3	1.8	0	9	0
18	0.15	4	7	4.2	0.6	0.6	0.8
14	0.195	19	26	15.6	3.7	4.3	5.6
13	0.356	23	49	29.3	8.2	12.5	16.4
16	0.385	13	62	37.1	5.0	17.5	23.0
15	0.4	7	69	41.3	2.8	20.3	26.6
12	0.458	24	93	55.7	11	31.3	41.1
10	0.521	28	121	72.4	14.6	45.9	60.2
19	0.53	45	166	99.4	24	69.9	91.7
11	6.3	1	167	100.0	6.3	76.2	100.0

Table 37. Human carrying capacity for Village 3, Estimate 1.

Soil Type [1]	Total Area in Hectares	Years of Cultivation	C.P. [2]	L.U. [3]	Area Required [4]	Carrying Capacity
22	550	4-10 5-15	75	4	4 x 1.3 = 5.2	105
95	25	Recultivation	75	1	1 x 1.3 = 1.3	20
						125

1/ Soil type is the soil type and vegetation class.

2/ C.P. = Cultivable Percentage. These percentages are given in Table 35.

3/ L.U. = Land Use Factor. The length of time in crop, length of time in fallow, expressed as a ratio.

4/ Area Required. For a single vegetational type, the area of land required is the proportion of the C.P to a base of 100 multiplied by percentage in crop.

POPULATION DATA

Population data were secured for several reasons: (1) to compute Allan's formula for human carrying capacity, (2) to provide information on population structure for evaluation of type of population structure, (3) to calculate residential density in the interests of using ERTS imagery for demographic purposes, and (4) to compare with rural population densities in the same administrative units--using available population estimates. Finally, the data are a guide to labor capability and food demand--the ratio of adult males to young, elderly and female dependents--to the extent that these can be assessed by age and sex distribution.

Population data (age and sex) were derived by listing the inhabitants of each compound using the genealogical method (the relationship of each person to the head of the compound, and hence with each other). The genealogical method allows a continuing check on internal consistency of data, especially useful when age determination are difficult to make. An additional guide to age determination is the creation of a list of local dates known to the villagers concerned and for which calendar dates are also known.

(1) Allan's human carrying capacity formula calls for calculating the average acreage per head of population. The three detailed analyses appear with each village.

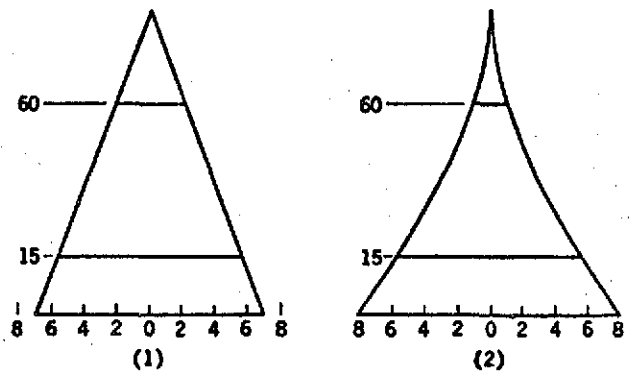
(2) Population Structure

The population structures in the three villages are not all alike. The Sonrai village population has a structure resembling that of a population with a relatively high birth and high death rate so that the

graphic expression is that of a broadly based tapering triangle, Type 1. The Hausa town population sample overall has similar characteristics although somewhat greater longevity than is customary with high death rates and the first age category shows a sharp increase. Though when this is adjusted for the next age category--here disproportionately small--the general picture pertains.

The Mossi village on the other hand has a population which is "typical of countries that are beginning to grow rapidly as a result of marked reductions in infant and child deaths, and are not yet reducing their fertility." This is Type 2.

The typical pyramid shapes are reproduced below, and are models of the population structures judged characteristic of the three villages surveyed.



Source: Thompson and Lewis, 1965.

Table 39 Comparison of Population and Structure in Villages 1, 2, and 3:

Age Category	Thompson-Lewis Type 1	Village 1	Village 2
0-14	37.44 per cent	38.7	37.9
15-59	56.89 per cent	54.9	48.2
60 +	5.66 per cent	6.4	13.9

Age Category	Thompson-Lewis Type 2	Village 3	Upper Volta sample census
0-14	40.65 per cent	41.1	33
15-59	55.84 per cent	49.8	60.7
60 +	3.51 per cent	9.1	6.3

(3) Indices for population densities

The several reasons just cited and the varying nature of settlement patterns in the three village-and-cultivation sites analyzed led to the calculation of more than one measure of population density. Useful for comparative purposes, conventional population density figures are given for number of persons per square kilometer and these are included in Tables which follow; the same calculation can also be used for the available population statistics. Where the amount of arable land is highly variable, a calculation of the number of persons per square kilometer of cropland, is of special use for comparing one part of the country with another or among different countries.

