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VOLUME I

REPORT ON THE ACCOMPLISHMENTS OF ERTS ZAIRE IN NORTH SHABA, 1980-1981

Jointly Sponsored by:

Bureau du President de la Republique
Programme ERTS-Zaire

and

United States Agency for International Development
(Under Contract No. AID/afr-C-1483 with Spectral Data Corporation)

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June 1981

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INTRODUCTION AND SUMMARY

In January of 1980 ERTS Zaire with the assistance of the United States Agency for International Development set out to demonstrate the feasibility and usefulness of conducting multidisciplinary resources surveys using LANDSAT derived imagery as a data base.

The objective was to demonstrate that such surveys can be useful to technology poor nations. The goal was to produce resource maps showing agricultural (potential and production) land use maps, deforestation maps, geologic and mineral potential maps and also to show that these surveys can be conducted by Zairian scientists.

The budget for this program was approximately Z95,000.00 Zaires, or $32,000.00 (U.S.) and about 24 man-months of time from the ERTS scientific team as well as 10 man-months time of AID provided consultants.

In spite of financial and other constraints, this work was concluded in 14 months; the total expenditures in Zaires was approximately Z150,000.00 (or $50,000.00 U.S.) and approximately 18 man-months of AID provided consultants.

This project was a part of a larger Government of Zaire/ USAID effort to train and equip a group of Zairian scientists and technicians to conduct such surveys. That effort lasted 26 months and was funded at a level of approximately Z1,000,000.00, or $300,000.00 U.S. Dollars and $420,000.00 U.S. Dollars allocated for purchase of training materials and equipment and the support of two consultants.

The enclosed reports demonstrate the work done in North Shaba, particularly in support of the GOZ and AID sponsored North Shaba Project. The reports clearly show that such surveys can provide hard facts related to resource inventorying.

The following conclusions can be drawn from the report:

1. Agricultural land use has increased in North Shaba since 1957, in some regions by as much as 300 percent (Manono, 1957-1980), in others by 120 percent (Kitengitengi, 1957-1980).

2. Deforestation does not pose as great a danger as was thought to be the case for the entire region of North Shaba.

3. Most of the deforestation is concentrated around Nyunzu.

4. In other areas the deforestation rate is either manageable or has been less than 5 percent since 1957.

5. Most agricultural expansion has been into the savanna, particularly the "savanna arbustive", but not into the forest per se.

6. Crops were and can be inventoried and production estimates can be reliably made using a "multi-level" sampling approach in conjunction with LANDSAT imagery.

7. Land use maps were produced.

8. Accurate though qualitative soils maps were produced.

9. Land use potential maps were produced.

10. Improved geologic maps were produced.

11. Improved mineral maps were produced.

12. Exploration target maps were and can be produced.

13. Certain mineral showings were located by the ERTS team.

14. New models for ore genesis have been proposed on the basis of the LANDSAT work.

15. A large variety of the socio-economic aspects become apparent upon reading the report and together with the hard facts present therein permit resource planners to improve their planning and decision making process.

It is the belief of those who were intimately involved in this demonstration project that this was highly profitable and that it clearly demonstrated the usefulness of LANDSAT imagery as a tool in resource inventories, planning and national development, and that LANDSAT, in fact, has a greater use and more potential benefits for technology and information for poor nations than for those which have greater resources available and consequently have a far more diverse and elaborate data base.

BUREAU DU PRESIDENT

PROGRAM E.R.T.S.

PART I

AGRICULTURAL INVENTORY OF NORTH SHABA, ZAIRE USING LANDSAT MSS DATA

Jointly Sponsored by:

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June 30, 1980

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INTRODUCTION.

Most officials concerned with food and agriculture agree a food problem exists in Zaire.

In 1975 there were 135 nations in which corn was produced. The highest national average yield was 7.2 metric tons per hectar in New Zeland, in the United States it was about 5.8 tons. Yet there were 112 countries with national average yields of less than 3.0 tons, 81 of them with less than 1.5 tons. Zaire ranks slightly better at 1.9 tons, as reported by the Food and Agriculture Organization of the United Nations. Some factors contributing to the low production figures in Zaire are, as identified in North Shaba; depletion and leaching of soils from years of continuous use; failure to control disease and pests; low productivity potential of local corn varieties and the lack of needed nutrients such as nitrogen from fertilizers.

The bulk of the food supply of Zaire is produced by individual farmers with small family-operated holdings. It seems apparent that improvment of productivity will require the introduction of new high-yielding crop systems tailored to the various environmental zones of Zaire. This must take in to consideration the ecological factors and combinations of soil, climate, biolcgical and economic conditions of individual localities/zones, such as the area of Project North Shaba. Not only are new agricultural techniques needed to improve yield, but other ingredients need to be considered. These include infrastructure, roads and marketing systems, fertilizers, pesticides, and the use of qualified agricultural extensionists. All of these ingredients contribute to the development of the rural economy, leading to increased family income, higher standard of living and improved health and nutrition.

Agricultural systems in all parts of the world can be characterized by their dominant crops. In every such case, however, other crops are grown too, sometimes in close, complex associations

with the main crop or crops. Such is the case of agriculture in the North Shaba region. The agricultural pattern which has emerged here is in part the result of the dominant ecological factors and also the result of economic and cultural factors of the local tribes in this region.

For hundreds of years the people of Shaba have practiced traditional subsistence agriculture. Probably beginning as hunters and gatherers and gradually moving up to sedentary farming where there has been a long, slow evolution of numerous systems of crop production. Traditional farming systems involve only man, his seed and his land, with little use for, or the involvment of government, industry or cooporation.

The farming system of North Shaba is traditional and it will be difficult to encourage farmers to break with tradition in order to try and improve yields. The peasants view their culture to be finely tuned, as it is, to their current needs and way of life. This system represents an ecological steady state which may continue indefinitely. Provided that the human population is held within the capability of the system, the culture is as safe as any system which can be devised. However, as population and demand is increased, external inputs such as improved seed and the use of fertilizer are needed to help meet the new demands.

The emphasis on corn production in the Kongolo area reflects not only the food value but also the relative ease of culture, harvest, transport and storage. The dominance of a certain crop in a specific region, such as corn and manioc in North Shaba, comes about as a result of the integration of a number of factors. The crops are well adapted to the environment and give a high yield. They also fit well into a plan of farm management and have a relatively low risk of failure. A market is available and it is possible for these crops to serve as a basis for income.

It has been demonstrated that projects through the government can take effective action to improve yield and production if the will exists. As demonstrated in certain sectors of North

Shaba, many farmers will adopt new technology given reasonable incentives and the opportunity to do so. Key elements for campaigns in increased yield are biological technology and improved infrastructure to support rural development. Also the assessment of risk and return has much to do with the behavior of local farmers of the Shaba area. The problems are simplified when the farmer centers his operation around a proved low-risk system. With a few crops he can acquire through experience and education a great deal of competence for dealing with the day to day adversities of weather, pests and transportation. Risk factors however, can be modified through technology. A successfull approach to this has been the introduction of Kasai I. Through plant breeding the tolerence to pests, climate and poor soil has been improved and in most cases yields increased (as evidenced in the tables of results) and risk factors slightly lowered.

Although increased technology for the individual farmer can increase yields, this is not to say that to go as far as mechanized agriculture is the solution as some technicians advocate. The use of machenry is very productive in terms of output per man-year, but is not as productive per unit of land as the highly labor intensive systems are, and it is good arable land that is a limiting factor in the study area.

Because of the limit and value of highly productive soils and arable land, the government of Zaire identified a need for indepth maps showing soil, agriculture and potential, and general land use of Shaba, it was decided by ERTS-Zaire to perform a demonstration agricultural inventory project of the area. The products of this project will be multifold :

1. Demonstrate the usefullness of satellite, and aerial data for land use inventories.
2. To train two representatives of ERTS-Zaire in the techniques of field data acquisition.
3. Produce a product usefull to the government of Zaire and project North Shaba for indepth planning of agricultural stratigies and management.

The problems of inventorying itinerant type agriculture in the Kongolo area are numerous. Itinerant or shifting agriculture is one of the lowest forms of human survival. This term usually means a nomadic type of existence. However, in the project North Shaba, PNS, area the main villages were found to be traditional and therefore have been occupied for many years. The primary agricultural sites, for the most part, are also fixed and traditional. However temporary seasonal farming villages are erected near the agricultural zones. Small agricultural plots will shift from year to year within the main production zone. Therefore the agricultural practices and patterns have all the characteristics of itinerant form except the people do not move great distances to cultivate.

This type of agriculture poses a problem for high altitude photo and satellite inventory methods. One example of the problem is that agricultural land is identified on imagery by pattern and spectral reflectance as differentiated from surrounding surface cover. The vegetation on agricultural sites which have been recently returned to forest/brush, frequently retain the same aerial view characteristics such as field pattern and spectral reponse. This makes it difficult to distinguish these areas from neighboring crop sites. In addition, each individual plot is small (.5-5 ha) and difficult to inventory using satellite methods. However, location identification can be made because many individual plots coalese to make up a larger agricultural commune. The problem arises as to within the total tract of agriculture, which areas are in production which are fallow and what is the percentage of area and yield of the crop types. Although each individual plot cannot be counted, a series of parameters have been developed as to the percentage of fallow land, crop land and crop types existing in any given agricultural commune.

In the North Shaba region agricultural, land can be found in either the savanna or forest biome. Savanna agriculture can usually be identified using satellite imagery but sites in the forest location are difficult to distinguish. Usually some thinning

of the forest takes place to make way for cropping. This can usually be identified. The problem is if this thinned area has or has not been put into crop production, or has it just entered the fallow part of the crop calendar.

Choosing the project area :

In order to provide training in; field data collection, resource inventorying and use of specialized equipment and techniques, it was decided that the best means to accomplish this goal was an actual demonstration project.

The area of North Shaba, Kongolo, was chosen as the project area for a number of reasons, among them :

- project North Shaba, located in Kongolo would be able to provide ERTS logistical support;
- AID and the GOZ have invested much time, effort and money to study and develop the area;
- North Shaba has been identified as having good potential in production of agricultural products;
- Program ERTS has sufficient Landsat coverage of the study area;
- Reports by PNS of heavy deforestation.

The plan for project North Shaba (PNS) is described in depth by various other sources available through the USAID office of food and agriculture in Kinshasa. Briefly, PNS is to introduce more productive strains of mais, ie Kasai I, to the area. Also PNS is concerned with the investigation into the applicability of modern farming methods, the use of fertilizers and the use of agricultural extensionists which hopefully will lead to increased yields. PNS is also working to strengthen the infrastructure, marketing systems, and to make current and future yield production predictions.

Description of study area :

A total of approximately 20.000^2 miles ($51,800^2$/km) has been mapped and agricultural land inventoried for the years 1957,

1973 (PNS area only), 1980. This area consists of the following one degree square blocks : (See accompanying index map 2).

Table 1

BLOCK	POSITION	
Kongolo	S 5°00' - S 6°00' E 27°00' - 28°00'	All
Nyunzu	S 5°00' - S 6°00' E 28°00' - 28°30'	West $\frac{1}{2}$
Lubunda	S 5°00' - S 6°00' E 27°00' - 26°00'	All
Sentery	S 5°22' around Sentery only E 25°40'	
Kabalo	S 6°00' - 6°30' E 26°00' - 27°00'	North $\frac{1}{2}$
Lukuswa	S 6°00' - 6°30' E 27°00' - 28°00'	North $\frac{1}{2}$
Luizi	S 6°00' - 6°30' E 28°00' - 28°30'	North West $\frac{1}{4}$

The area is defined as a rectangle starting at the Kivu-Shaba frontier then south to approximately 60 miles south of Nyunzu, west to Sentery and east to Niemba; The area is centered approximately at the confluence of the Lualaba, Lukuga rivers. All of project North Shaba territory lies within this study area.

The area can be described as consisting mainly of savanna with pockets of forests dispersed intermittently along streams and hill sides. Average elevation of the area is 2430' with hill tops as high as 4300' in the eastern portion of block Kongolo.

South of the Lukuga and east of the Lualaba river, the topography can be best described as a highly disected plateau underlain by flat lying sedimentary. A dendritic drainage pattern has developed which disected and eroded the plateau to a rolling terrain. However, some drainage is also controled by jointing. North of the Lukuga the area is more complex but can be described as a poorly drained ancient ridge and valley province in which folded rocks are overlain by sediments of various ages.

The geology of the western portion of the total study area, near Sentery, is of lower Permian to upper Carboniferous age composed of sedimentary, continental sheet deposits.

The center portion of the study area is transected by the Lualaba, Lukuga and Luvidjo rivers and has little vertical relief. Through-out this basin area three rock types predominate : Pleistocene and Recent lacustrine and alluvial deposits. These deposits form a thin cover on and between metamorphic, Ruzizian and Kibaran deposits. The alluvium is also composed primarily of gneiss and schists trending in a NE to SW direction. An indepth geologic account of the study area will be presented in a forthcoming paper.

Vegetation.

The study area is largely composed of light wooded to grassy savanna land dotted with islands of scrub forest (forêt arbustive) and forêt galerie along some of the streams. Following the major rivers of the area one will find marsh in the low lands and semi-deciduous forest along the higher hill sides. There is very little steppe except on the higher mountain peaks.

Dense forest is located in three distinct areas. One forest expanse east of Makutano covers approximately 62,500 hectars. This by far is the most valuable forest stand of the area. Another forest area beginning about 15 kilometers north west of Kongolo covers roughly 36,250 hectars. This area is less dense than the reserve near Makutano and is composed of more heterogenous scrub types.

Twenty-five km west of the town of Lukuga lies an expanse of approximately 49,375 hectars of dense forest, dry land, non deciduous types of moderate to low economic value.

Climate.

Climate of the study area is well described in a number of sources, one of which being by Humpel, "Stratégies Agricoles pour le Projet Nord Shaba". In addition to work presented by Humpel, climatological data table for the Kibangula station (S4°52' x 27°04') is presented on the following page. This table was taken from "Can Primative Farming be Modernised?" by F. Jurion. In addition to this table, Cit. Etina references Koppen in his report "Evaluation des potentialités des terrains de la Sous-Région du Tanganyka" which is paraphrased below.

There are basically four distinct climatic zones recognized in the study area :

1. The climatic type AW_3, tropical, humid, characterized in the area north west of the Kongolo zone. The average temperature is 25°C and the yearly rainfall varies between 1100 and 1300 mm. The dry season which lasts for three months begins in mid May and lasts up to the month of September.

2. The climatic type AW_4, hot and humid, covers parts of the zones of Kongolo, Nyunzu and Kabalo. The dry season lasts about four months, mid May to mid-late September.

3. The climatic type AW_5, hot and humid, is characteristic of the area south of the Moba zone. The annual rainfall varies between 900 and 1000 mm, most of which falls between the months of May to the end of September.

4. The climatic type CW, climate tempered by altitude, is characteristic of the high plateaus and mountain tops of the study area.

Table 2*. Rainfall for sellected stations of the study area.

STATION	MONTHLY RAINFALL (IN MM)												ANNUAL RAINFALL
	J	F	M	A	M	J	J	A	S	O	N	D	
LUSAKA	113	103	145	106	11	10	-	10	9	38	90	152	753
KONGOLO	144	85	151	92	30	5	10	64	58	121	140	213	1113
NIEMBA	188	121	159	106	9	8	3	27	49	102	175	182	1087
KALEMIE	191	151	170	232	139	1	5	1	26	55	181	166	1250
KIAMBI	140	110	198	86	17	8	-	16	32	67	107	206	944

* Ref. ETINA, 1979.

Table 3*. Kibangula Station - L:S4°52'; l.:E27°04'; Alt.:685m.

ELEMENTS	PERIODS	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
. Solar radiation														
I	1954-1957	151	153	183	183	243	275	256	227	184	177	159	149	2340
Ir	1954-1957	45	51	55	60	74	87	80	71	59	54	49	44	61
. Air temperature (°C)														
T_M	1954 -1957	28.7	29.7	30.5	30.5	31.3	31.9	31.5	31.4	31.3	29.7	28.9	28.8	30.3
T_m	1954-1957	18.5	18.9	19.1	18.9	18.5	16.7	16.4	17.3	18.3	18.2	18.3	18.5	18.1
T_u	1954-1957	23.7	24.3	24.8	24.7	24.9	24.3	24.0	24.3	24.8	23.9	23.7	23.7	24.3
T_A	1954-1957	33.2	34.8	34.3	34.0	33.8	34.3	34.3	34.8	35.8	35.2	32.2	32.6	35.8
T_a	1954-1957	15.0	16.3	16.2	16.2	14.6	12.0	11.6	14.0	15.4	15.8	15.8	16.2	11.6
T_{mg}	1954-1957	17.1	17.6	17.4	17.6	16.6	13.3	12.3	14.2	15.5	16.1	16.6	16.9	15.9
T_{ag}	1954-1957	12.4	13.2	11.8	12.4	10.2	8.0	7.2	9.7	10.9	12.8	10.6	13.3	7.2
. Rainfall (mm)														
P	1954-1957	140.1	160.2	163.1	167.2	60.1	1.7	24.5	41.2	87.1	141.9	195.5	212.5	1395.1
. Evaporation (cc)														
Eva	1954-1957	58.4	64.7	76.6	74.8	108.3	164.5	156.9	135.9	114.3	77.6	59.3	59.5	1150.6
Eve	1954-1957	96.1	112.2	130.6	122.9	176.7	290.5	254.0	209.6	180.1	131.1	98.5	105.5	1907.8
. Atmospheric humidity														
e_6	1954-1957	21.4	21.7	21.9	21.7	20.9	17.7	18.1	19.4	20.8	21.1	21.4	21.5	20.6
e_{18}	1954-1957	25.7	26.5	25.9	26.0	25.0	22.3	21.3	22.4	23.5	24.1	24.5	25.5	
e_{15}	1954-1957	10.7	12.8	13.5	14.2	17.7	24.7	24.3	21.7	18.7	13.3	10.5	10.5	16.1

* F. JURION.

Key for Table 3 climatological data.

SOLAR RADIATION

I monthly and annual hours of sunshine

Ir monthly or annual sunshine as % of possible total from 7 to 17 hours.

AIR TEMPERATURE

TM average monthly or annual daily maximum temperature

Tm average monthly or annual daily minimum temperature

Tu average monthly or annual of average daily temperature

$$\frac{TM \times Tm}{2}$$

TA absolute maximum temperature

Ta absolute minimum temperature

Tmg average monthly or annual daily minimum temperature

Tag absolute minimum temperature

RAINFALL

total monthly rainfall in millimeters

EVAPORATION

Eve total monthly evaporation in cubic centimeters under cover

Eve total monthly evaporation, external

ATMOSPHERIC HUMIDITY

e6 average monthly vapor pressure at 6AM, millibars

e18 average monthly vapor pressure at 6PM, millibars

d15 average monthly saturation deficit at 3PM, millibars.

Soils.

The topic of soils will be covered in a forthcoming paper by Gambel. However, during Dr. Gambels visit in Kinshasa he was able to collaborate with the ERTS consultants. A soil potentiality map was prepared by combining field data gathered by the ERTS team,(Feb, March 1980) and Gambel (April, May 1980). This map shows four classes of soil potential for agricultural production. A copy of the map is presented with this paper. (Map 6).

PURPOSE.

As stated previously, the roll of the consultants was to conduct a Landsat demonstration project and to train ERTS staff in agricultural inventory methods. It was determined that the most effective training could be accomplished through the demonstration project of the PNS area. This approach has two obvious advantages : one is a "hands-on" in the field training program for two Zairois agriculturalists, the other is the production of a series of maps and data usefull to the GOZ and PNS for future project planning and evaluation.

Until mapping of agricultural distribution in the Kongolo bloc began, no one agency or individual had a reasonnable idea of the number of hectars in crop production, yield, location and crop types. However, the Government of Zaire has an idea of crop production in relation to tax collected in each zone. This is a poor basis on which to judge production because some crops are locally consumed and some are moved to higher value market areas. In addition not all corn is marketed through the Kongolo or Nyunzu centers.

In addition to completing an agricultural inventory, the ERTS staff was also interested in investigating a report by Humpel and PNS of wide spread deforestation giving way to agricultural production. This has been investigated for the PNS area using as a comparisor the IGZ/CSK aerial photography dated 1957, Landsat imagery dated 1973 - 1976, and aerial reconnaissance during field investigation, Jan, Feb, March 1980.

Another purpose of the ERTS mission was the identification of areas which can be used to handle the expansion and intensification of crops. A final identification of the land potential is presented in a map accompanying this paper. Map #5 shows areas where soils can handle more intensive culture, and areas where traditional practices should not be changed.

PREVIOUS WORK.

During the years 1977 to 1979, William Wigton of the USDA, Statistical Research Division worked on a landuse classification project for the Shaba region. The study area encompassed an area of 500,000 square kilometers or eight Landsat scenes. Although the project was never funded to the extent needed to do an adaquite job, Wigton proposed a stratigy for land use classification and attempted a pilot project. An attempt was made by USDA to collect ground truth data but due to the unavailablity of flight fuel the project never get off the ground. This program advocated the use of computer classification of Landsat imagery.

There are two techniques in electronic data processing for classifying Landsat data, these are the supervised and unsupervised approaches. After inventorying the Shaba region for agricultural land use it was determined by the consultants that an unsupervised classification will yield absolutely no useable information. A supervised classification will at best give a 50 % (estimated) accuracy, by following the approach prescribed by USDA. These conclusions are explained.

In 1973, ERTS-Zaire collaborated with the World Bank for computer support in Landsat data analysis. The Kalemie scene, among others, was classified using the Bendix unsupervised system. Results of this exercise were brought to Kongolo during the ERTS field trip, 1980. Classified data presented on the Bendix scene was compared to what the team viewed on the ground and came to the conclusion that there was little or no correlation. For example, the area surrounding Kalemie, west of lake Tanganika was classified by Bendix as mixed grassland/savanna scrub. After flying over Kalemie one can see that the structural basin in which Kalemie lies is completly agricultural. Whereas the Bendix scene shows at most, 100 hectars of agriculture, mostly along the coast. These 100 hectars, although not verified, probably represent bare rock areas. Based on ERTS 1980 work the only areas which seem to be classified correctly are water, clouds and some forest areas.

In light of the gross inaccuracies described above, it is the opinion of the consultants that an unsupervised computer classification performed by USDA will yield little if any useable results. A supervised classification is also unadvisable for the following reasons.

One Landsat scene covers more that 32,000 square kilometers. Within this area there are many socio-economic groups each having its own agricultural technique. Some peoples burn land in September to clear for agricultural purposes. Others burn in September for hunting purposes. Also there is the occurance of fire by natural causes. Therefore burns are really not a good clue to identifying agriculture, the computer would not be able to differentiate the difference.

Also, one must realize that the more ground truth data used as input, to "program" the computer, the more accurate the final results will be. The investigator must determine how much ground data is needed for input to achieve a certain accuracy level. Because agricultural plots in the Shaba region are not homogeneous and are notoriously small, it is difficult to gather sufficient ground data for the production of accurate, computer generated maps. To ground truth as many plots as needed for an effective supervised computer classification would require more time, effort and money than a more accurate aerial survey. Therefore the whole object of a Landsat analysis is lost.

USDA proposed to conduct the computer analysis facet of the project for 15,000 dollars. This would be approximately $ 1900,00 per scene, on the basis of eight scenes. It is hard to believe that sufficient computer time is being allocated for the integration of field and ancilary data to produce accurate agricultural land use maps.

A viable solution for the use of computers and landsat data would be to merge data from many sources. This includes a base map of trails and roads, village locations and approximate population, aerial photography sampling data and operator interaction capability. It is believed however that this approach would be very costly.

However, inexpensive interactive systems such as the General Electric Image 100 sould be investigated.

In lieu of the use of electronic data processing, the ERTS-Zaire staff chose to merge many sources of data and to produce agricultural land use maps through classic visual photo interpretation methods. The technique used will be explained in the methodology section of this report.

In addition to the work described above, Cit. Etina (of ERTS-Zaire, 1979) who has worked with Wigton, USDA, went on to complete a series of reports and maps of the Tanganika subregion. Some products of this effort are maps showing :

"Soil potentials"
'Soil resources"
"Slope classes"
"Vegetation resources"

Maps and final report were worked on by ETINA with the aid of South Dakota State University, Brookings. Final report is titled "Evaluation des potentialités des terrains de la Sous-Région du Tanganyka".

The methodology described in the report seems to be adequate to produce a good series of maps showing land use, surface cover characteristics. However, the final maps leave something to be desired for these reasons :

1. cale of the maps is 1:1,000,000 which is not usefull for planning agricultural strategies.
2. Maps make no reference to geographic points, such as towns, rivers, latitude/longitude. This makes it difficult to find the exact area which is being delimited.
3. Boundaries of classes are too large and to general. The maps do not portray closely enough what the real surface cover is like.
4. Many of the soils are missclassified, according to Dr. Jack Gambel, (1980) pedologist for project North Shaba.

5. Identification of vegetation resources are incorrect.

A selected bibleography of other previous works is presented in APPENDIX "A" of this report.

METHODOLOGY FOR DATA COLLECTION AND IMAGE ANALYSIS.

As stated previously, remote sensing is a data gathering tool. Therefore this report is not on attempt to make value judgements on seed and crop types, cultivation practices etc. Most material and evidence presented will be of a quantitative rather that qualitative nature.

The method and reasons for choosing Kongolo, North Shaba for a project area have been described earlier. Following is a program of the methodology for the mission preparation.

Landsat based maps for the study area have been produced from a combination of Joint Operations Graphics charts (JOG charts) and Landsat imagery. Primary Landsat scenes used for this investigation are as follows :

Date	Scene center	ID number
04 June 78	S5°46' x E26°24'	30091-07413
29 June 73	S5°42' x E27°45'	1341-07474
09 July 78	S5°46' x E27°50'	30126-07361

More current Landsat MSS data as well as RBV data dated June - Feb. 1979-80 is on file at the USGS, EROS Data Center, Sioux Falls, South Dakota. This imagery has been ordered and may arrive by August 1980.

Many sources of information and ancillary materials were gathered prior to departure, among them :

1. Landsat scenes for Kongolo, Lubunda, Lukushwa and Manono, for the dates 1973 and 1978. These were in the form of 1:200,000 color composite prints and black and white prints of bands 4, 5, 7 1: ,000,000 scale color composite prints and black and white prints of bands 4, 5, 7.

2. Joint Operations Graphics (JOG) charts for the entire North Shaba area.

   JOG chart numbered :

   1501CSB3501 through 16

   1501CSC3501 through 8

Two copies of each chart were brought to Kongolo. These were paper copies at a scale of 1:250,000.

In addition transparent film copies were made and enlarged to the scale of 1:200,000 for map numbers' :

1501GSB3501 - 16.

3. IGZ/CSK aerial photography dates 1957 was selected for the following grographic areas :

Kongolo	E27°00' x S5°22'
Timpa	E27°05' x S5°05'
Mbulula	E27°25' x S5°24'
Mabunda	E27°32' x S5°35'
Malwa	E27°30' x S5°50'
Koswe	E27°46' x S5°34'
Piana	E27°35' x S5°07'
Segala	E27°53' x S5°21'
Nyunzu	E28°00' x S5°58'
Kumwa	E27°05' x S5°58'

4. 324 frames of color negative film
   360 frames of color reversel (slide) film

5. Miscellaneous equipment consisting of 35mm cameras, field books, office supplies, camping and survival gear.

Prior to departure from Kinshasa, a group of four Zairois technicians, Bakajika, Kazadi, Kazyumba and Etina along with the two ERTS consultants spent time making Landsat overlays for the identification and location of IGZ 1957 aerial photography. Landsat scenes were analyzed and areas which warrented further field investigation were marked. IGZ aerial photography was gathered for these areas as outlined in number three, above. Along with the Landsat scenes, JOG and air charts were consulted and used for planning indepth field and aerial investigations.

Field trips for ground truth of agricultural sites were planned to :

Mbulula
Sola
Zola

Makutano
Nyunzu
Sentery
and other outlying areas.

There are certain areas on the Landsat scenes which were questionable as to identification. Areas in question were marked on maps and field trips were planned to verify them either on ground or by air. One problem identified by the team was that the imagery was for June and July of 1973 and 1978. At the time of planning we realized that the date and season of Landsat imagery were divergent from the season of the field trips. Landsat scenes were imaged during the dry season and the field trip was made during the wet season. This makes it difficult to ground truth because much of the surface characteristics have changed not only from season to season but year to year. Areas which during June were burns, now are over grown by elephant grass.

Upon arrival in Kongolo logistical support was analyzed and field trips further planned according to accessability and the needs of PNS. In addition to ground truth sampling, data in the form of statistical tables was collected from PNS, at Kongolo and Nyunzu.

Project North Shaba identified the following areas which warrented investigation for future agricultural development. This area encompasses most of the $\frac{1}{4°}$ block (S5°00' to S5°30', E27°00' to E27°30') which includes :

Kongolo
Mbulula
Sola
Zola
Lufutuka river valley
Northern Lukuga, Kabeya-Mayi to Bulamoyo
Londo.

In order to aid in the collection of data, project North Shaba provided the ERTS mission with a Blazer and also 20 hours of air time in the project plane (Cessna 206). For vertical aerial photography the plane was modified by taking out all the rear seats and fabricating

a 80mm hole in the rear, bottom fuselage of the plane. The 206 was thus made adequate for both vertical and oblique aerial photography.

Aerial photo missions were flown for the following areas. (See map # 4).

Sortie I.

Kongolo, north along the Lualaba river approximately 35 air miles from the airport. Photography started at the river. As the plane flew in an easterly heading continuous black and white, vertical photography was taken using two 35mm cameras. Color oblique photograph was taken mostly on southerly aspect. This continued to the geographical point of S5°10' x E28°21', NE of Katanta.

At this point sortie I turned south for approximately 15 miles to Kashiege, then west. On the way back, black and white vertical photography was taken of agricultural areas only. Color oblique photos were taken both north and south. These photos focused primarily on agricultural plots.

Flight altitude was approximately 8500'MSL which gives a nominal height AGL of 5800'.

Sortie I ended at the Lualaba river 2 miles north of Kongolo. Approximately 150 black and white and 80 color photos were taken.

Sortie II.

This photo mission was flown at an altitude of approximately 7000' MSL but varied according to cloud conditions over the areas of interest. This mission unlike the first one was flown in a meandering pattern generally following roads and areas of agricultural concentration.

The general areas covered are as follows : Kongolo, Keba, along the road to Mbulula, north following the road to Makutano, west along the road to Sola, north to Kivu, Shaba boarder, south to

Keba, NE road to Zimbe, SE road to Mbulula, SE along Lufutuka river valley and NW to Kongolo.

Over three hundred air miles were flown, 70 black and white vertical and 40 color oblique photos were taken of agricultural areas.

Sortie III.

This mission traversed the areas of blocks Kongolo, Nyunzu, Kalemie, Lukuswa and Luizi. Within the project area, locations flown and photographical are : Mbulula east along the road to Londu, along the railroad to Nyunzu, north following the road to Kabeya-Mayi, then south west along the Lukuga to Kabalo.

A total of 400 air miles were flown, however only 95 miles were within the Project North Shaba area. Approximately 95 vertical and oblique, black and white photos were taken as well as 60 color oblique photographs.

Other miscelaneous flights were made by the consultants on which photos and notes were taken regarding agriculture. These flights covered Kongolo to Lubumbashi, Kabalo, Manono and Nyunzu. Many photos were taken on these flights, and catalogued appropriately. After the three photo missions were completed PNS allowed ERTS access to the photo lab. Despite the hot and humid conditions, not condusive to good photo reproduction, 500 frames of black and white negatives were processed. The type of film used was TRI-X Pan films. Developer used was microdol at a 1:8 dilution factor. 8 x 10 inch enlargments were made using Kodak, Polycontrast Rapid II RC paper. Prints were developed in Dektol at a 1:12 dilution solution. All negatives and enlargments were marked and indexed according to flight line.

After development of photos, ground identifications were made according to photo points identified. Because of time and logistical problems, ground checks were made for sites near Kongolo only.

Upon return to Kinshasa, further aerial data was collected from IGZ. Aerial photography for the entire blocks of Kongolo, Lubunda, Nyunzu, Kabalo, Lukuswa and Luizi was acuired and a detailed crop inventory made by consultant Pessutti with the help of Cits Bakajika and Musungayi. Although the date of this photography is 1957, the information derived will be usefull in change detection, crop type identification, hectarage tabulations and location of agricultural areas. 1957 data will also be usefull as a base on which to begin mapping 1980 agricultural distribution using Landsat imagery.

The method used in extracting crop data from aerial photography is as follows. Block Kongolo is made up of 22 flight lines flown in a north-south direction. Photo overlap is approximatly 60 % and side lap varies generally from 5 - 15 %. Below are the flight specifications of block Kongolo :

Date of photography	June - July 1957
Camera	Wild RC5a
	Aviagon n° 88
	115 mm Focal length
Altitude MSL	5780 m
Altitude AGL (Avg)	4680 m
Scale, approx.	1:40,000
Surface coverage	314,000 Km^2

Because of the 60 % overlap factor, every other photograph in each flight line was analyzed. When an area of agriculture was identified a clear film acetate overlay was placed over the photo and agricultural areas outlined. The overlay was numbered according to the photo number. After each flight line was finished the hectarage of the crop lands was determined. This was accomplished by using a precision dot grid which was placed over the overlay and the hectarage within the agricultural areas counted. Each dot represents a certain number of hectars according to the absolute scale of the photography.

Base maps of block Kongolo have previsiously been prepared on mylar overlays. The overlays were than registered to Landsat scenes and plan made to transfer photo detail. Each IGZ photo covers an area of 7,2Km x 7,2Km, depending on absolute scale. At a scale

of 1:200,000 (Landsat scale), each IGZ photo frame covers an area of approximately 3.6 cm square.

Photo areas were identified on Landsat imagery with little difficulty. The approximate location of agricultural areas was transfered to the Landsat based map in its relation to adjacent roads, streams and most important agricultural relation to forest areas. At the same time as the crop lands were being plotted from the photography, note was made as to areas which have been deforested since 1957 (which is the date of photography), as compared to the current Landsat scene dated 1978.

The entire study area, consisting of more than six one degree square blocks was done in this manner. The final product of this exercise will yield a Landsat based map at 1:200,000 scale showing primary transportation network, major hydrography, villages and 1957 agricultural distribution.

The next phase of work was to map agricultural lands for 1973 from Landsat scene #1341-07474. The base map overlay previously used to compile 1957 agricultural location was laid over the Landsat scene and another clean mylar sheet overlaid on the base map. Areas of 1973 crops were identified and plotted on the clean sheet.

Mylar overlays
- 1973 agriculture
- Base map, 1957 agriculture
- Landsat scene 1973.

It could be thought that the use of the base map and previously compiled 1957 data may have tended to bias the dicision making process of the interpreter, however, due to the nature of Shaba agriculture it was a virtually impossible task to map agriculture without the aid of roads, villages and agricultural center locations. The manner in which the supplemental data helped is to educate the interpreter as to the pattern, and justaposition of agricultural fields.
Decisions as to newly interpreted fields from 1973 and 1978 Landsat images is based on previous Landsat interpretation experience. For instance, it was noted that during aerial reconnaissance there is little or no agriculture far away from the main routes and places of

habitation. (The only exception to this is the agriculture of the pygmie culture). Another key to interpretation is that little agriculture of economic importance is outside of certain soil districts. The ground truthing during the field trip to North Shaba has an influence on the performance of the interpreter. Without supplemental ground truth input, an agricultural inventory by manual or machine processing would be pure conjecture and yield inaccuracies of more than 60 %.

Methodology for percentage tabulations :

Thus far this report has covered the methology for mapping agricultural lands for 1957 and 1973. To map accurately the agricultural distribution for 1979-80 posed a somewhat more difficult problem.

As mentioned earlier, sample verticle aerial photography was taken over areas of agricultural concentration. Scale of photography was determined to be 1:5000 and one photograph (3" x 5") covers about 280 hectars.

Each photograph in the entire mapping area was interpreted and noted for the following features :

FI. This is described as temporairly fallow land where no crop at time of photography can be identified. The land, however has been worked, is in good cultivative condition and reflects either that the plot has just been seeded; has recently been harvested; or recently cleared, burned and prepared for cropping.

FII. This land is described as completly fallow. Plots are covered by brush and land has been returned to natural succession. These areas have been denominated as agricultural, fallow II. Nevertheless many paths and roads intersect the area, giving it a symmetrical, organized appearence.

C. Standing corn at various stages of growth.

M. Manioc at various stages of growth.

O. Other crops including peanuts, cotton, sesame, beans, tobacco,

manioc and corn which has not maturued to a stage at which it can be accuratly identified.

N. Those are areas that are not agricultural, such as villages, dense forest, savanna not identified as being under cultivation, water and marsh, and other lands not suitable.

Interpretation of the sampling photography was done by placing a film overlay over the photography. Colored pencils were used to indicate the above mentioned field surface types. A dot grid was then used to determine hectarage, one dot equaling 0.156 hectars. Hectarages and percentages were derived for the entire photo and tabulated on the back of the picture as follows : (See figures on next page).

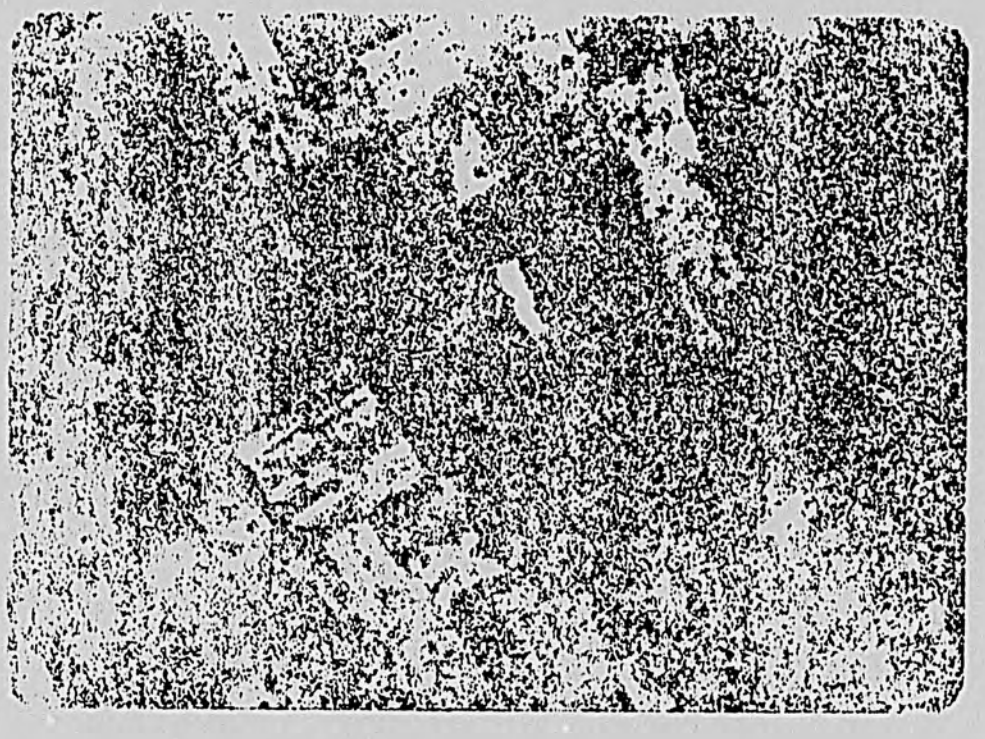
After a sampling flight line of photography was interpreted and tabulated in the manner illustrated on the following pages, the resulting figures were than applied to the total agricultural commune as follows :

An agricultural commune near the sampling photography area was identified on Landsat. This single zone may have a total area of 75 hectars. If the statistics generated from the photography are applied to this 75 hectar zone the following percentages will result :

Type	Percent*1 x Total			Hectars*2
Manioc	13.25	x	75ha	9.94
Corn	2.8	x	75ha	2.1

*1 These figures will vary from flight line to flight and are applied to nearest neighbor agricultural zones identified from Landsat.

*2 These figures represent the amount of hectars of corn and manioc expected with in the total agricultural zone of 75 hectars.



Photograph 1

Sample aerial photograph of agricultural zone near Sola. (#4F)

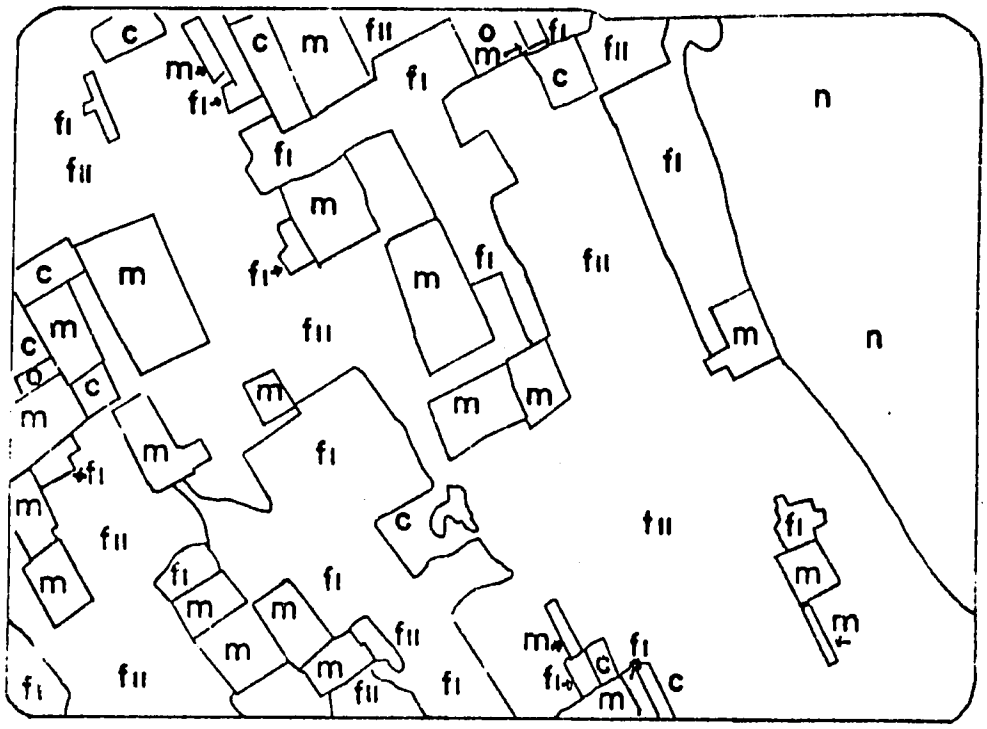


Photo map.

Interpretation example of preceeding aerial photograph.

Surface cover type	Hectars	Percentage*
F I	51.5	18.4
F II	136.0	48.6
O	1.7	.6
M	37.1	13.25
C	8.0	2.8
N	46.0	16.4
Total	280.3	100.05

* These figures are then averaged with those of other photos to generate a valid estimate of surface cover.

The numbers of hectars of corn estimated in a certain region were then combined with ground data. Within the region, ears of mature corn were gathered, dried, shelled and weighed. This information was then combined with the average number of ears per 25 square meters and a tons per hectar of corn determined. This tonnage figure was then multiplied by the number of hectars of corn within the homogeneous zone to eventually yield a total tons of corn produced figure.

After analysis of aerial photography was completed, Landsat was used to inventory the entire study area. 1980 ERTS photographs were correlated to Landsat to help recognize agricultural sites. The most recent Landsat scene available at the time of the inventory project for North Shaba is dated 09 July 78, 3012607361. To begin, a composit of agricultural data derived for 57 and 73 was overlaid on the 78 image. A new sheet of mylar was placed over the composit for compiling the 1978-80 data.

Mylar overlays
- New sheet for 1980 analysis
- Composit 57, 73
- Landsat 1978

Supplemental data used as input consisted of :

1. Aerial photography collected during 1980 field trip.
2. Ground notes taken while visiting fields.
3. Statistical data gathered from PNS and local agricultural officials.

1980 ERTS aerial photography showing agriculture was first plotted on the overlay. This is the most recent and accurate data available.

The ERTS aerial photographic data, plotted on the 1978 Landsat scene indicated correlation of agriculture interpreted from photos and images. This is a means for further identification of crop lands by extrapolation of identified crop sites to areas not covered by 1980 ERTS aerial photography. After all photo points of known agri-agriculture were identified, interpretation of the entire scene began.

The final products of the mapping and data gathering exercise are :

1. Landsat based maps of roads, villages, hydrography
2. Maps of agricultural distribution, 1957
3. Maps of agricultural distribution, 1973 (for PNS area only)
4. Maps of agricultural distribution, 1978-80
5. Statistical tables.

RESULTS.

The following page lists villages which have been visited and an interview with the local agronomist was attempted. Each agricultural zone visited was analyzed for :

major crop types
crop rotation calendar
field patterns
corn yield per hectar

and any other usefull information offered by the local PNS agronomist or farmer. Yield was determined by taking a random 5 meter x 5 meter area in a corn field. The number of stalks and ears of corn was counted and sample ears were collected. The kernels of corn were stripped from the ear, dried and weighed. An average tons per hectar was then estimated.

Table 4. Fields visited near Kongolo and along the route to Kaseya*1

FIELD	LOCATION	FERTILIZER	VARIETY	METHOD OF CUL-	TONS/HA
1	Kongolo	None	Kasai I	Modern	1,494
2	-"-	Yes (*2)	-"-	-"-	3,233
3	-"-	Yes	-"-	-"-	3,084
4	-"-	Yes	-"-	-"-	2,288
5	-"-	Yes	-"-	-"-	1,191
6	Route to Kaseya 6 miles	-	local	traditional	2,500
7	10 miles	-	-"-	-"-	2,245
8	16 miles	-	-"-	-"-	2,080
9	Mugila	-	Kasai I	-"-	2,967
10	Mugila	-	Kasai	-"-	1,745

*1 Data gathered from PNS agronomist in Kongolo.

*2 Diamonium phosphate and urea are the common fertilizer types used.

Names of towns where agricultural statistics were gathered by ERTS (See map 3) :

- Kongolo
- Keba
- Sola
- Kilubi
- Timpa
- Mugumo
- Kateba
- Kingulungu
- Mugila
- Bugama Lwamba
- Bugama Pyana
- Makutano
- Zola
- Kayanza
- Mbulula
- Lengwe
- Nyunzu
- Kasongo
- Luizi
- Muhuya
- Ngombe Mwana
- Mulongo
- M. Kasongo
- Songa
- Hanga-Goi.

KATEBA

Major crops are : corn, manioc, peanuts.

Most corn is grown by traditional methods using local seed and no fertilizers.

Four fields were tested as to tons of corn per hectar. Following are the results :

Field 1

Local seed, traditional methods. No fertilizer, yielded 2,4 T/ha.

Field 2

Modern seed, traditional methods. No fertilizer, yielded 4,9 T/ha.

Field 3

Local seed, modern methods. No fertilizer, yielded 1,6 T/ha.

Field 4

Local seed, traditional methods. No fertilizer, yielded 2,2 T/ha.

BUGANA LWAMEA and ZOLA.

Principle crops :

corn, rice, cotton, palm, manioc, peanuts, tobacco.

Rotation :

YEAR	1 2 3	4 5 6	7 8 9 10	11 12 13
FOREST	Corn & rice	Fallow	Corn & rice	Fallow
SAVANNA A	Corn & rice	Fallow	Corn & cotton or palm	
B	Peanuts & Corn	Fallow	Manioc & cotton or palm	

Most fields in both forest and savanna were of regular pattern. Average size is about .5ha. Use of local seed and Kasai I and modern/traditional methods are equal. Also there seems to be little difference in yield between methods of culture, 2,5 T/ha estimated average.

Fertilizer is used only on the cotton cultures.

Corn yields are as follows :

Forest

Local seed 2,5 T/ha

Kasai I 3,0 T/ha

Savanna

Local seed 2,5 T/ha

Kasai I 3,0 T/ha

MUHUYA

Major crops are :

corn, manioc, peanuts, sesame, cotton.

In each zone, mais and sesame are the crops grown in forest culture. Manioc, peanuts and cotton are all savanna crops.

Crop rotation :

YEAR	1 2 3 4	5 6 7 8 9 10 11	12 13 14 15
FOREST	Corn & sesame	Fallow	Corn & sesame
SAVANNA	Cotton / Manioc / Peanuts	Fallow	Cotton / Manioc / Peanuts / Fallow

Approximate plot size varies from 1-5 hectars in the forest. Savanna plots run up to 10 hectars each, the average being approximately 5 hectars. When Filtisaf had large concerns in the area for cotton production, most plots were rectangular in nature. Now all forest plots are of irregular shape and some new savanna plots are taking on irregular patterns.

Average corn yield is 3.0 T/ha.

KILUEI

Major crops are :

corn, peanuts, manioc, cotton, soya.

Forest culture is corn mixed with rice or soya. All other crops are grown in savanna lands.

Crop rotation :

YEAR		1 2 3	4 5 6 7 8 9	10 11 12	13
FOREST	A	Corn and rice or soya	Fallow	Corn and rice or soya	Fallow
	B			Corn and/or Peanuts	
SAVANNA	A	Peanuts and/or corn			Fallow
	B	Cotton Manioc	Fallow	Cotton Manioc	Fallow

Cotton is always grown in pure culture however some farmers do mix manioc with peanuts.

Savanna is prepared by rapid burning. Forest is prepared by cutting brush, selective cutting of timber, rapid burning after 3-4 weeks of cessation. All fields in the savanna were rectangular or square in nature and forest plots were irregular. No chemicals are used in preparing the ground and there seems to be a 50/50 mix of local seed, traditional methods/Kasai I and modern methods for the savanna. Forest culture is mostly traditional.

It seems that the farmers who work with PNS and Filtisaf have an average field size of 100m x 50m (.5ha). The average field size for other farmers in this area is 1 hectar. Yield estimates for this region are :

Savanna, 1,5 - 2,5 tons/ha local/traditional methods;

2,5 - 3 tons/ha in well maintained fields with modern seed/method;

1,5 - 2 tons/ha in poorly maintained fields with modern seed/method.

Forest, 1,5 - 2 tons/ha poor maintence, traditional seed/methods;
2,5 - 3 tons/ha well maintained traditional seed/methods;
3 - 3,5 tons/ha well maintained modern or traditional seed/methods.

MUGUMO

Principal crops :

corn, manioc, peanuts, banana, rice and cotton.

Crop rotation :

YEAR	1 2 3 4	5 6 7 8 9 10 11 12	13 14 15
FOREST	Corn with rice	Fallow	Corn with rice
SAVANNA SEASON A	Corn with peanuts & banana	Fallow Banana	Corn with peanuts & banana
SAVANNA SEASON B	Banana Cotton	Fallow Banana	Banana & cotton
		Fallow	

Banana grows is between large rows.

Forest culture is about 30 %.

Corn yield is as follows

Forest

Local seed	2.0 T/ha (some as high as 5 T/ha)
Kasai I	2.8 T/ha

Savanna

Local seed	1.5 T/ha
Kasai I	2.5 T/ha.

MUGILA:

Principal crops are :

corn, cotton, rice, peanuts, manioc, beans.