Highly variable settlement patterns, discussed in detail for each village-and-cultivation site, made measurement of residential population density of special importance. By residential population density is meant

Table 40 Compounds as percentage of total residential area:

Village 1 - Sonrai

COMPOUNDS AS PERCENTAGE OF TOTAL RESIDENTIAL AREA

Compounds	2.8	Percentage = 82 per cent
Residential area	3.4	

Village 2 - Hausa town sample

COMPOUNDS AS PERCENTAGE OF TOTAL RESIDENTIAL AREA

Compounds	1.1	Percentage = 91 per cent
Residential area	1.2	

Village 3 - Mossi

COMPOUNDS AS PERCENTAGE OF TOTAL RESIDENTIAL AREA

Compounds	.54	Percentage = 1.4 per cent
Residential area	37.5	

specifically the number of people in each compound (and all the compounds in the village) with the total area within which compounds are found. Sonrai year round villages are compact and discretely situated one from another. Only paths and very limited open space intervene between one compound and another or even one quarter and another as may be seen in Plates 7, 10a and 10b, whereas Mossi compounds both cluster and are also quite widely dispersed, with very different population densities as a result, as may be seen in Plate 29. To convert this observation into numerical data, a distinction is made between compounds--(walled living quarters cum domestic working space and thethering grounds--used by each single compound family)--and total village residential area, the most economic perimeter of the area within which all the compounds of a single village are found. The percentage of compounds to total village residential area thus gives a very accurate expression of compound dispersion. The radical differences between Sonrai, Hausa and Mossi villages in this regard are evident in Table 40 below.

What population densities can be assigned to the dots in the ERTS imagery which, through location, context and shape can be confidently identified as villages? Compact villages and compound clusters are visible in the imagery and measurable even at the 1:1,000,000 scale.

There is an extremely good likelihood, given the nature of one-story house construction and the prevailing notions that each independent compound head should have separate housing, that a real extent of compounds can be related to population densities. The limitations are the limits of the same type of settlement pattern, within a single ethnic-culture area. With adequate sampling, standards internal to all ethnic-culture areas can be established.

A finding of possibly major significance is that the dots visible in MSS Band 7, now determined to be villages, or parts of villages, carry different population densities in Sonrai and Mossi villages. Rural Hausa observed but not studied, are almost certainly occupied at yet another population density. The importance of this finding for demographic purposes must be emphasized.

The residential area of village 1 is 3.4 hectares. The total village population is 486 counting the actual population present and 538 counting those who can claim residence in the village. Since most of the absent are men, who in fact have empty houses in the village, the latter figure gives the most accurate assessment of ratio of persons to housing. The population density (present and absent) is 158 persons per hectare. The village may be seen in Plate 6, the 1:50,000 enlargement of the ERTS

scene, as well as in Plates 7 and 10a. It measures 225 meters across in the aerial photo, and 250m.in the enlargement of the ERTS scene. The village is well defined in the ERTS imagery.

Village size and ERTS

In the dry season ERTS imagery of the 23rd of April, a well defined dot of approximately 500 m in diameter can be seen in the vicinity of the cluster of compound determined to be part of the Mossi village (Village 3). The print and enlargement from ERTS of this same area comes from the imagery taken on the 25th of October. The two scenes are different in important ways. The cluster of compounds corresponds to the dark circular area in the MSS Band 5 enlargement as determined by field work and location in the aerial photos. The area is approximately 200 m across, and visible in both MSS Band 5 and 7.

The greater area--the 500 m dot or circle in the imagery of 23 April is determined to consist of: (1) a residual patch of woods, residually green, still near the end of the dry season; (2) a probable village site, judged as such on the basis of a low circular mound with numerous potsherds and small pebbles remaining from the breakdown of mud bricks, and the cluster of 10 compounds--each of the three being circular in shape, adjacent to each other, located by a stream and surrounded by cultivations. These other criteria lead to the recognition of villages in imagery.

In conclusion:

1. Repetitive imagery is necessary for adequate interpretation.
2. Population density cannot be assumed on the basis of size of dot irrespective of settlement pattern in the Sahel.
3. Shape and location are relevant in making judgment on villages.

4. Enlargement to the scale of 1:50.000 from the ERTS imagery serve useful analytical purposes despite the rather blurry of the imagery.

In the dry season ERTS imagery of the 23rd of April, a well defined dot can be seen in the vicinity of the cluster of compounds determined to be part of the village 3. For other reasons (vegetation and field patterning), an enlargement of the ERTS scene of October 25 is chosen for inclusion in the report. In that scene enlargement, the cluster of compounds does not appear to be nearly as well defined as does the Sonrai village (village 1), although the area involved is very nearly the same--225-250 meters across.

The field research finding is of a cluster of 10 non-contiguous compounds, with cultivations between each compound. The total present population in the 10 compounds is 74. One compound stands empty, its inhabitants having moved away, and two other compounds are reduced in size because their former compound head owners have died and the widows have allowed a portion of the compounds to fall into disuse. The remaining compounds in this village are not visible or distinguishable as such in the imagery, Plate 14 shows several of the compounds which compose this cluster.

The results of the comparison between the Sonrai village and the Mossi village are: (1) The population density difference between them is on the order of 6.5:1. (Sonrai 486: Mossi 74) or Sonrai 538: 74 + 10 as the average number of persons in the village 3 compounds, assuming that the area is the same. (2) More than half of the population of Mossi village does not inhabit compounds visible in the imagery, although all of the Sonraid villagers do. (3) The dry season imagery is much better for determining village location than is rainy season imagery--for both types of village. Although no time was available for studying a Hausa rural village (nor were aerial photos available), observation of Hausa suggest

that Hausa villages are almost surely in between Sonrai villages and Mossi villages in population density.

Unlike the problems associated with compact vs. dispersed settlement patters, Sonrai, Mossi and Hausa alike live in compounds and through the compound household listings and compound measurements the number of people per compound hectare can be directly compared.

Despite an impression that compound densities might well turn out to be more or less uniform, the results are that Mossi compounds are the most densely occuped (at the rate of 302 people per hectare) and Sonrai villagers with intermediary and town Hausa the least densely settled per compound.

Table 41. Indices for Residential Population Density - Village 1

P ÷ A = D

AREAS

# of People Present/Absent	Compounds in hectares	Residential area in hectares	Cropland in km^2	Total Village Lands in km^2
Present/Absent				
538	2.8	3.4	4.1	10.9
Present Only				
486				

DENSITIES Present and Absent

	# per h.	# per h.	# per km^2	# per km^2
538	192	158	131	49

DENSITIES Present Only

486	174	142	118	45

Tillaberi Arrondissement

Population 102,820 Area 11,668 km Density 8.8 per km^2

Population Structure for Village 1.

The population data are given in Table 42. If the absent persons are included with those present, the result is an even balance between male and female. However, twenty percent of the adult men are absent --- but noted as such. They retain residence, land and familial rights in the village. Thirty-one of these men are compound heads --- more than one-third of all compound heads and property owners, which is rather remarkable. Many of the men have families (one of whom served as spokesman for the compound head) and these families are supported, in part, by money and goods sent by the absent men. Some of these men are expected to return for the rainy season cropping this year. Except for 7 men who have large bush fields allocated to them, the field holdings are negligible, suggesting that distribution is an important constraint in access to land resources.

The average number of dependents of men present is 3.5. The average number of dependents of men who rent lands outside of the village is 5.8 --- suggesting quite strongly that land is a constraint for these men. The average number of dependents of men who are absent is 6.8, leading to a similar conclusion.

Table 42. Population Data for Village 1, Male and Female, Present or Absent.