Most agriculture takes place in the forest.

Rotation :

YEAR	1 2 3	4 5 6	7 8 9	10 11 12 13
FOREST	Corn and rice	Fallow	Corn and rice	Fallow
SAVANNA A	Cotton or corn	Fallow	Cotton or corn	Fallow
B	Cotton or peanuts	Fallow	Cotton or peanuts	Fallow

Most fields in both forest and savanna are regular in shape.

Corn yield per hectar :

Forest

Local seed	2,5 T/ha
Kasai I	3,3 T/ha

Savanna

Local seed	2,0 T/ha
Kasai I	2,5 T/ha.

MULONGO

Major crops in order of importance for this locality are :

corn
manioc
peanuts
cotton.

Most agriculture in the Mulongo district is in savanna however as reported by local chefs, some 25 - 30 % of its plots are in forest culture. Little new forest clearing takes place as most agriculture is located in traditional zones.

Crop rotation :

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FOREST	Corn	Manioc	Cotton							Fallow*					
SAVANNA	Corn Peanuts		Manioc Peanuts							Fallow					

It is believed that the peanut yield is higher than the corn yield in this area and that many farmers are turning to more intensive cultivation of peanuts.

Most agricultural plots tend to be in an irregular pattern. Seed and cultivation techniques are generally traditional.

Average corn yield was estimated at 2.0 tons per hectar.

* The local agronomist was vague concerning the fallow period of savanna lands, stating usually more than ten years.

GOMBE MWANA.

Major crops in Gombe-Mwana are, in order of importance :

corn, peanuts, manioc, cotton, sesame.

Corn is the only major crop grown in the forest, however sesame is occasionally intercroped with corn. All other crops, including sesame are generally grown in the savanna.

Crop rotation :

YEAR	1 2 3 4	5 6 7 8 9	10 11 12 13	14 15 16 17 18
FOREST	Corn & sesame	Fallow	Corn & sesame	Fallow
SAVANNA	Cotton Peanuts / Manioc Peanuts	Fallow	Cotton Peanuts / Manioc Peanuts	Fallow

It was stated by the local agronomist that little burning is done in the savanna and that most savanna burning is for hunting purposes. This takes place in June. Forest burning usually takes place in August, the ground prepared in September and seeded in October.

Field shape in the forest is irregular and average field size is large, 3 hectars up to 10 hectars.

Savanna fields are rectangular and usually small, .25 to 1 hectar each.

Corn yield for Gombe-Mwana is 4 tons/ha for modern method, seed and fertilizer and 3 tons/ha for traditional method, seed w/o fertilizer.

LUIZI.

Major crops in order of importance as perceived by the local peasents are :

manioc
peanuts
cotton
corn.

All agricultural plots are located in the savanna, no plots were observed in the flood plane and little forest agriculture exists. Average field size is 100m x 60m (.6ha).

Crop rotation :

YEAR	1 2 3 4	5 6 7 8	9 10	11 12	13 14 15 16
TRADITIONAL FARM AREA SAVANNA	Cotton and/or peanuts	Fallow	Manioc Peanuts	Manioc or corn	Fallow

Cotton is grown in season B.
Manioc mixed with corn or peanuts is grown from September to January. Sometimes the corn is left in the field and not harvested until June, However most corn is harvested in January of February.

The yearly burn calendar for Luizi is July-August burn for hunting purposes; August-September farmers burn for agricultural purposes. Corn seeding takes place in October.

In the Luizi area most agricultural plots are rectangular in nature. However little by little, farmers are going back to irregular field pattern. It was also observed that Kasai I seed, fertilizer and modern methods are only being used by PMS farmers in the demonstration fields and have not yet been accepted by the average peasent farmer as yet.

Average corn yield per hectar in this area was determined to be 1.5 tons.

MBULULA.

Forest

Local seed	3,0	T/ha
Kasai I	3,0 - 3,5	T/ha

Savanna

Local seed	2,5	T/ha
Kasai I	3,0	T/ha

MAKUTANO

Forest

Kasai I/modern methods 3,2 T/ha

Kasai I/traditional methods 1,9 T/ha

Savanna

Kasai I/traditional methods 2,6 T/ha

Local seed/traditional methods 1,2 T/ha.

Key to yields :

1. Modern method, Kasai I, fertilizer
2. Modern method, local seed, fertilizer
3. Traditional methods, Kasai I, no fertilizer
4. Traditional method, local seed, no fertilizer.

KEBA

1. 5.3 T/ha
2. 2.6 "
3. 2.9 "
4. 2.5 "

SOLA

1. 7.0 T/ha
2. 4.1 "
3. 5.6 "
4. 3.2 "

KYANZA

1. 3.9 T/ha
2. 2.7 "
3. 2.0 "
4. .75 "

LEKGWE

1. 4.3 T/ha
2. 2.0 "
3. 1.9
4. 1.0 "

NYUNZU

1. 5.2 T/ha
2. 3.6 "
3. 2.7 "
4. 1.4 "

KASONGO

1. No data
2. No data
3. 2.0 T/ha
4. 1.3 "

SONGA

1. 3.4 T/ha
2. 1.8 "
3. .97 "
4. 1.6 "

The following is a list of figures showing total hectars in each category of agriculture. These figures were derived from analysis of aerial photography taken during the field trip Jan-March 1980. Separate figures were derived for each 1/4 degree block; Makutano, Kongolo, Nyunzu, Luizi.

During field investigations it was found that old manioc culture takes on the same aerial characteristic as fallow II. It was very difficult to differentiate the two using aerial photography, particularly when the two types are adjacent to each other. Therefore a factor of 10 % of the total manioc culture was taken from the fallow II class and applied to manioc to compensate for this miss-classification. This change is reflected in the following table.

The percentage figures of corn, fallow and manioc culture derived for total agricultural land determined from 1980 ERTS photography were compared to those of 1957 photography and found to be similar. However more reliability is found in 1980 photos compared to 1957 IGZ photography because of the scale difference. (1980 1:5,000; 1957 1:40,000).

Table 5. Percentage of cover type for agricultural plots, by 1/4 degree block for PNS area. (Refer to map 6).

Index n°	1/4° Block	Percent	Hectars 1957	Hectars 1973	Hectars 1980
E	MAKUTANO				
	Corn	5.1	182	204	335
	Manioc	5.5	196	220	362
	Others	2.9	103	116	191
	Fallow I	14.3	509	572	940
	Fallow II	72.2	2570	2888	4747
	Total		3560	4000	6575
D	1/4° Block KONGOLO				
	Corn	4.7	629	800	1181
	Manioc	5.0	669	851	1256
	Others	2.6	348	443	653
	Fallow I	15.9	2127	2707	3995
	Fallow II	71.8	9603	12224	18040
	Total		13,376	17,025	25,125
J	1/4° Block LUIZI				
	Corn	4.2	191	148	372
	Manioc	5.1	233	180	451
	Others	2.9	132	102	257
	Fallow I	13.3	606	469	1177
	Fallow II	74.5	3397	2626	6593
	Total		4559	3525	8850
K	1/4° Block KITENGETENGE				
	Corn	4.9	236	456	597
	Manioc	5.0	241	465	609
	Others	2.8	135	261	341
	Fallow I	15.5	748	1442	1887
	Fallow II	71.8	3464	6680	8741
	Total		4824	9304	12,175

Index n°	1/4° Block MALOEA	Percent	Hectars 1957	Hectars 1973	Hectars 1980
Q	Corn	4.9	312		270
	Manioc	4.8	306		265
	Others	3.0	192		166
	Fallow I	15.0	956		829
	Fallow II	72.3	4609		3995
	Total		6375		5525
F	1/4° Block KIYI				
	Corn	5.1	267		265
	Manioc	5.5	287		286
	Others	2.9	152		151
	Fallow I	14.3	747		744
	Fallow II	72.2	3772		3754
	Total		5225		5200
P	1/4° Block YAURI				
	Corn	4.2	404		363
	Manioc	5.1	491		441
	Others	2.9	279		251
	Fallow I	13.3	1280		1150
	Fallow II	74.5	7171		6445
	Total		9625		8650
L	1/4° Block NIEMI				
	Corn	5.4	336		576
	Manioc	4.8	299		512
	Others	3.2	199		342
	Fallow I	14.5	903		1548
	Fallow II	72.1	4488		7697
	Total		6225		10,675

Index n°	1/4° Block GOMBE-MWANA	Percent	Hectars 1957	Hectars 1973	Hectars 1980
R					
	Corn	5.5	304		435
	Manioc	4.8	265		379
	Others	3.5	193		277
	Fallow I	14.5	802		1145
	Fallow II	71.7	3961		5664
	Total		5525		7900
C	1/4° Block LUBUNDA				
	Corn	4.9	358		522
	Manioc	5.3	387		564
	Others	3.4	248		362
	Fallow I	14.5	1059		1545
	Fallow II	71.9	5248		7657
	Total		7300		10,650

Presented in next table is an estimation of corn yield per hectar for each 1/4° block inventoried. These blocks cover all of the area of project North Shaba and approximately 90 % of Landsat scene numbers :

30091-07413 June 78
30126-07361 July 78
1341-07474 June 73

Refer to the enclosed index map to reference location of blocks.

Table 6. Yield table.

1/4° block	Average Tons/hectar	Total estimated yield for 1980
D Kongolo	2.8	3309 metric tons
E Makutano	2.5	838 " "
F Kiyi	2.5*	663 " "
J Luizi	2.0	744 " "
K Katengetenge	2.6	1552 " "
L Niemba	3.0*	1728 " "
Q Maloba	3.0	810 " "
P Yauri	2.0	726 " "
R Gombe-Mwana	2.8	1218 " "

1/4° block		
A Sentery/Lubao		
B Kamina		
C Lubunda	2.5	1195 metric tons
G Penge		
H Katea		
I Bumambwe	These figures to be presented in a future report.	
M Songia		
N Mosambi		
O Kabalo		
P Manono		

* These figures estimated from nearest neighbour land potentiality, soil types and density of agriculture. Field samples of corn were not taken in these areas.

CONCLUSIONS.

Because the ERTS effort in the project North Shaba area was the first of its kind for both Program ERTS and PNS, certain difficulties arrose.

One problem identified was that aerial photography and ground truthing took place at the end of growing season A. This season generally starts at the end of September and harvest begins around January 1. The ERTS ground truth mission took place essentially during the month of February. The problem is evident. Corn harvesting had perhaps a six week head start on the ground and air data collecting activity by ERTS. This, in essence will yield a much lower percentage of corn identified on aerial photography. During ground truthing certain fields showed evidence of corn being previously grown there but one can not be certain. In some areas perhaps as much as 15 % of the total corn crop had been harvested.

The classification of Fallow I (FI) for most sectors inventoried is generally around 15 % of the total agricultural commune. There is a strong possibility that a large percentage of the Fallow I class was in corn during the immediately preceeding growing season. One can not be certain of the exact figure. Therefore only standing corn was identified and tabulated.

The second significant problem identified is the fact that peasants are cultivating during two growing seasons in a twelve month period. From data gathered during the ERTS ground truth mission in February (end of season A) there is no way to assertain the hectarage of corn grown during season B. Corn crops are usually not grown in the same plot on consecutive seasons. Again, the total agricultural production figure for this report will fall short of the actual hectarage for a one year, two growing season period.

A third problem identified was the lack of quality and resolution in the 1978 Landsat scene used. Because of atmospheric attenuation, Landsat beinging turned off over Zaire for a long period of time and seasonal change of vegetation, there was little choice of

satellite coverage over the study area. However, the imagery was useable. The multispectral scanner data used (MSS) had to be photo-mechanically streatched in order to penetrate atmospheric haze. This streatch technique also reduces the ground resolution from 50 meters to somewhere around 100-150 meters. It is recommended that future efforts use the Landsat Return Beam Vidicon (RBV) system. RBV is a panchromatic, black and white rendition yielding an expected ground resolution for the study area to be in the neighborhood of 20-30 meters. With special computer processing both MSS and RBV ground resolution can be increased.

After analysis of the results and review of the total effort, certain problems were identified in technique and a plan formulated to improve the methodology to yield more accurate results. In addition to problems identified in preceding sections, the results yielded a number of significant observations concerning land use and agricultural land distribution throughout the study area.

Prior to beginning the survey, the ERTS team was informed that the Government of Zaire has made claims of wide spread deforestation in the study area. After a Landsat analysis was made using 1978 data, and compared to ICZ aerial photography dated 1957, conclusions were reached regarding these claims.

First, one must define what the word "deforestation" means and what parameters does this word encompass. After talking with the staff of Project North Shaba, A.I.D., and remarks made by the staff of the GOZ Department of Agriculture it was determined that the term "deforestation", as used by these entities, was to mean :

- The clear cutting of all trees of primary growth (climax succession) to make way for agricultural expansion.

After completing a superficial deforestation analysis, the following conclusions were reached.

1. In the area north-east of Kongolo it was found that approximately 5-7 % of the total forest land of primary growth has been converted to agricultural production from 1957 to 1978.

2. In the Nyunzu area, approximately 15-20 % of the primary forest growth has been converted to agricultural production lands from 1957-1978.

3. In all regions it was rare to see an area clear cut of tree cover. Usually a form of thinning takes place, cutting approximately 75 % of the larger trees, clearing and burning 100 % of the under brush and leaving 25 % of the trees for shading.

4. It is theorized by the consultants that the claims of wide spread deforestation in the PNS area is based on the following: Within some traditional farming communes the fallow period for plots may be as long as twenty years and at the least seven years. In tropical areas this is sufficient time for second growth trees to flourish and become quite large. The traditional agricultural plot, lying in fallow for twenty years, has returned to forest of secondary growth. As the need arrises the peasants return to farming this traditional agricultural fallow area by removing the trees, preparing the ground and planting. This practice should not be confused with deforestation of primary growth species. The trees that return during the fallow can be considered a crop in itself. The wood can be used for fuel, charcoal and implements.

In essence it is believed that the claims of deforestation lies in the fact that traditional farming land is being returned to production.

A second observation made is that of the relation ship between soils, agricultural locations and roads. Dr. Jack Gambel, TDY soil scientist for PNS, took a number of soil samples in the project area and a preliminary identification of types and potential was made. On Dr. Gambels return to Kinshasa the soil scientist collaborated with the ERTS consultants to produce a "Soil Potential Map" of Project North Shaba (a draft copy of this map, No.7, is presented with this report). The soil types and potential were identified by Dr. Gambel and the boundaries for these classes delimited by the ERTS consultants.

In addition to soil boundaries identified, an overlay

of 1980 agricultural locations and major routes of transportation was prepared. The resulting map and overlap at a scale of 1:200,000 showed the following corrolations. (Refer to map No.6).

The area from Kongolo, north and east along the road to Sola lies primarly in a zone of average soil potential. This area is also host to one of the most intensively cultivated sectors of the PNS area. However, there appears to be room for agricultural expansion between the north-south road to Sola and the river. Most good arable land east of the road between Sola and Kabemba is being cultivated.

Another area of high agricultural concentration is Nyunzu. This is a zone of high soil potential and a farly good transportation network has developed.

A third area of agricultural concentration is that near Kitengetenge, this zone, like that of Nyunzu, also lies in an area of high soil potential.

It appears that the combination of soil potential and transportation network has an influence on the location and development of agricultural concentrations. One may be lead to believe that the road network was developed to exploit the good soils and facilitate the marketing of crops. Weather the transportation routes were constructed to aid in crop production/marketing or weather agricultural concentrations sprouted in close proximity to existing roads is not the object of discussion at this time. It is evident, however, that where there are no roads there is a lack of agricultural development, even in areas of high soil potential. It is believed by the consultants that if roads were constructed in areas of low development but high soil potential, and if sufficient population exists near by or temporary seasonal farming villages were erected, that the following areas can be brought under increased cultivation. (Refer to map "Terres recommandées pour le développement de l'agriculture", No.8).

MUGIZIA, TIMPA.

This is an area identified as having a good to high degree of potential for increasing the number of hectars under cultivation. Some of the limiting factors presently are poor roads, (from Mugizia to Timpa) and no roads directly to the east and south east of Timpa. In addition, road transport is poor between Timpa and the Bomba River. Mugizia presently is the site of fairly good corn production which indicates that this area of good soil resource could be tapped to increase area crop production. Further work is needed to accurately delimit the soil boundaries and slope of the area before plans are made to expand production.
East of Mugizia is the town of Makutano which lies in an area of high soil potential, good road network and fairly low utilization of land for agriculture. It appears that this zone can be brought into increased agricultural production first along the existing roads before the interior lands are exploited.

The land south of the road from Makutano, Zola up to Bugana-Muhila can easily be brought into increased production. The soil of the area is good and the road is adaquite to accomodate large trucks for the marketing of corn. One limiting factor is sufficient population to work the fields. Distances between villages are great and the size of the existing villages is relatively small.

There are a number of small valleys which run in a northeasterly direction from Makutano which also shows promise for increasing agricultural hectarage. Probably one small road from Makutano towards Kiziba could open up an area which encompasses approximately 2000 hectars. Of course not 100 % of this area can be cultivated. There are spots within this zone which is heavily forested, rocky or wet.

Another area identified for the possibility of increased production is centered on the village of Kigumba, located south of Mbulula. This area consisting of approximately 4000 hectars lies on a ridge of high soil potential. There currently is corn production in this area however it can be significantly increased. Two limiting

factors are adequacy of the roads and a few places which seem to be poorly drained.

The road which runs west from Mbulula to Kongolo passes through an area which appears to be lacking agricultural development. This area is about 5000 hectars. It is bounded on the south by the Mbulula-Kongolo road, on the west by the Mwana-Goi to Kilunga road, on the north to a point near Kalemba and the east to Kagungu. This rectangular area lies on high potential soils. Road access is good and there is probably sufficient near by population to cultivate the fields. This area needs further investigation as to why agriculture is currently at a low state of development.

In the territory of Nyunzu there are two areas which seem to show potential for agricultural development. Ths first zone lies north of the city of Nyunzu between the Luhungwe and luawe streams. Along the road north , out of Nyunzu, there is good development, (near Lombwa). However as one travels further west off the main road the cultivated areas begin to thin out. Poor access is one reason for this as well as the area is approximately 35 % forest.

The second area in the territory of Nyunzu which warrents further investigation is located west and south of Kitengetenge. This zone lies on high potential soils and is traversed by two major roads coverging at Kitengetenge. Agricultural development currently is moderately high but within this 20,000 plus hectar area there is adequate room for expansion. This is one of the most promising regions in PNS. Further work is needed in slope, drainage, soils and surface cover before development of the region begins.

RECOMMENDATIONS FOR FUTURE WORK.

If future land use or agricultural studies are to take place anywhere in Zaire it is imperative to have both Landsat imaging systems turned on over the project areas for both growing seasons, and at best for repetitive year to year coverage.

The ERTS mission is unique in the fact that no previous significant soil, geological or land use mapping has ever been done in the study area. The ERTS team went into North Shaba knowing very little about the physical environment. This makes it difficult to set up ground and air sampling sites of homogeneous zones and to know how many points per mapping unit or zone are needed to produce reliable results. Now that soils have been roughly delimited, areas of agricultural concentration identified and deforestation sites located, future efforts can be concentrated in the areas of interest.

The ERTS mission has always been underfinanced. Due to the lack of adequate monies available for this survey, many important steps in the analysis have been neglected. Much time, effort and money was spent working in areas of low agricultural potential. At the time of the ground truthing, these areas were not known to be lacking potential and therefore the valuable resources mentioned above were spent identifying these areas. Now that areas of high potential and low potential have been identified, the resources such as time and money can be better spent in the sectors of higher agricultural productivity and potential.

After the survey by ERTS was completed, certain conclusions were reached regarding the technique of agricultural inventories in Zaire. Many problems were encountered and due to this, solutions and techniques were devised by the consultants to carry out crop and soil inventories in Zaire to a higher degree of accuracy.

It is recommended that a program be instituted to monitor crop production, expansion, condition and project effectiveness for not just the North Shaba area but at the onset of simular programs in developing areas. If inventory work and mapping is completed prior

to project implementation one would have a base line on which to equate effectivness and evaluate program performance.

Prior to the commencement of a program such as project North Shaba, certain features of the area should be analyzed. These include soil, population, roads, slope, aspect and climate. All these items can be integrated and a plan formed as to where the most logical areas to increase production are located. The best possible source of information is that derived from aerial photography. The agronomist, soil scientist, regional planner, photogrammetrist and road builder all benefit from this tool. Soil classes, land capability and slope/aspect can be identified along with surface cover and drainage when combined with some field work. This information can be used to locate future agricultural sites based on sound multidisciplinary advice.

It is felt that a tool such as aerial photography is invaluable for regional agricultural planning at the onset of a program. However, at this late stage of development in the life of PNS, complete aerial photo coverage probably would not be a feasible or economical venture. Therefore a proposal to use low altitude sampling aerial photography combined with Landsat data and ground truth is recommended. The benefit of a program as described is multifold. If the same sample areas are flown season after season, a series of statistics can be generated as to the amount of corn, manioc and peanuts are grown, and to evaluate if there is net increase or decrease in crop production land and fallow. Also, data can be derived as to what rate an area is expanding and what percentage of deforestation is taking place. This information can be used in the decision making process on where and what future efforts should be taken. Another use for an aerial surveillance program is to check on the accuracies of ground generated statistics gathered by local statisticians and census reporters. The data generated from the sampling photography can then be expanded to cover the entire project area by using Landsat RBV data. A season by season crop forcast can be made if hectarages are combined with field samples of corn.

Because ERTS has done preliminary work in North Shaba it will not be difficult to lay out flight lines and plan missions for air and ground sampling. The project area should first be divided into homogeneous zones of agriculture or surface cover types and then flight lines planned to sample each of these zones. One flight line per zone should be sufficient. It is felt that approximately twelve flight lines of twenty kilometers each will yield sufficient data on which crop statistics can be generated.

The ERTS mission used a 35mm camera which yielded satisfactory results, however, for advanced work a 50mm or 70mm motor drive camera with intervalometer should be purchased along with bulk film loader, cassette and bulk Kodak aerographic color film.

Before areas are flown, the beginning and end of each line should be ground located and identified with a small bench marker. It would be easiest to begin and end the transects at points of road crossings. Prior to flight time these bench markers should be targeted with white flagging so they can be recorded on film. This will help guarentee that the same areas on the ground are photographed on future missions. The ground markers can also be used as a base line identification point to identify areas for ground data collection.

During the flying season, statisticians can be collecting ground data on field size and number of fields simultaneously. Sample ears of corn should be collected the end of the growing season, these samples will be used for tonnage forcasts. After the film is processed and returned from the states an analysis can be made of surface cover. This should be done in the same manner as explained previously in this report. The sample statistics generated for each homogeneous zone can then be applied to the total zone. This is a facet in which the help of a statistician experienced in aerial data reduction applied to agriculture would be helpfull.

The Landsat RBV data along with field data on soils, topography and other surface characteristics will be used to identify zones of homogeneity as well as to identify and tabulate the hectarage of total crop production lands. The boundaries of communal crop lands

can easily be identified on RBV, the problem lies in the identification of each specific crop which makes up the population of the identified area. This is why low altitude sampling photography is used.

Once areas are identified on RBV, sample ground checks should be made. This is to ensure that a consistent error in identification is not made, such as identifying low scrub vegetation as agriculture. Ground checks also include the measurement of a few fields so hectarage can be determined on the RBV scene. This practice is known as confidence building for the interpreter.

For future work it is important to have repetitive satellite coverage to identify which areas are expanding or decreasing in size, measure this change to help evaluate the effectivness of agricultural extensionists. Using repetitive coverage will also give the regional planner information on the rate of deforestation and help in guiding expansion to desired areas.

A P P E N D I X A

PHOTOGRAPHS

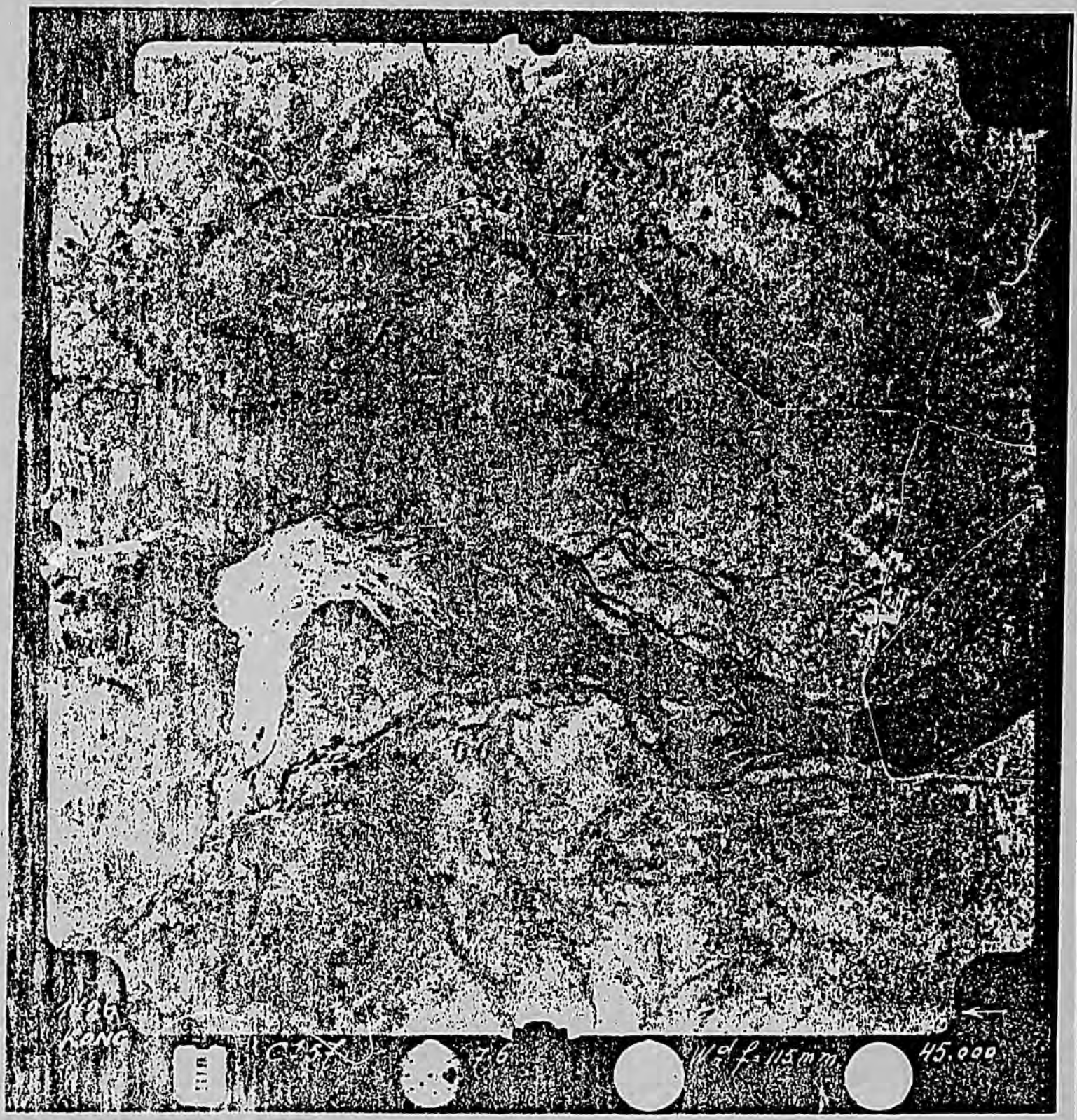


Photo 2

Sample ICE photograph (Kong 1420) over Kongolo.

BEST AVAILABLE DOCUMENT

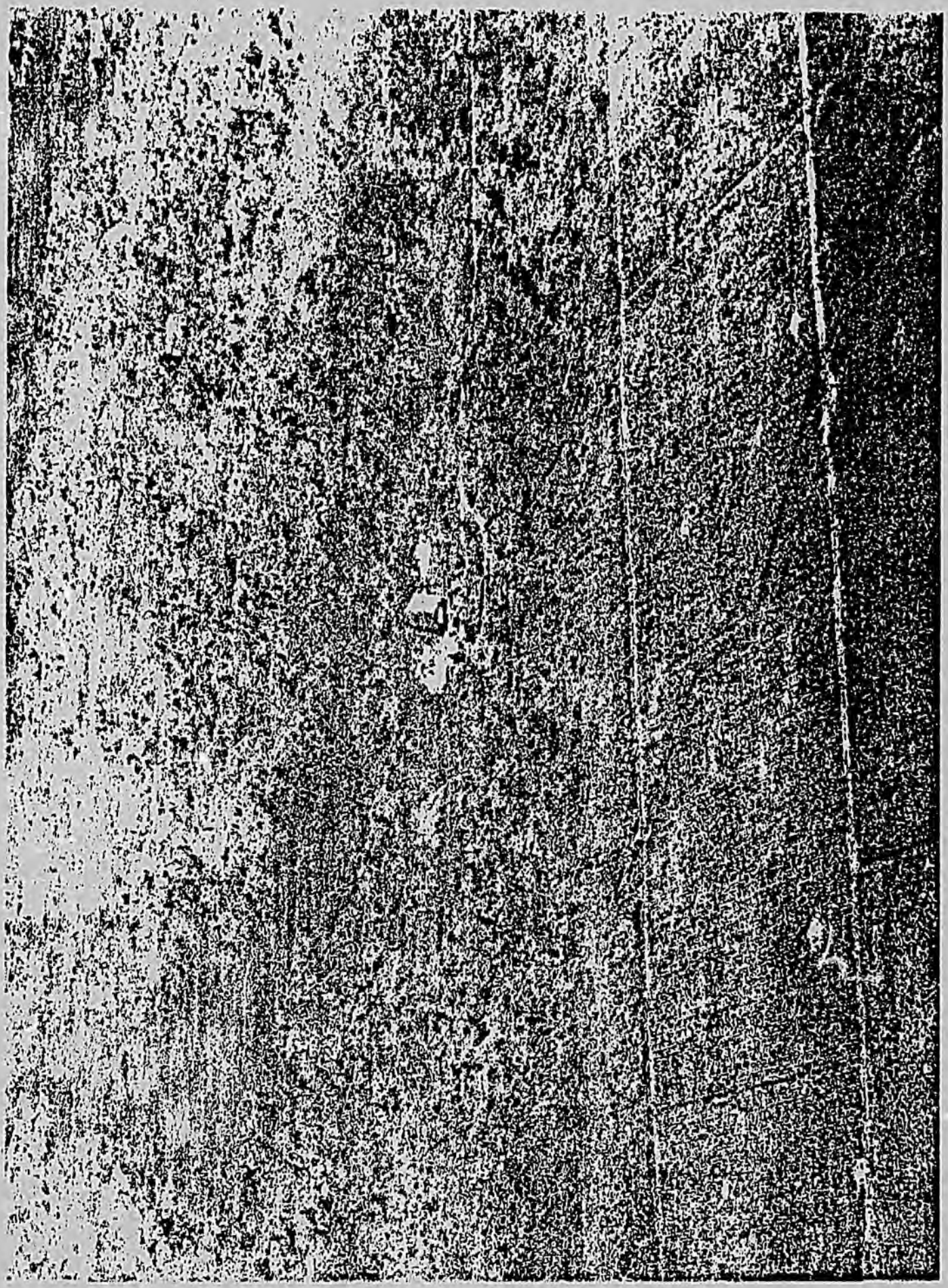


Photo 2

ERTS black and white oblique of Neaba test field sites.

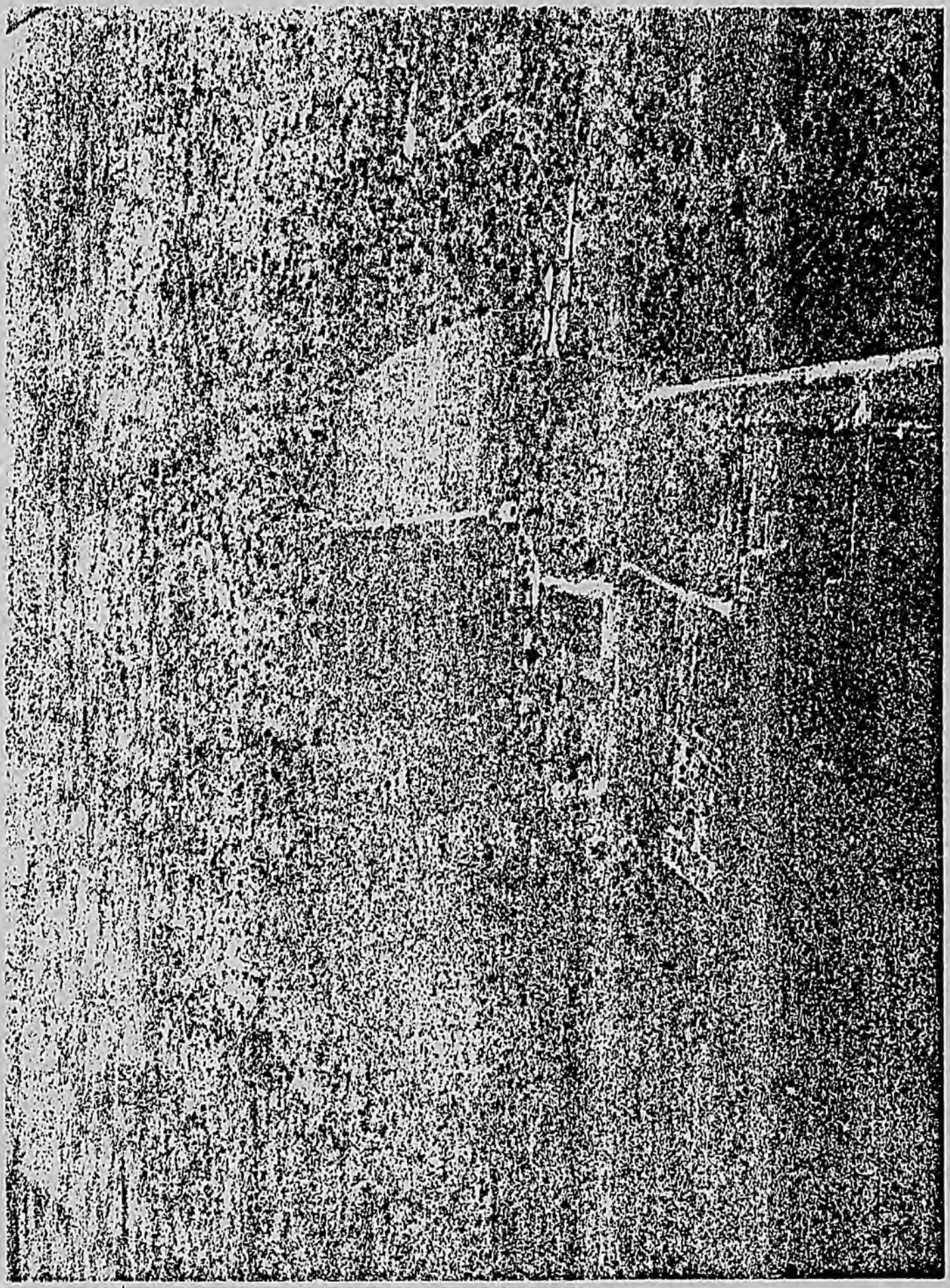


Photo 4 ERTS black and white oblique of Ngaba facilities.

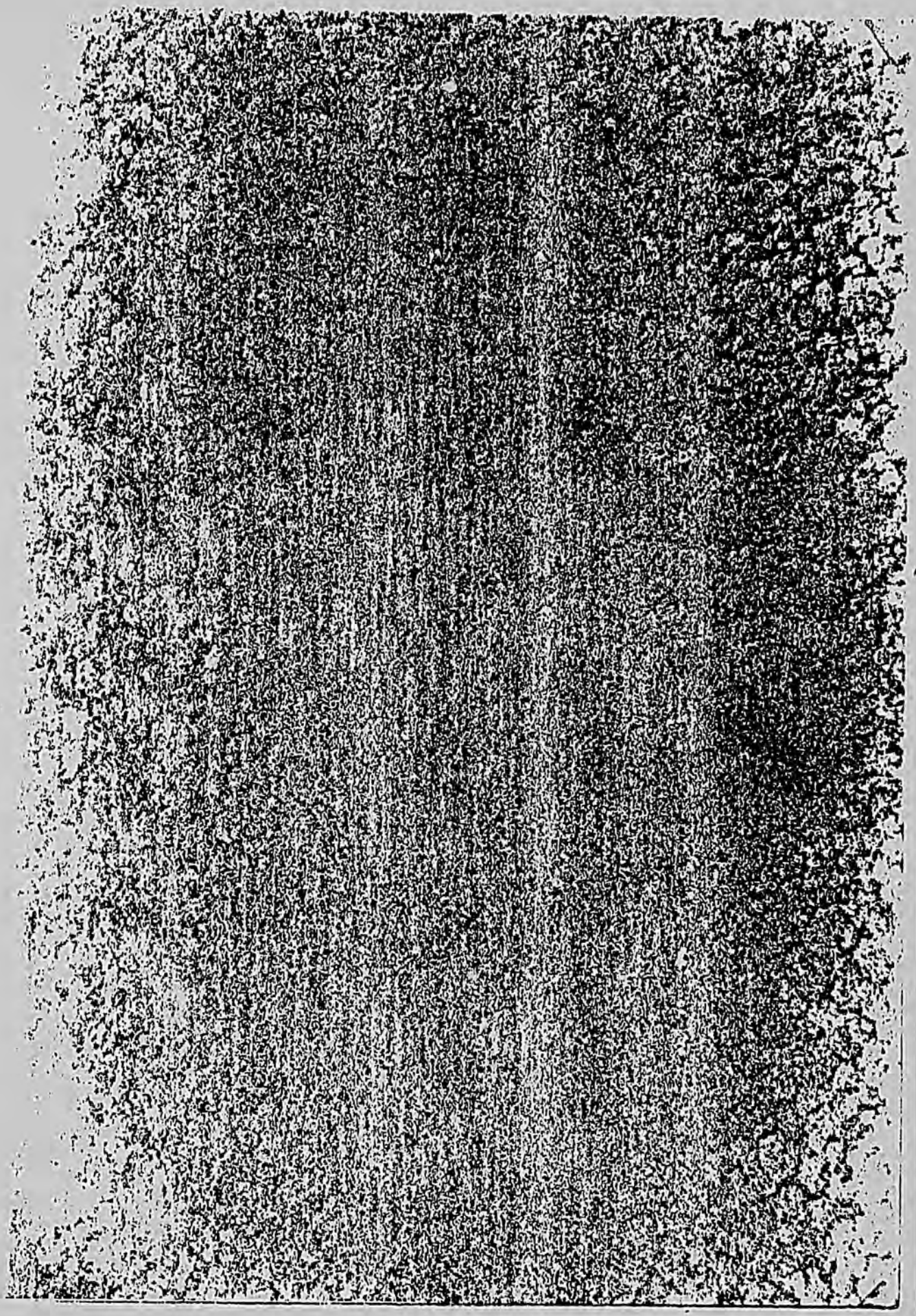


Photo 5

ERTS black and white vertical of heavy forest vegetation.

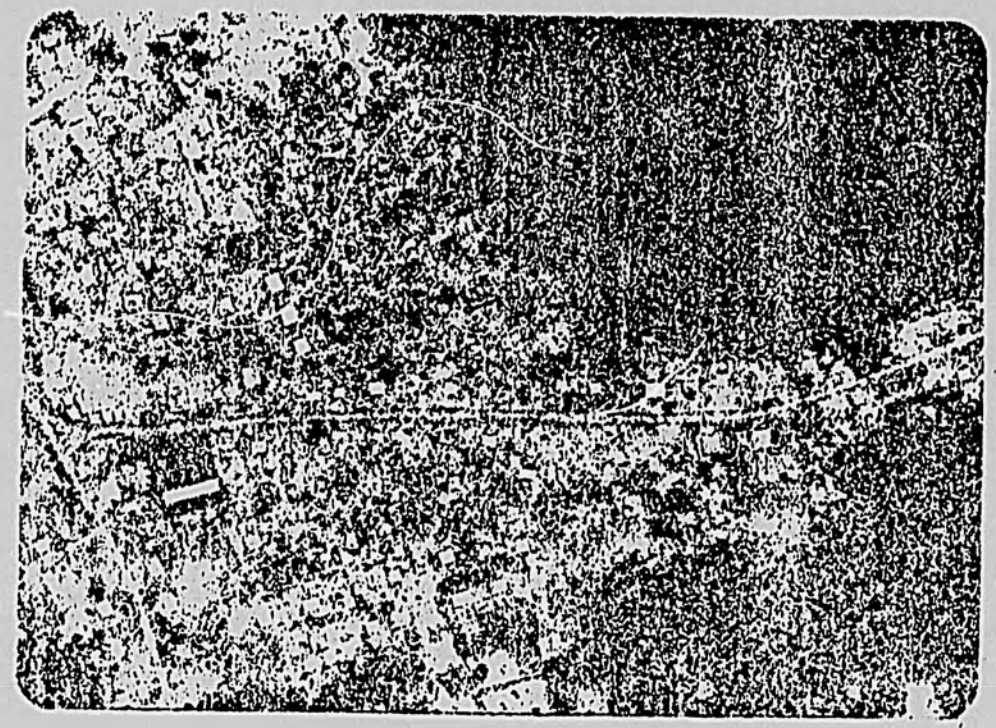


Photo 6

ERTS color vertical of Sola.

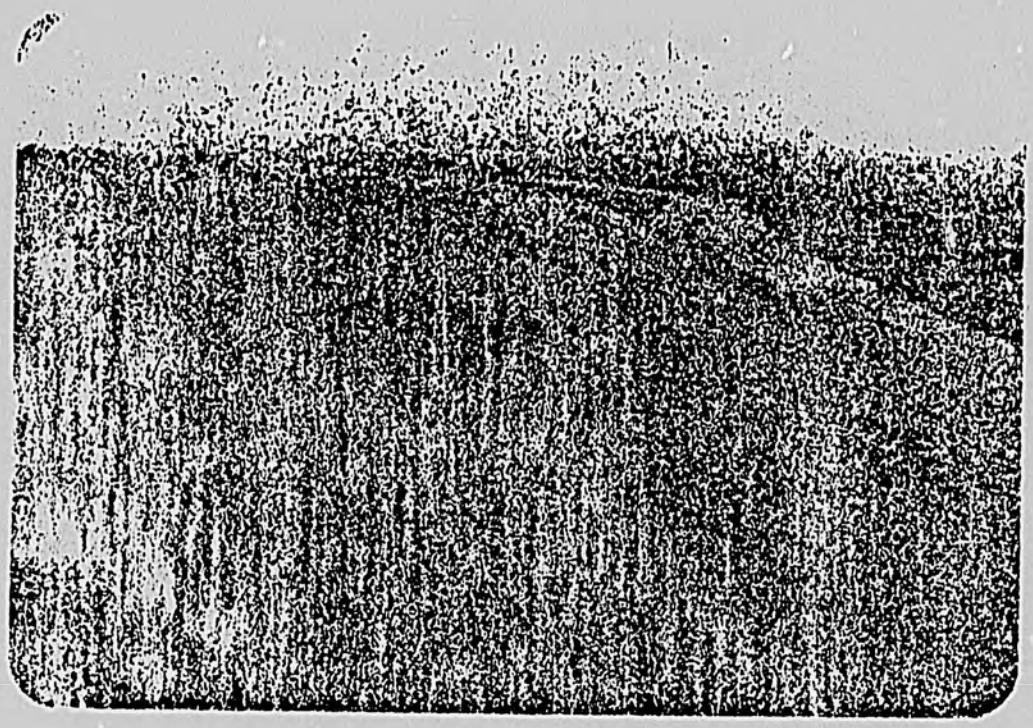


Photo 7

ERTS color oblique of Zaire River near Kongolo.

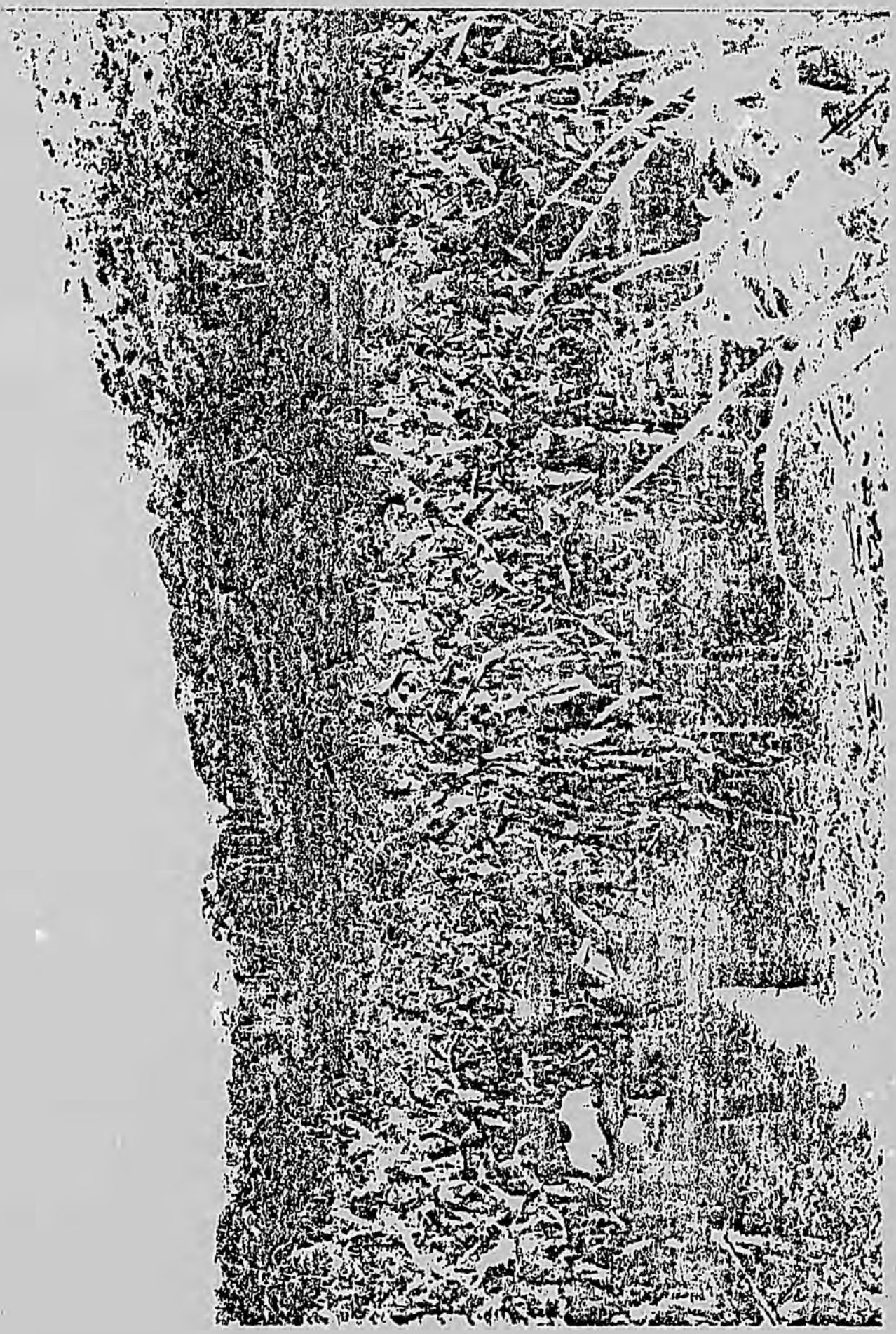
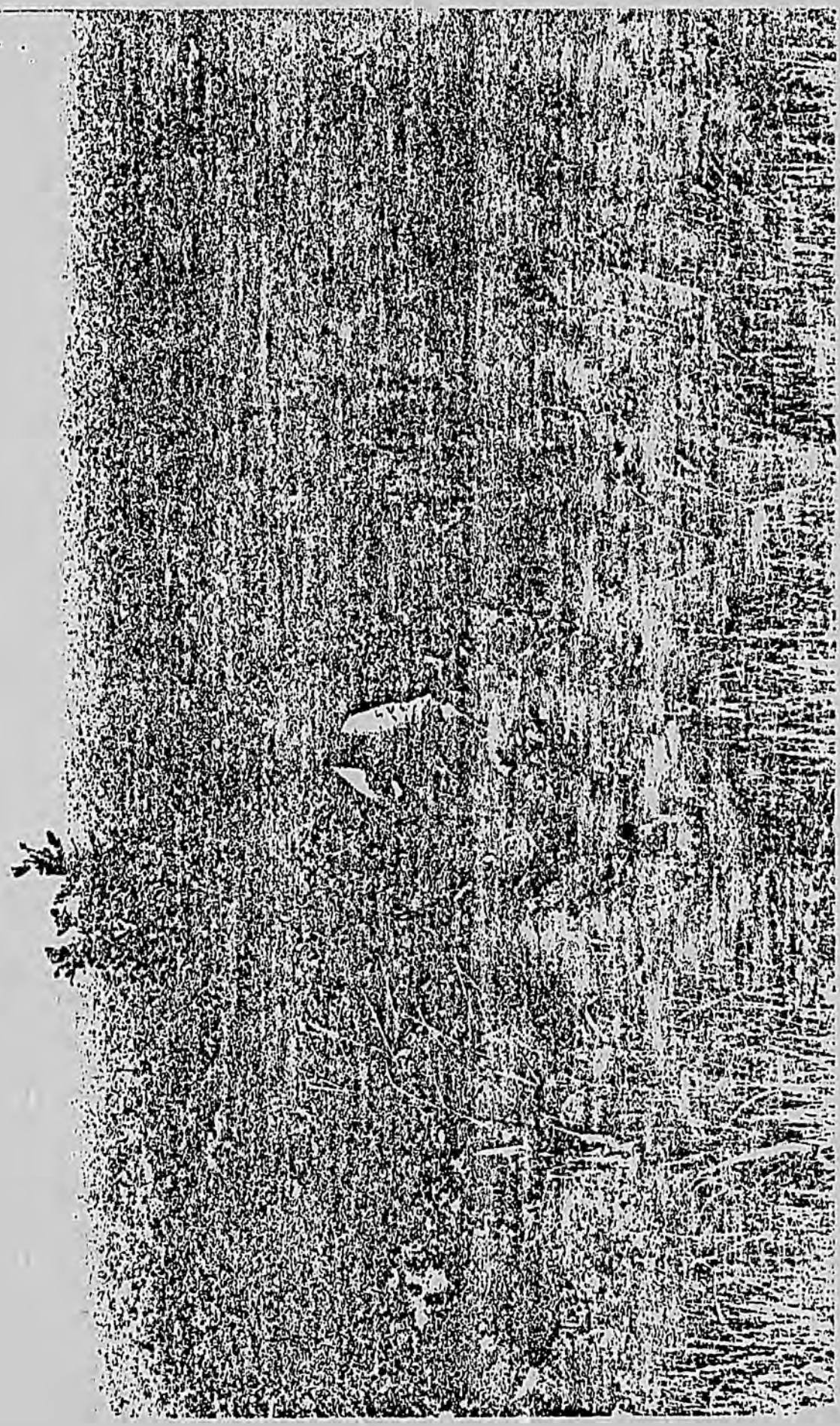


Photo 8

Ground photograph of cornfiel in savane boisee biome.



oto 9

Ground photograph of savana arbustive.