VILLAGE 1 MALES PRESENT

VALUE	FREQ.	PERCENT	AGE
1	34	14,91	0-4
2	43	18,86	5-9
3	24	10,53	10-14
4	21	9,21	15-19
5	19	8,33	20-24
6	17	7,46	25-29
7	8	3,51	30-34
8	14	6,14	35-39
9	9	3,95	40-44
10	7	3,07	45-49
11	8	3,51	50-54
12	6	2,63	55-59
13	8	3,51	60-64
14	7	3,07	65-69
15	1	0,44	70-74
16	1	0,44	75-79
17	0	0,00	80-84
18	0	0,00	85-89
19	0	0,00	90-94
20	0	0,00	95 and over
99	1	0,44	no data
	228		

VILLAGE 1 MALES ABSENT

VALUE	FREQ.	PERCENT	AGE
1	2	4,26	0-4
2	0	0,00	5-9
3	0	0,00	10-14
4	1	2,13	15-19
5	2	4,26	20-24
6	3	6,38	25-29
7	1	2,13	30-34
8	5	10,64	35-39
9	6	12,77	40-44
10	6	12,77	45-49
11	6	12,77	50-54
12	4	8,51	55-59
13	0	0,00	60-64
14	1	2,13	65-69
15	0	0,00	70-74
16	0	0,00	75-79
17	0	0,00	80-84
18	0	0,00	85-89
19	0	0,00	90-94
20	0	0,00	95 and over
99	10	21,28	no data
	47		

VILLAGE 1 FEMALES PRESENT

VALUE	FREQ.	PERCENT	AGE
1	33	12,79	0-4
2	47	18,22	5-9
3	25	9,69	10-14
4	24	9,30	15-19
5	13	5,04	20-24
6	21	8,14	25-29
7	20	7,75	30-34
8	15	5,81	35-39
9	17	6,59	40-44
10	12	4,65	45-49
11	1	0,39	50-54
12	4	1,55	55-59
13	7	2,71	60-64
14	4	1,55	65-69
15	5	1,94	70-74
16	2	0,78	75-79
17	0	0,00	80-84
18	1	0,39	85-89
19	0	0,00	90-94
20	0	0,00	95 and over
99	7	2,71	no data
	258		

VILLAGE 1 FEMALES ABSENT

VALUE	FREQ.	PERCENT	AGE
1	1	20,00	0-4
2	0	0,00	5-9
3	1	20,00	10-14
4	0	0,00	15-19
5	0	0,00	20-24
6	1	20,00	25-29
7	1	20,00	30-34
8	0	0,00	35-39
9	0	0,00	40-44
10	0	0,00	45-49
11	0	0,00	50-54
12	0	0,00	55-59
13	0	0,00	60-64
14	0	0,00	65-69
15	0	0,00	70-74
16	0	0,00	75-79
17	0	0,00	80-84
18	0	0,00	85-89
19	0	0,00	90-94
20	0	0,00	95 and over
99	1	20,00	no data
	5		

Table 43. Indices for Residential Population Density - Village 2 - Sample of Canton.

AREAS

# of People Present/Absent #824	Compounds in Hectares	Residential area in hectares, as proportion of sample	Sample Cropland in km^2	Total Canton Lands in km^2
- 824 (158)	1.1	1.4 (as proportion)	.9	790[1] (158 km^2)
+ 824 (233)	1.2	1.6	1.75	790

DENSITIES Present and Absent

	# per h.	# per h.	# per km^2	# per km^2
- # 824 = 158	143	112	175	16
+ # 824 - 233	194	145	133	16

DENSITIES Present Only

- # 824 = 154	140	110	171

Dogondoutchi Arrondissement

1. No published data are available for area and population of Dogondoutchi Arrondissement.

2. The Canton of Dogondoutchi has an estimated population of 10,000. The figure of 13,000 is used for making an estimate of Canton population density.

Table 45. Indices for Residential Population Density - Village 3

AREAS

# of People Present/Absent	Compounds in hectares	Residential area in hectares	Cropland in km^2	Total Village Lands in km^2
Present/Absent				
167	.54	37.5	1.0	5.8

DENSITIES Present and Absent

167	309	4.4	167	28

DENSITIES Present Only

163	302	4.3	163	28

Kaya Cercle

Population 207,000 Area 4,718 Density 43 per km^2

Population Structure in Village 3

The population data are given in Table 46. In the age range of adults (15-59), the number of men present is 35 percent of all adults. The gap, the absent men is not at all filled by the few men (six) whose absence is noted and who can be expected to return to compounds, and land rights. Rather they are absent and unaccounted for, even though the rainy season was well started at the time of village study. Permanence of migration among some men may be related to sickle cell anemia incidence vital for those moving from the dry Sahel-Savanna to moist forest (Dobzhansky, 1962).

The average number of dependents is six plus, higher than the Sonrai village and almost as high as the Hausa townsmen. On a preliminary basis Mossi village economy now would appear to be relying on the contribution of women, who do much of the agricultural work, and less on the few absent men who are responsible in part for maintenance of village families.

Quality and sheer inadequacy of land have already been noted. Labor is also a constraint here if the division of labor is projected as a balanced requirement between men and women throughout the year.

Despite their ranking as staple crops, cereal production appears to be only a part of village economy, especially among the Mossi, but also among the others. Villages are sustained on economic and social bases more inclusive than one man: one compound: one set of fields and intensive and extensive herds of small stock. The division between actual or potential intensive (rice, manioc, mango, kitchen gardens) and extensive (sorghum and millet) is a useful one because the potential for intensification can be perceived in the ERTS imagery --- once what one is looking for is known.

Table 46. Population Data for Village 3, Male and Female, Present or Absent

VILLAGE 3 FEMALES PRESENT

VALUE	FREQ.	PERCENT	AGE
1	19	19.00	0-4
2	14	14.00	5-9
3	6	6.00	10-14
4	9	9.00	15-19
5	6	6.00	20-24
6	8	8.00	25-29
7	5	5.00	30-34
8	2	2.00	35-39
9	7	7.00	40-44
10	4	4.00	45-49
11	7	7.00	50-54
12	0	0.00	55-59
13	4	4.00	60-64
14	0	0.00	65-69
15	3	3.00	70-74
16	1	1.00	75-79
17	0	0.00	80-84
18	0	0.00	85-89
19	2	2.00	90-94
20	1	1.00	95 and over
99	2	2.00	no data
	100		

VILLAGE 3 MALES PRESENT

VALUE	FREQ.	PERCENT	AGE
1	10	16.67	0-4
2	11	18.33	5-9
3	8	13.33	10-14
4	4	6.67	15-19
5	3	5.00	20-24
6	5	8.33	25-29
7	4	6.67	30-34
8	4	6.67	35-39
9	2	3.33	40-44
10	2	3.33	45-49
11	2	3.33	50-54
12	0	0.00	55-59
13	0	0.00	60-64
14	2	3.33	65-69
15	1	1.67	70-74
16	0	0.00	75-79
17	1	1.67	80-84
18	0	0.00	85-89
19	0	0.00	90-94
20	1	1.67	95 and over
99	0	0.00	no data
	60		

VILLAGE 3 FEMALES ABSENT

VALUE	FREQ.	PERCENT	AGE
1	0	0.00	0-4
2	0	0.00	5-9
3	0	0.00	10-14
4	0	0.00	15-19
5	0	0.00	20-24
6	0	0.00	25-29
7	0	0.00	30-34
8	0	0.00	35-39
9	1	*****	40-44
10	0	0.00	45-49
11	0	0.00	50-54
12	0	0.00	55-59
13	0	0.00	60-64
14	0	0.00	65-69
15	0	0.00	70-74
16	0	0.00	75-79
17	0	0.00	80-84
18	0	0.00	85-89
19	0	0.00	90-94
20	0	0.00	95 and over
99	0	0.00	no data
	1		

VILLAGE 3 MALES ABSENT

VALUE	FREQ.	PERCENT	AGE
1	0	0.00	0-4
2	0	0.00	5-9
3	1	16.67	10-14
4	1	16.67	15-19
5	0	0.00	20-24
6	3	50.00	25-29
7	1	16.67	30-34
8	0	0.00	35-39
9	0	0.00	40-44
10	0	0.00	45-49
11	0	0.00	50-54
12	0	0.00	55-59
13	0	0.00	60-64
14	0	0.00	65-69
15	0	0.00	70-74
16	0	0.00	75-79
17	0	0.00	80-84
18	0	0.00	85-89
19	0	0.00	90-94
20	0	0.00	95 and over
99	0	0.00	no-data
	6		

Population Structure of Village 2, the Sample of the Canton of Dogondoutchi.

The population data are given in Table 44. In the sample, the number of men turned out to be forty-three percent of the number of women, though only four men were noted as being absent. We are led to conclude that the men are in fact absent but no longer retain residential or cultivation rights as they do in Village 1, nor do they have families remaining behind.