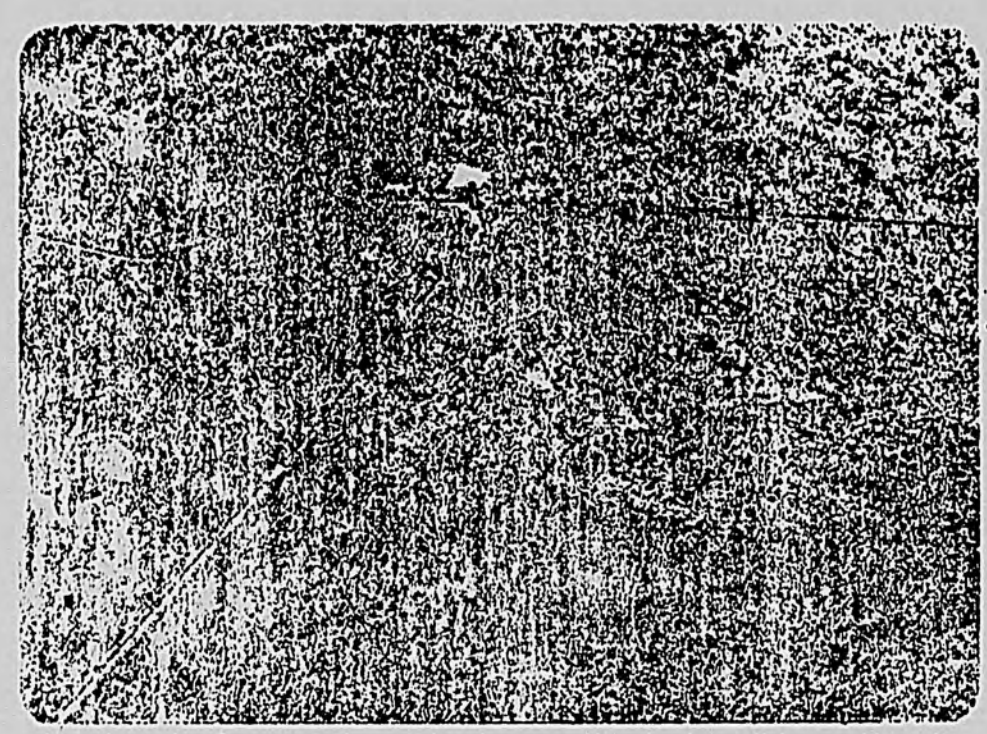


Photo 10

ERTS color oblique of agricultural plots at Mukundi (29G).

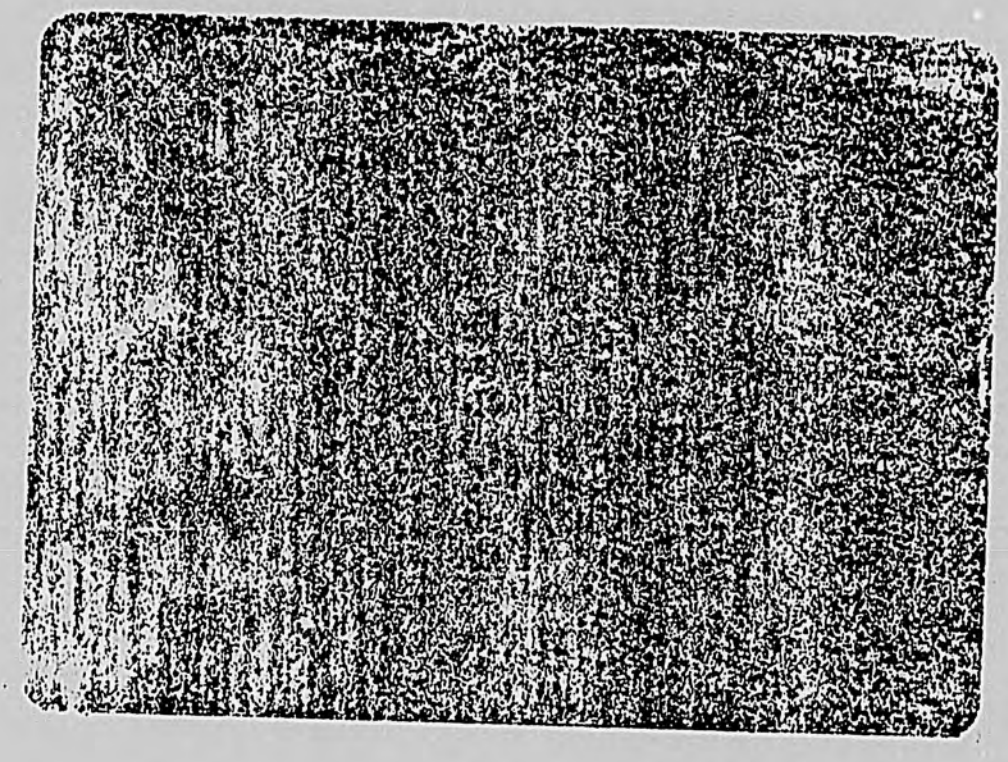


Photo 11

ERTS color oblique of agricultural plot 5 kilometers west of Koswe (31G).

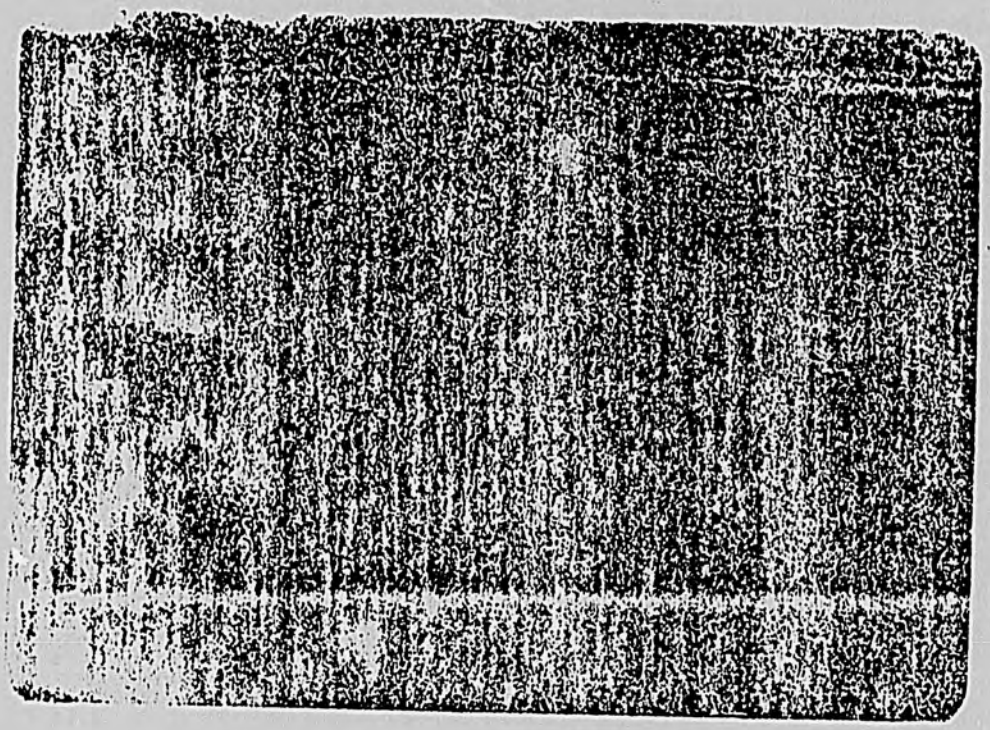


Photo 12

ERTS color oblique of agricultural zone near Lengwe (27G).

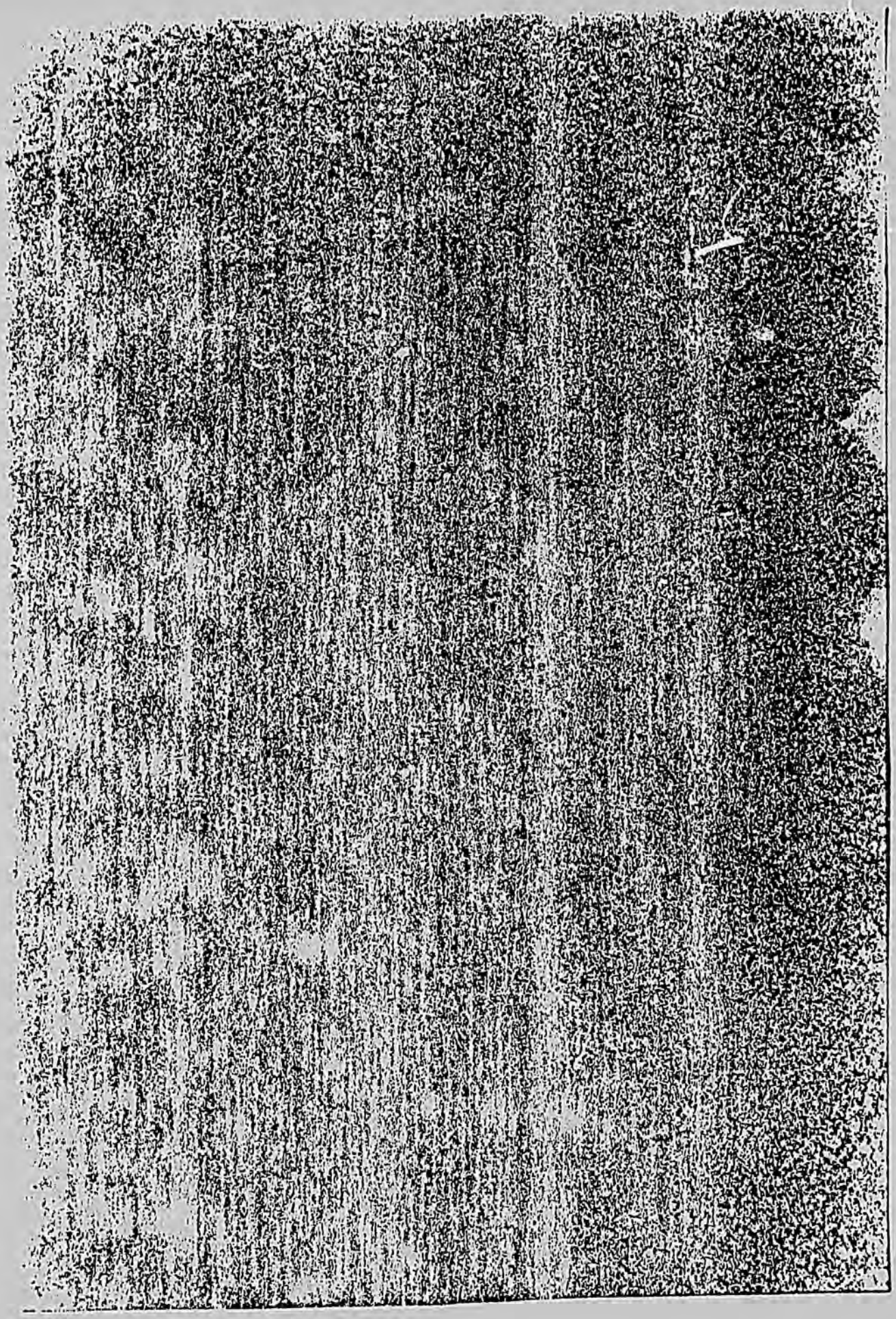
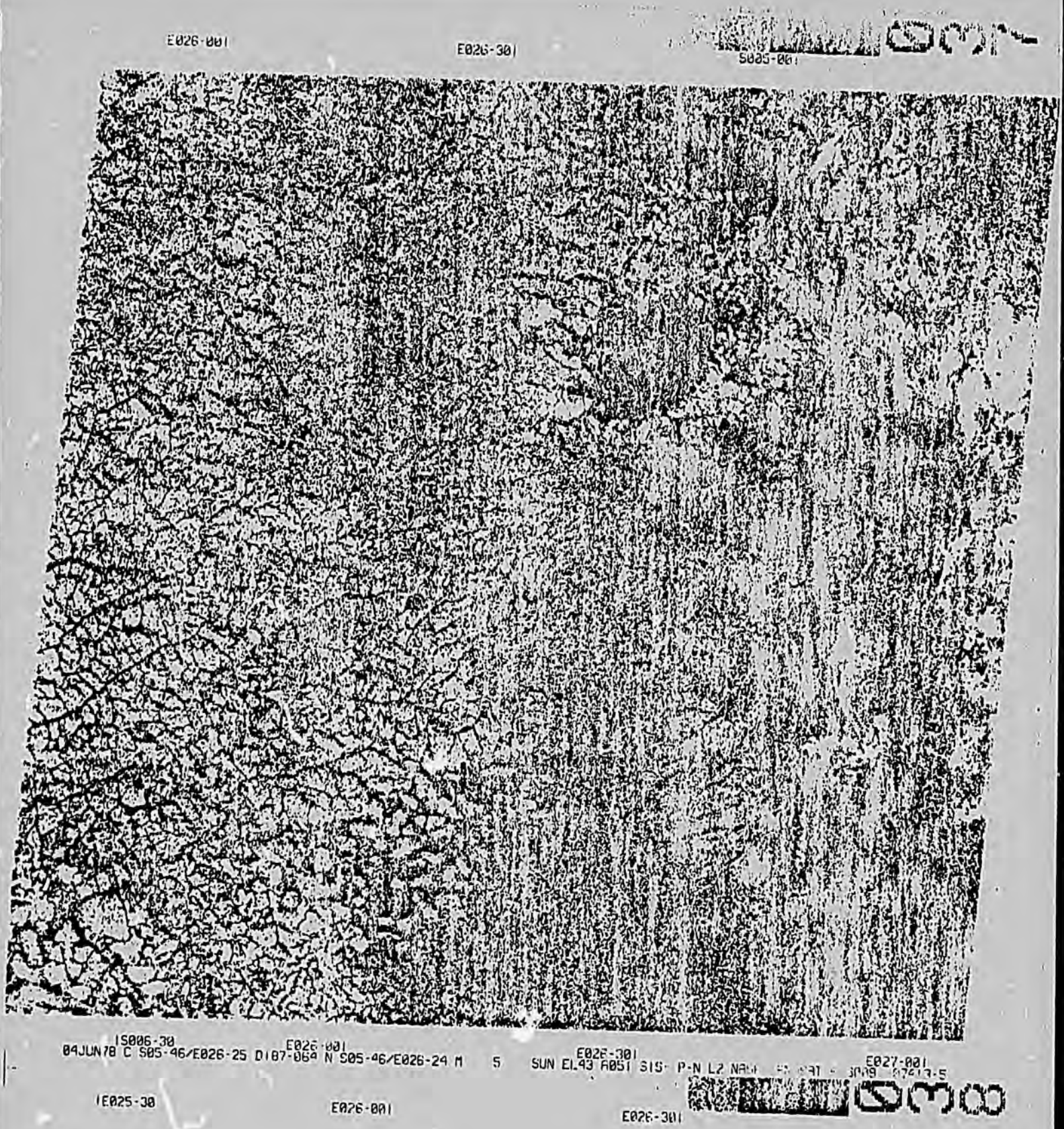


Photo 13

ERTS black and white vertical, showing agriculture near Kayi (R7, #20).



oto 15

Landsat, MSS, 1978, 1:100,000 scale. Kongolo and Sentery (Lubunda scene)

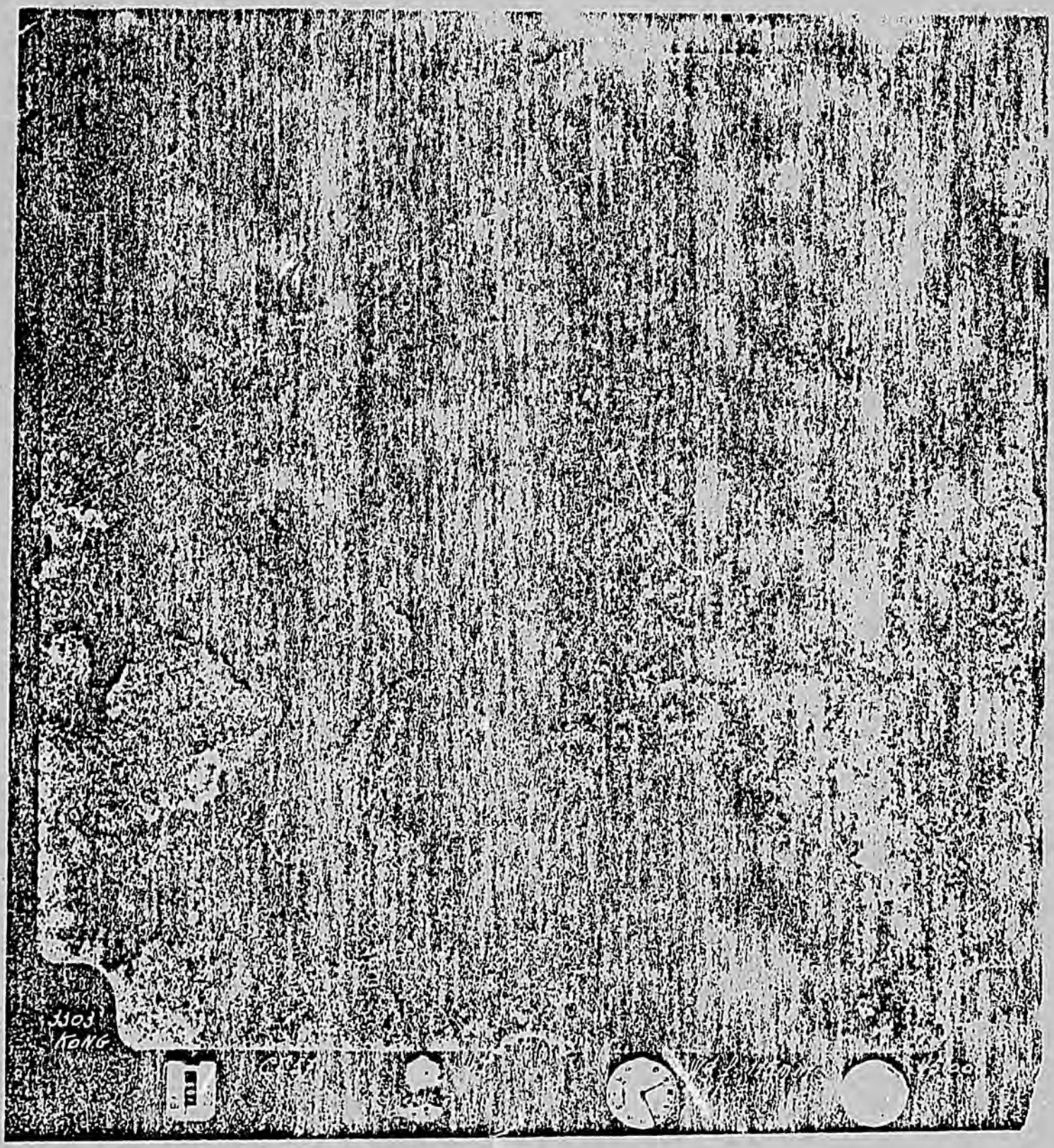
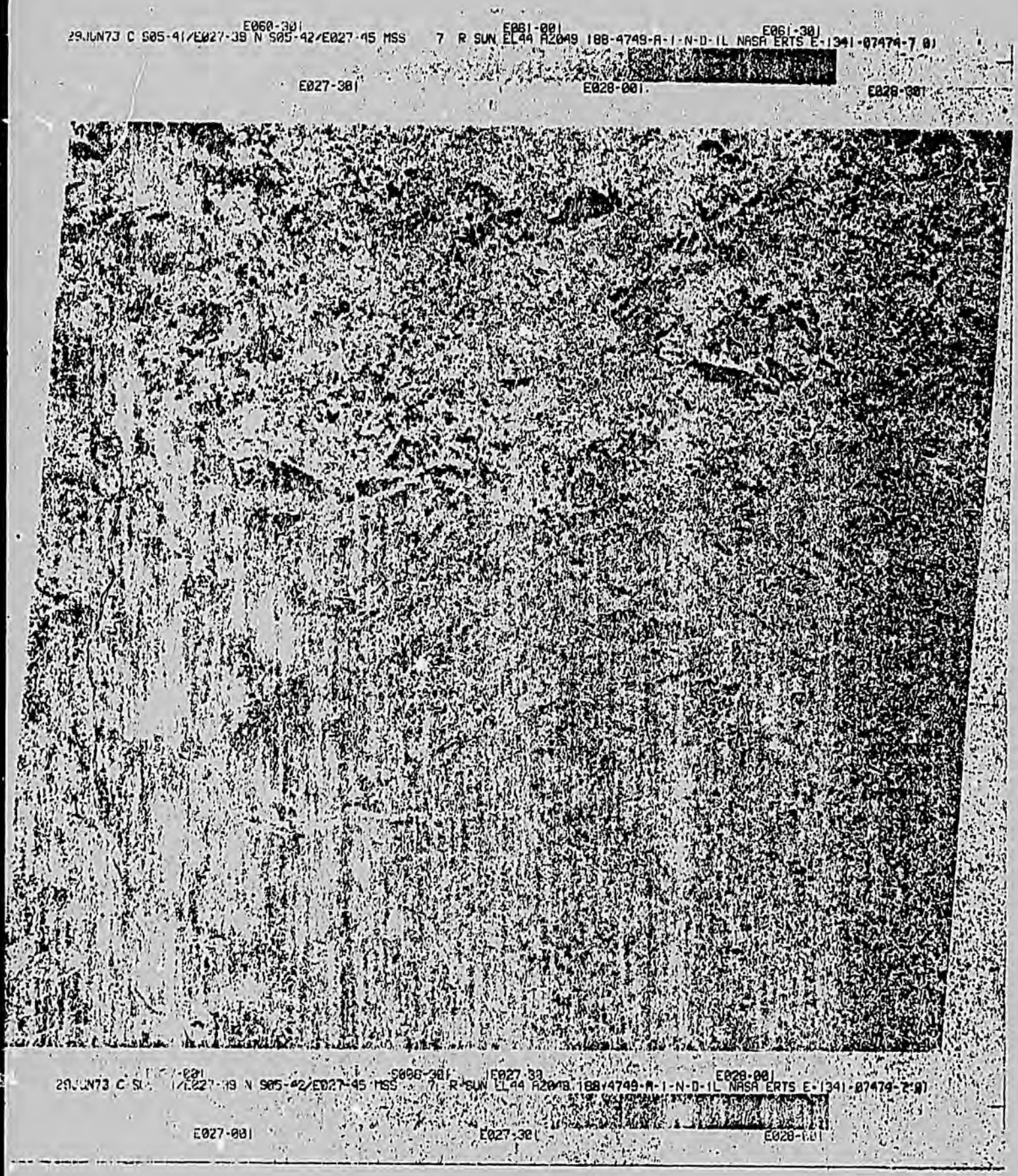


Photo 16

IGZ photo of Nyunzu agriculture and deforestation areas



to 14

Landsat, MSS, 1973, 1:1,000,000 scale. Kongolo and Nyunzu (Kongolo scene)

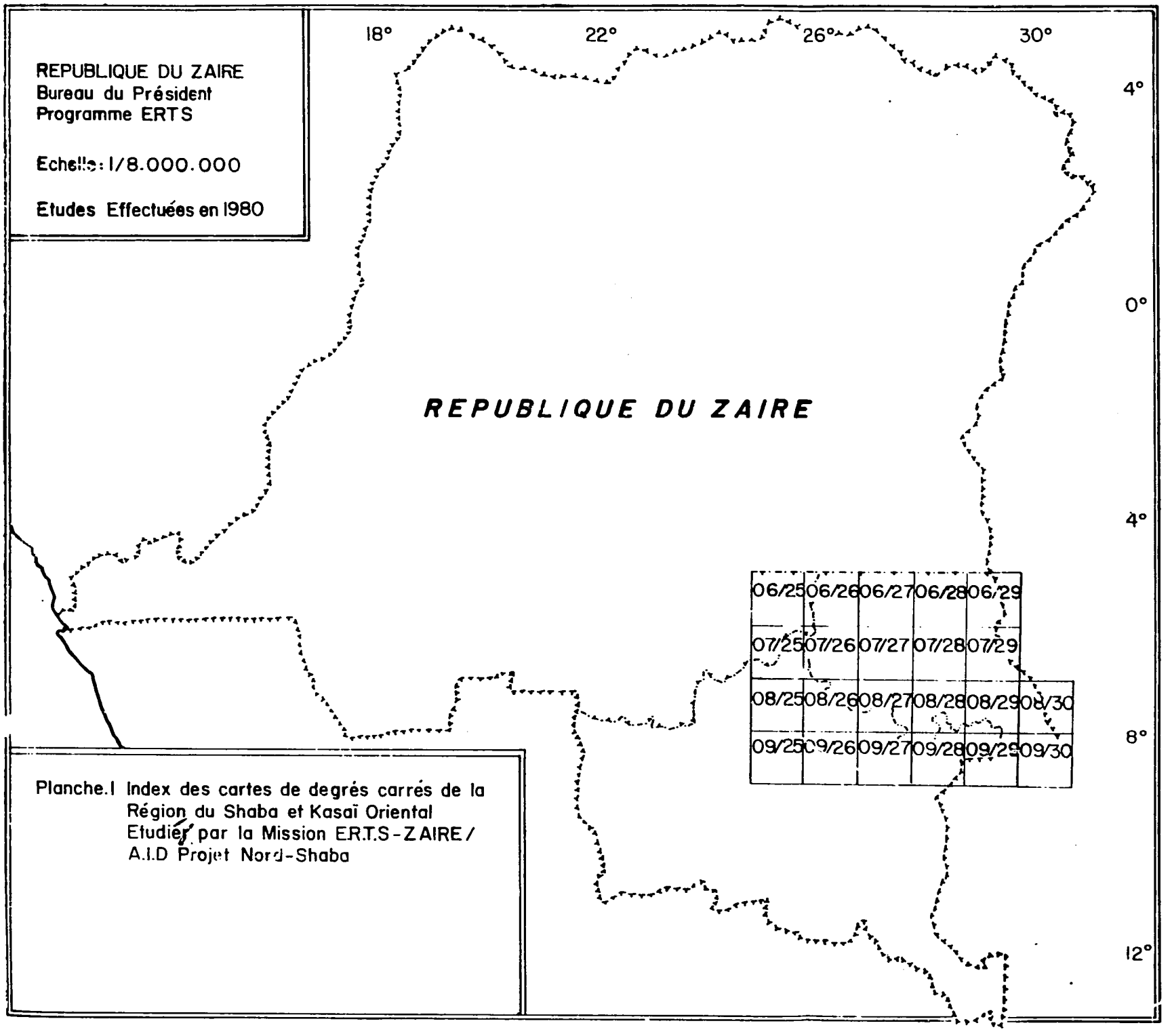
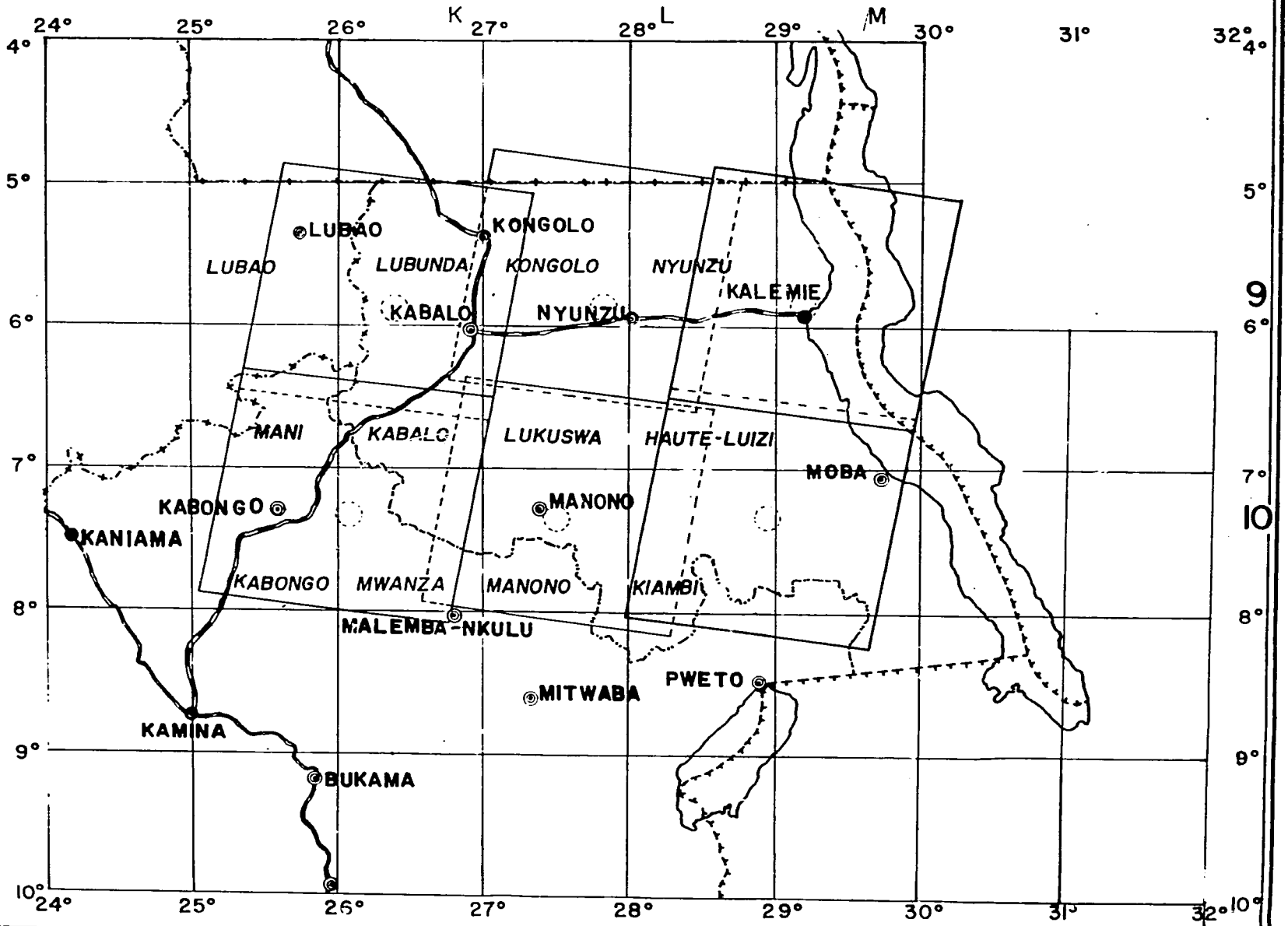
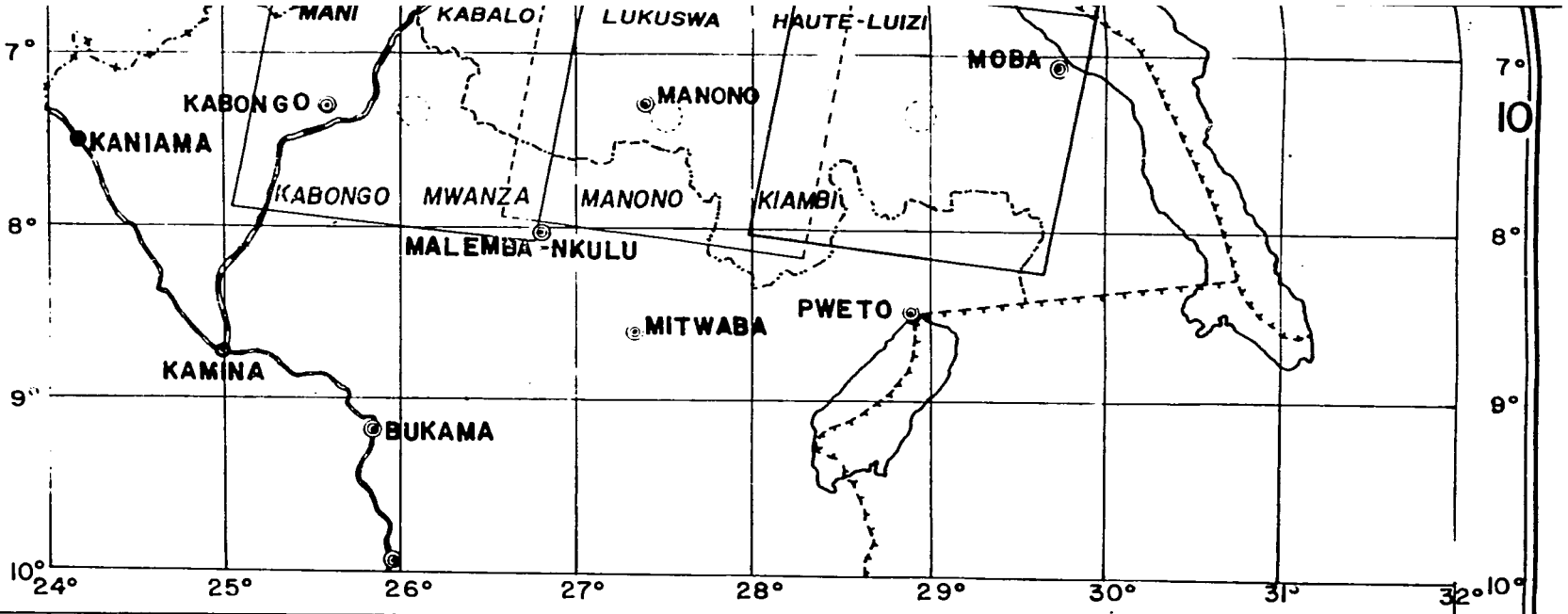


Planche.I Index des cartes de degrés carrés de la Région du Shaba et Kasaï Oriental Etudiés par la Mission E.R.T.S-ZAIRE/ A.I.D Projet Nord-Shaba

Planche.2 Index de la couverture Landsat



REPUBLIQUE DU ZAIRE Bureau du Président Programme ERTS	Index de la couverture Landsat pour le Projet ERTS-ZAIRE/AID Nord-Shaba			
	Index ERTS	Degrés Carrés	Images Landsat	
			Dates	I.D



REPUBLIQUE DU ZAIRE
Bureau du Président
Programme ERTS

Echelle: 1/3000.000

Etudes Effectuees en 1980

LEGENDE

Centre d'Image

Direction des Orbites

K-9 Coordonnés d'Images

Centre de Zone

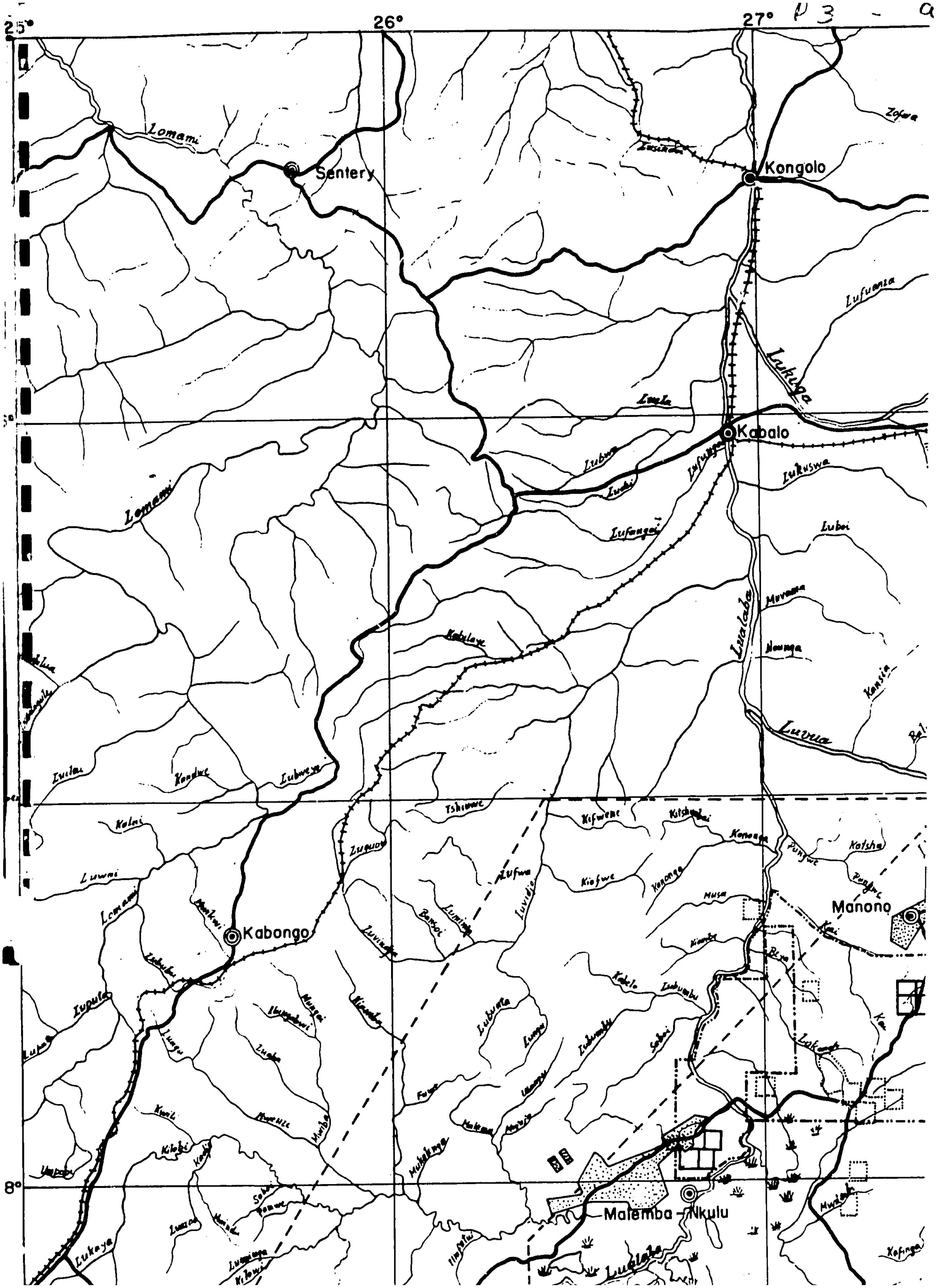
MANI Degré Carré

Index de la couverture Landsat pour le Projet ERTS-ZAIRE/AID Nord-Shaba

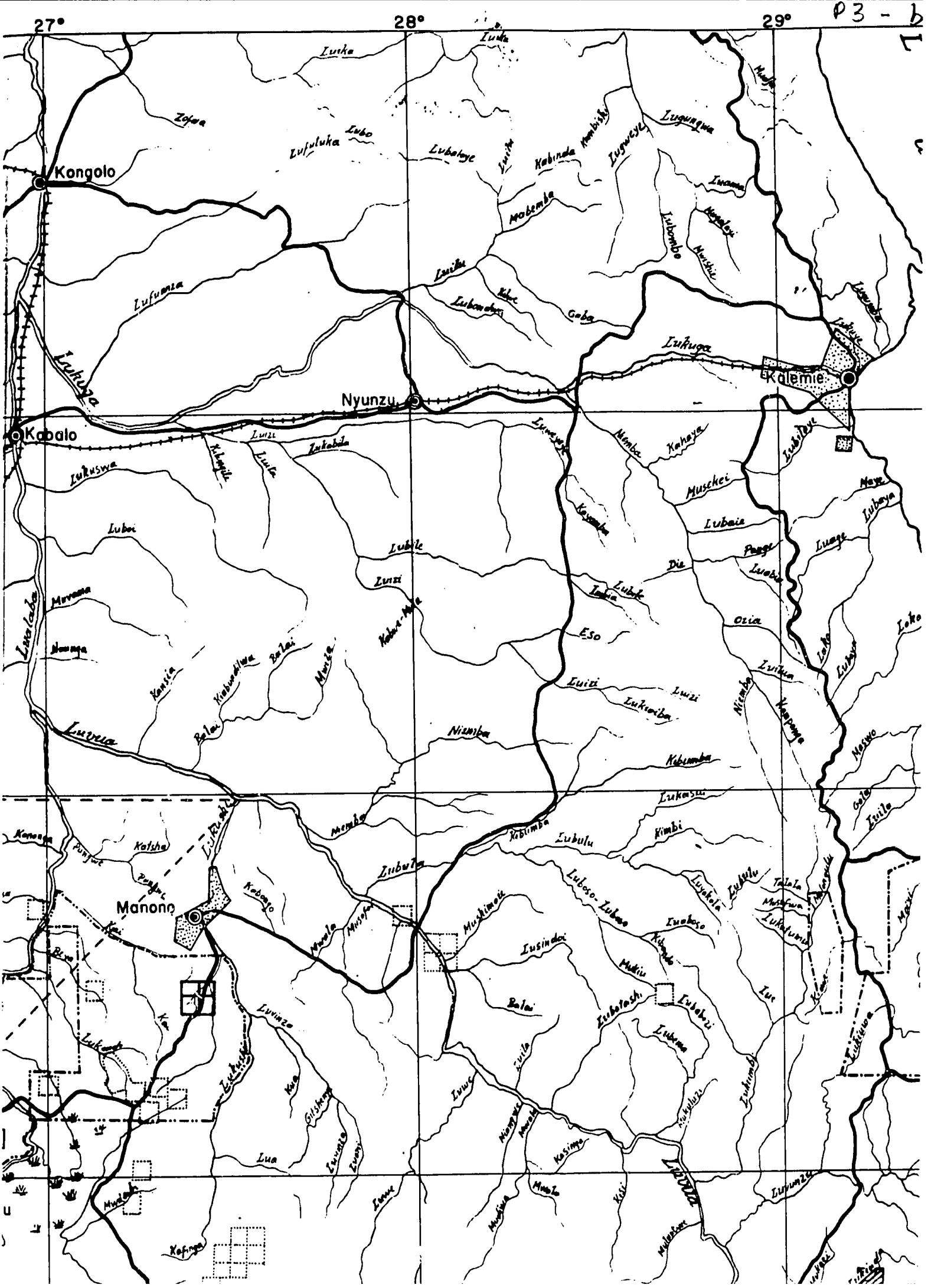
Index ERTS	Degrés Carrés		Images Landsat	
			Dates	I.D
K-9	Lubunda Kabalo	Mani Lubao	04 Juin 1978	30091-07413
K-10	Kabongo Kabalo	Mwanza Mani	04 Juin 1978	30091-07415
L-9	Haute-Luizi Lukuswa	, Kongolo , Nyunzu	29 Juin 1973	1341-07474
L-9	"	"	22 Février 1975	2031-07363
L-9	"	"	09 Juillet 1978	30126-07361
L-10	Manono, Kiambi, Lukuswa Haute-Luizi,	Mwanza	14 Septembre 1972	1053-07474
L-10	"	"	09 Juillet 1978	30126-07364
M-9	Kalemie Mpala	Haute-Luizi Nyunzu	13 Septembre 1972	1052-07413
M-10	Kiambi Haute-Luizi,	Moba Mpalo	13 Septembre 1972	1052-07420

P 2 - b

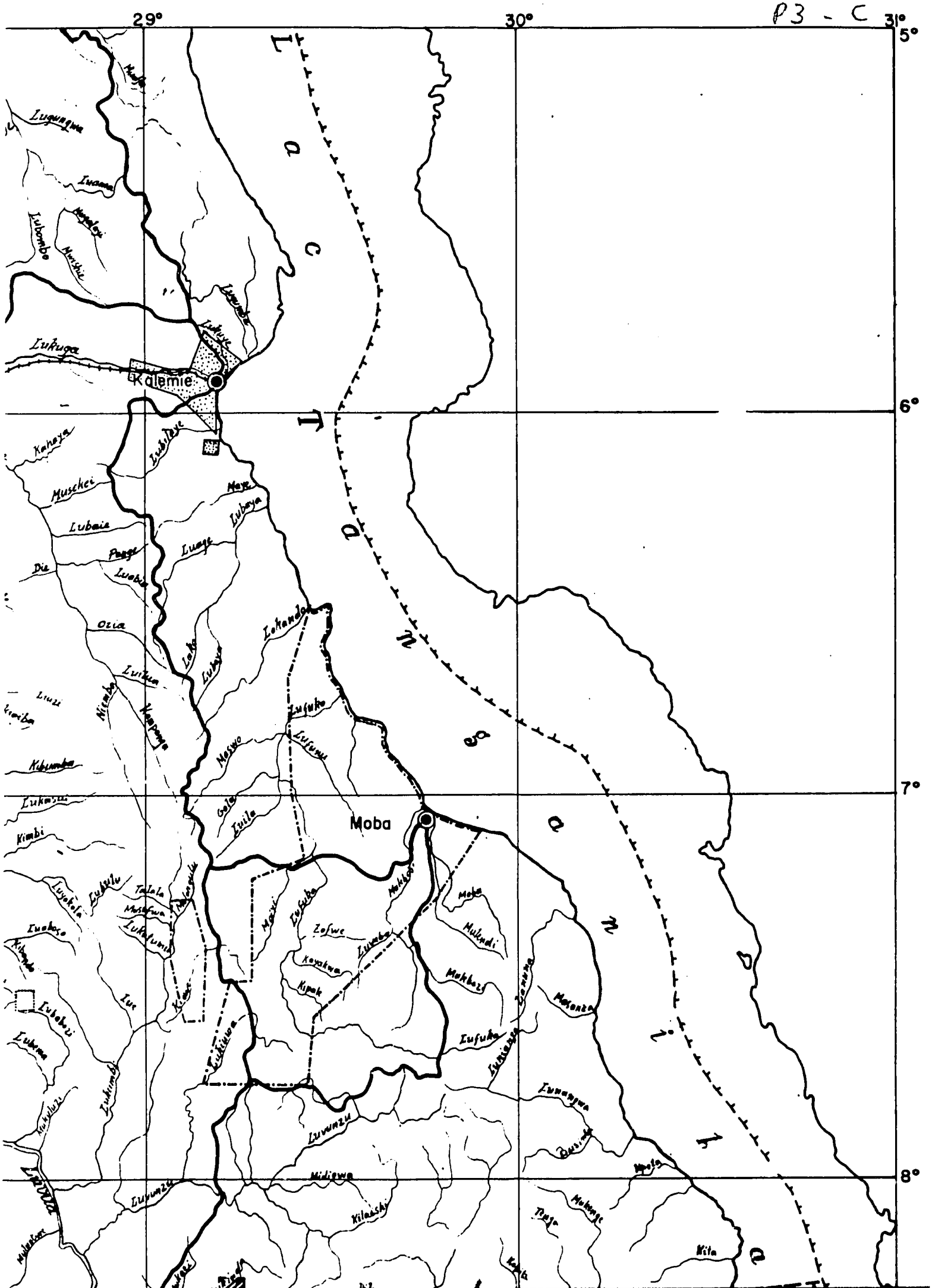
P 3 - a

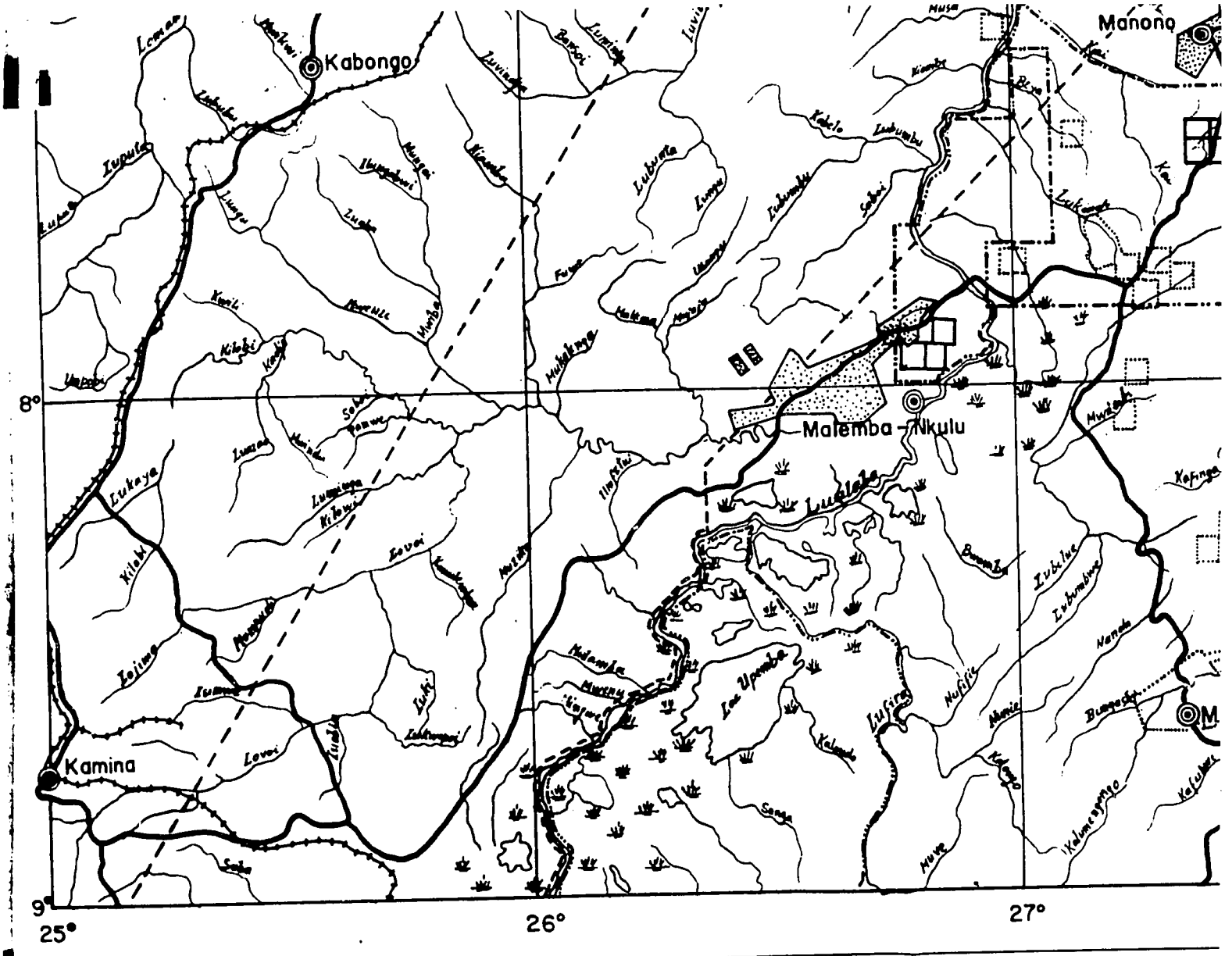


25°
26°
27°
8°
Sentery
Kongolo
Kabalo
Kabongo
Manono
Malemba - Nkulu
Lomami
Lukuga
Lualaba
Luvua
Lufuanza
Lukuswa
Lubwe


27°
28°
29°
Kongolo
Nyunzu
Kabalo
Kalemie
Manono
Lukuga
Lufumza
Zofwa
Lufuluka
Lubo
Lubalaye
Kabinda
Mombiski
Lugungwa
Lugwuyu
Lwama
Mabemba
Lubombo
Mwashi
Luvuba
Luikilu
Lubamba
Goba
Lukuga
Luvuba
Lukuswa
Lubai
Lubile
Luzi
Kabwe-Mwa
Mwana
Kansia
Kibwadiwa
Balai
Muriza
Luvuza
Nzimba
Kabumba
Luvuza
Mwana
Punjwe
Katsha
Luvuba
Kabango
Mwola
Musofe
Mushimoi
Luboso-Lubaa
Luvakala
Lukulu
Lusindoi
Balai
Luvinza
Luvuba
Lua
Kofinga
Luvuzu
Kasimba
Kisi
Mulaster
Luvuzu
Lukuga
Mumba
Kahaya
Muschei
Lubaie
Luaga
Luabo
Ozia
Eso
Luizi
Lukuviba
Nzimba
Kapanga
Kabumba
Lukasu
Kimbi
Lubulu
Luboso
Kibondo
Mukiu
Lubobosh
Lubobosi
Luboma
Lukumbi
Kiubyuzu
Luvuzu
Lukuvuwa
Lukuga
Lufuluka
Lubalaye
Kabinda
Mombiski
Lugungwa
Lugwuyu
Mabemba
Lubombo
Mwashi
Luvuba
Lubamba
Goba
Lukuga
Luzi
Zukabila
Lukuswa
Kibwile
Luta
Lubai
Lubile
Luzi
Kabwe-Mwa
Mwana
Kansia
Kibwadiwa
Balai
Muriza
Luvuza
Nzimba
Kabumba
Mumba
Kahaya
Muschei
Lubaie
Luaga
Luabo
Die
Luba
Eso
Ozia
Luikua
Luizi
Lukuviba
Nzimba
Kapanga
Kabumba
Lukasu
Kimbi
Lubulu
Luboso-Lubaa
Luvakala
Lukulu
Lusindoi
Balai
Luvinza
Luvuba
Lua
Kofinga
Luvuzu
Kasimba
Kisi
Mulaster
Luvuzu

P3 - C

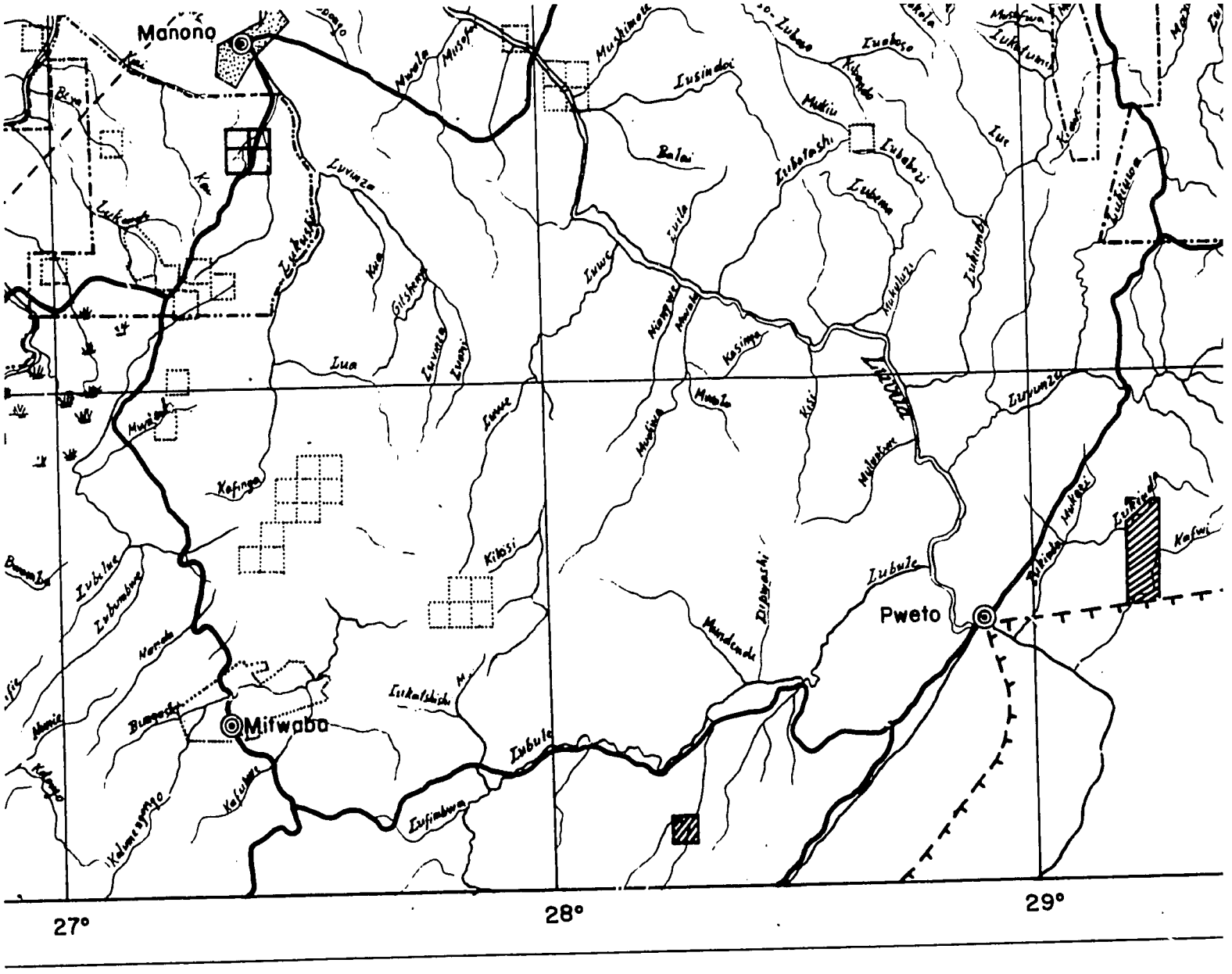

29°
30°
31°
5°
6°
7°
8°
Lac Tanganyika
Kalemie
Moba
Luguungwa
Luvama
Lubombo
Lukuga
Kahaya
Muschei
Lubaie
Die
Ozia
Kibumba
Kimbi
Lukusu
Lukulu
Talala
Luboko
Lubelu
Luba
Lukumbi
Kalulu
Luvunzu
Midiewa
Kilasshi
Kita
Moba
Mukundi
Mokbazi
Masenza
Luvungwa
Lufuko
Lufunu
Lofwe
Kipak
Mokbo
Mokbazi
Luvunzu

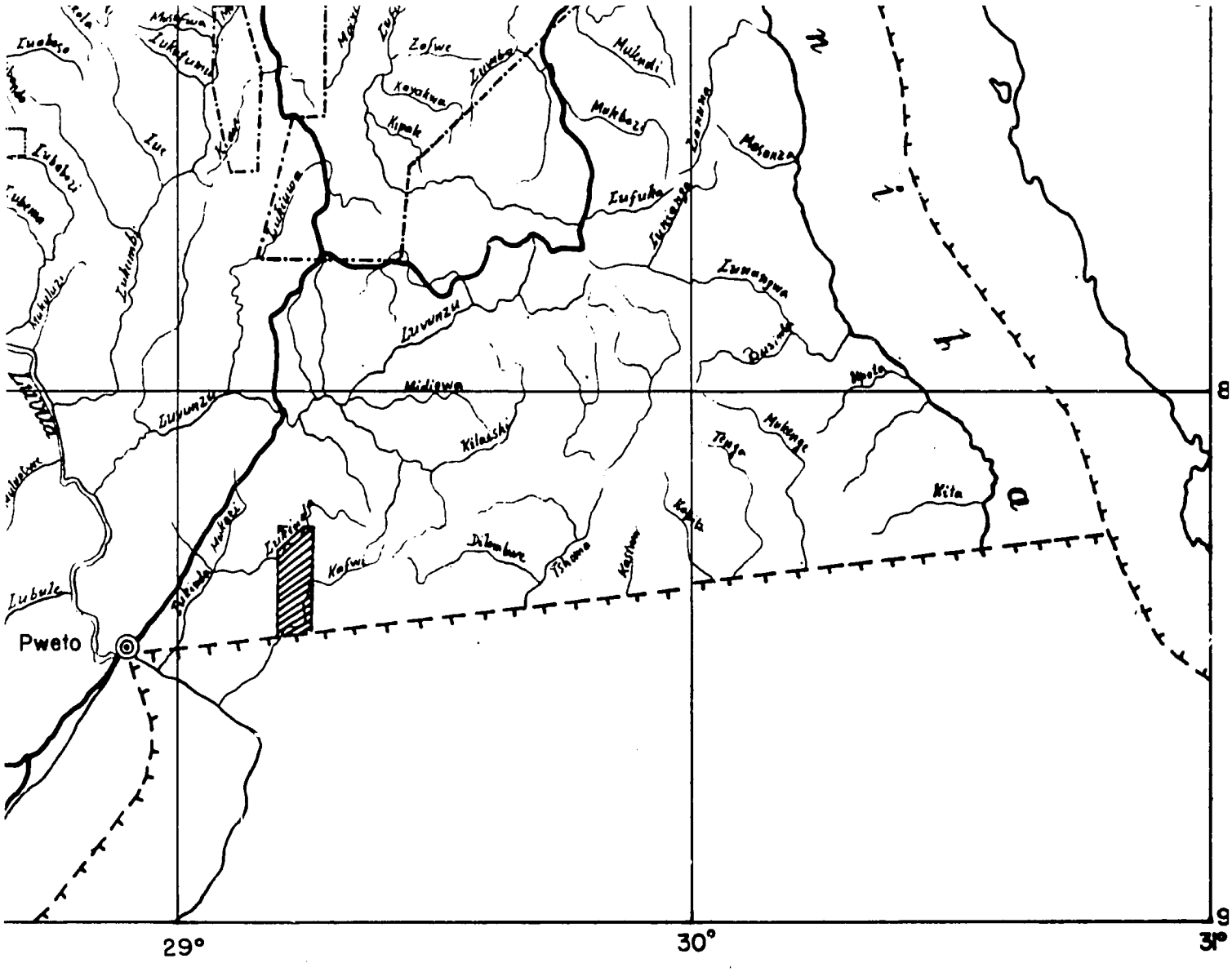


LEGENDE

- Zone R.Z
- SOMIBA
- Z.E.R SEREMI
- Zone D'Etain GECAMINES
- E.M.Za
- S.M.D.G
- SEREMI
- ZAIRE-ETAIN

P 3 - d


Manono
Mitwaba
Pweto
27°
28°
29°

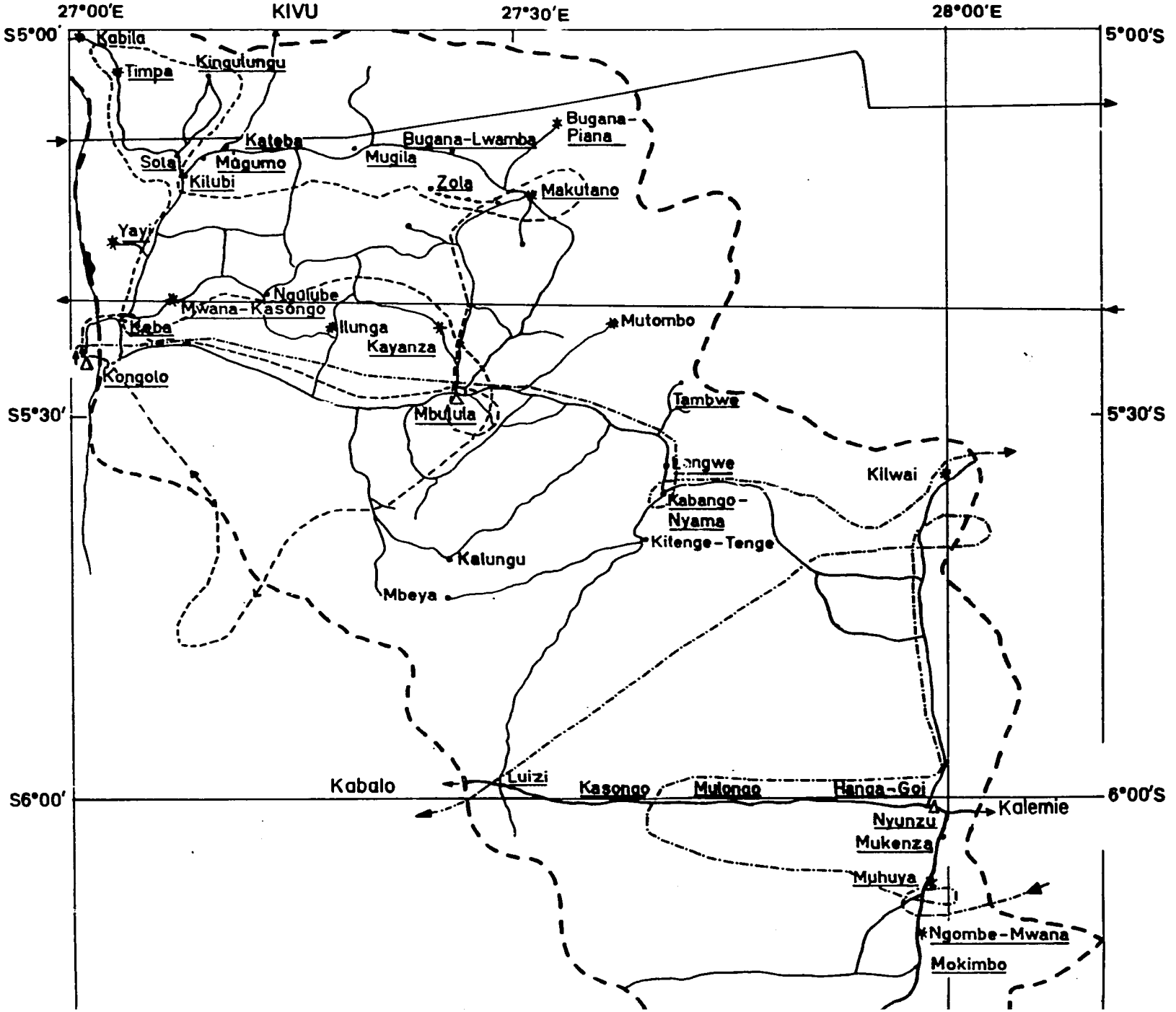


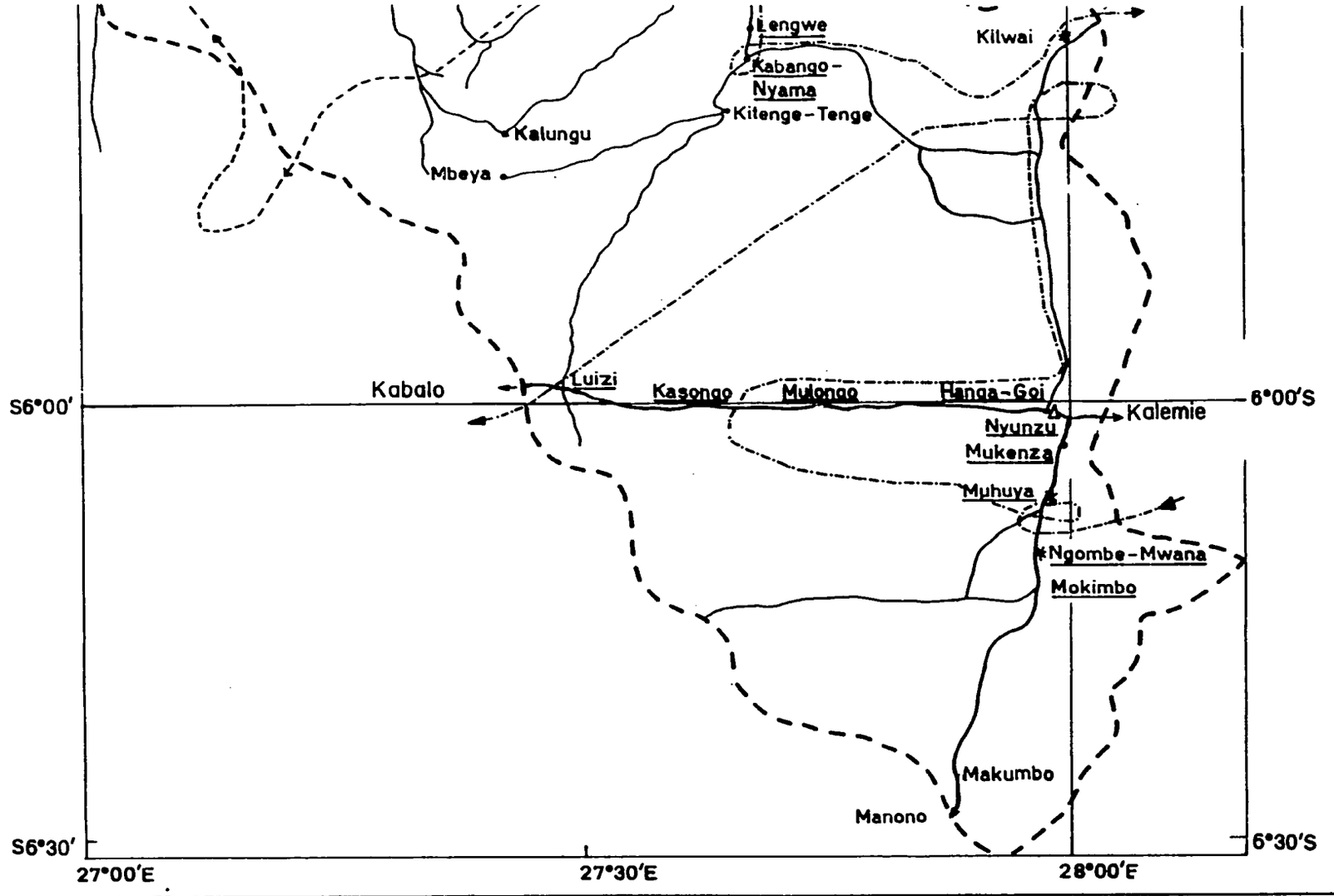
REPUBLIQUE DU ZAIRE
Bureau du Président
Programme ERTS

Echelle : 1/1000.000

Planche: 3 Réproduction d'une partie de la retombe Minière éditée par le Département des Mines le 01-01-1980

P 3 - 4


27°00'E
KIVU
27°30'E
28°00'E
S5°00'
5°00'S
S5°30'
5°30'S
S6°00'
6°00'S
Kabila
Timpa
Kingulungu
Kateba
Bugana-Lwamba
Bugana-Piana
Sola
Mugumo
Kilubi
Mugila
Zola
Makutano
Yayi
Ngulube
Mwana-Kasongo
Kaba
Ilunga
Kayanza
Mutombo
Kongolo
Mbulula
Tambwe
Kilwai
Kabango-Nyama
Kitenge-Tenge
Kalungu
Mbeya
Kabalo
Luizi
Kasongo
Mulongo
Hanga-Goi
Kalemie
Nyunzu
Mukenza
Muhuya
Ngombe-Mwana
Mokimbo



LEGENDE

△ Secteur Projet Nord Shaba

✳ Centres Agricoles

Luizi Villages Visités

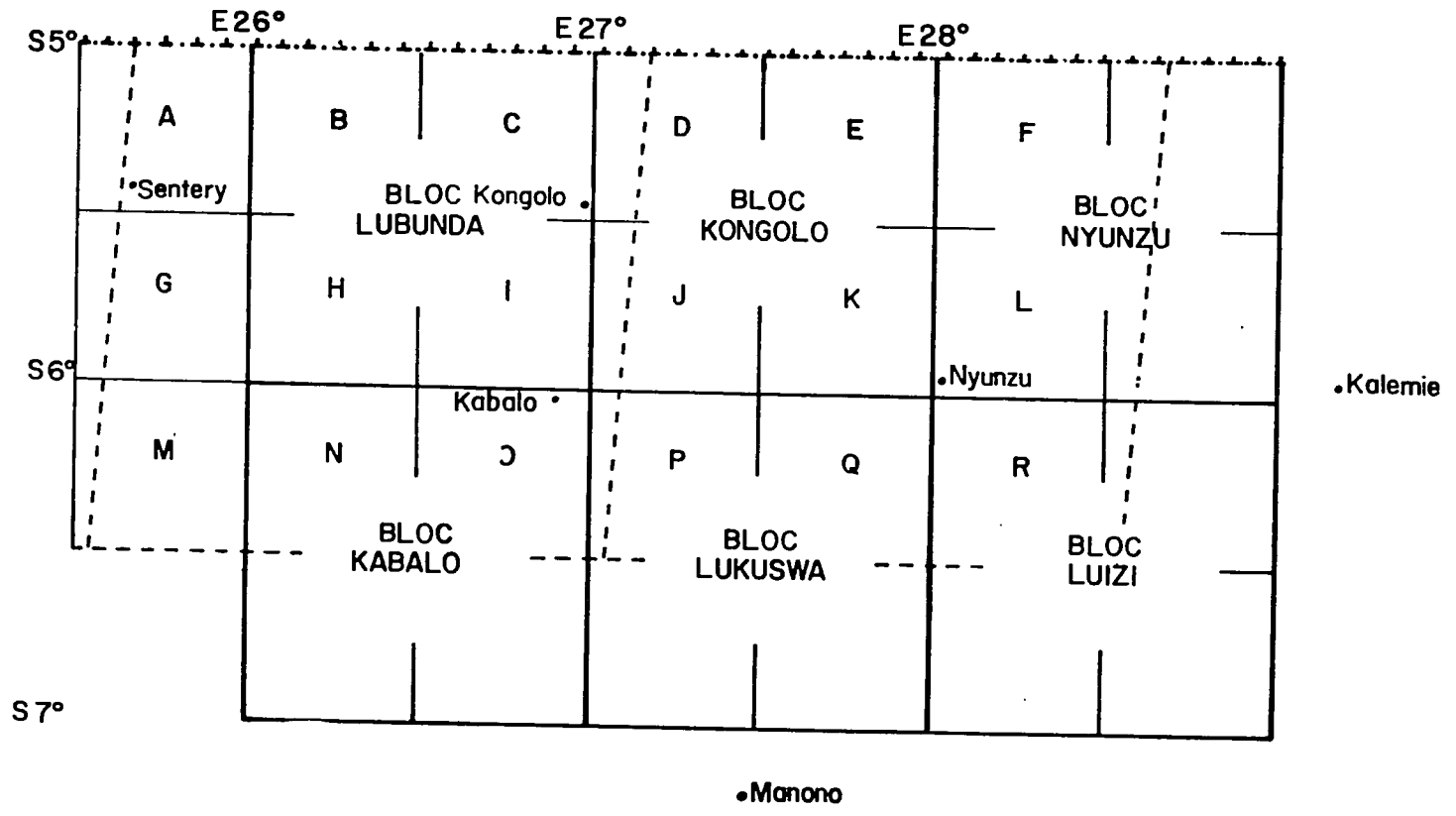
—— Sortie 1
----- Sortie 2
-·-·- Sortie 3

CARTE DES VILLAGES PROSPECTES EN VUE D'ELABORER LES STATISTIQUES AGRICOLES

Echèlle: 1/550.000

PLANCHE 4

INDEX de Feuille pour chaque 1/4 de degrés carrés

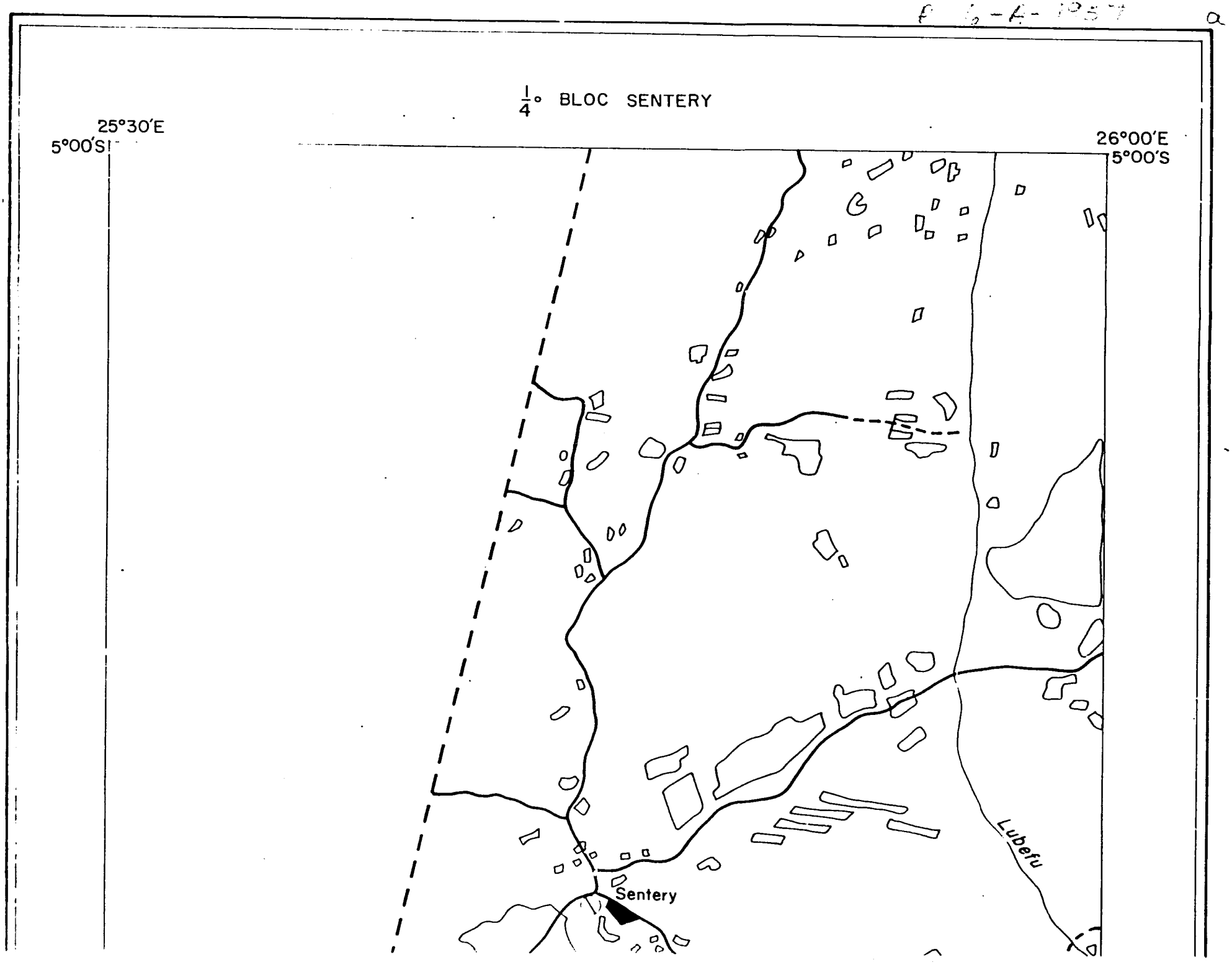


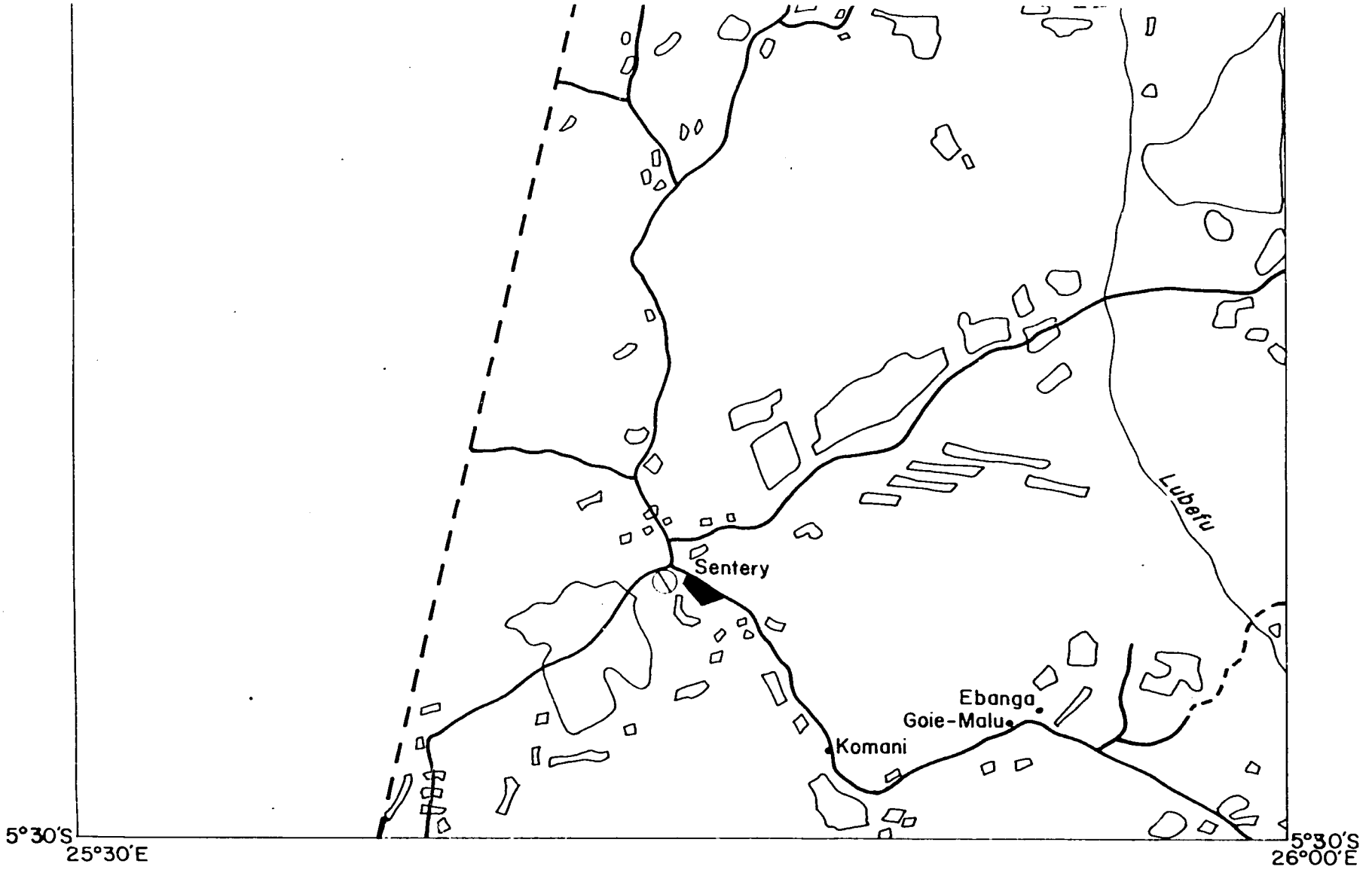
- - - - - Scène Landsat

Echelle: 1/2.000.000

0 20 40 60 80 100 Km

PLANCHE 5


1/4° BLOC SENTERY
25°30'E
5°00'S
26°00'E
5°00'S
Sentery
Lubefu



CARTE D'UTILISATION AGRICOLE DES TERRES

1957

Superficie : 15150 Has

Echèlle : 1/200.000

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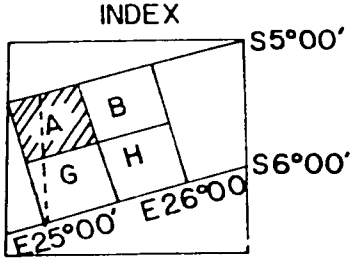
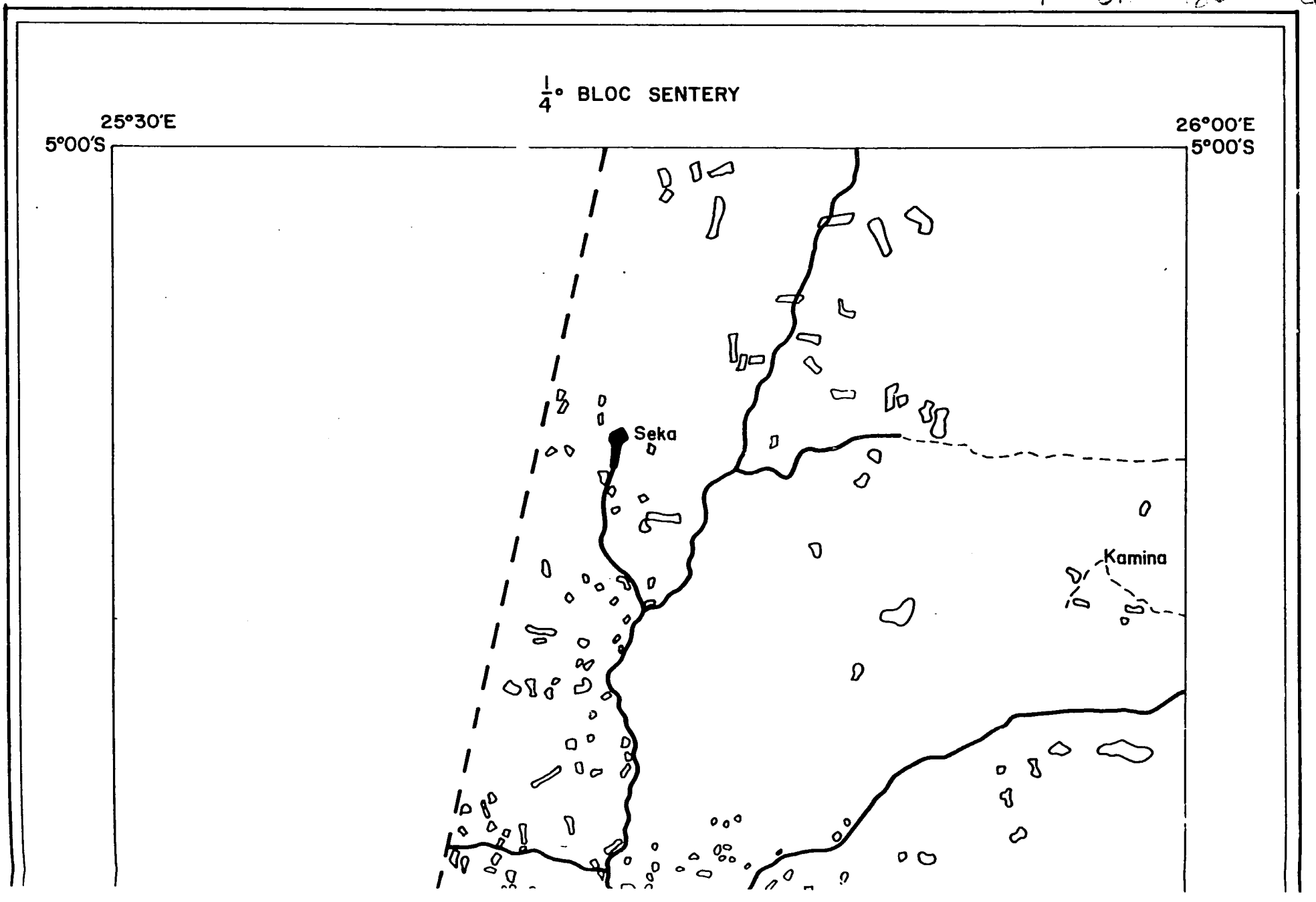
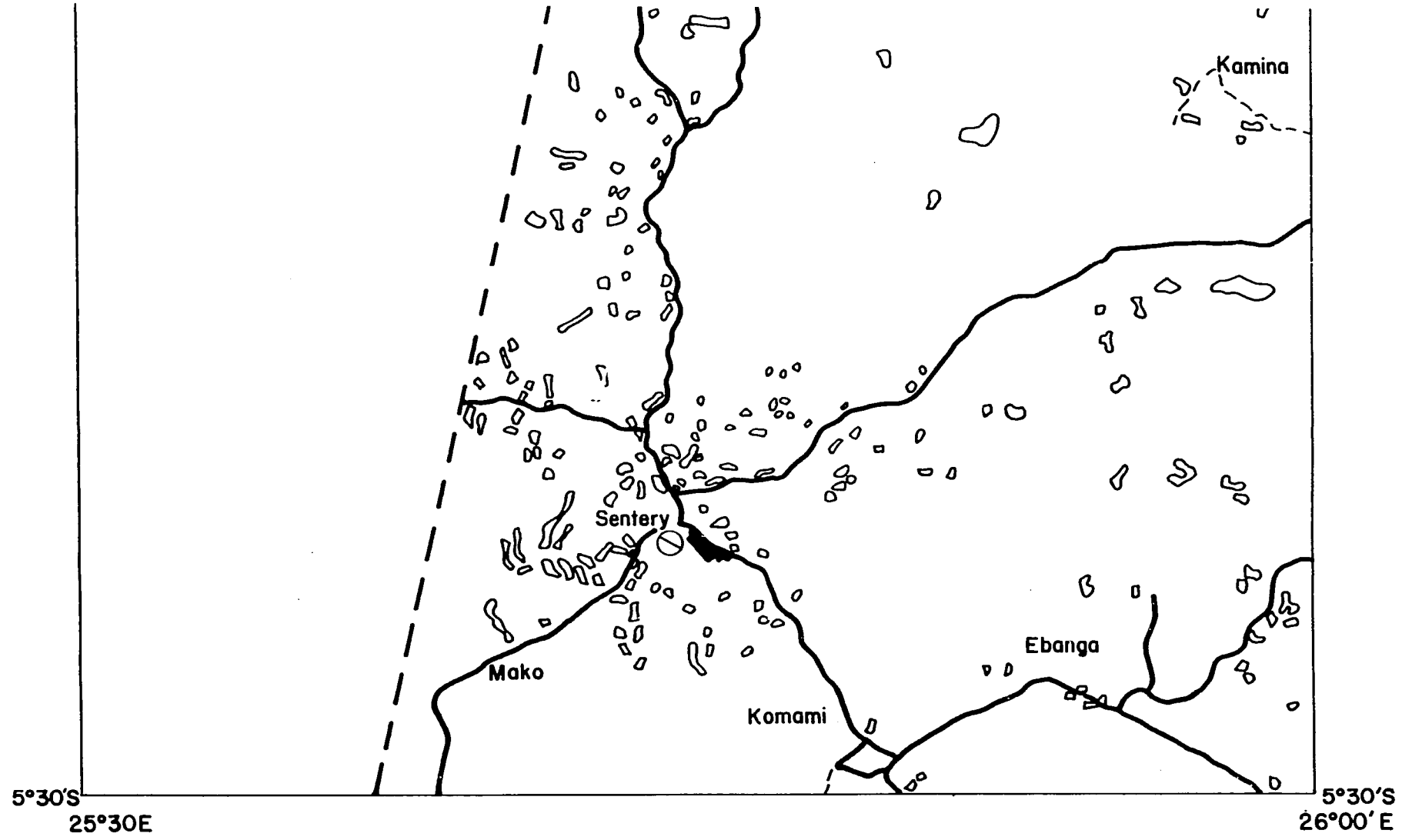


PLANCHE 6-A-1957

b

P 6A-1980 a





CARTE D'UTILISATION AGRICOLE DES TERRES

1980

Superficie Cultuvée :

Echelle: 1/200.000

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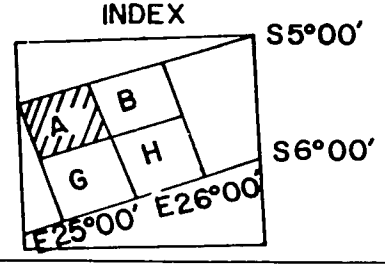
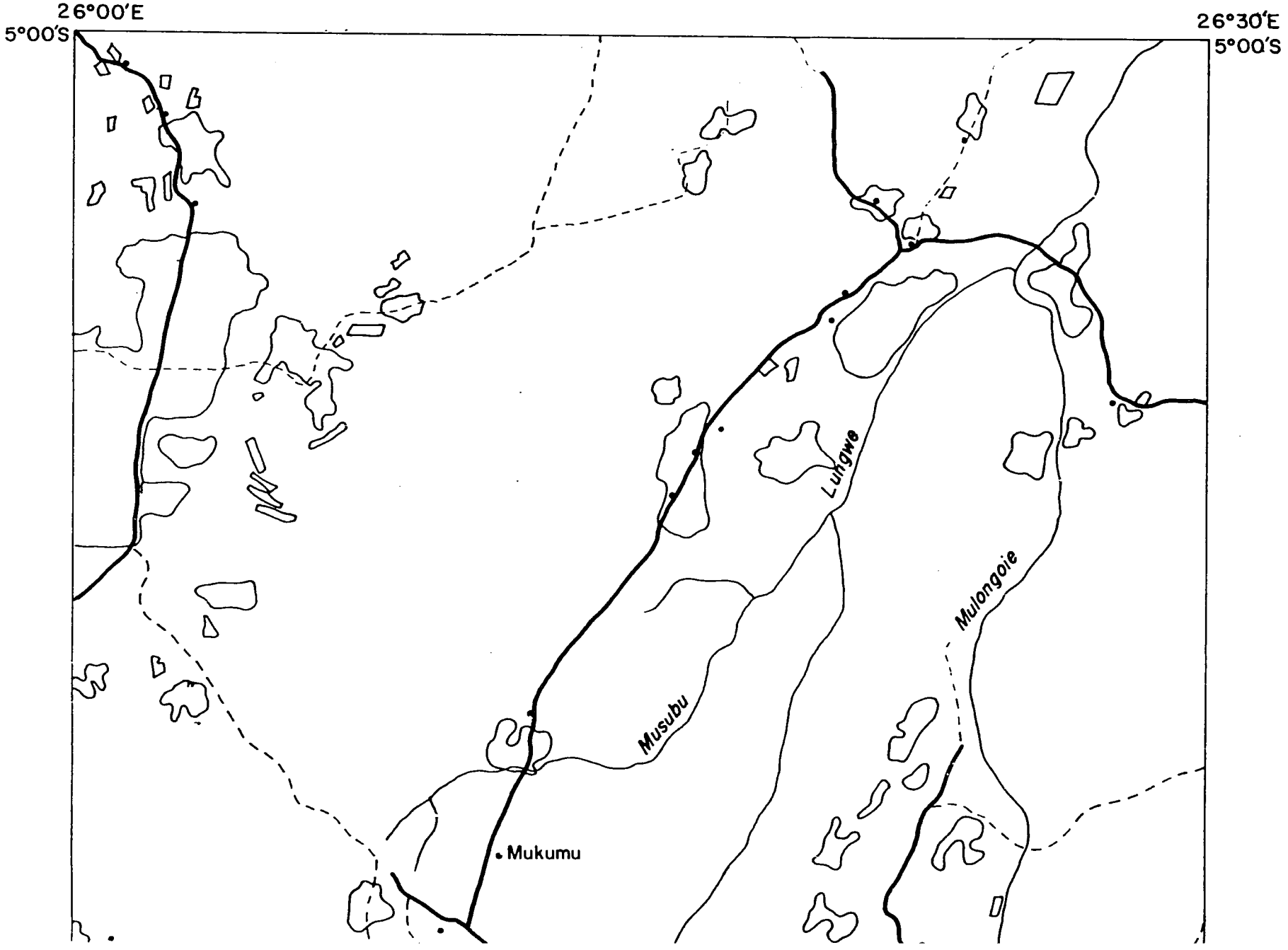
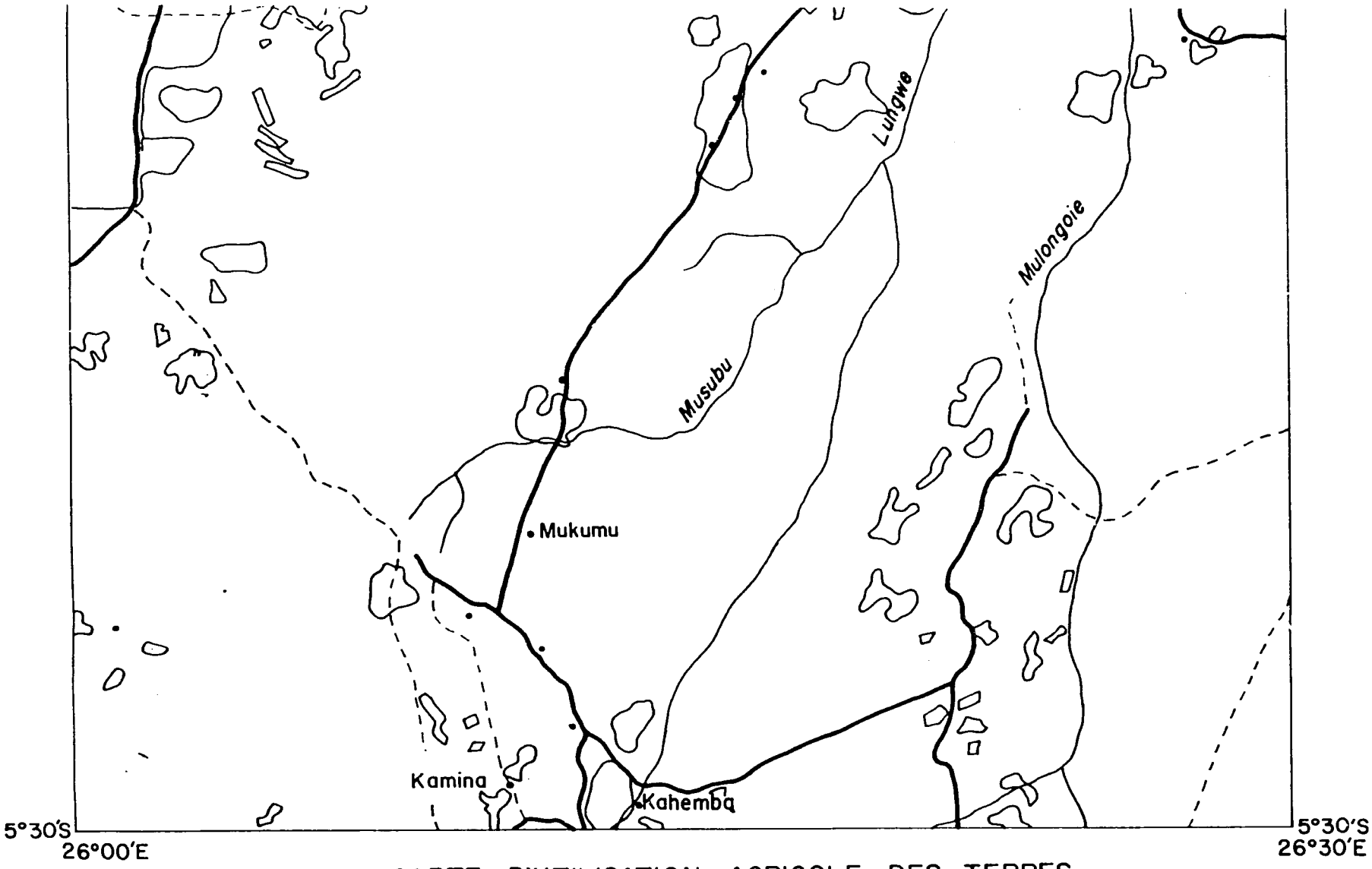


PLANCHE 6A - 1980

P 6-8-1957 2

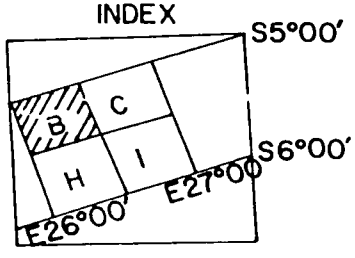
$\frac{1}{4}$° BLOC KAMINA





CARTE D'UTILISATION AGRICOLE DES TERRES

1957



Superficie Cultuvée 19825 Has

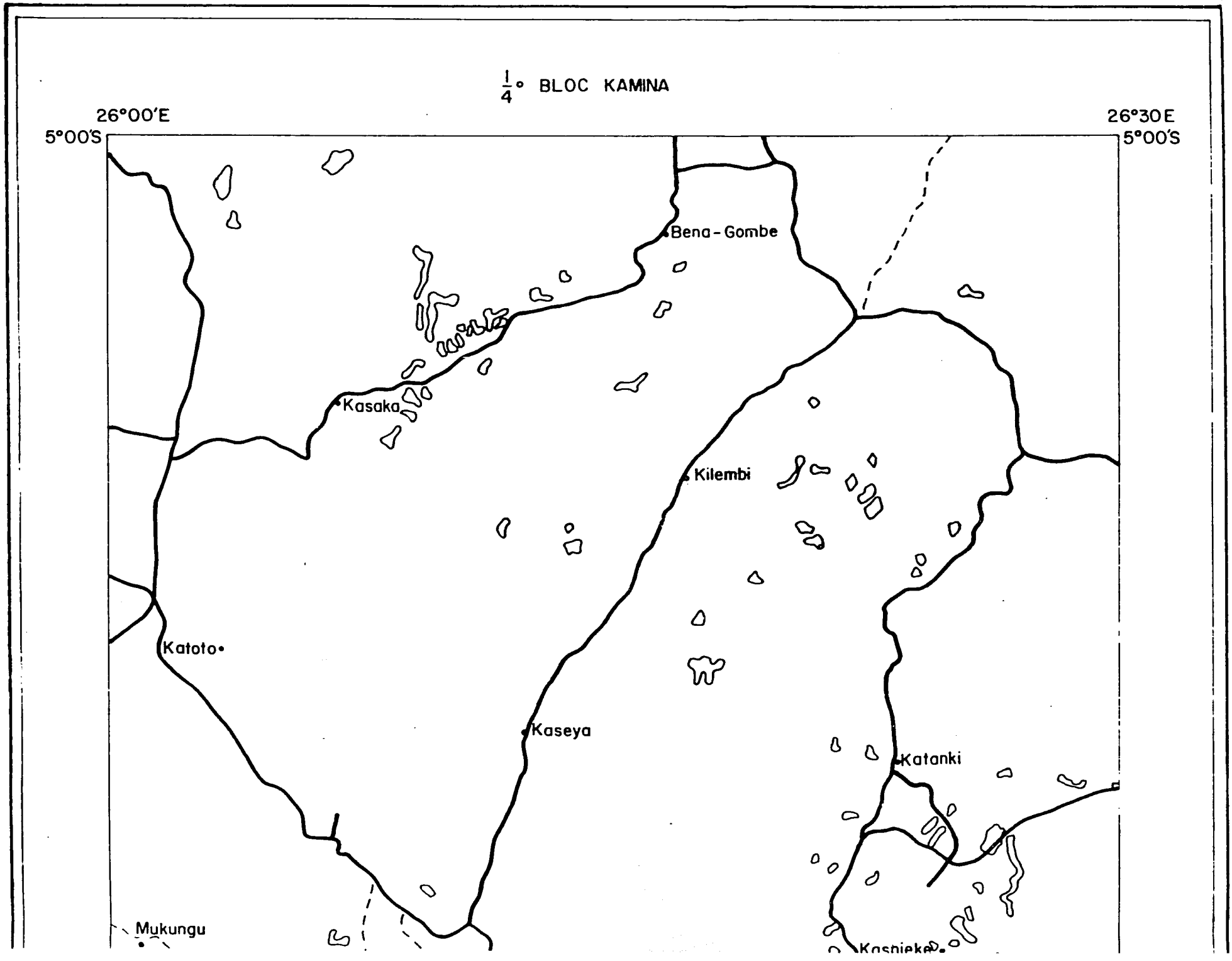
Echèlle: 1/200.000

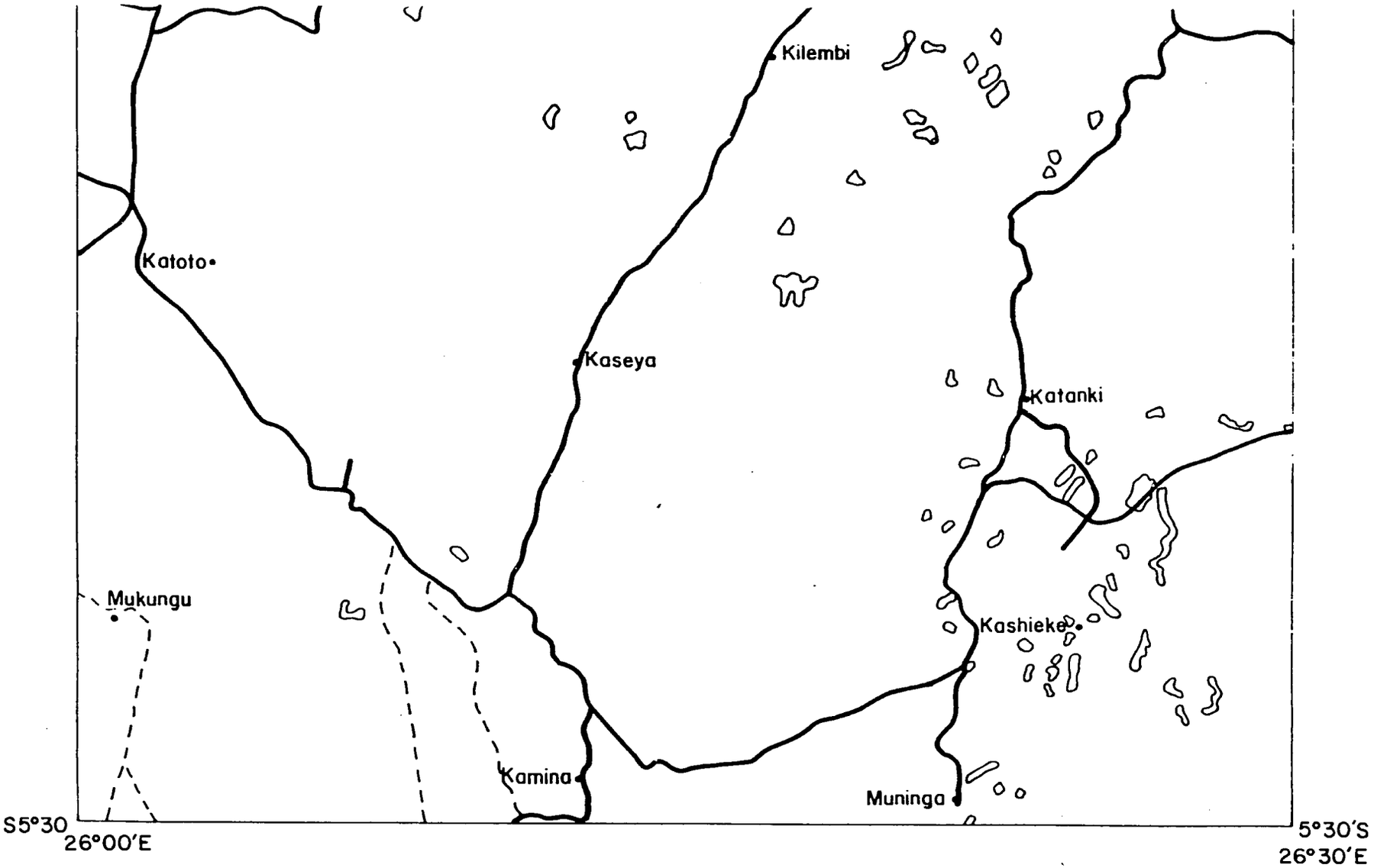
5 0 5 10 15

PLANCHE 6-B-1957

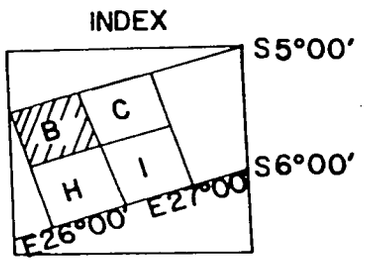
b

P 6-5-1950 a


1/4° BLOC KAMINA
26°00'E
26°30E
5°00'S
5°00'S
Bena-Gombe
Kasaka
Kilembi
Katoto
Kaseya
Katanki
Mukungu
Kashieke