The average number of dependents of adult men (in the age ranges 20-59) is seven, quite a lot higher than is the case in the Sonrai river village. Since eight compound heads are also landless, the pressure of providing for their families in the town of Dogondoutchi is considerable. Additional, or outside occupations are both more common and more necessary than in the Sonrai village. On the other hand intensification of horticulture is less common among these town Hausa (as compared with rural Hausa) than among the Sonrai.

Table 44. Population Data for Village 2, Male and Female, Present or Absent

VILLAGE 2 MALES PRESENT

VALUE	FREQ.	PERCENT	AGE
1	17	25.00	0-4
2	8	11.76	5-9
3	5	7.35	10-14
4	3	4.41	15-19
5	3	4.41	20-24
6	4	5.88	25-29
7	4	5.88	30-34
8	4	5.88	35-39
9	5	7.35	40-44
10	3	4.41	45-49
11	1	1.47	50-54
12	0	0.00	55-59
13	3	4.41	60-64
14	2	2.94	65-69
15	4	5.88	70-74
16	0	0.00	75-79
17	0	0.00	80-84
18	1	1.47	85-89
19	0	0.00	90-94
20	1	1.47	95 and over
99	0	0.00	no data
	68		

VILLAGE 2 MALES ABSENT

VALUE	FREQ.	PERCENT	AGE
1	0	0.00	0-4
2	0	0.00	5-9
3	0	0.00	10-14
4	0	0.00	15-19
5	0	0.00	20-24
6	1	25.00	25-29
7	1	25.00	30-34
8	1	25.00	35-39
9	0	0.00	40-44
10	0	0.00	45-49
11	0	0.00	50-54
12	0	0.00	55-59
13	0	0.00	60-64
14	0	0.00	65-69
15	0	0.00	70-74
16	0	0.00	75-79
17	0	0.00	80-84
18	0	0.00	85-89
19	0	0.00	90-94
20	0	0.00	95 and over
99	1	25.00	no data
	4		

VILLAGE 2 FEMALES PRESENT

VALUE	FREQ.	PERCENT	AGE
1	16	16.84	0-4
2	11	11.58	5-9
3	7	7.37	10-14
4	7	7.37	15-19
5	6	6.32	20-24
6	7	7.37	25-29
7	5	5.26	30-34
8	4	4.21	35-39
9	5	5.26	40-44
10	3	3.16	45-49
11	6	6.32	50-54
12	2	2.11	55-59
13	2	2.11	60-64
14	2	2.11	65-69
15	4	4.21	70-74
16	0	0.00	75-79
17	3	3.16	80-84
18	0	0.00	85-89
19	0	0.00	90-94
20	0	0.00	95 and over
99	5	5.26	No data
	95		

Appendix 1.

Data Position Descriptor

1. Village
2. Quartier/Lineage
3. Compound
4. Personal ID #
5. Age
6. Sex
7. Village of Origin
8. Quartier of Origin
9. Relationship to compound Head
10. Number of living children
11. Present or Absent, in village
12. Village Political Status
13. Village Status
14. Property Owner/Compound Head Status
15. Occupation
16. Migrant Labor
17. How long away
18. Developmental Cycle of Domestic Group
19. Number of Houses
20. Size of Compounds
21. Number of Granaries
22. Status of granaries
23. Soil type of residential area
24. Fields inside/outside village
25. Soil type rice
26. Number of rice fields
27. Estimated area rice fields
28. Measured area rice fields
29. Soil type manioc parcs
30. Number of manioc parcs
31. Estimated area manioc parcs
32. Measured area manioc parcs
33. Soil type mango trees
34. Number of mango trees
35. Estimated area mango trees
36. Measured area mango tree orchards
37. Number of millet fields
38. Soil type millet
39. Estimated area millet fields
40. Measured area millet fields
41. Number of sorghum fields
42. Soil type sorghum
43. Estimated area sorghum
44. Measure area sorghum
45. Number of millet sorghum fields
46. Soil type millet sorghum
47. Estimated area millet sorghum
48. Measured area millet and sorghum.
49. Number of peanut fields
50. Soil type peanuts.
51. Estimated area peanuts
52. Measured area peanuts
53. Number of Bambara fields
54. Soil type Bambara fields
55. Estimated area Bambara
56. Measured area Bambara
57. Number of kitchen gardens
58. Soil type kitchen garden
59. Estimated area kitchen garden
60. Measured area kitchen garden
61. Horses
62. Cows
63. Sheep
64. Goats
65. Fowl
66. Donkeys
67. Other Property (includes camels, bycycles, mobilettes).