CARTE D'UTILISATION AGRICOLE DES TERRES
1980
Superficie Cultuvée
Echelle: 1/200.000



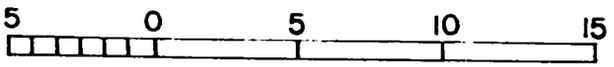
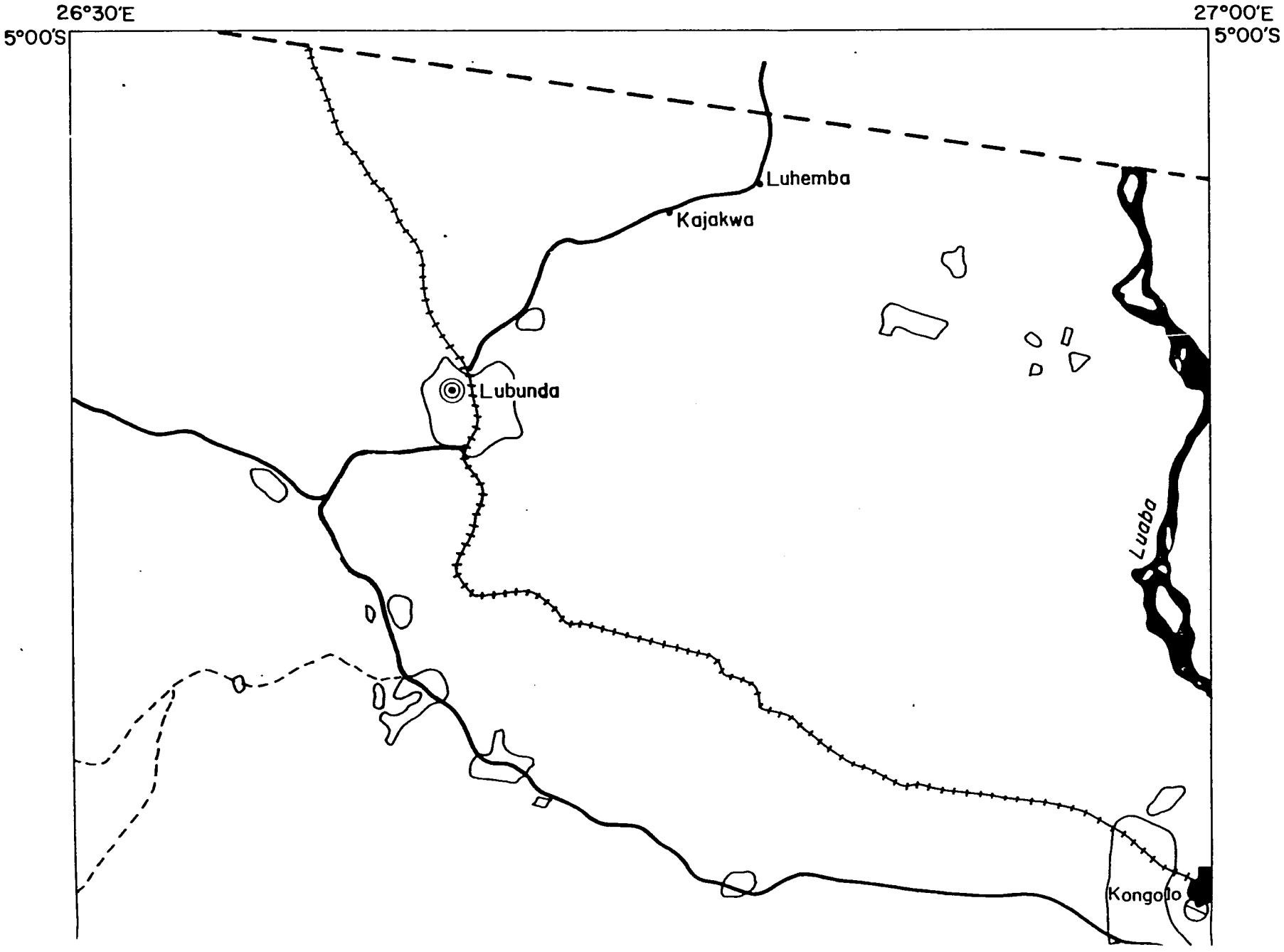
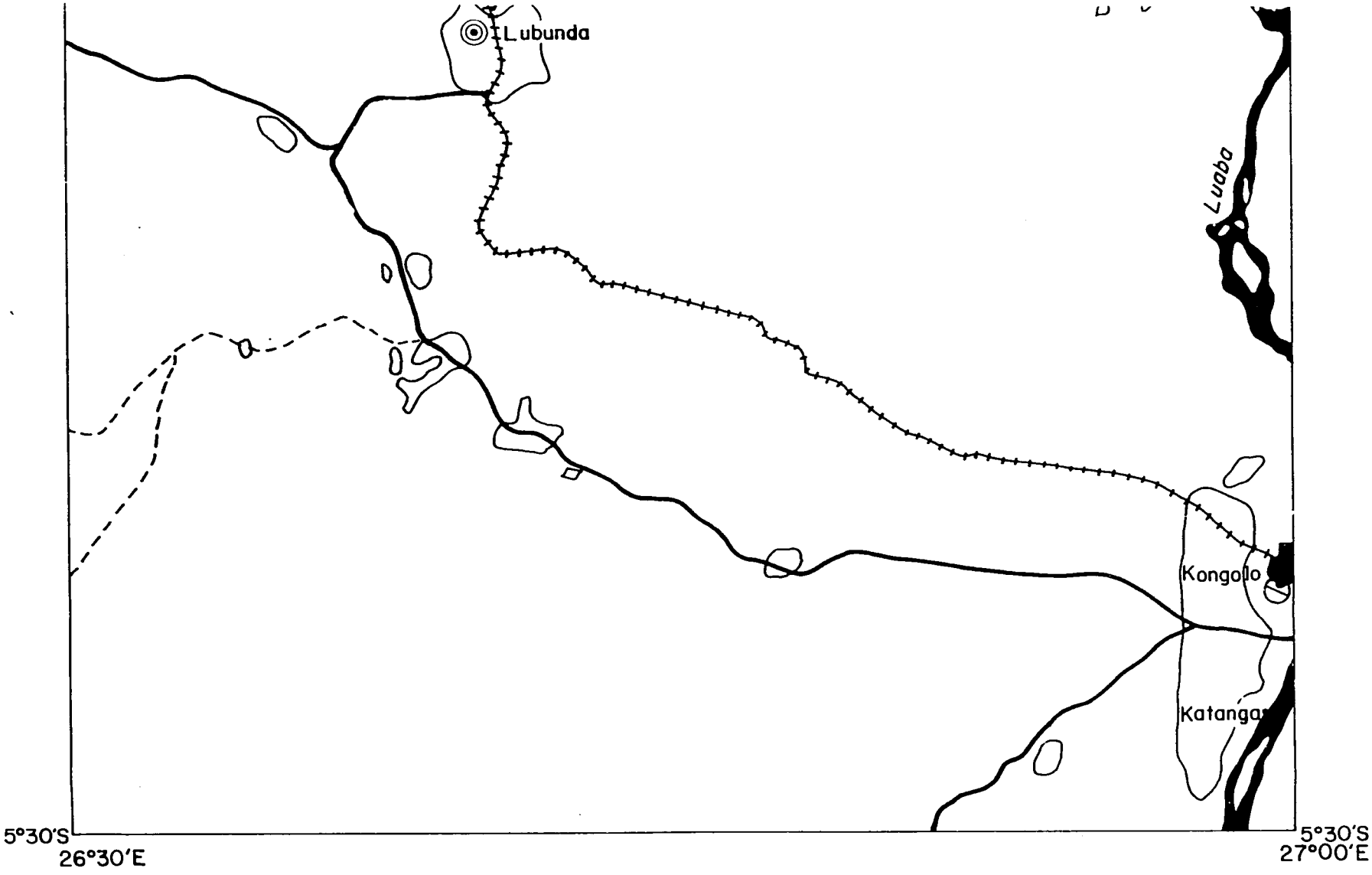


PLANCHE 6-B-1980

$\frac{1}{4}$° BLOC LUBUNDA



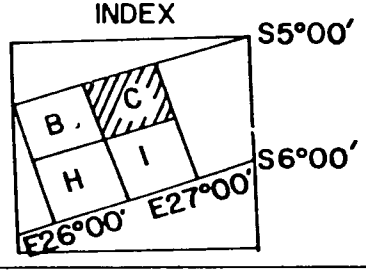


CARTE D'UTILISATION AGRICOLE DES TERRES

1957

Superficie Cultuvée : 7300 Has

Echèlle : 1/200.000



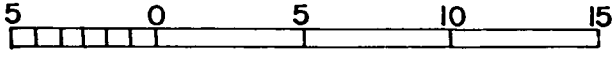
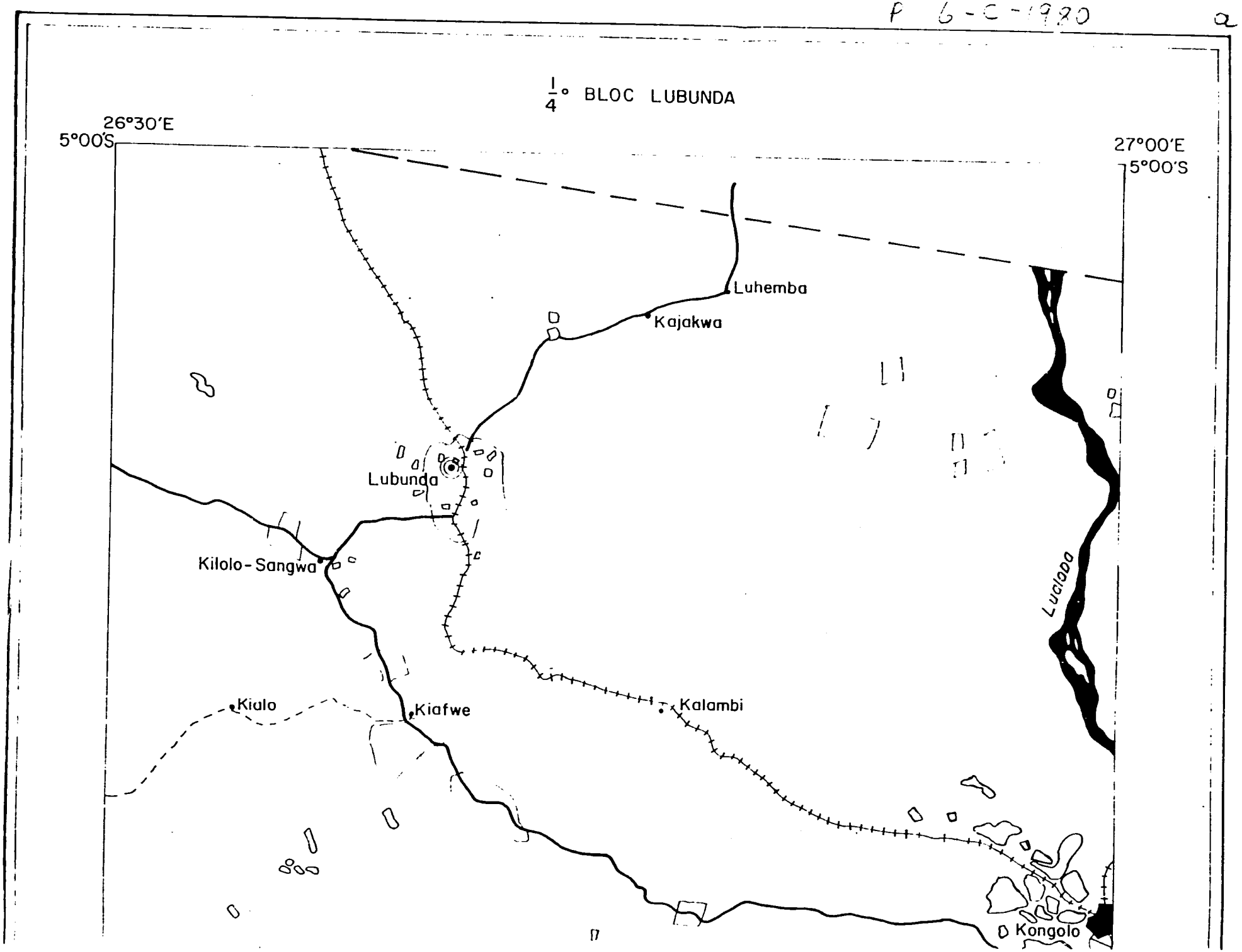


PLANCHE 6-C-1957

b

P 6-C-1920 a


1/4° BLOC LUBUNDA
26°30'E
5°00'S
27°00'E
5°00'S
Luhemba
Kajakwa
Lubunda
Kilolo-Sangwa
Kiafwe
Kiulo
Kalambi
Kongolo
Lualaba

Lubunda

Kilolo-Sangwa

Kiulo

Kiafwe

Kalambi

Lualaba

Kongolo

Katanga

5°30'S
26°30'E

5°30'S
27°00'E

CARTE D'UTILISATION AGRICOLE DES TERRES

1980

Superficie Cultivée

Echèlle: 1/200.000

5 0 5 10 15

INDEX

S5°00'

S6°00'

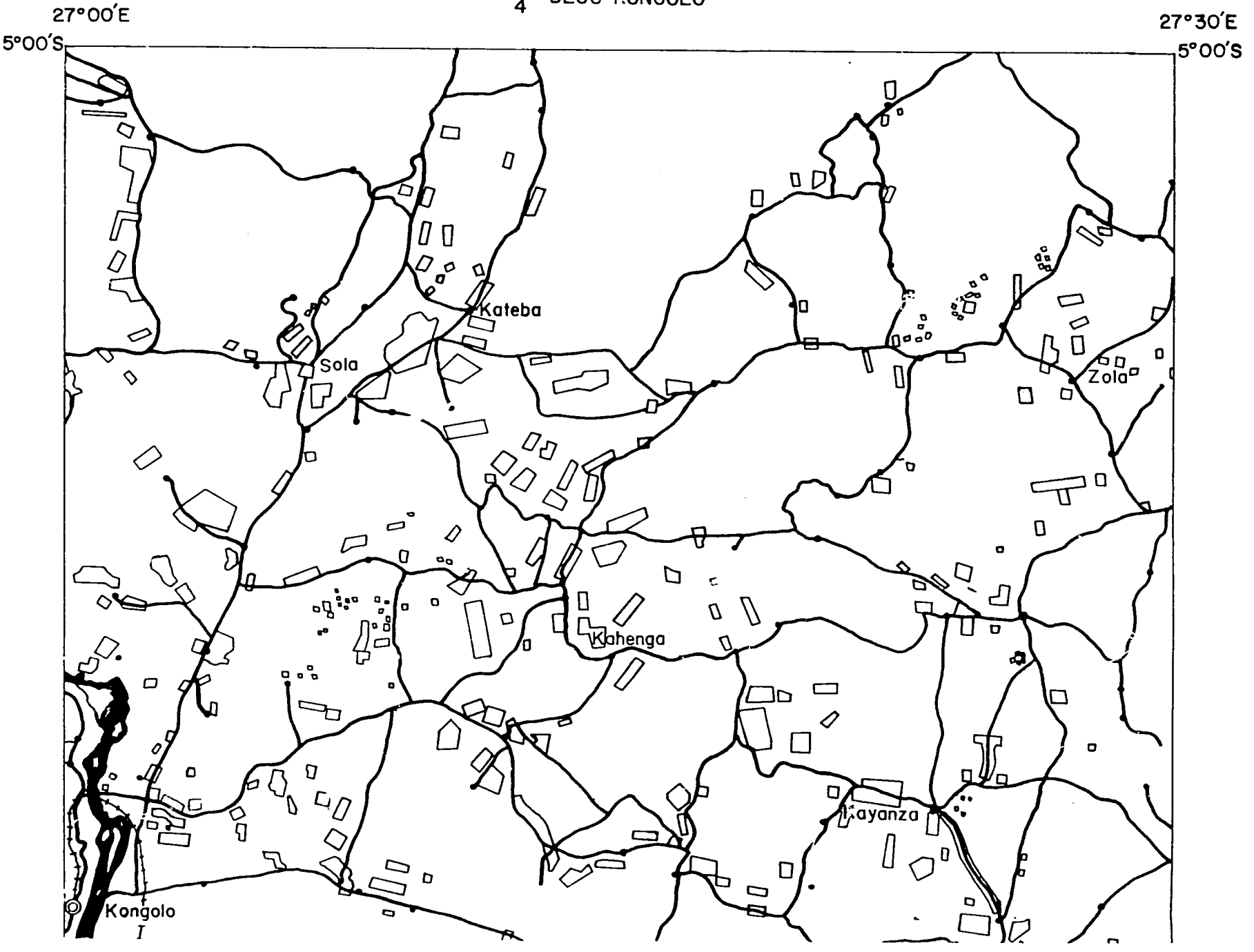
B C H I

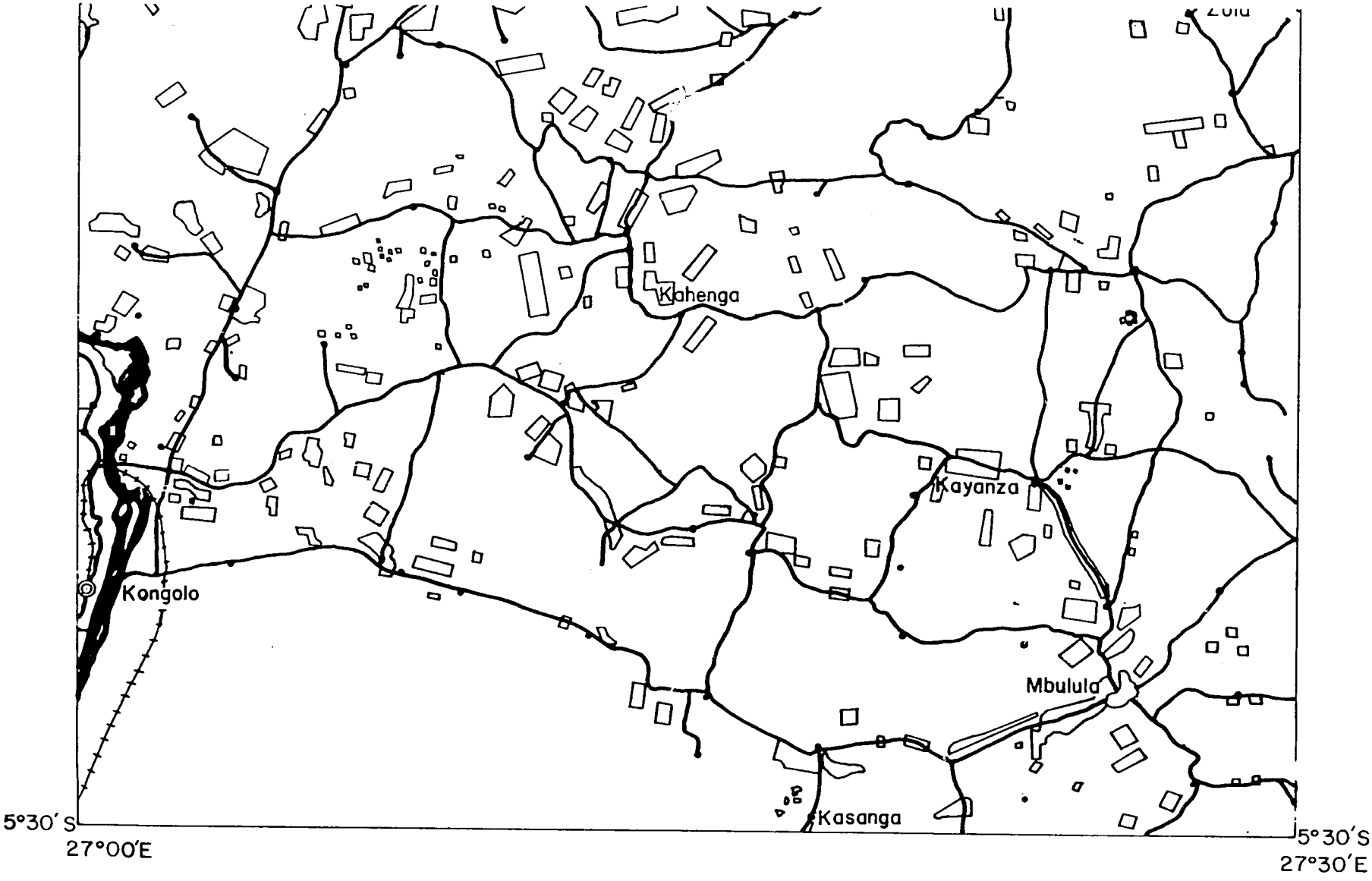
E26°00' E27°00'

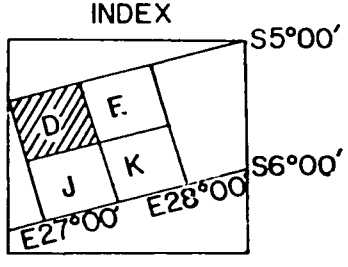
PLANCHE 6-C-1980

6

$\frac{1}{4}$° BLOC KONGOLO







CARTE D'UTILISATION DES TERRES

1957

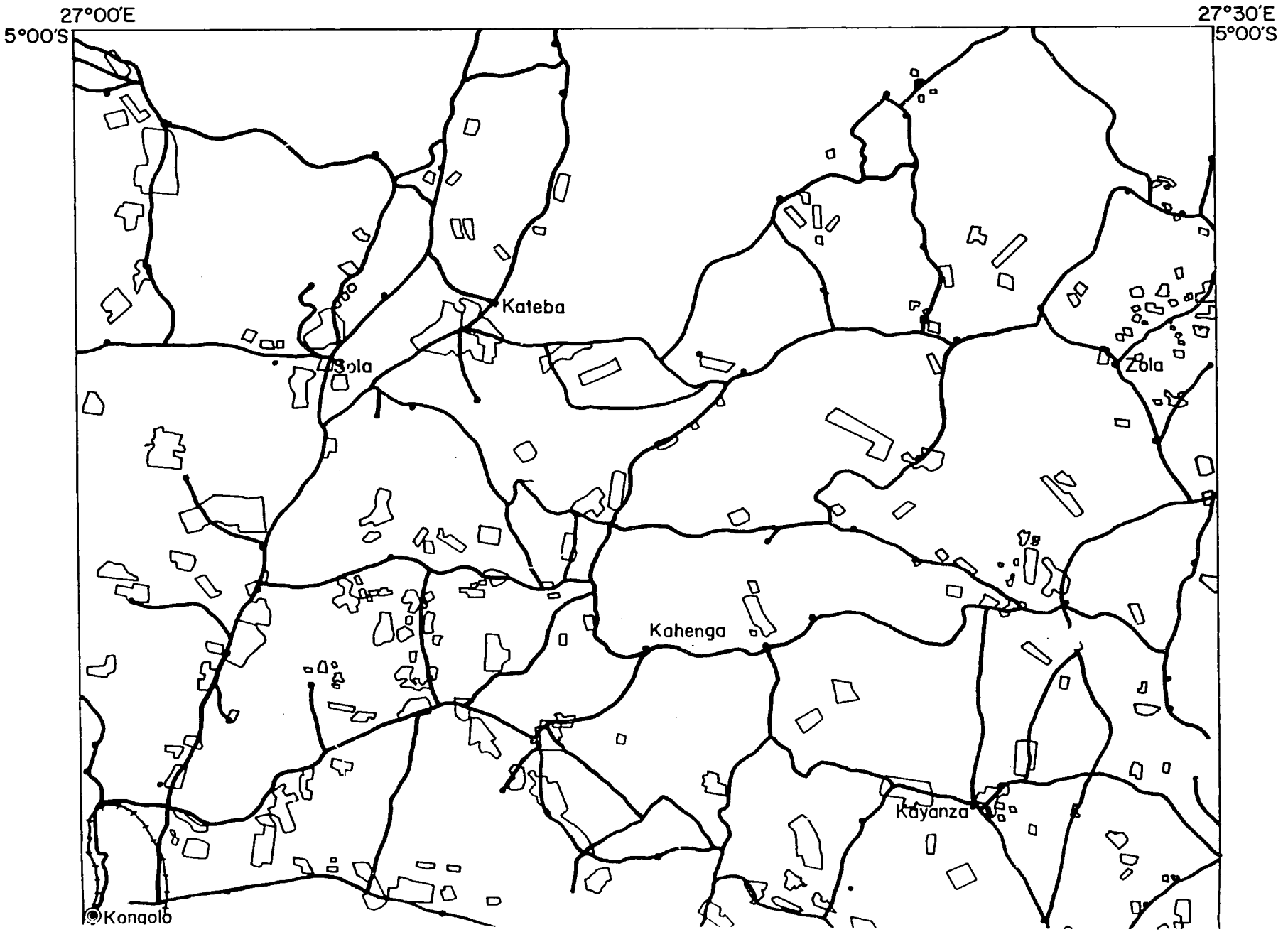
Echelle : 1/200.000

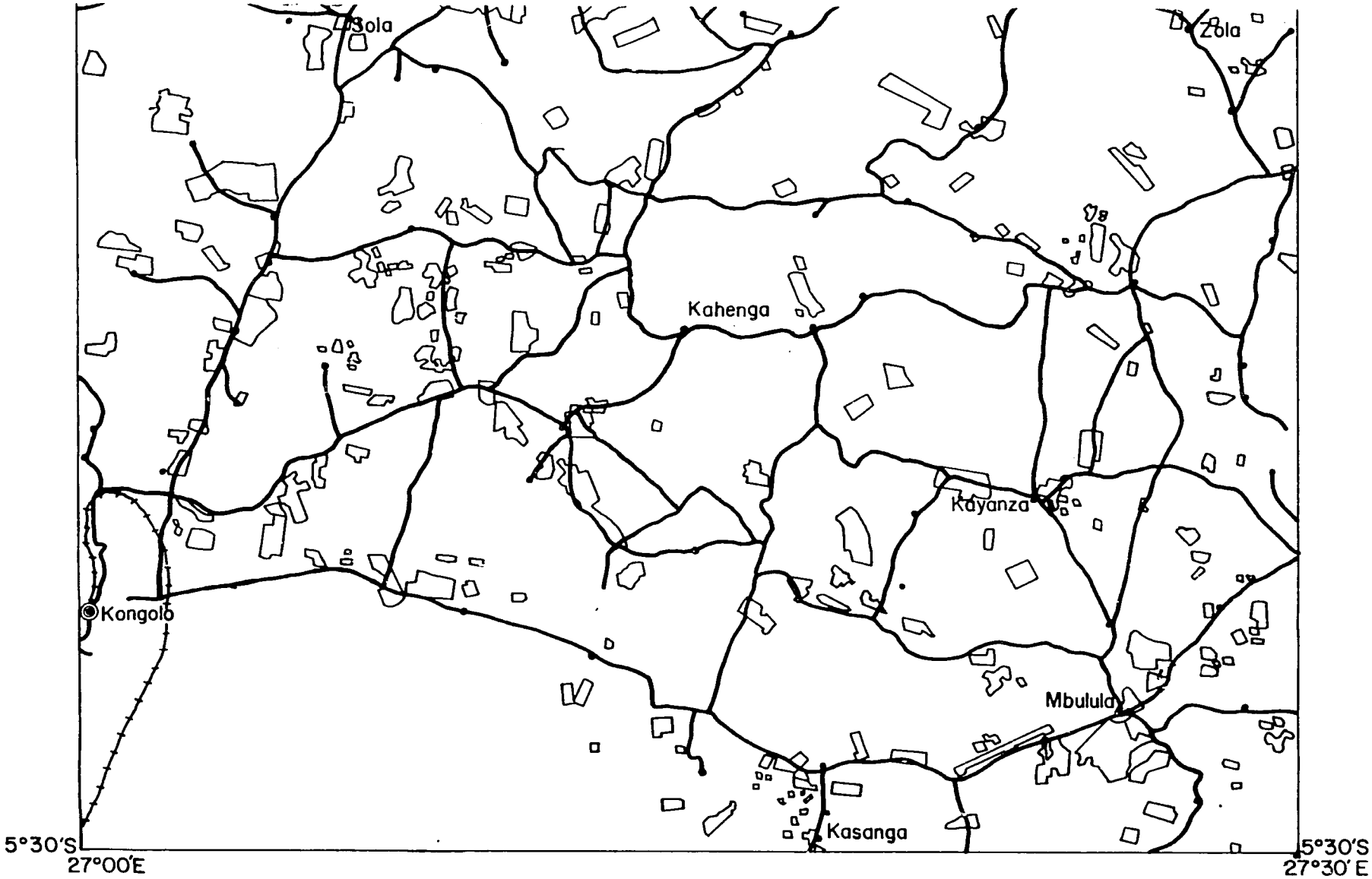
5 0 5 10 15

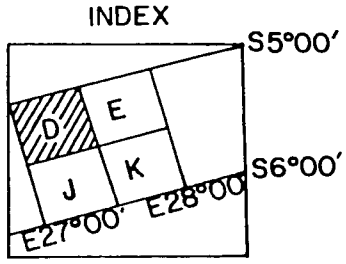
PLANCHE 6-D-1957

P 6-0-1973

$\frac{1}{4}$° BLOC KONGOLO







CARTE D'UTILISATION AGRICOLE DES TERRES 1973

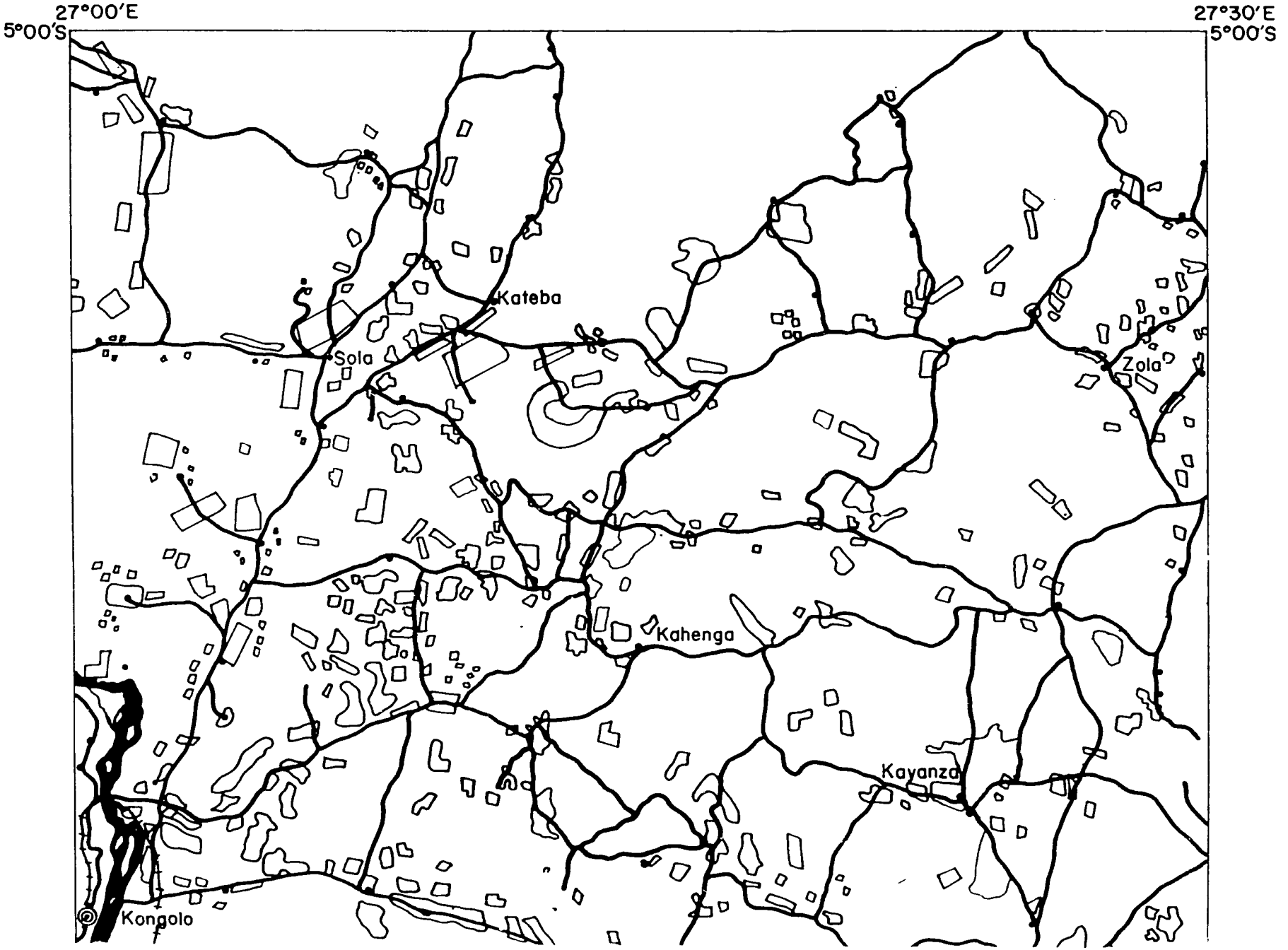
Echèle : 1/200.000

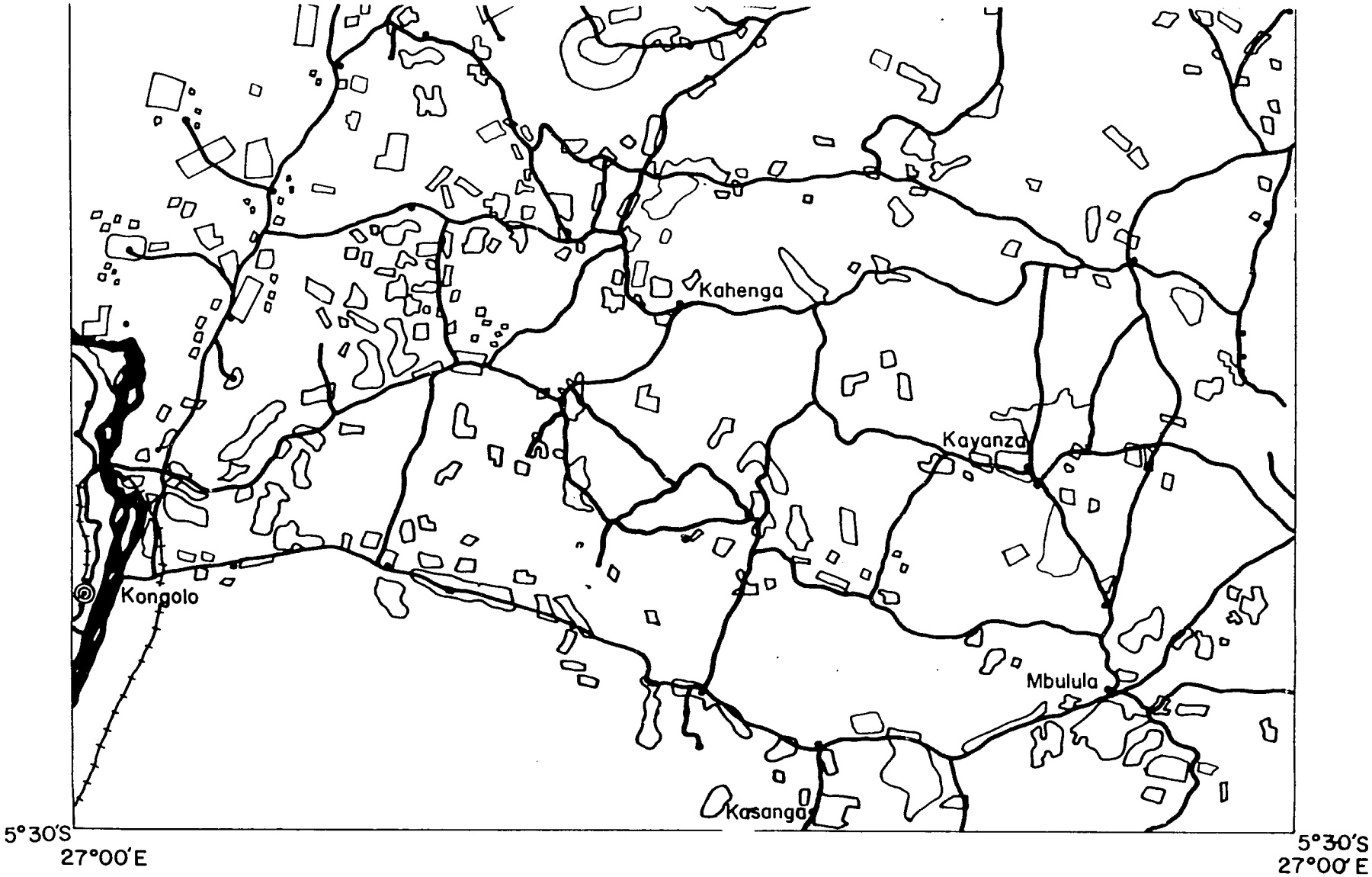
5 0 5 10 15

PLANCHE 6-D-1973

P 6-E-1

$\frac{1}{4}$° BLOC KONGOLO





CARTE D'UTILISATION AGRICOLE DES TERRES

1980

Superfie : 21675 Has

Echèle : 1/200.000

5 0 5 10 15

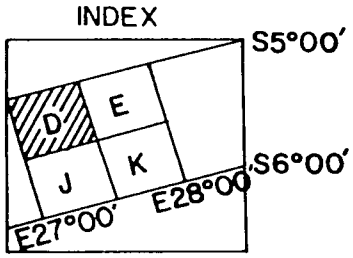
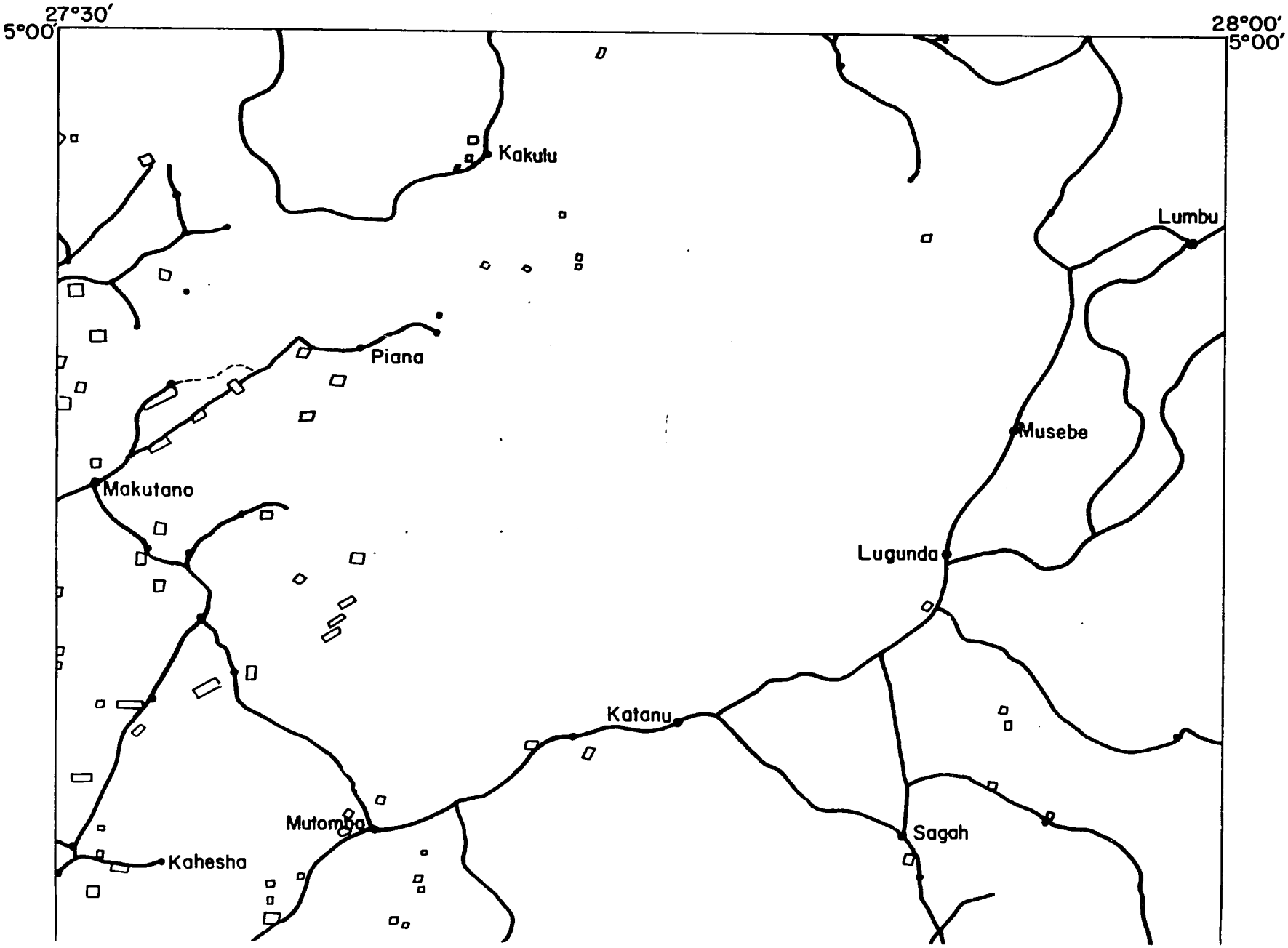


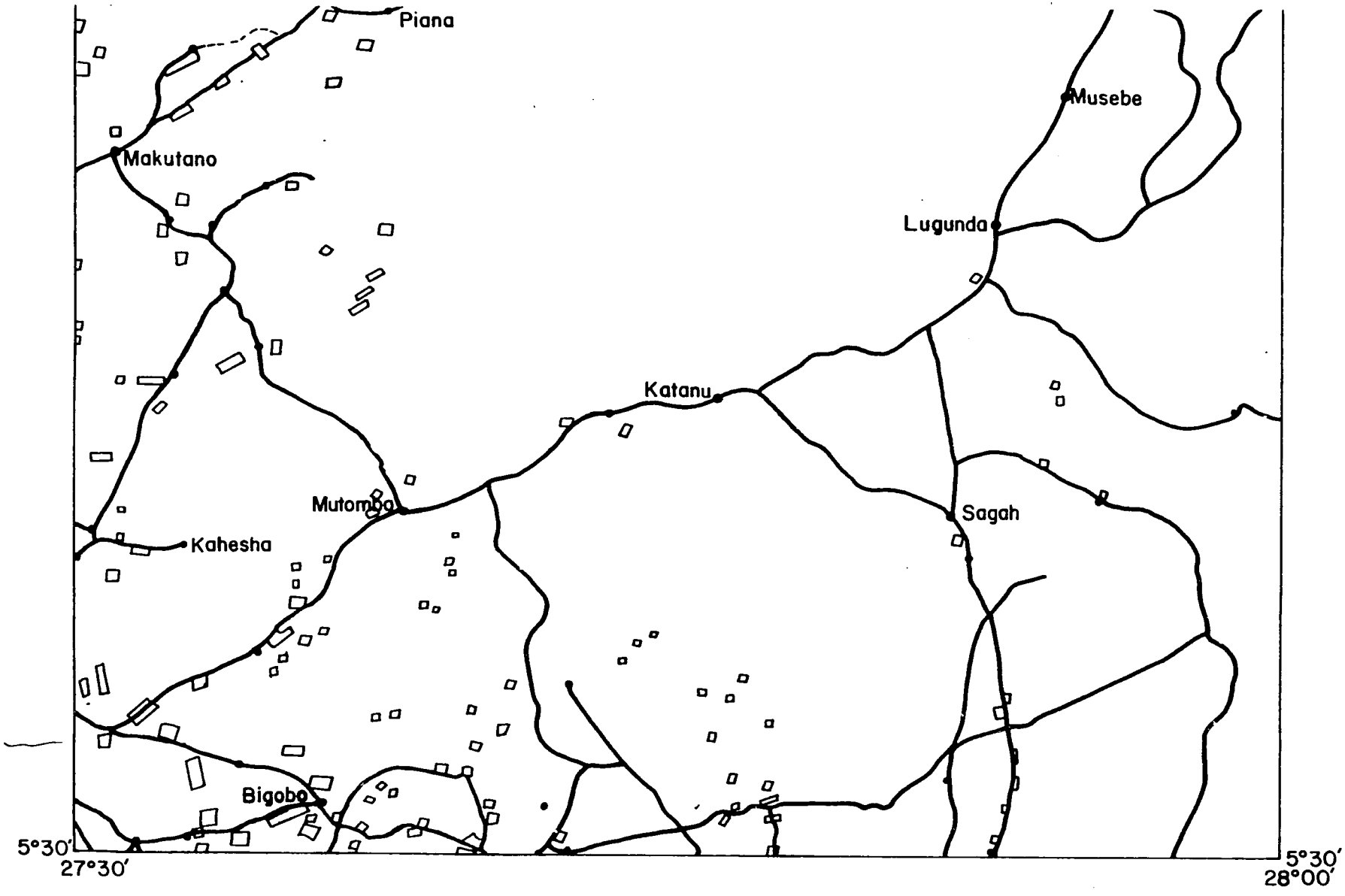
PLANCHE 6-D-1980

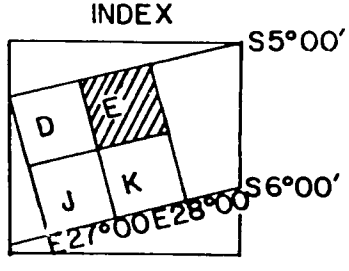
b

P 6-3-1-2-3 a

$\frac{1}{4}$° BLOC MAKUTANO







CARTE D'UTILISATION DES TERRES
1957

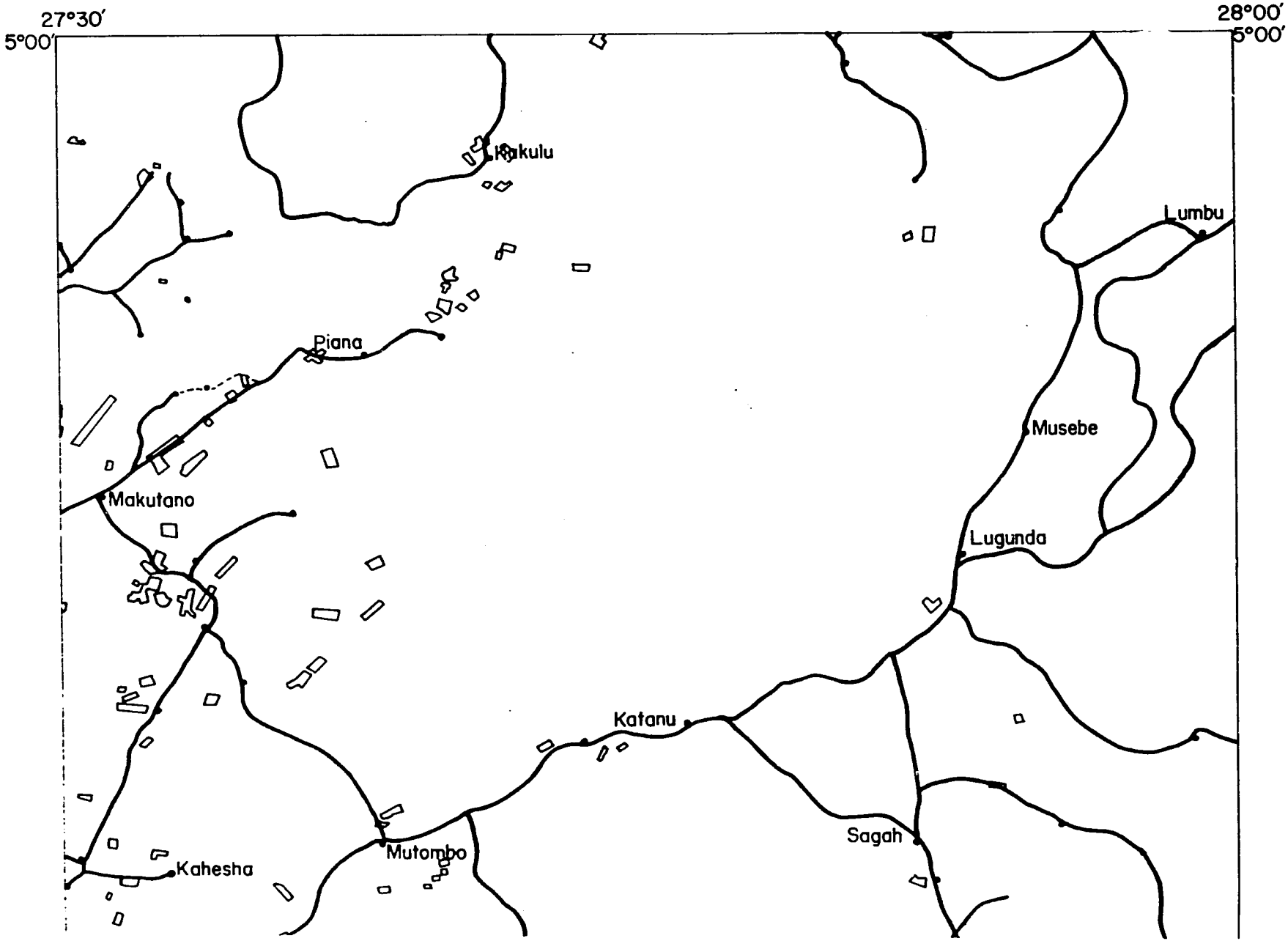
Echèlie: 1/200.000

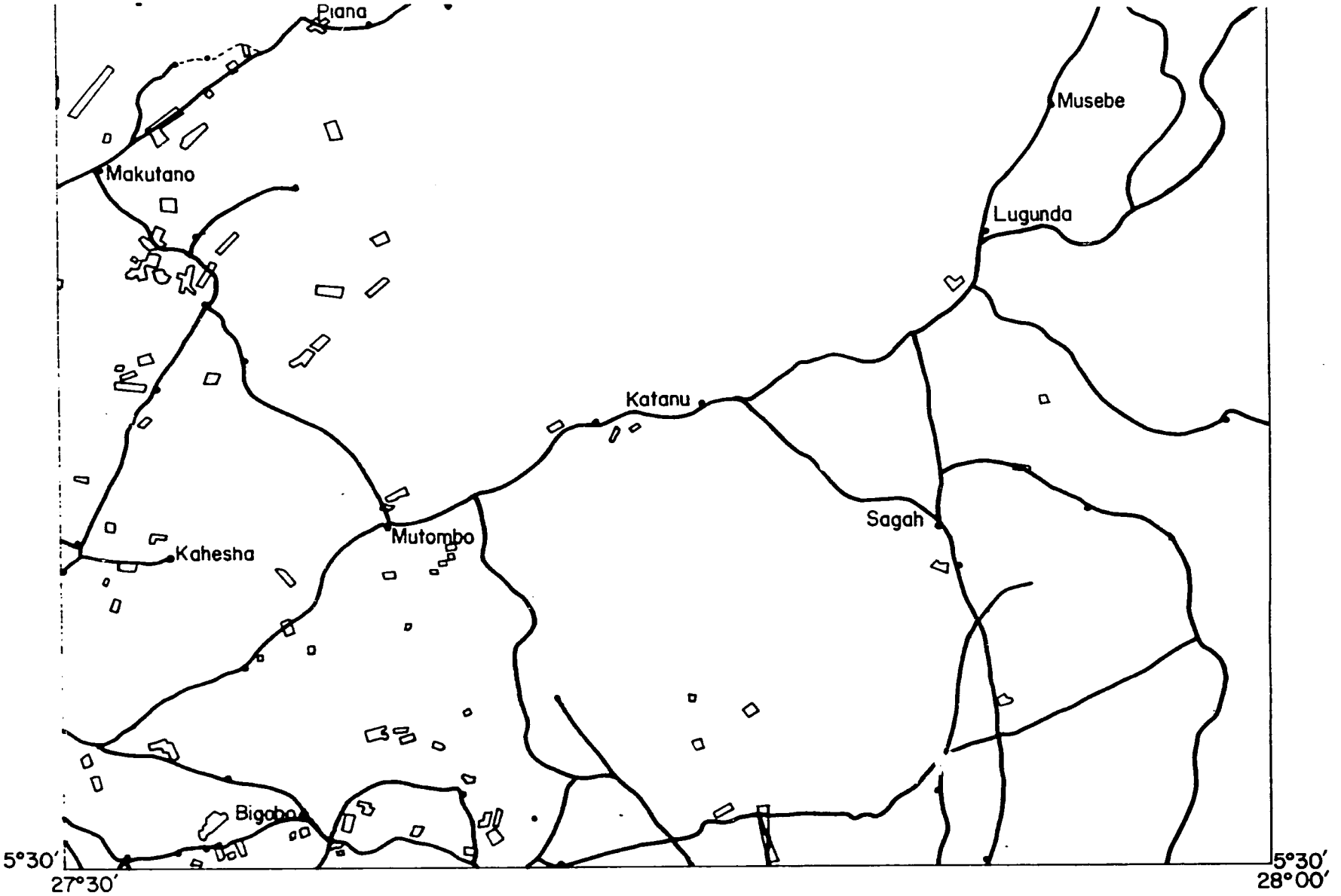
5 0 5 10 15

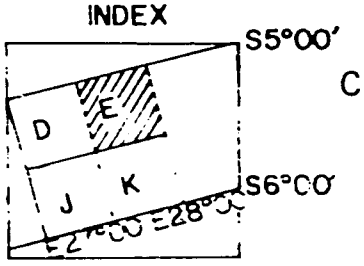
PLANCHE 6-E-1957

P 6-E-1973 a

$\frac{1}{4}$° BLOC Makutano





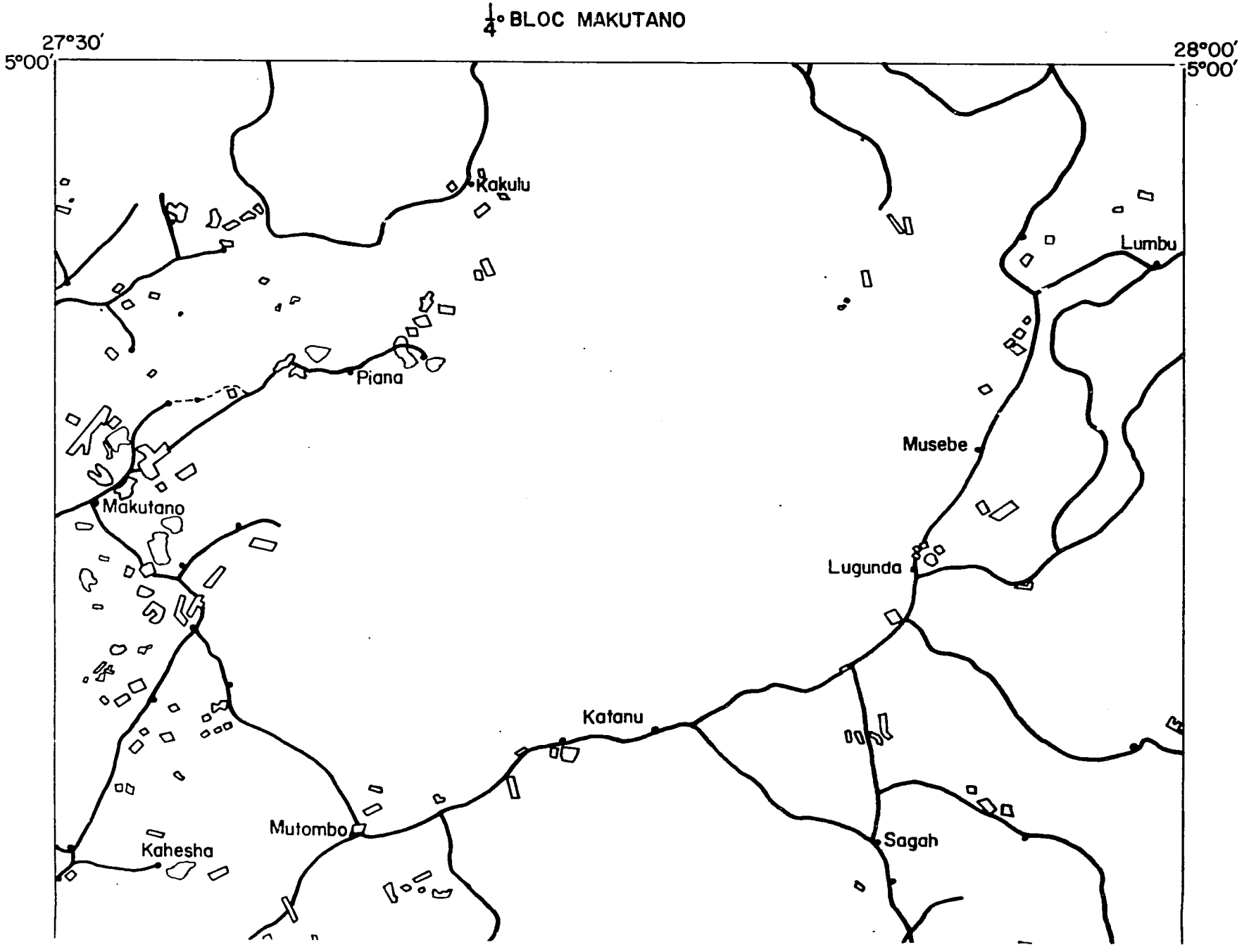


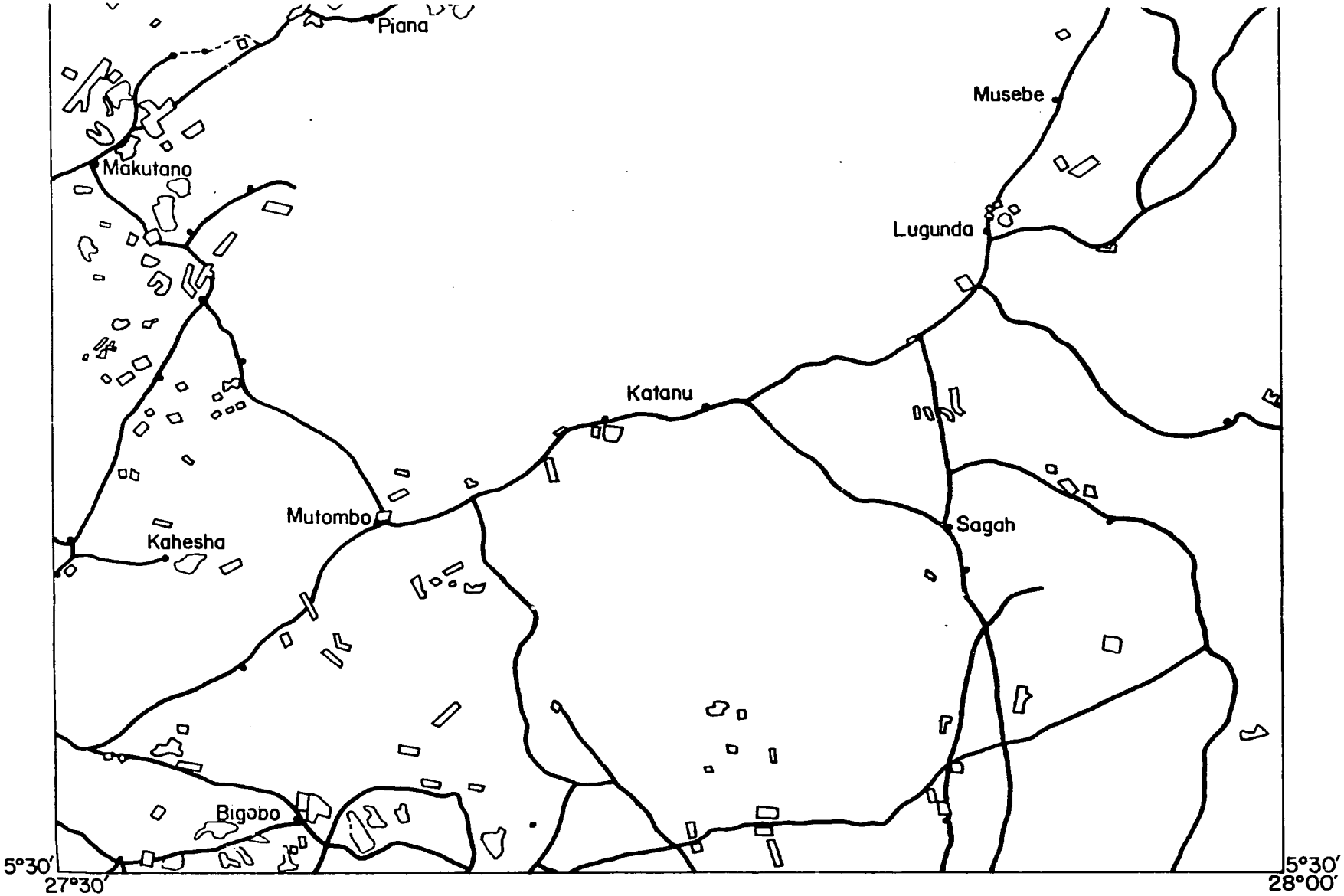
CARTE D'UTILISATION AGRICOLE DES TERRES 1973

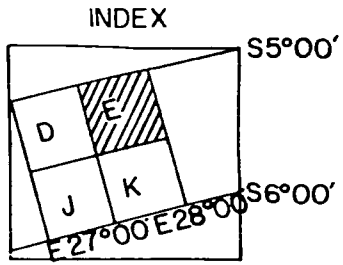
Echèlle : 1/200.000

5 0 5 10 15

PLANCHE 6-E-1973 b


¼° BLOC MAKUTANO
27°30'
5°00'
28°00'
5°00'
Kakulu
Lumbu
Piana
Musebe
Makutano
Lugunda
Katanu
Mutombo
Kahesha
Sagah





CARTE D'UTILISATION AGRICOLE DES TERRES

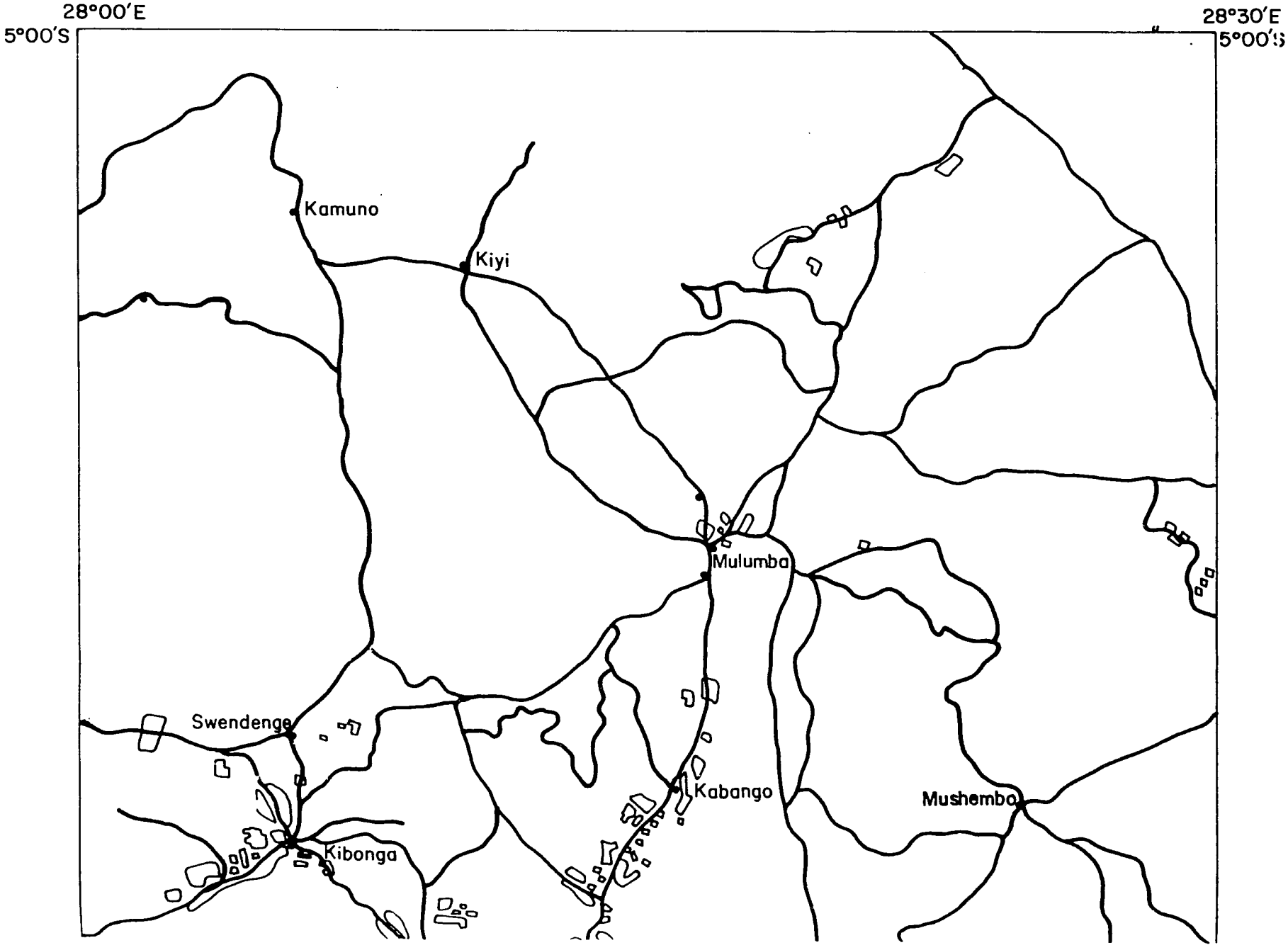
1980 **Superficie Cultuvée: 5.750 Has**

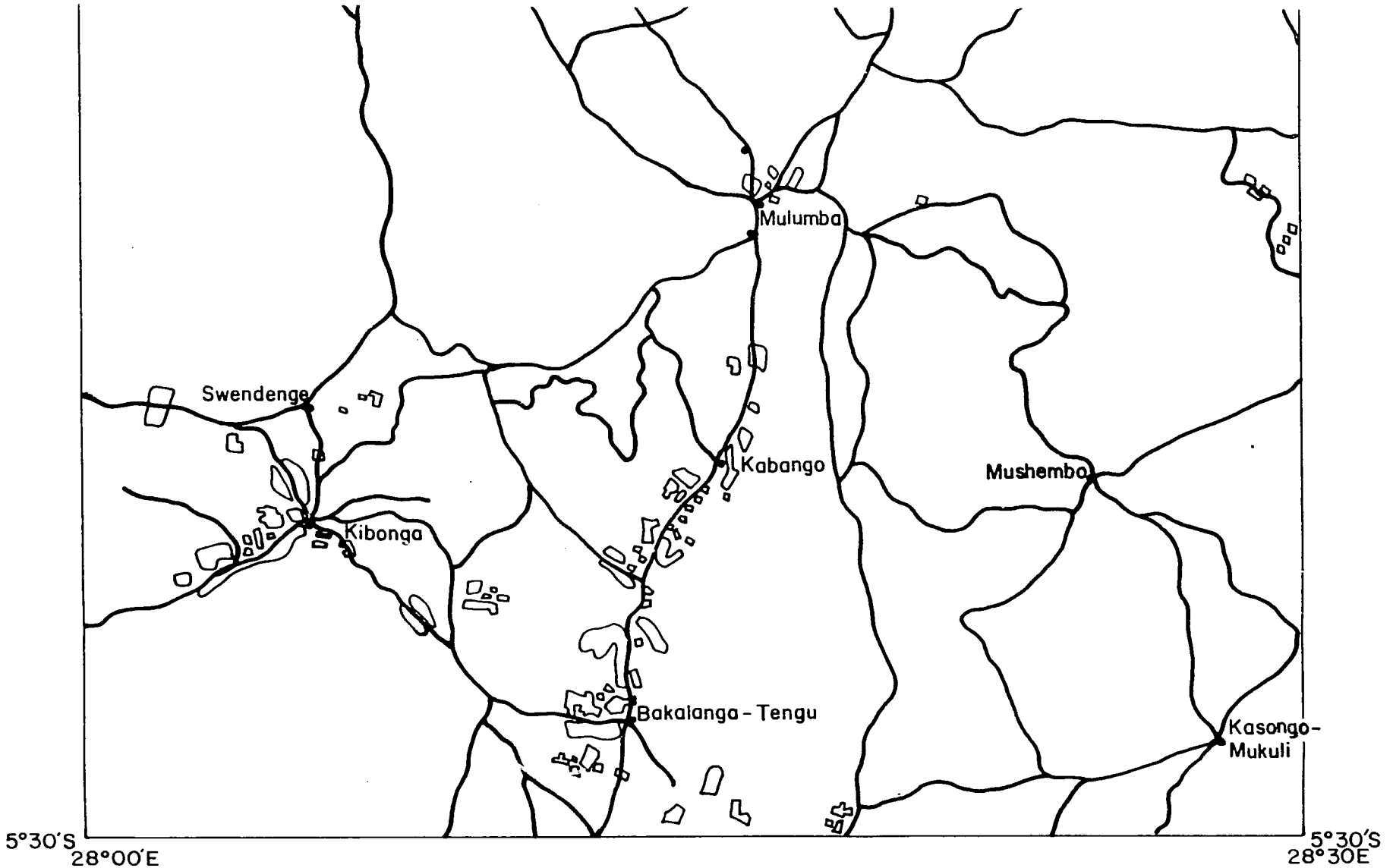
Echèlle: 1/200.000

5 0 5 10 15

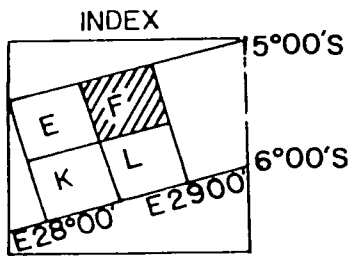
PLANCHE 6-E-1980 b

$\frac{1}{4}$° BLOC KIYI





CARTE D'UTILISATION AGRICOLE DES TERRES
1957



Superficie Cultuvée: 5225 Has
Echèlle: 1/200.000

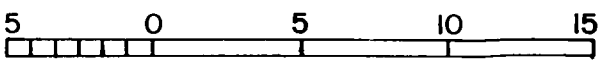
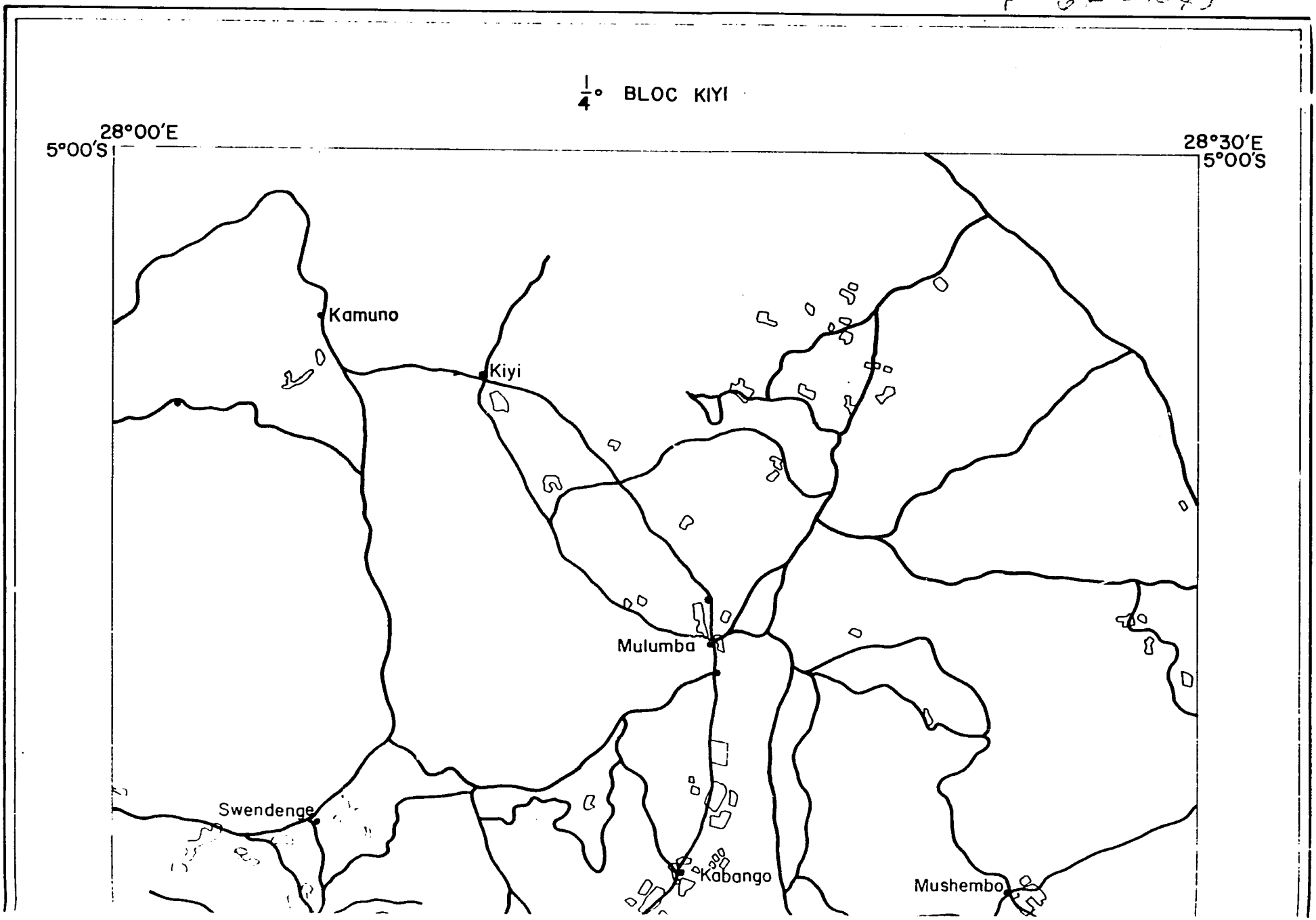
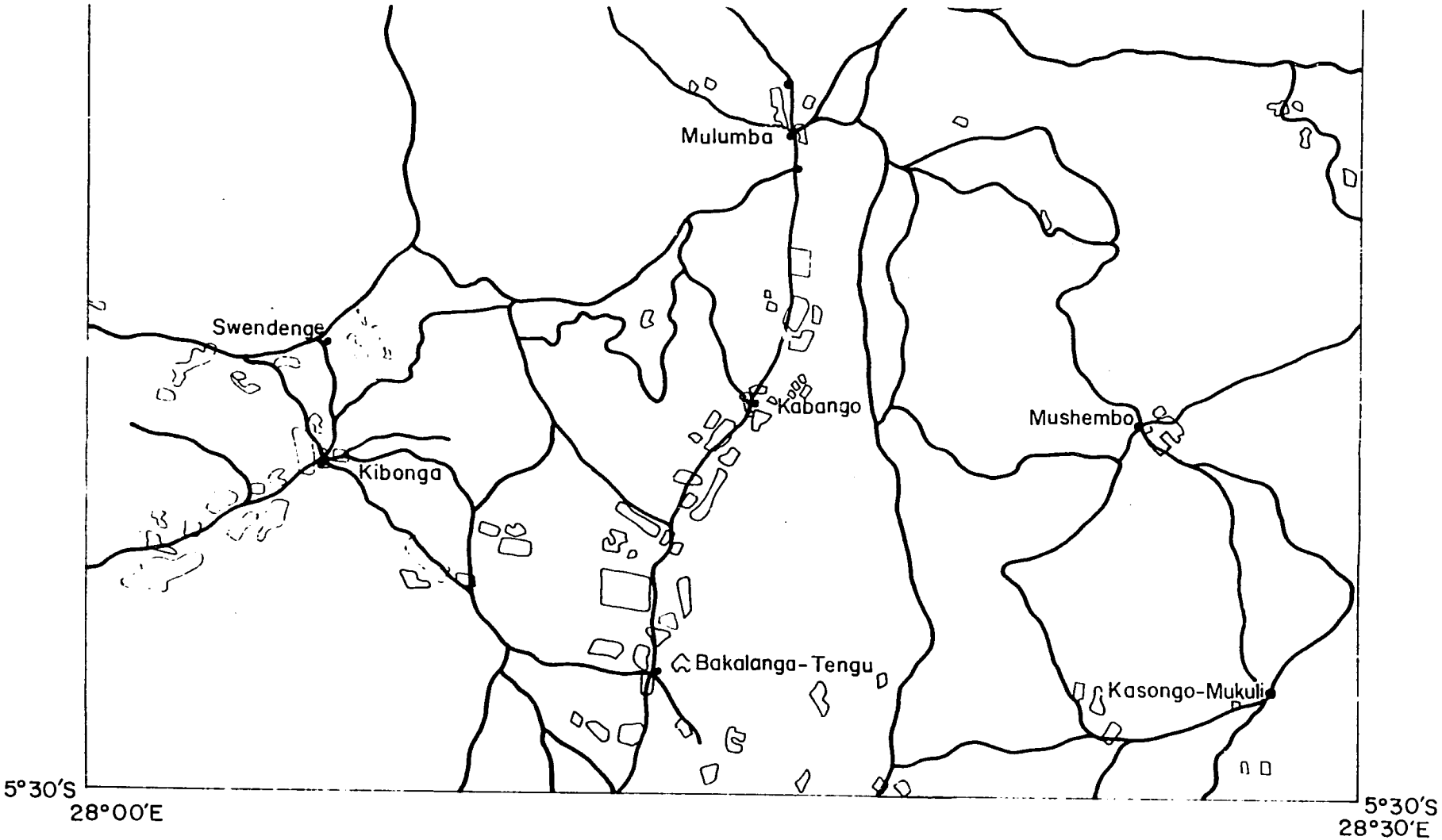


PLANCHE 6-F-1957

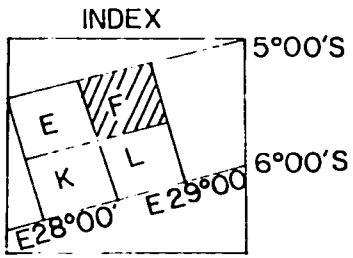
b

P 6E - 1970


1/4° BLOC KIYI
28°00'E
5°00'S
28°30'E
5°00'S
Kamuno
Kiyi
Mulumba
Swendenge
Kabango
Mushembo



CARTE D'UTILISATION AGRICOLE DES TERRES
1980



Superficie Cultuvée : 6050 Has

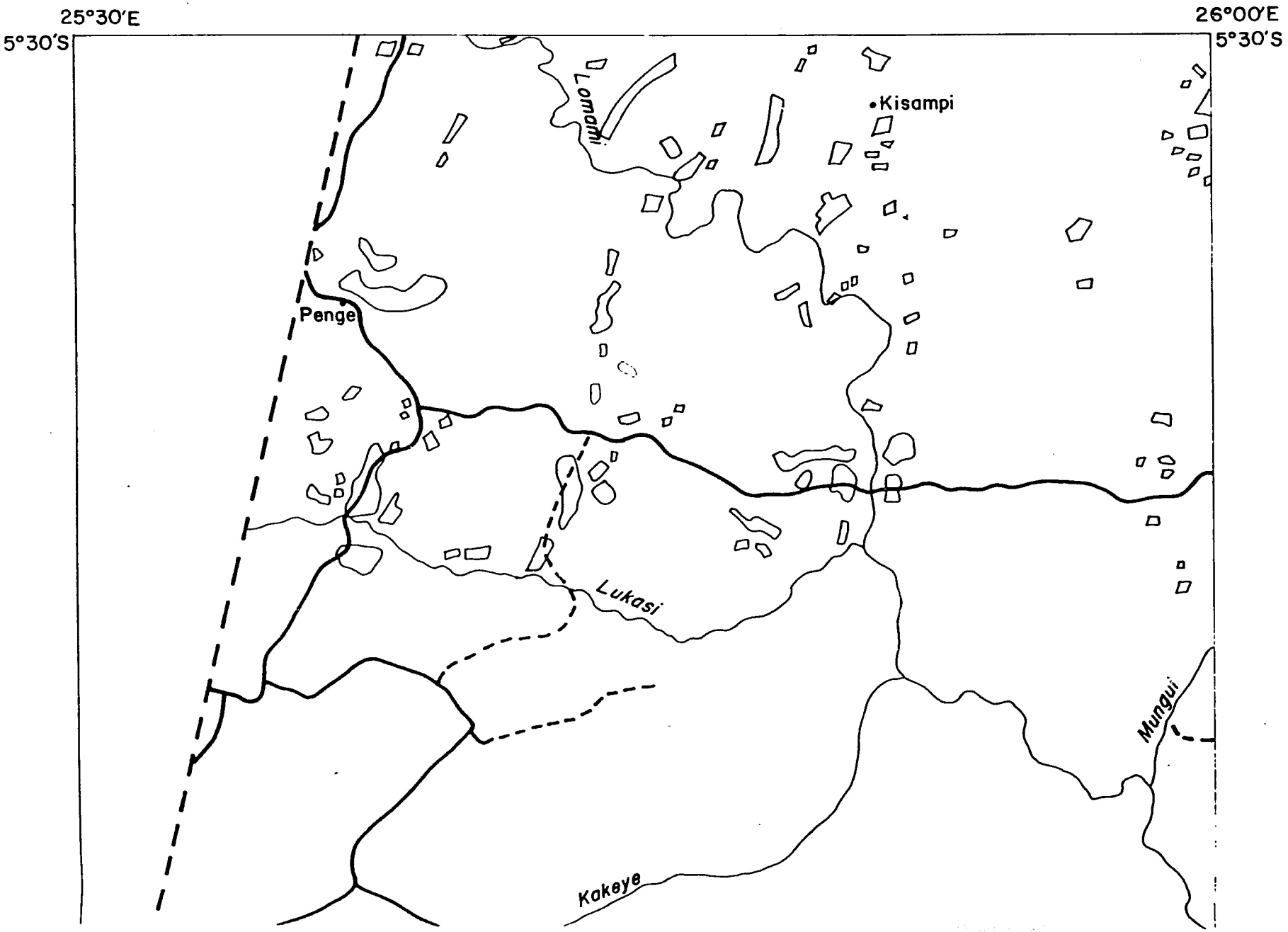
Echèlle : 1/200.000

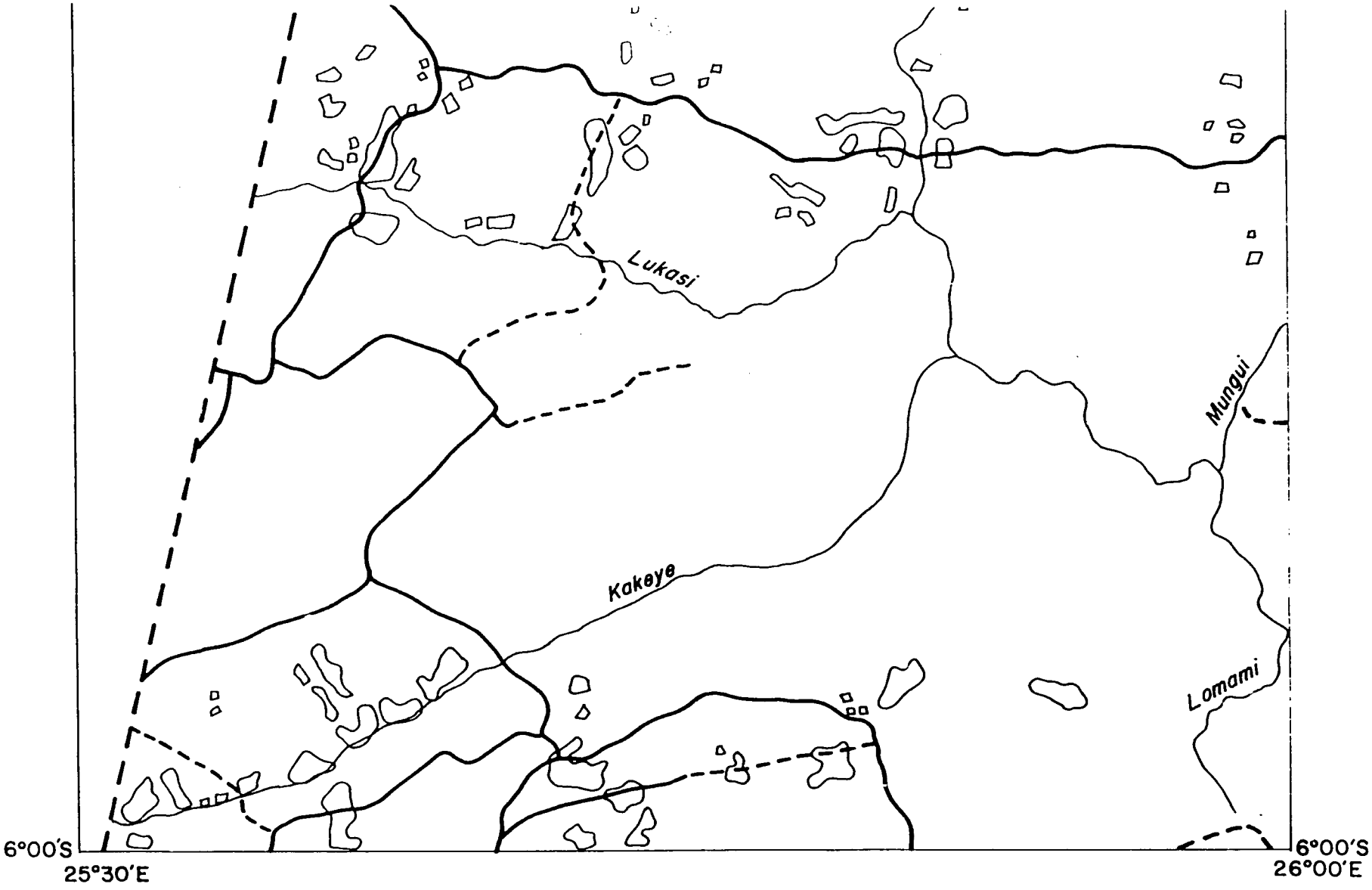
5 0 5 10 15

PLANCHE 6F - 1980

P - 6 - 6 - 257

$\frac{1}{4}$° BLOC PENGE





CARTE D'UTILISATION AGRICOLE DES TERRES

1957

Superficie Cultuvée : 7125 Has

Echèle : 1/200.000

5 0 5 10 15

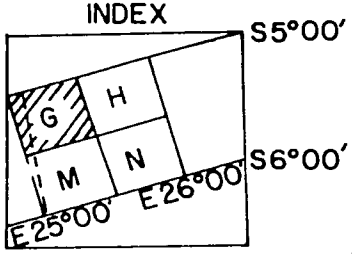
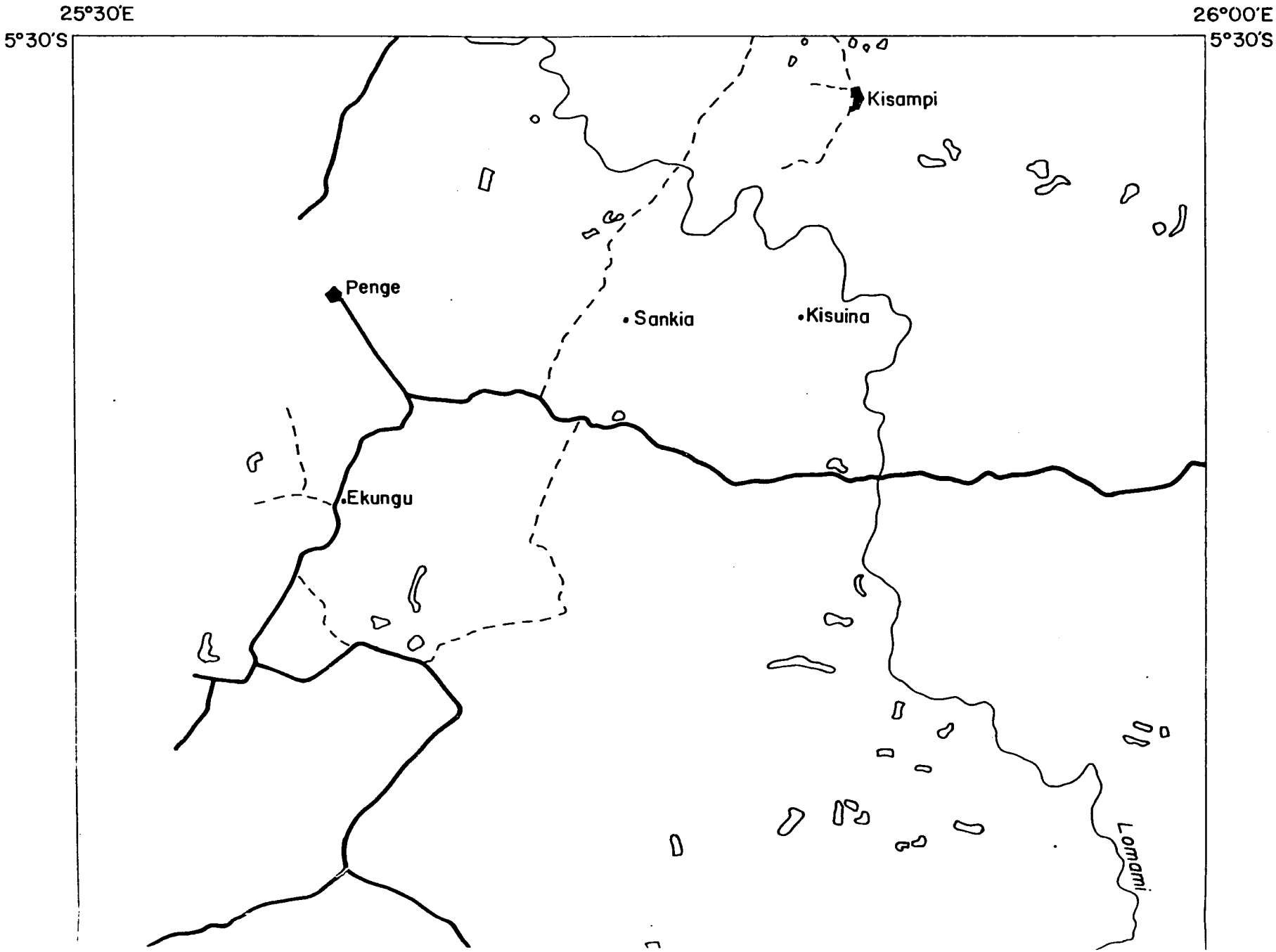
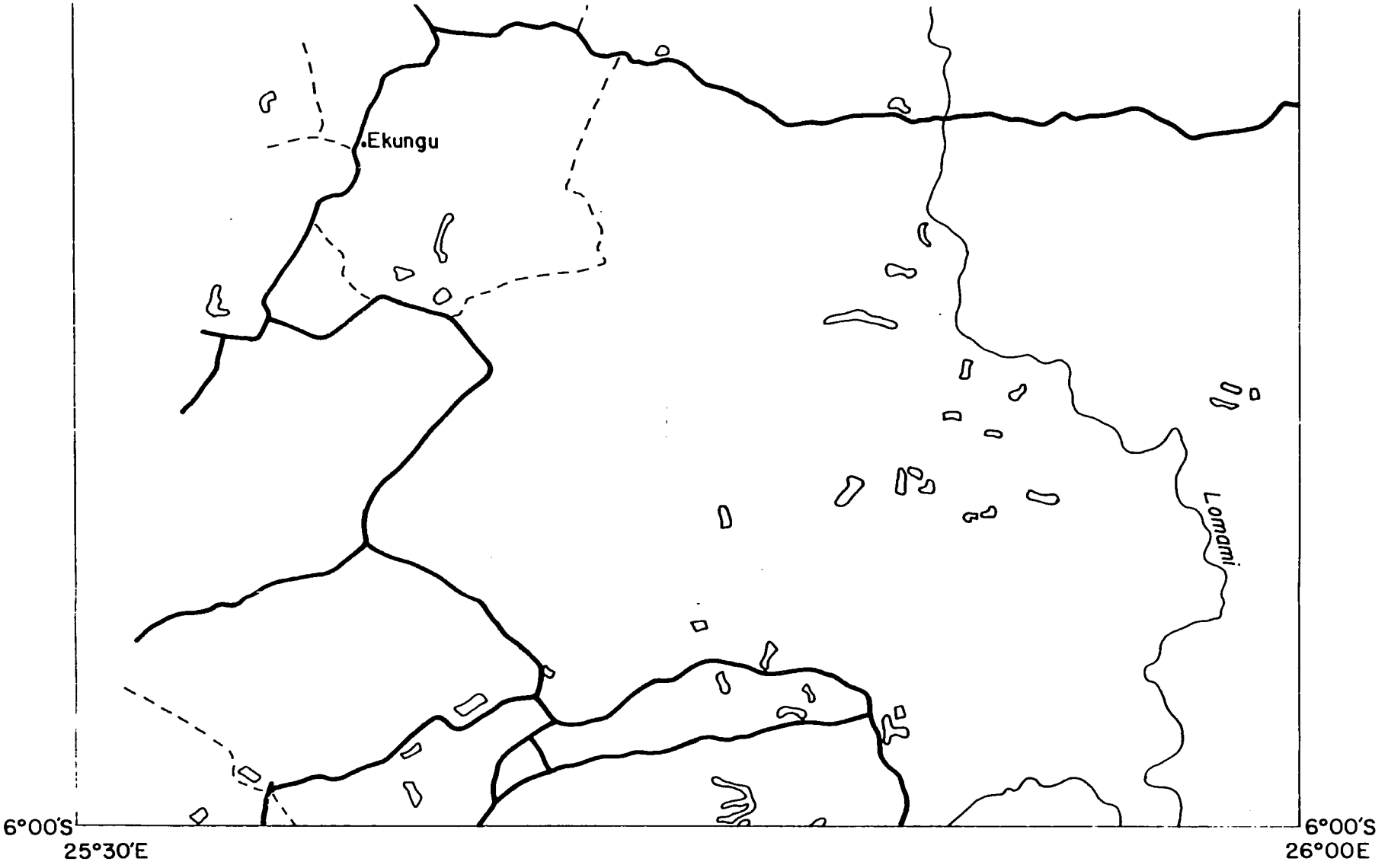


PLANCHE 6-G-1957 b

F 6-G-1990

$\frac{1}{4}$° BLOC PENGE





CARTE D'UTILISATION AGRICOLE DES TERRES
1980
Superficie Cultuvée
Echelle: 1/200.000