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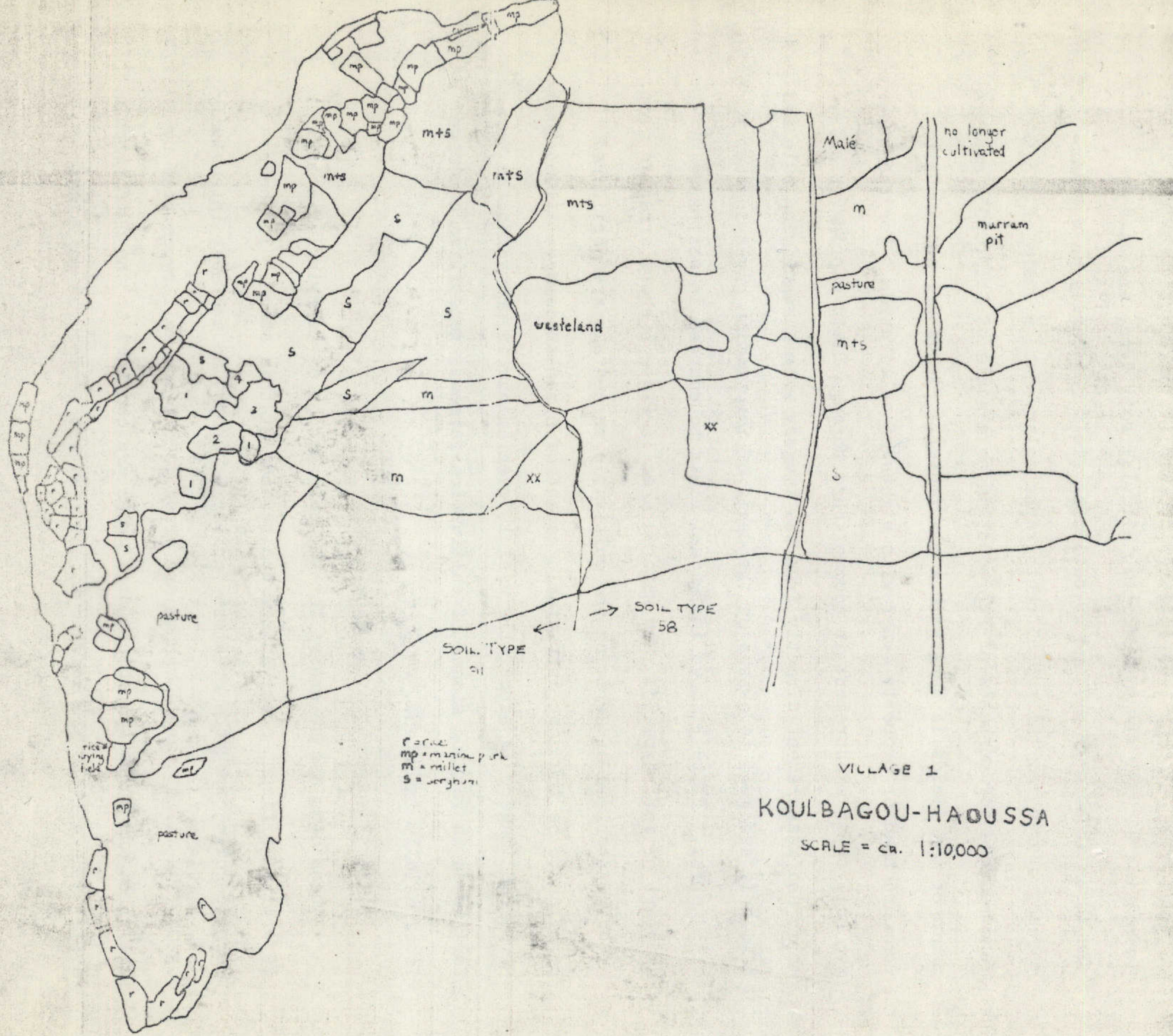
mp
mts
mts
s
s
s
s
m
m
mts
mts
wasteland
xx
xx
Malé
no longer cultivated
m
murram pit
pasture
mts
s
pasture
pasture
rice drying field
SOIL TYPE 58
SOIL TYPE 511
m = millet
VILLAGE 1
KOULBAGOU-HAOUSSA
SCALE = ca. 1:10,000