5 0 5 10 15

INDEX

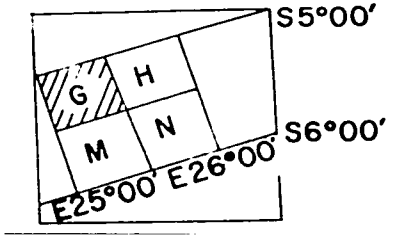
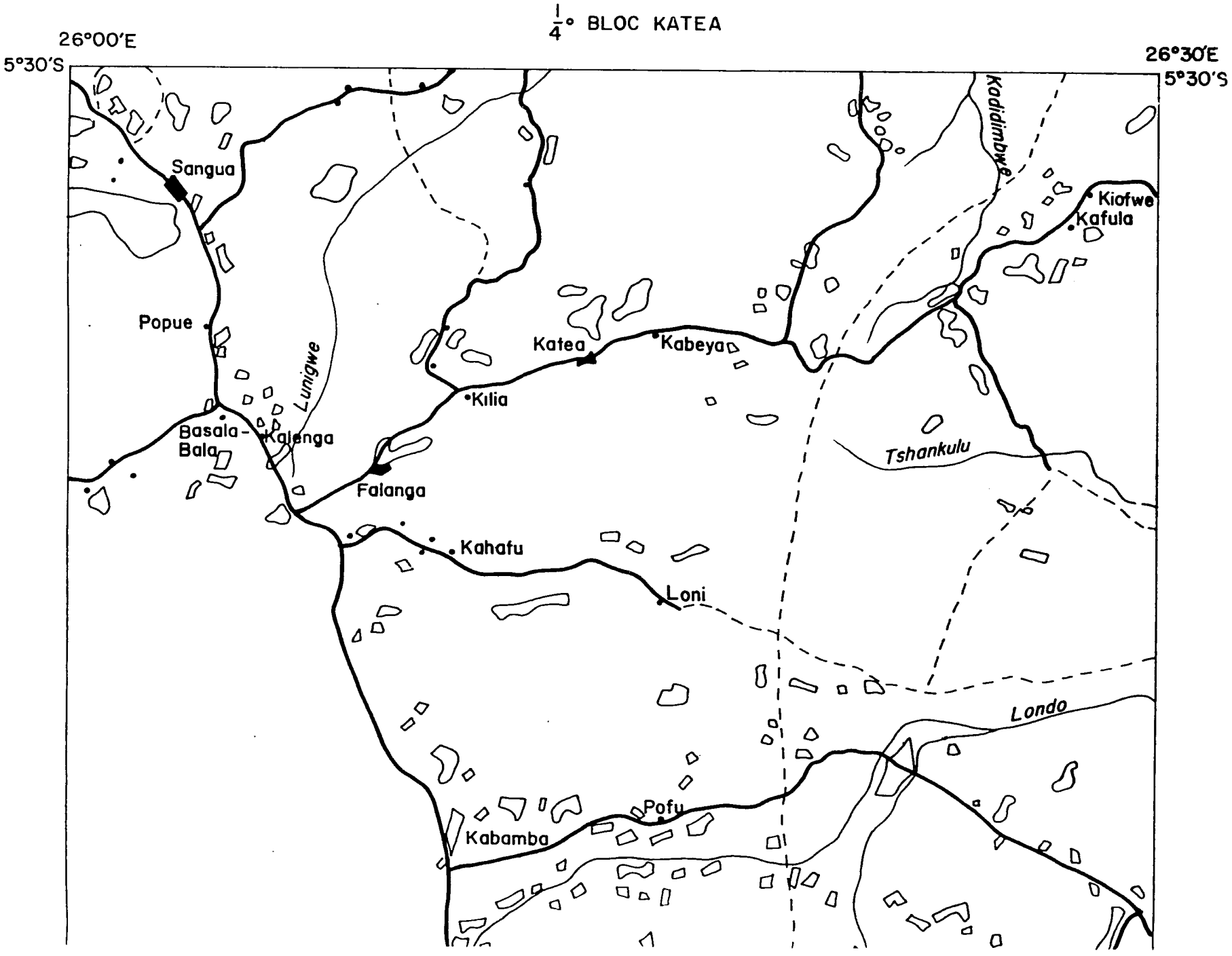
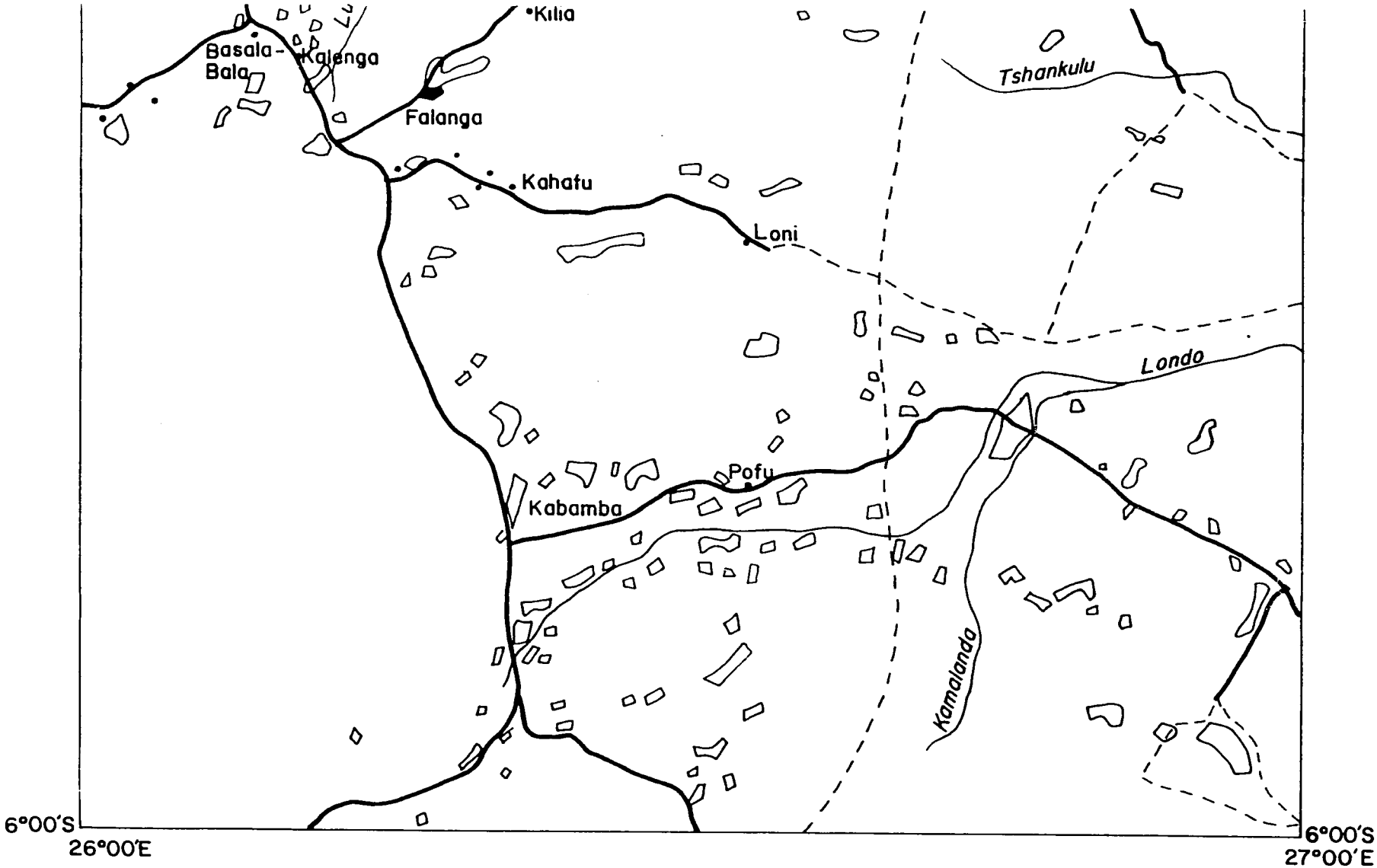


PLANCHE 6-G-1980

b

P 6-4-1957


1/4° BLOC KATEA
26°00'E
5°30'S
26°30'E
5°30'S
Sangua
Popue
Lunigwe
Basala-Bala
Kalenga
Falanga
Kilia
Katea
Kabeya
Kadidimbwe
Kiofwe
Kafula
Tshankulu
Kahafu
Loni
Londo
Pofu
Kabamba



CARTE D'UTILISATION AGRICOLE DES TERRES

1957

Superficie Cultuvée : 10.350 Has

Echèlle : 1/200.000

5 0 5 10 15

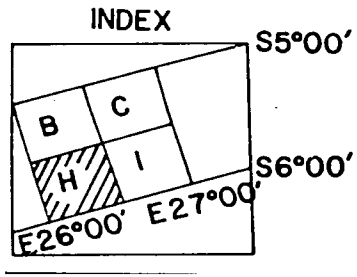
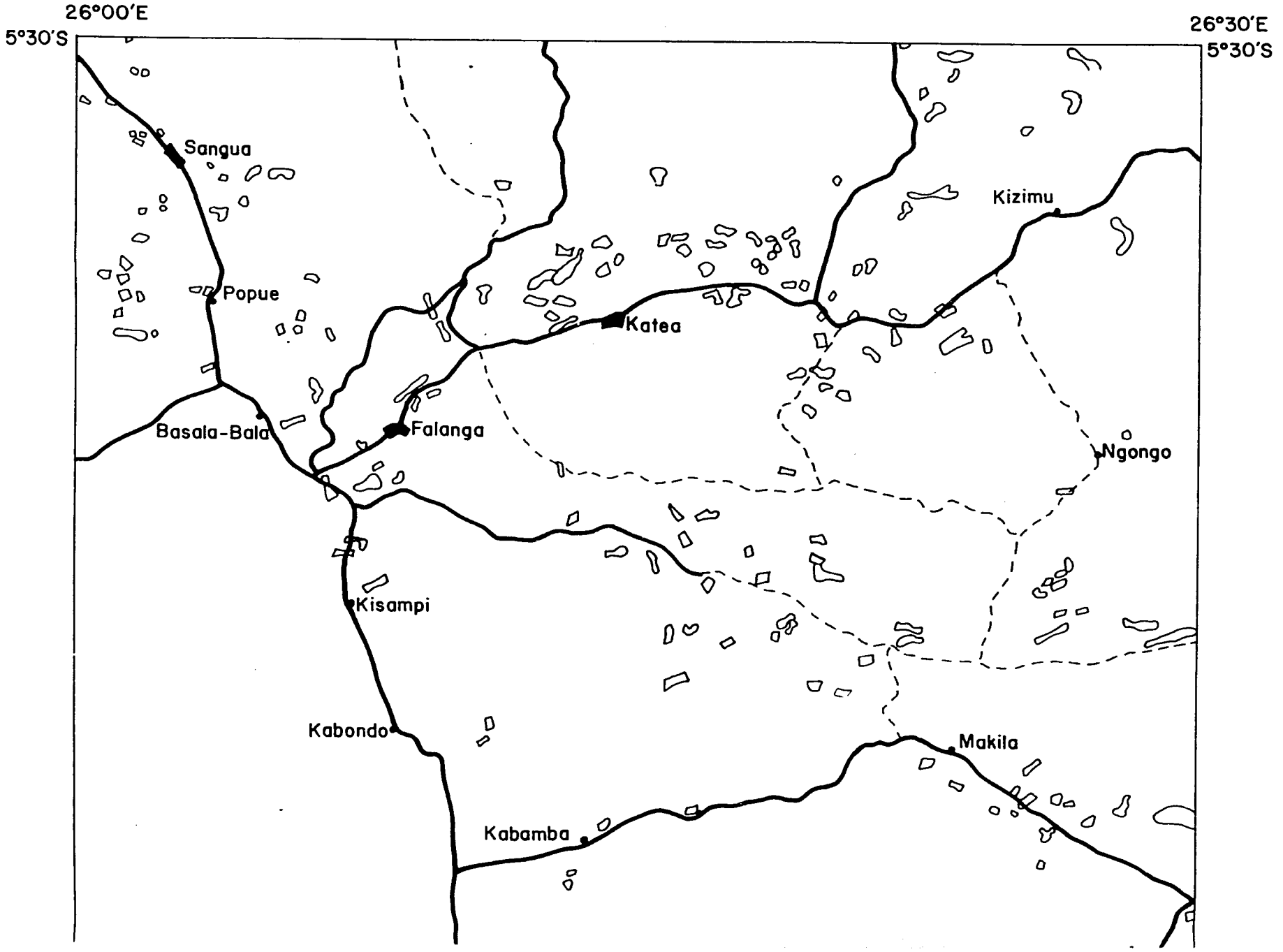


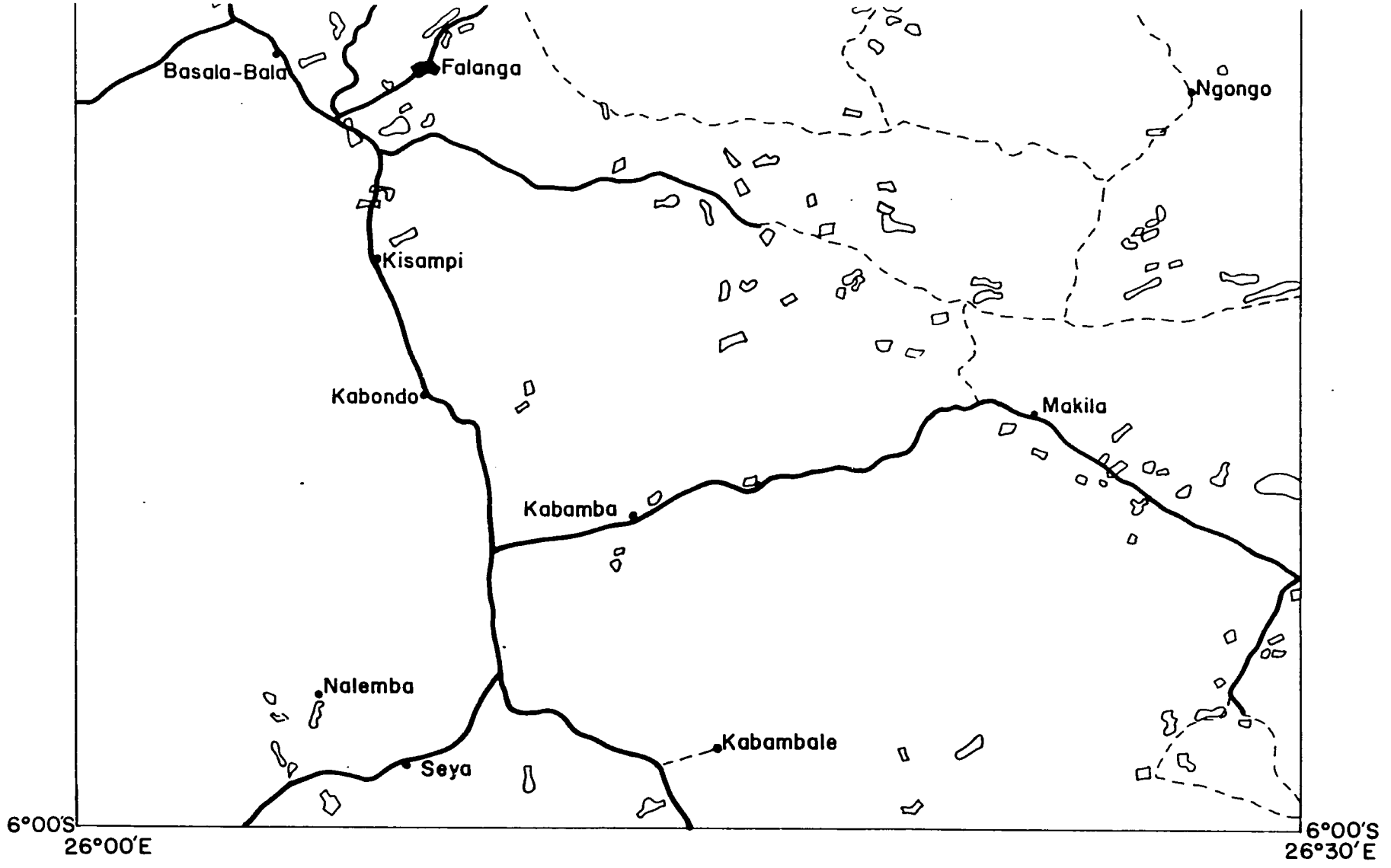
PLANCHE 6-H-1957

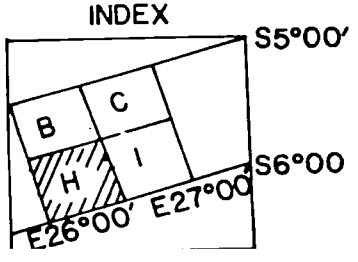
b

P 6-F-020 a

$\frac{1}{4}$° BLOC KATEA







CARTE D'UTILISATION AGRICOLE DES TERRES

1980

Superficie Cultuvee :

Echelle : 1/200.000

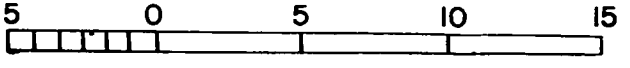
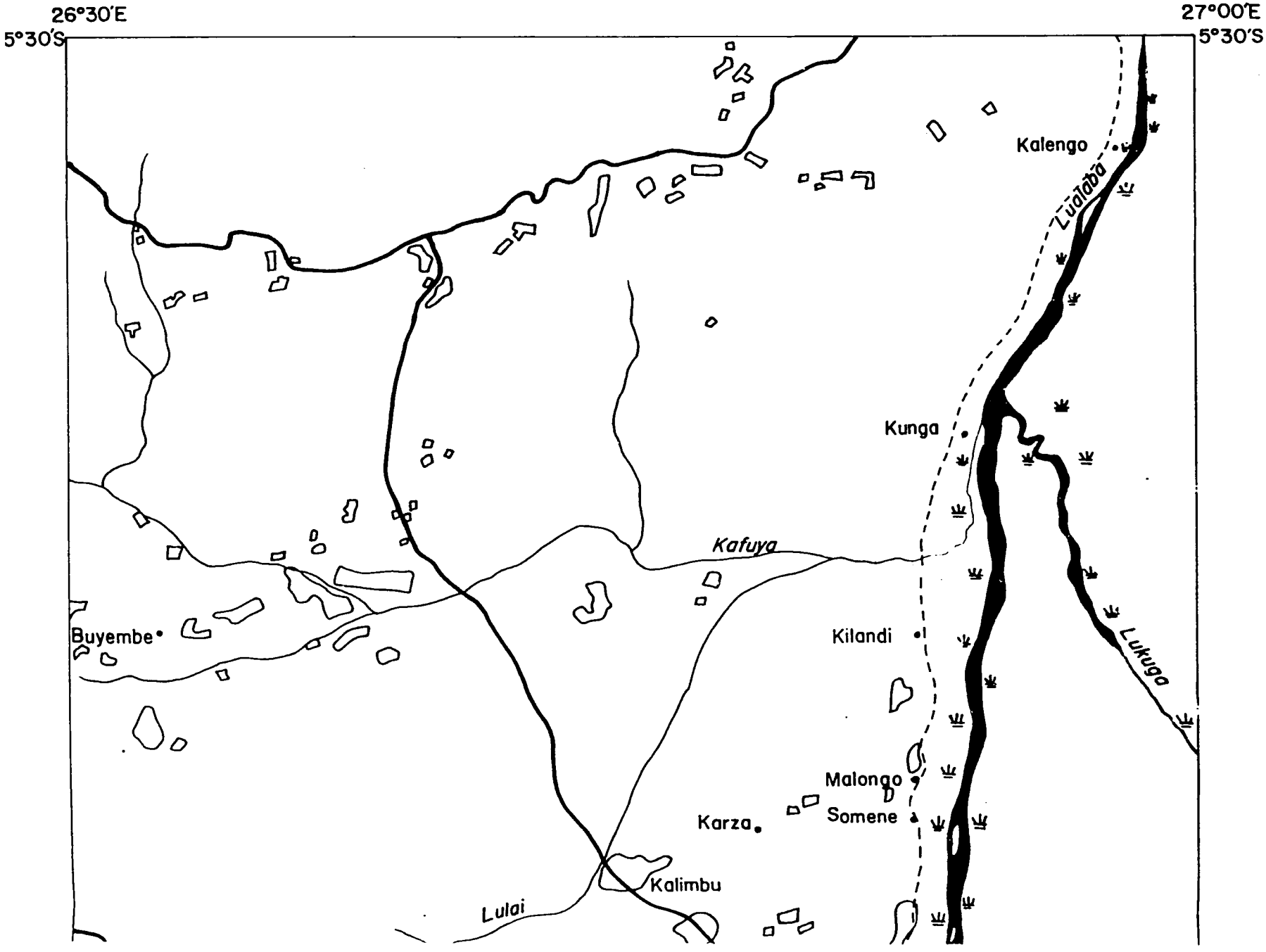
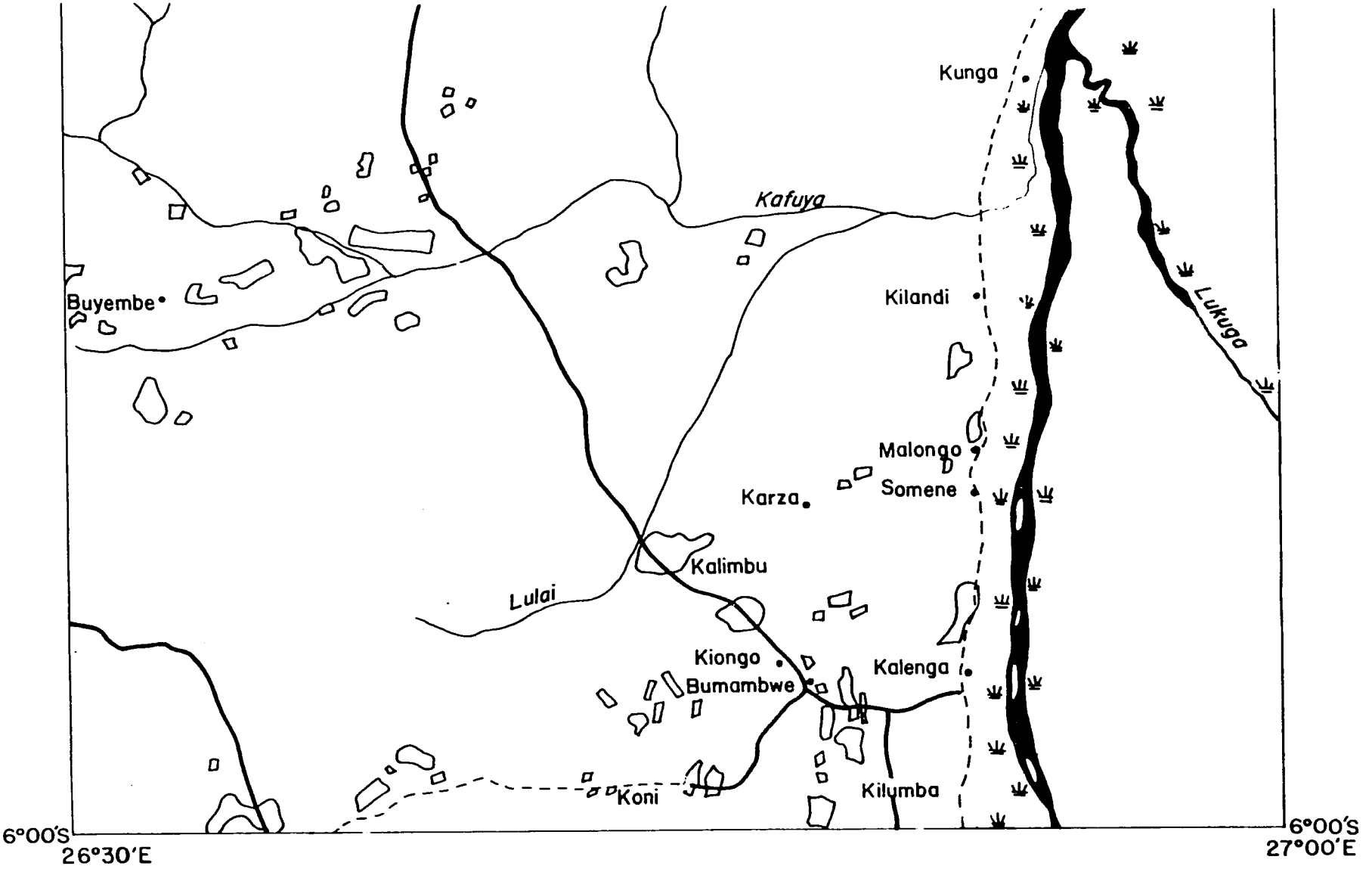


PLANCHE 6-H-1980

P-6-1-1957 a

$\frac{1}{4}$° BLOC BUMAMBWE





CARTE D'UTILISATION AGRICOLE DES TERRES

1957

Superficie Cultuvée : 5.750 Has

Echelle : 1/200.000

5 0 5 10 15

INDEX

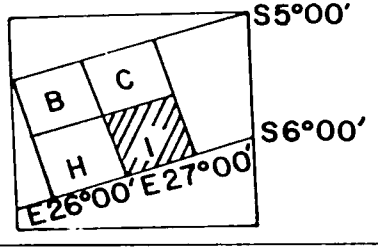
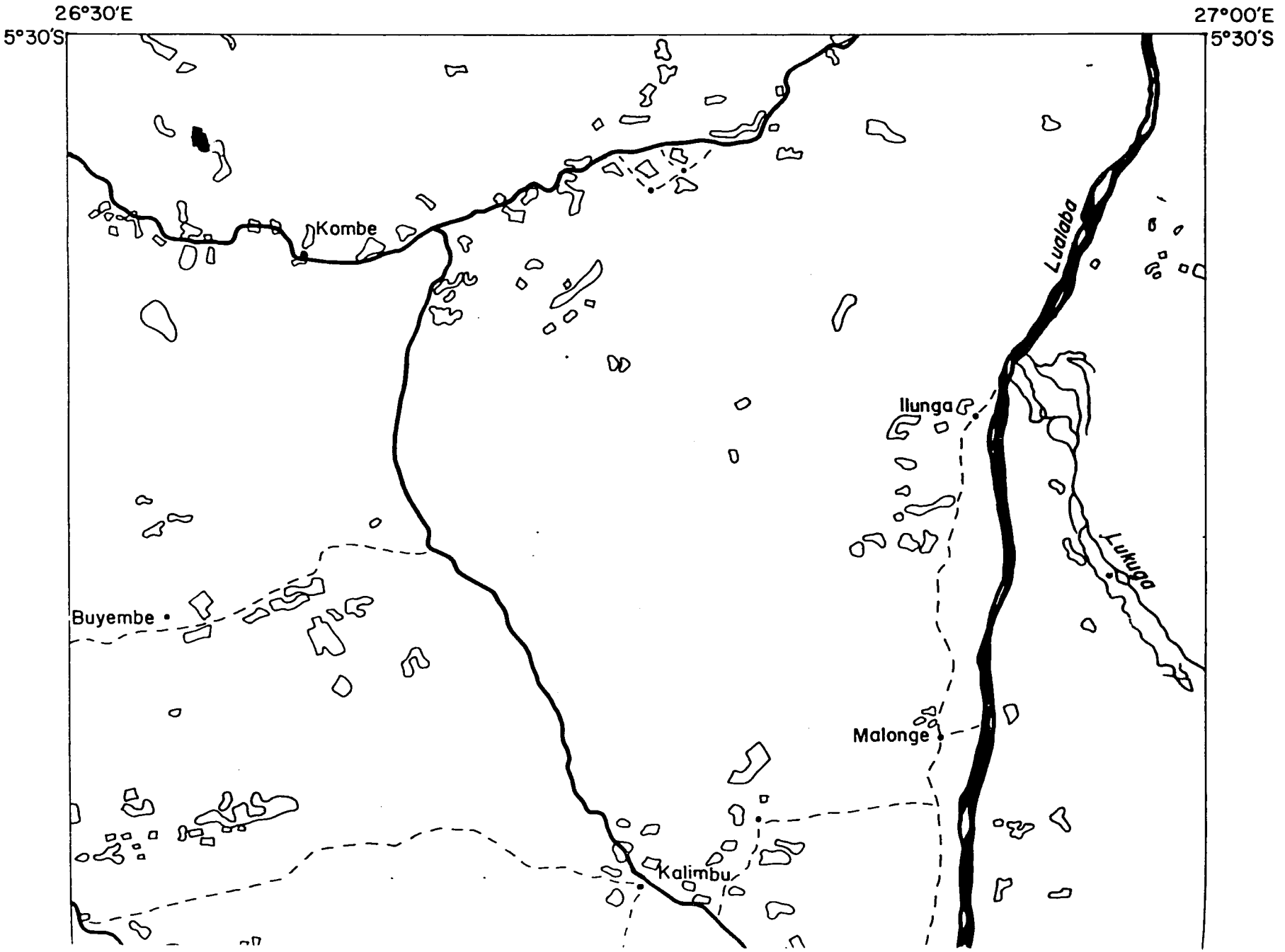


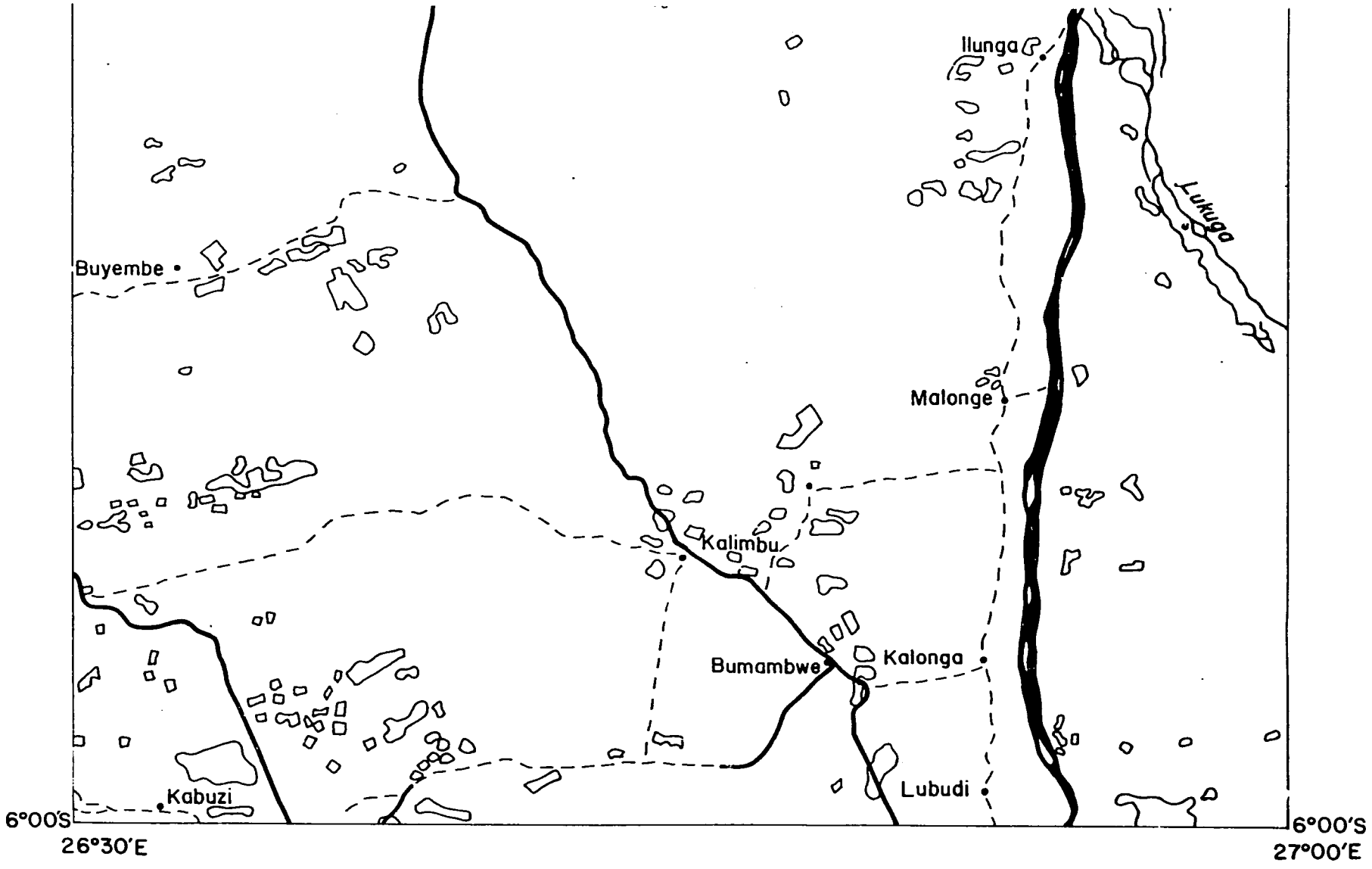
PLANCHE 6-I-1957

b

P-6-1-1980 a

$\frac{1}{4}$° BLOC BUMAMBWE





CARTE D'UTILISATION AGRICOLE DES TERRES

1980

Superficie Cultuvée :

Echèlle : 1/200.000

5 0 5 10 15

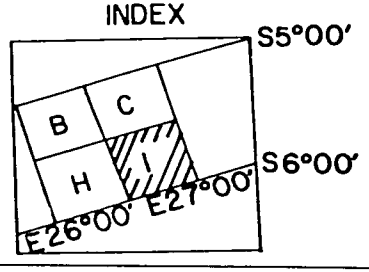
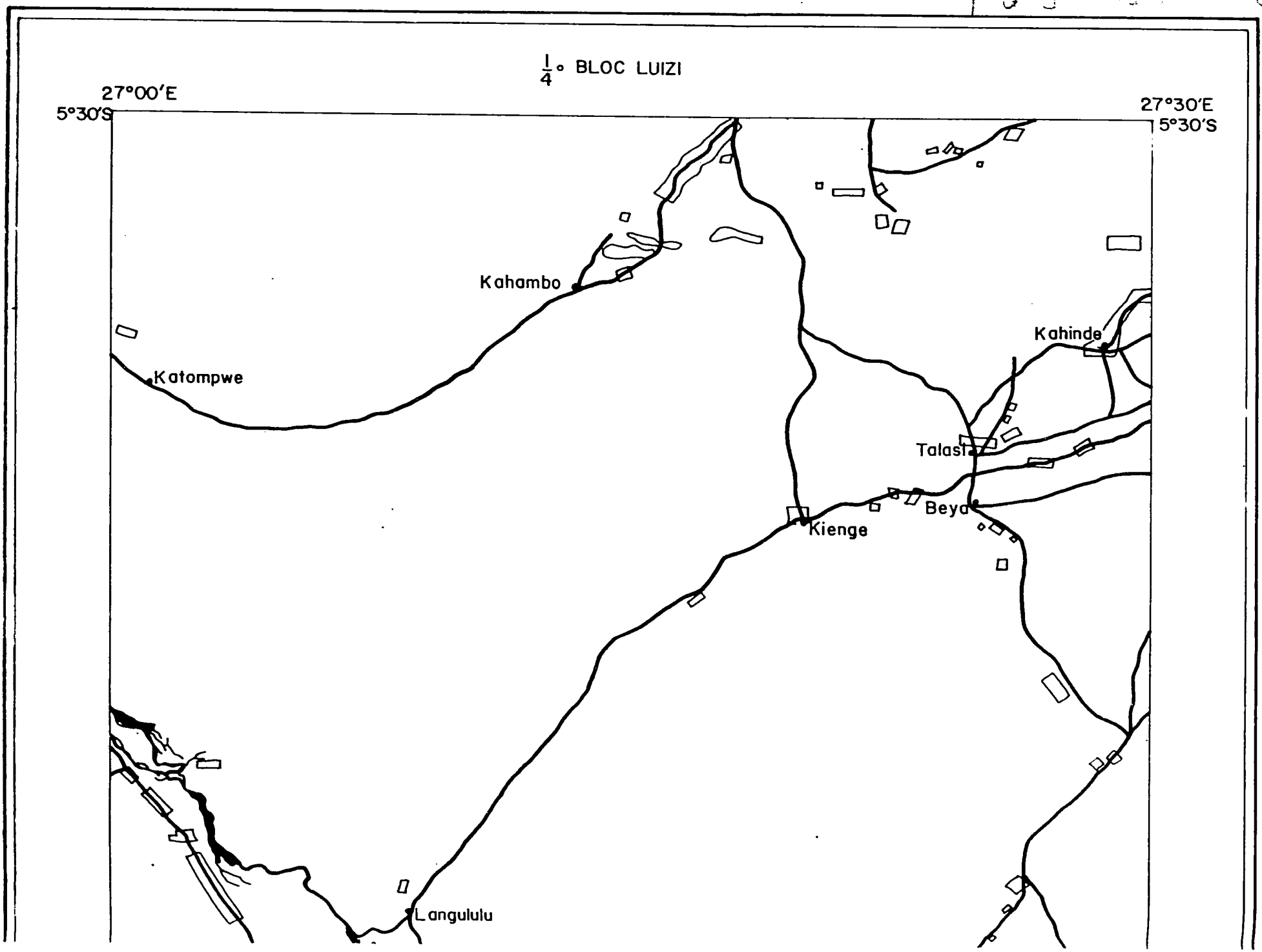
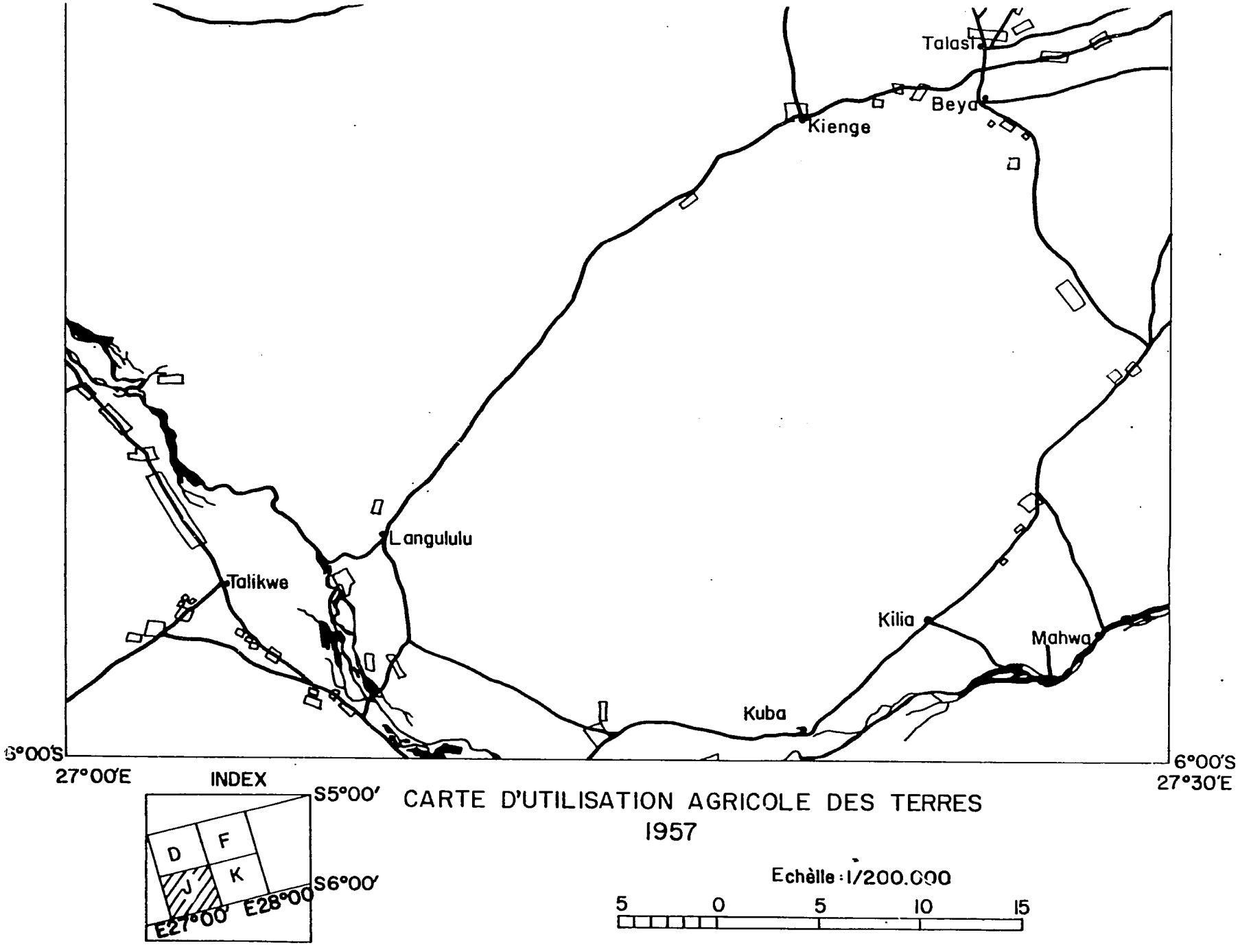


PLANCHE 6-I-1980

b

P 6-J-1957 a


1/4° BLOC LUIZI
27°00'E
5°30'S
27°30'E
5°30'S
Kahambo
Katompwe
Kahinde
Talasi
Beya
Kienge
Langululu



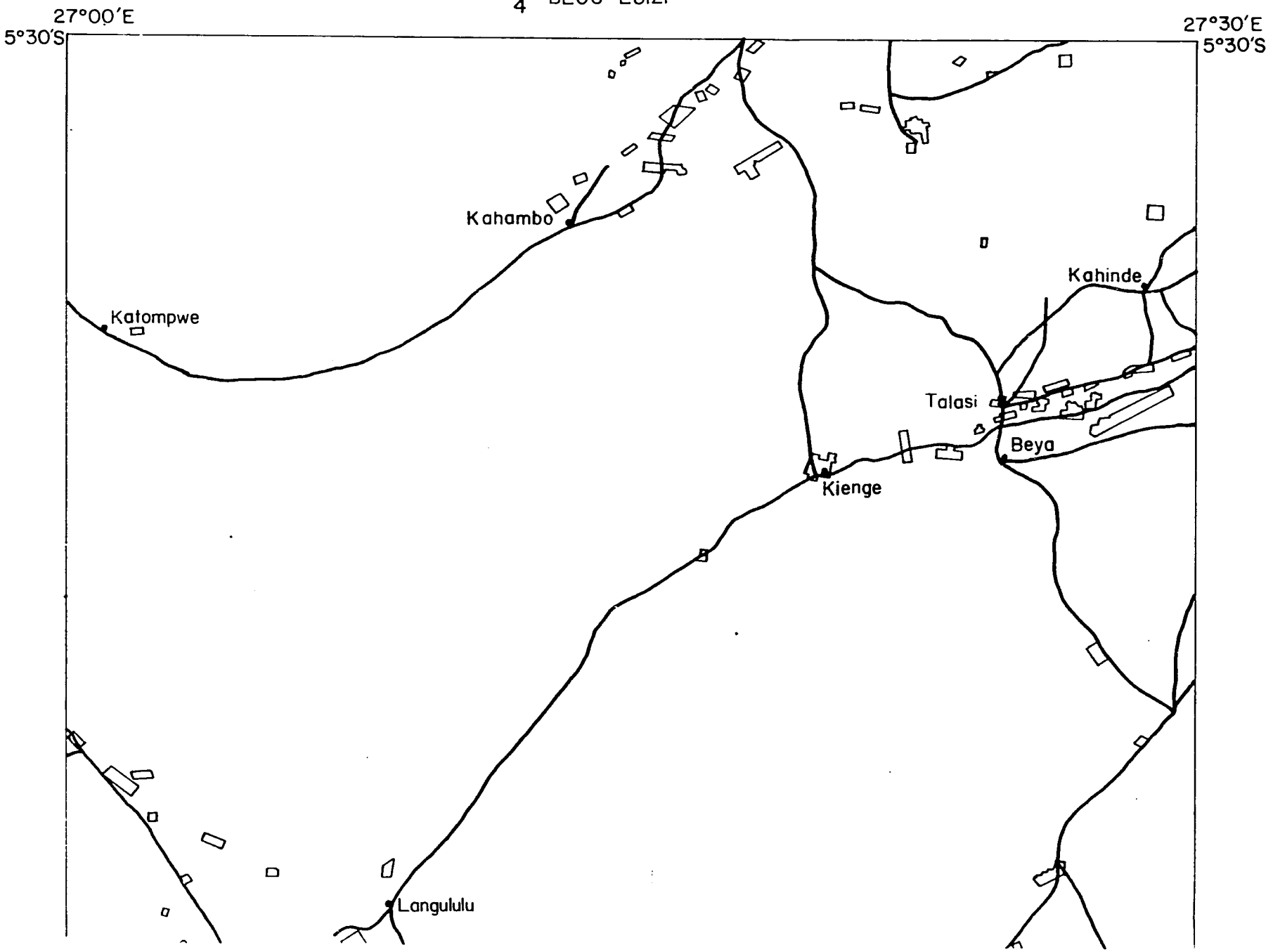
CARTE D'UTILISATION AGRICOLE DES TERRES
1957

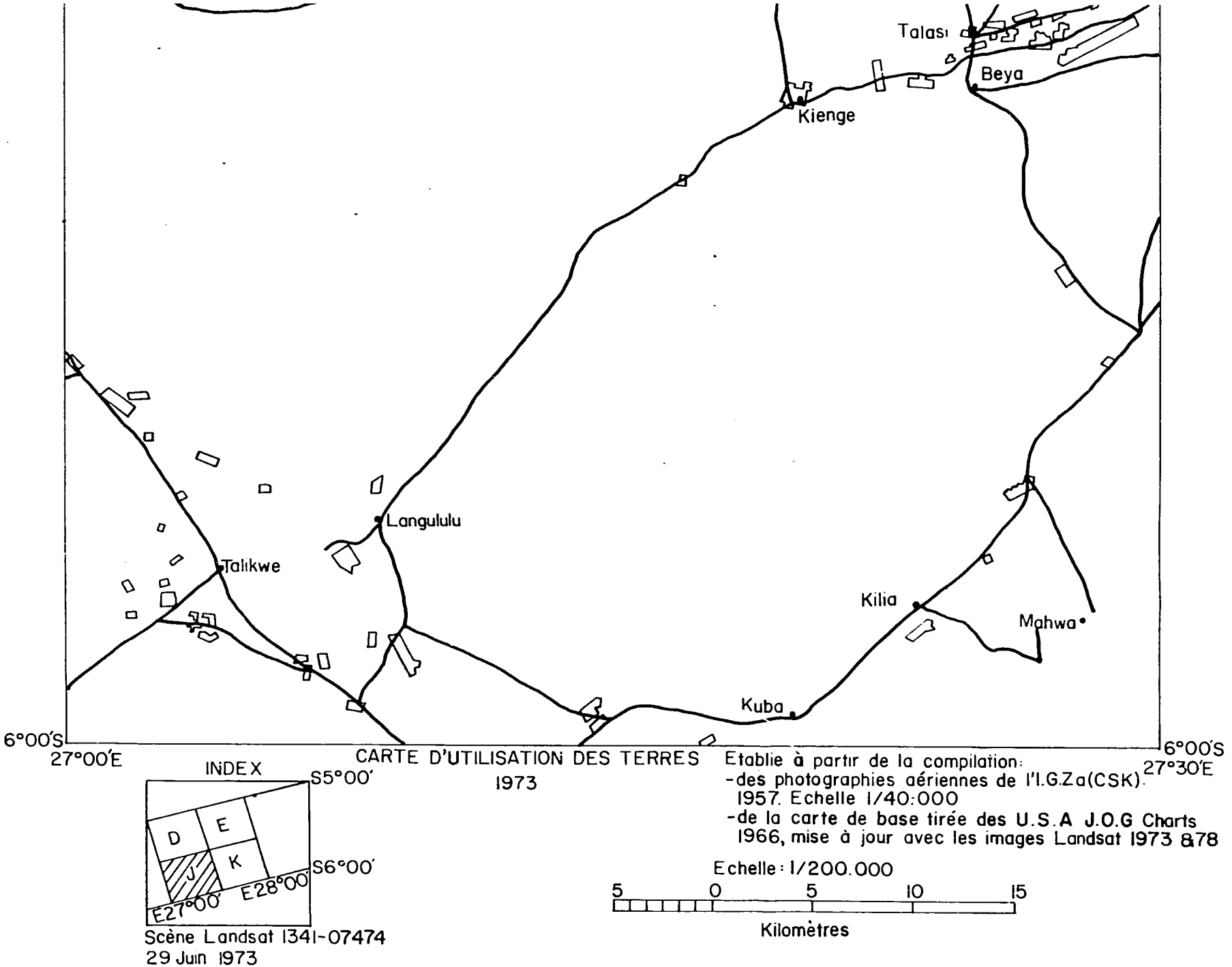
PLANCHE 6-J-1957

6

P-6-J-1973

$\frac{1}{4}$° BLOC LUIZI



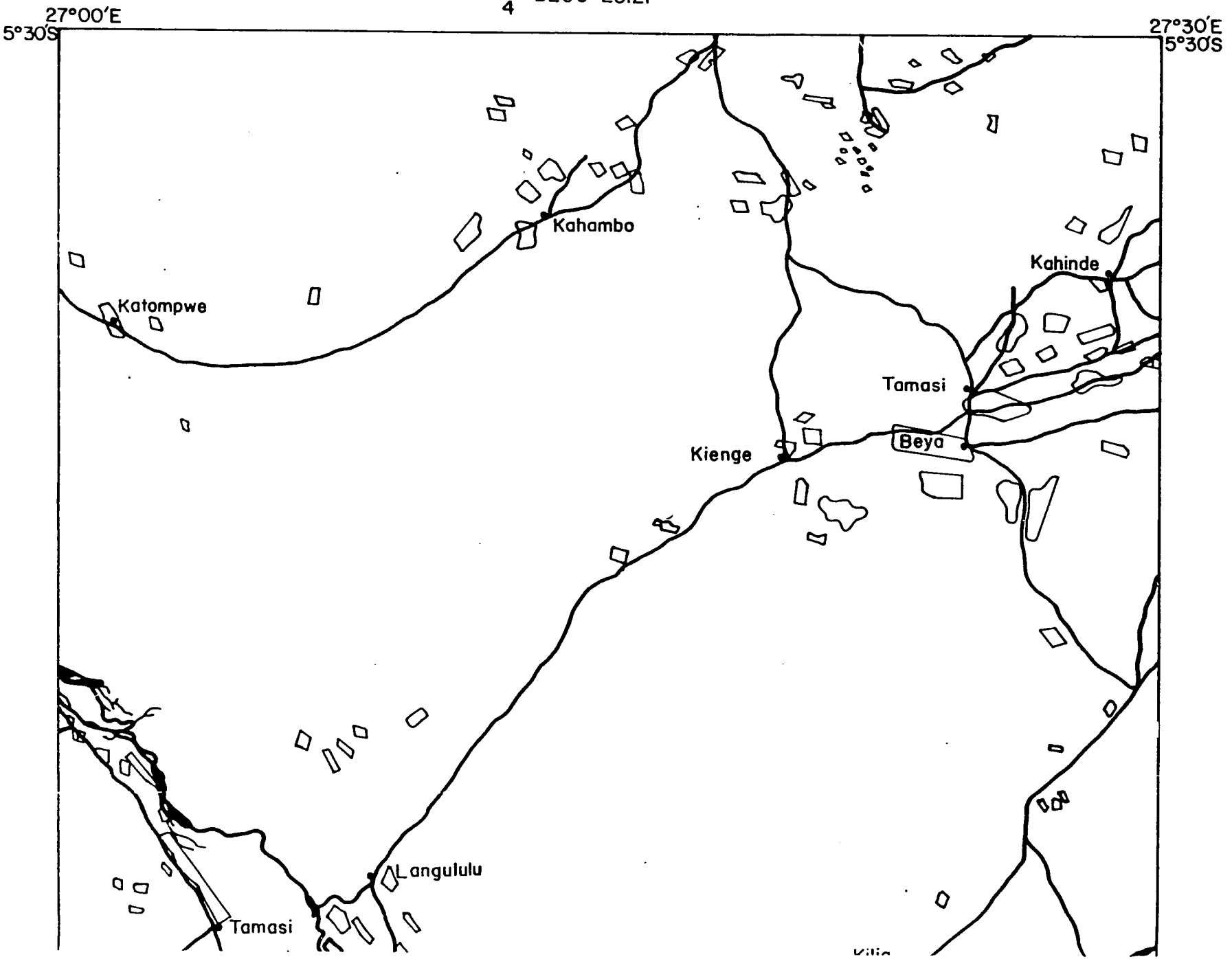


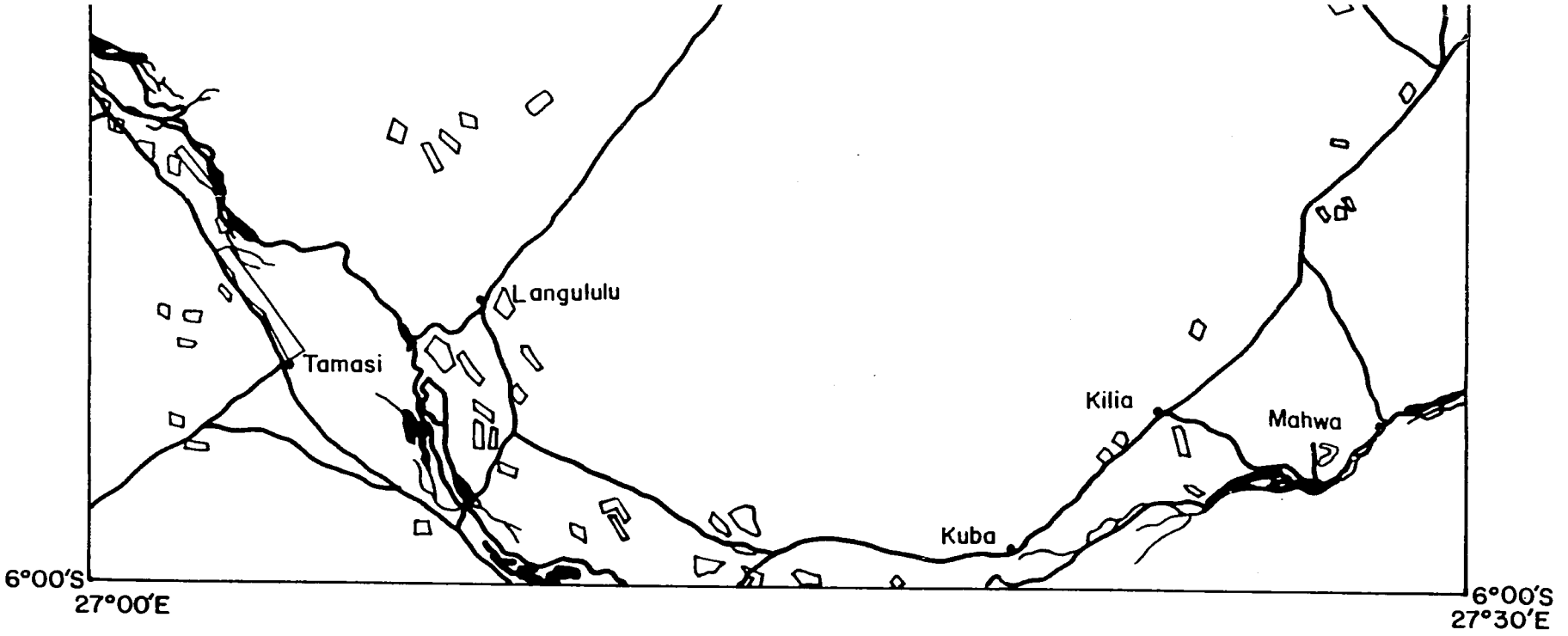
CARTE D'UTILISATION DES TERRES
1973

Etablie à partir de la compilation:
- des photographies aériennes de l'I.G.Za(CSK). 1957. Echelle 1/40:000
- de la carte de base tirée des U.S.A J.O.G Charts 1966, mise à jour avec les images Landsat 1973 & 78

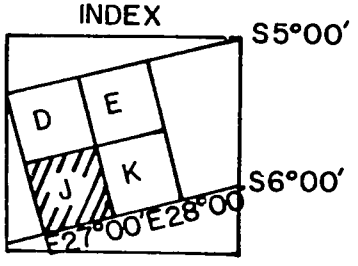
PLANCHE 6-J-1973

$\frac{1}{4}$° BLOC LUIZI





CARTE D'UTILISATION AGRICOLE DES TERRES
1980



Superficie: 6800 Has

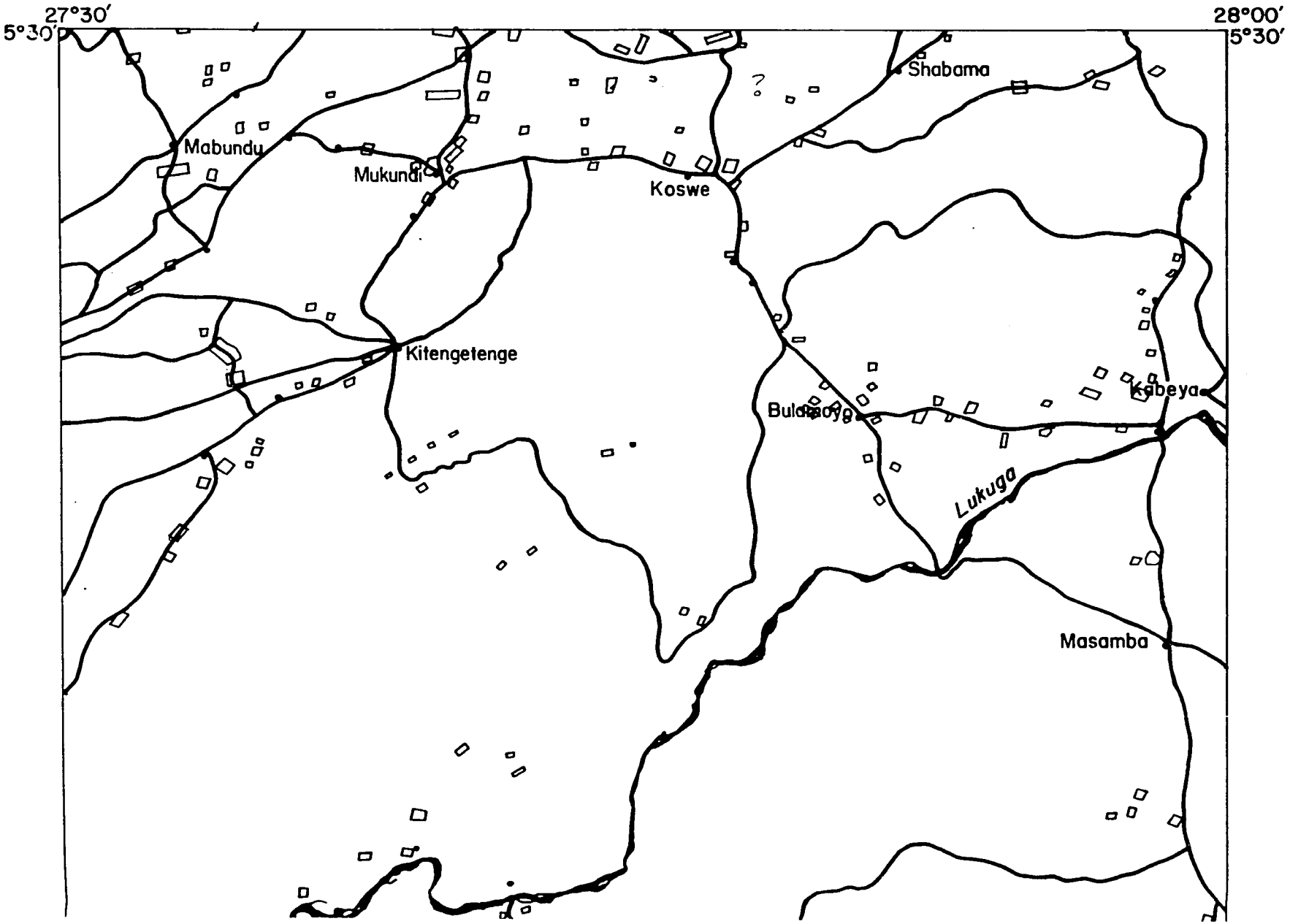
Echèlle: 1/200.000

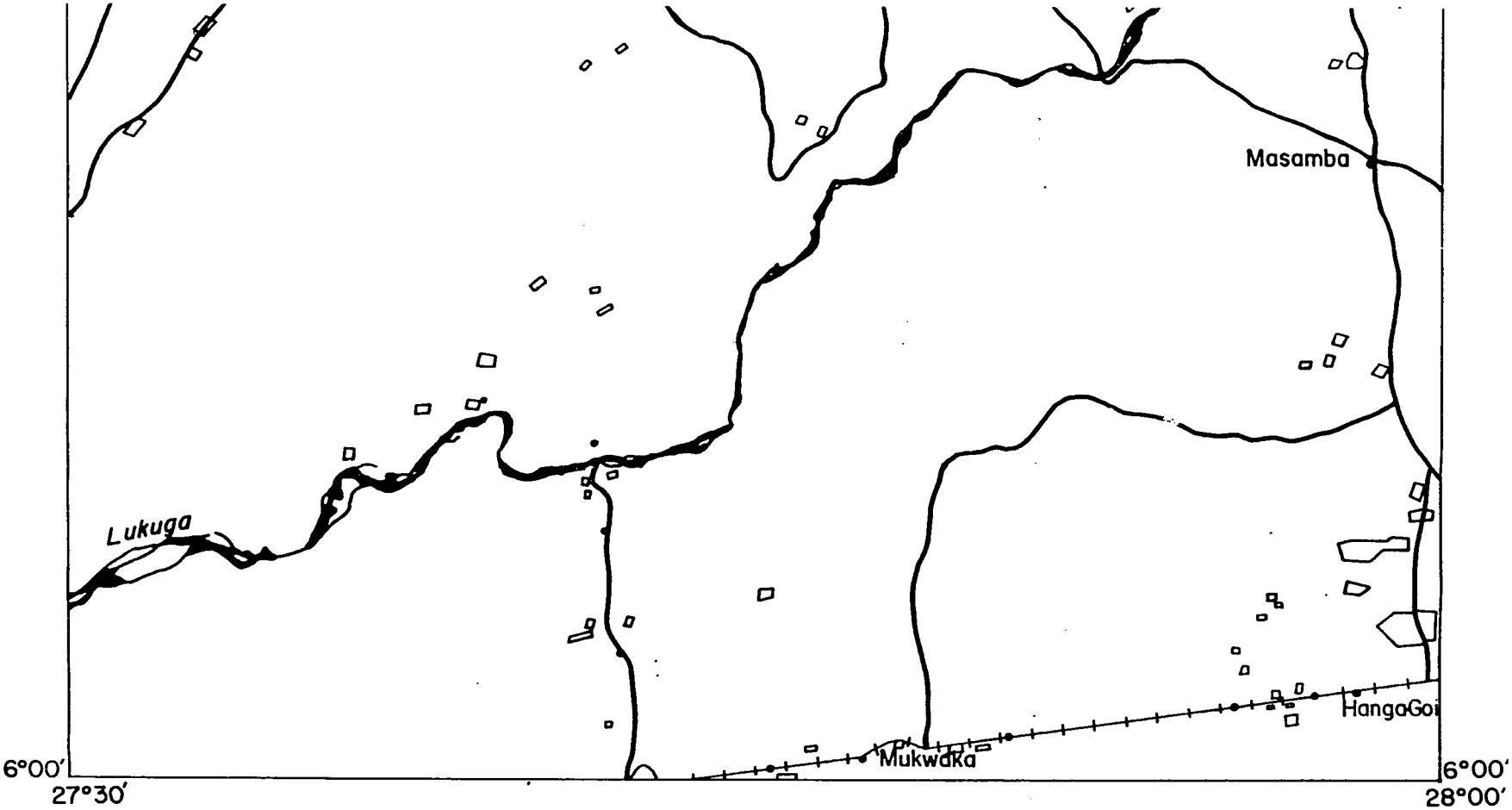
5 0 5 10 15

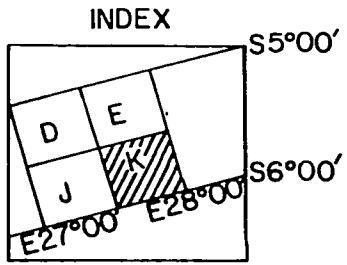
Kilomètres

PLANCHE 6-J-1980

$\frac{1}{4}$° BLOC KITENGETENGE







CARTE D'UTILISATION DES TERRES 1957

Etablie à partir de la compilation:
-des photographies aeriennes de l'I.G Za (CSK) 1957. Echèlle 1/40.000
-de la carte de base tirée des U.S.A J.O.G Charts 1966, mise à jour avec les images Landsat 1973 & 78

Echèlle : 1/200.000

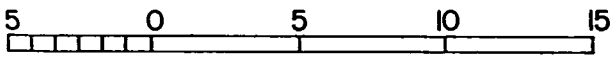
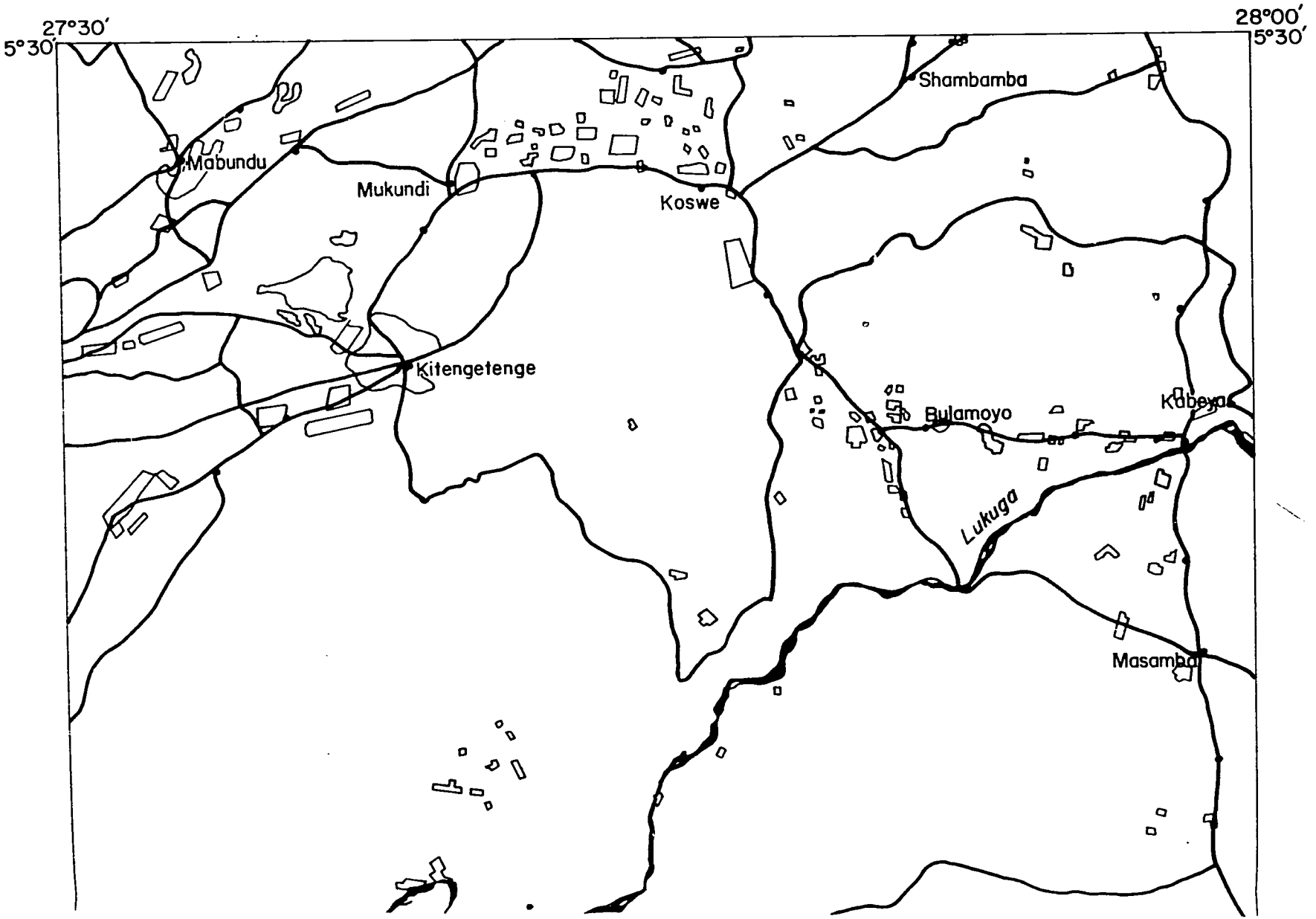
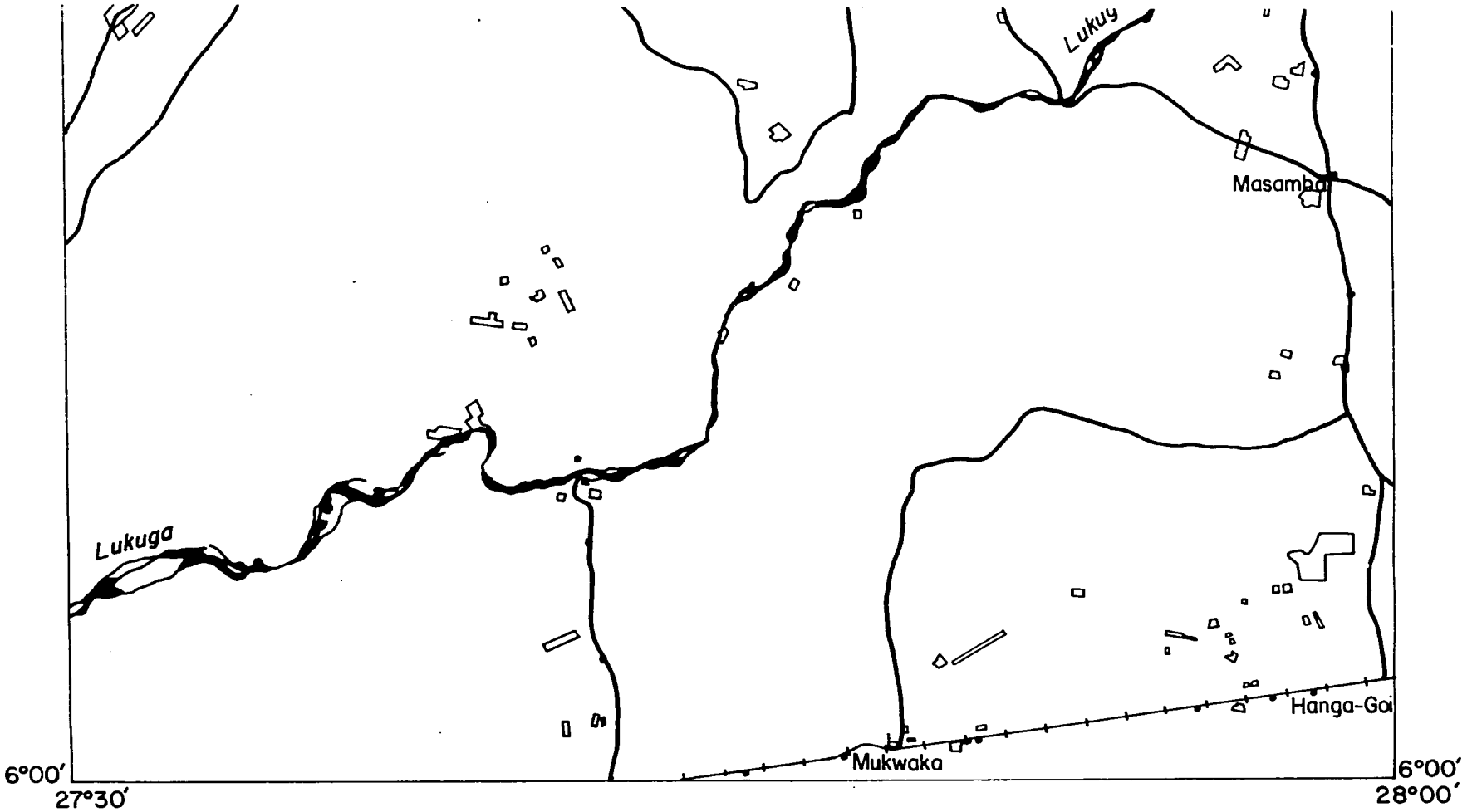
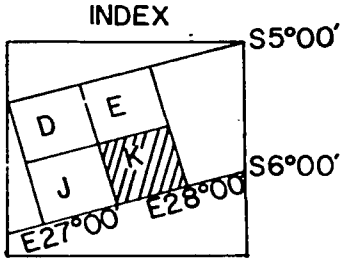


PLANCHE 6-K-1957 b

$\frac{1}{4}$° BLOC KITENGETENGE







CARTE D'UTILISATION AGRICOLE DES TERRES 1973

Superficie Cultuvée : 6575 Has

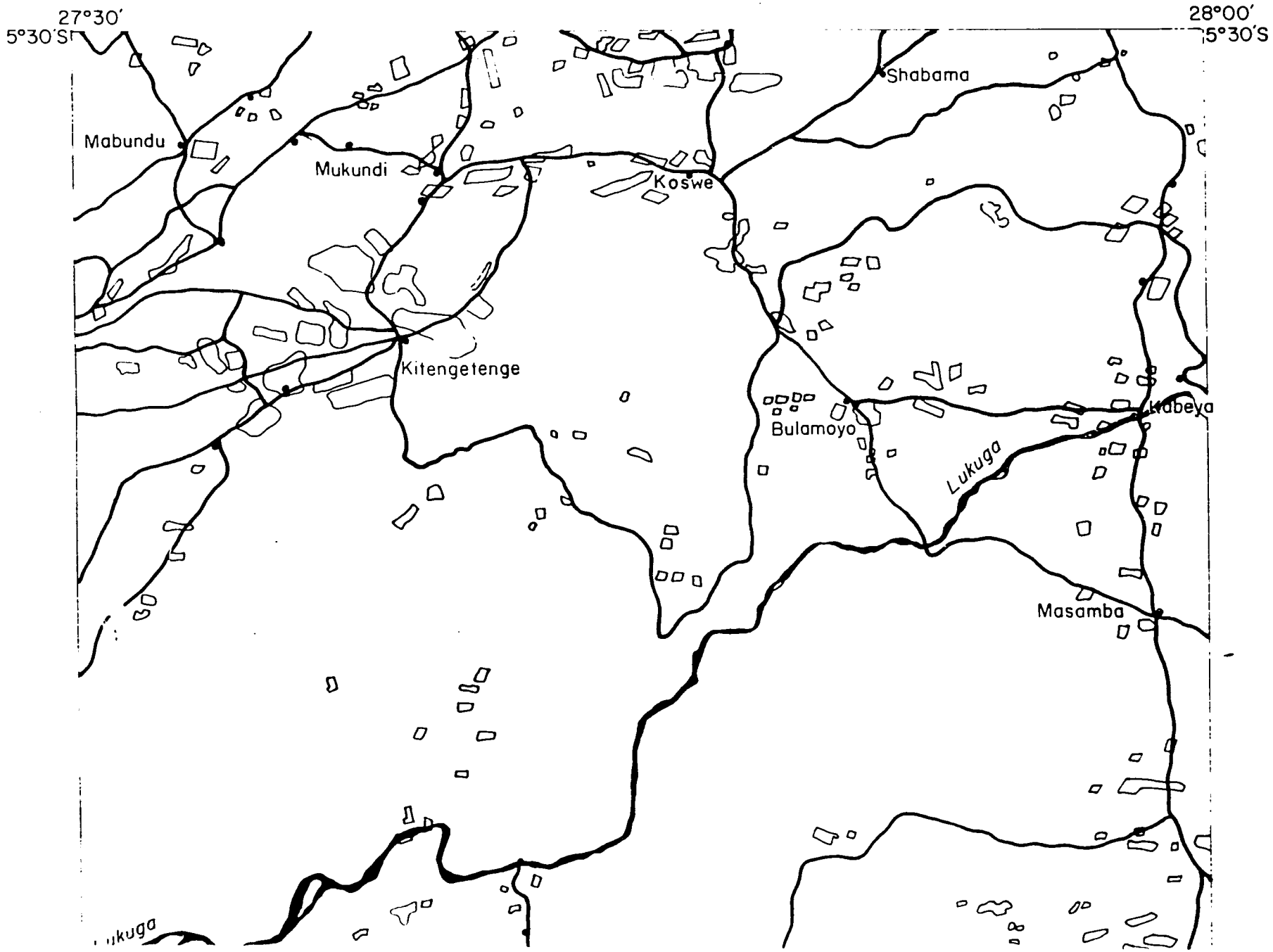
Echèlle : 1/200.000

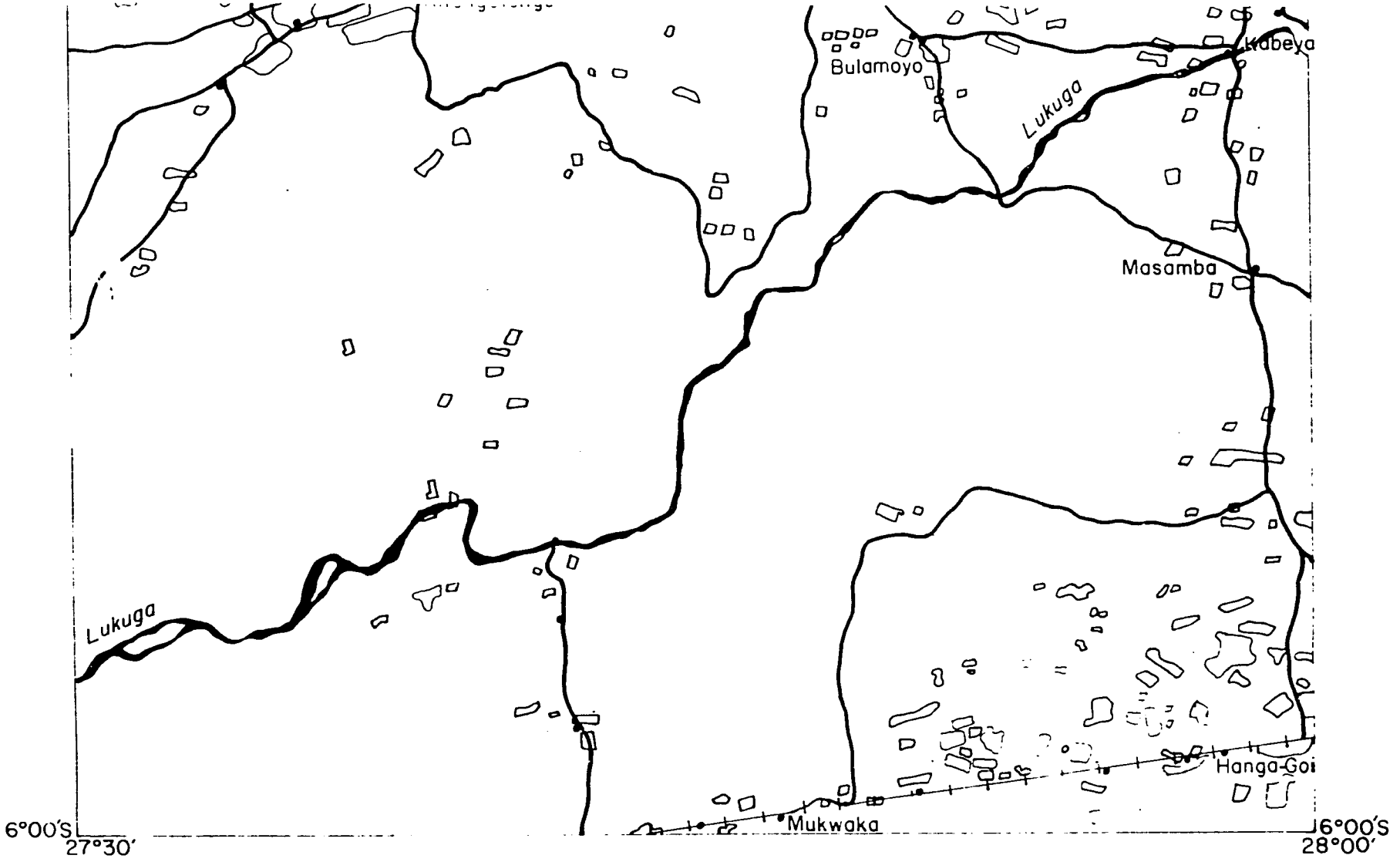
5 0 5 10 15

PLANCHE 6-K-1973 6

P 6-K-1020 a

$\frac{1}{4}$° BLOC KITENGETENGE





CARTE D'UTILISATION AGRICOLE DES TERRES 1980

Superfie 10.300 Has

Echèlle 1/200 000

5 0 5 10 15

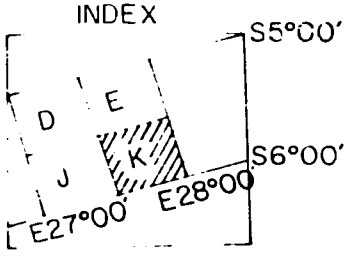
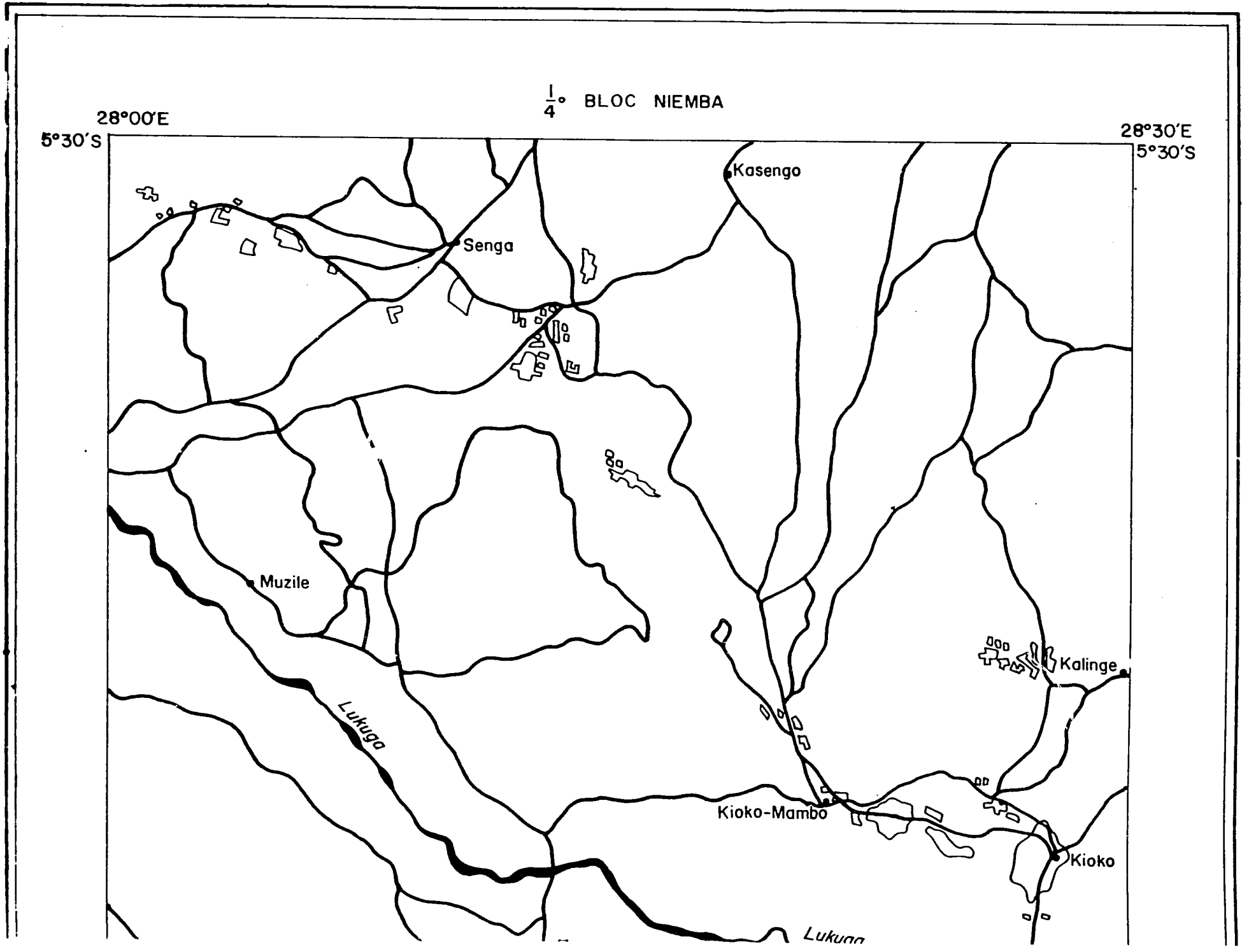
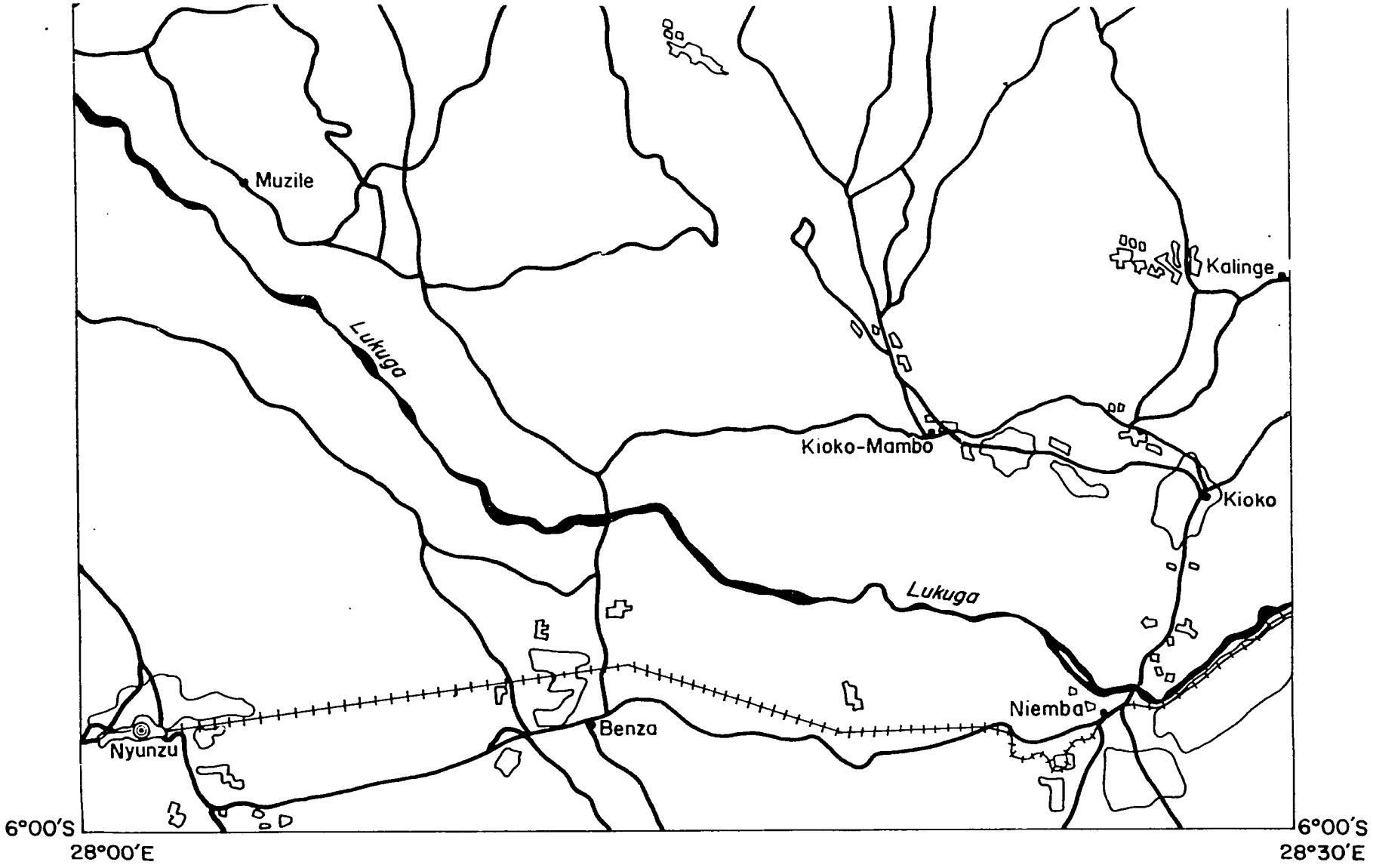


PLANCHE 6-K-1980

b

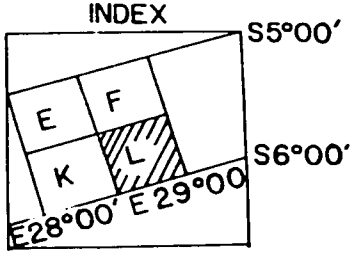
P 6-L-1957 a


1/4° BLOC NIEMBA
28°00'E
5°30'S
28°30'E
5°30'S
Kasengo
Senga
Muzile
Lukuga
Kalinge
Kioko-Mambo
Kioko
Lukuga



CARTE D'UTILISATION AGRICOLE DES TERRES

1957



Superficie Cultuvée: 6225 Has

Echèlle: 1/200.000

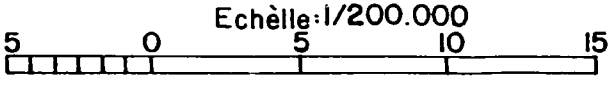
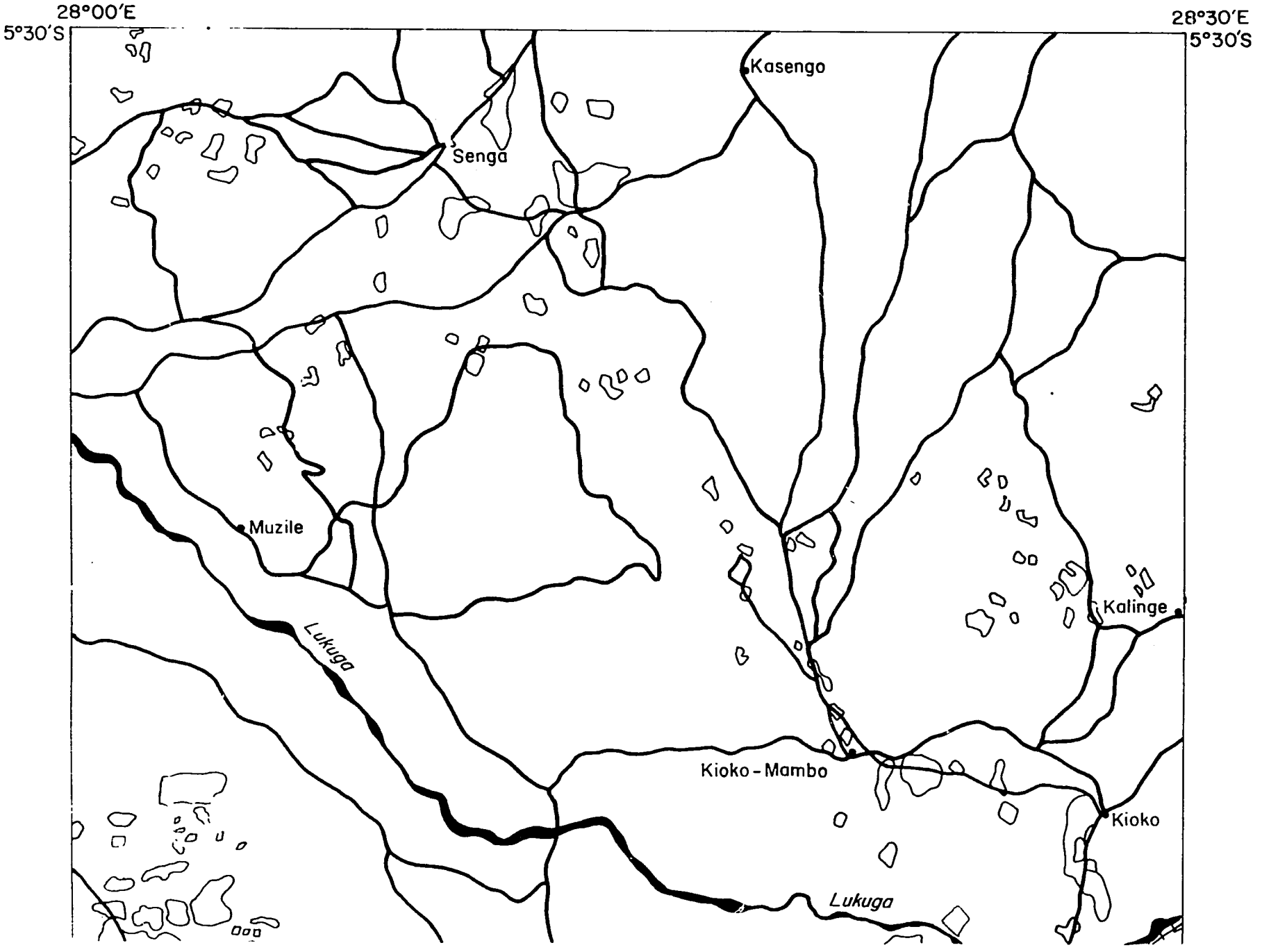
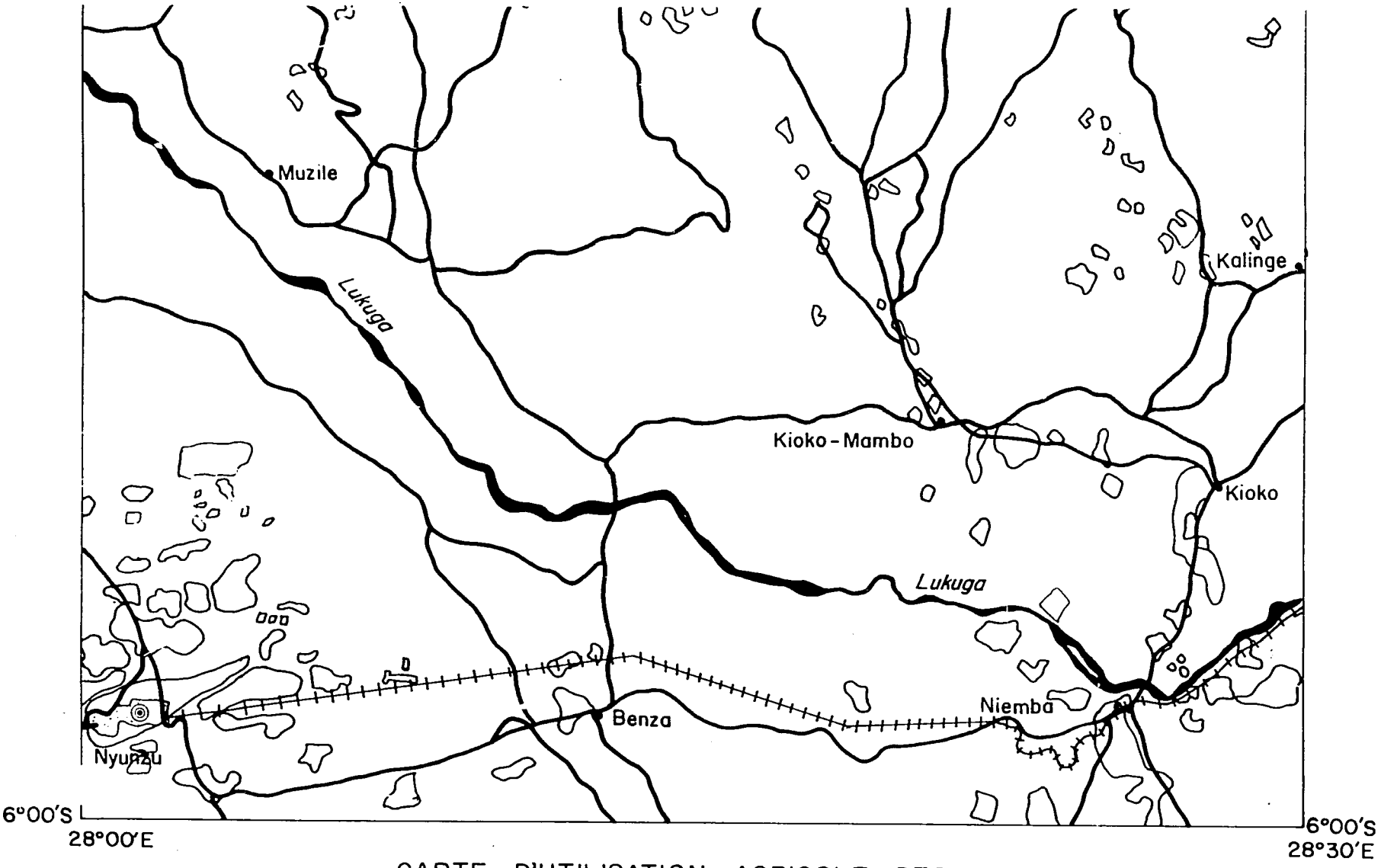


PLANCHE 6-L-1957

b

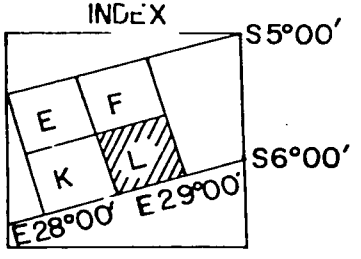
$\frac{1}{4}$° BLOC NIEMBA





CARTE D'UTILISATION AGRICOLE DES TERRES

1980



Superficie Cultuvée : 9600 Has

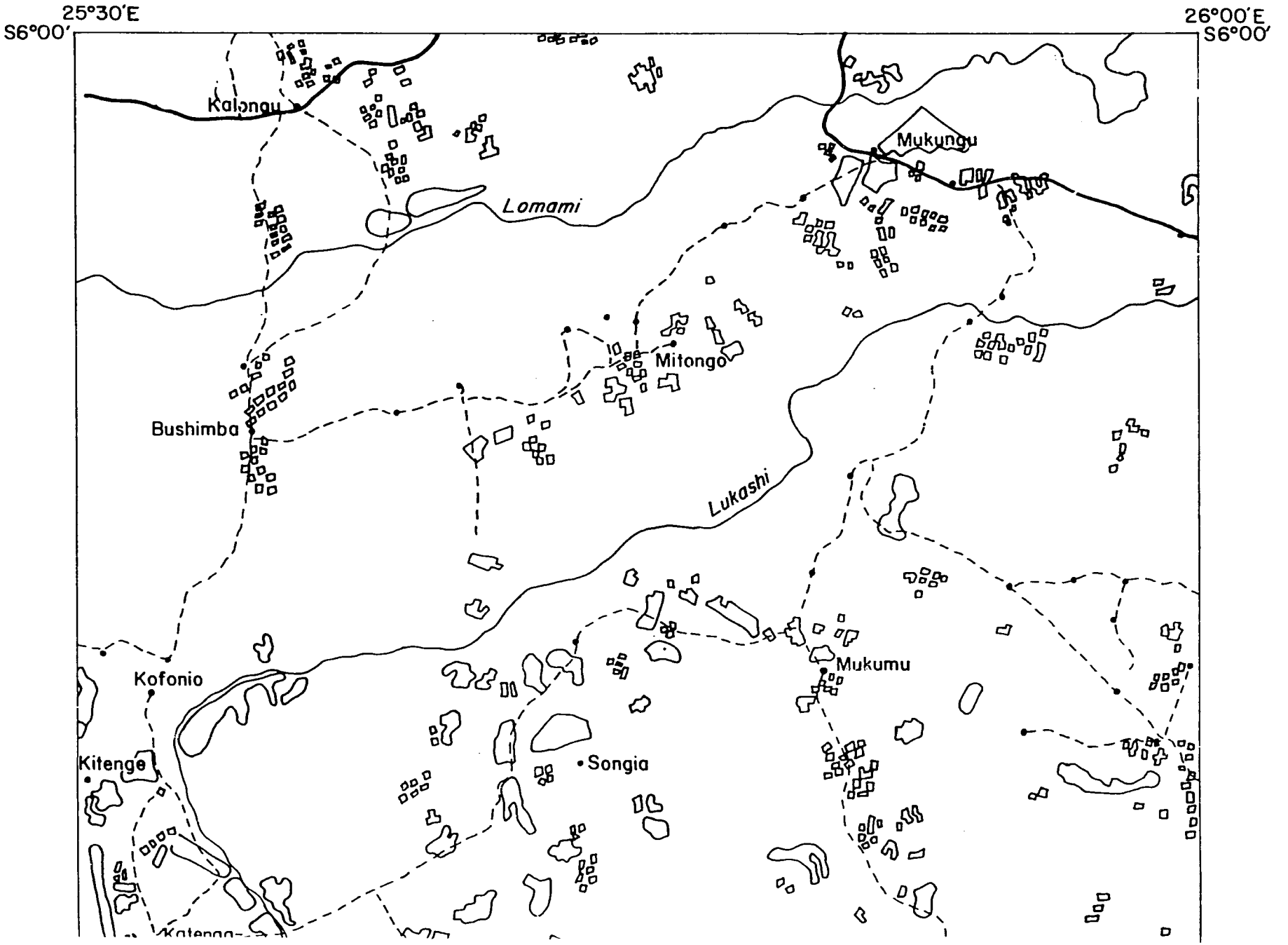
Echèlle : 1/200.000

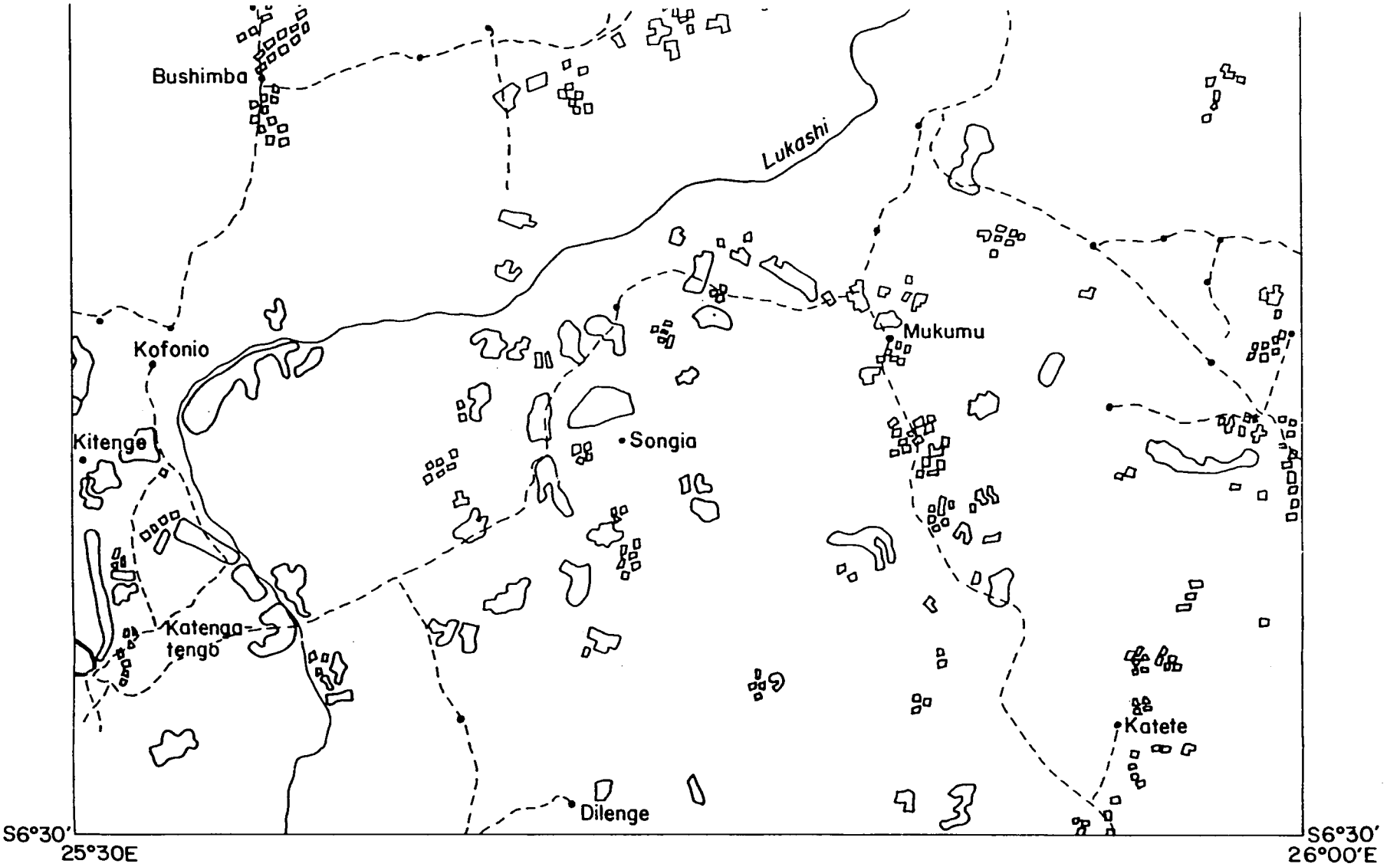
5 0 5 10 15

PLANCHE 6-L-1980

P 6-M-957

$\frac{1}{4}$° BLOC SONGIA





CARTE D'UTILISATION AGRICOLE DES TERRES

1957

Superficie Cultuvée : 20.525 Has

Echèle : 1/200.000

5 0 5 10 15

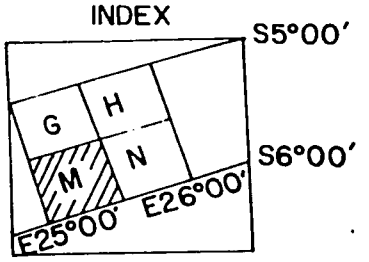
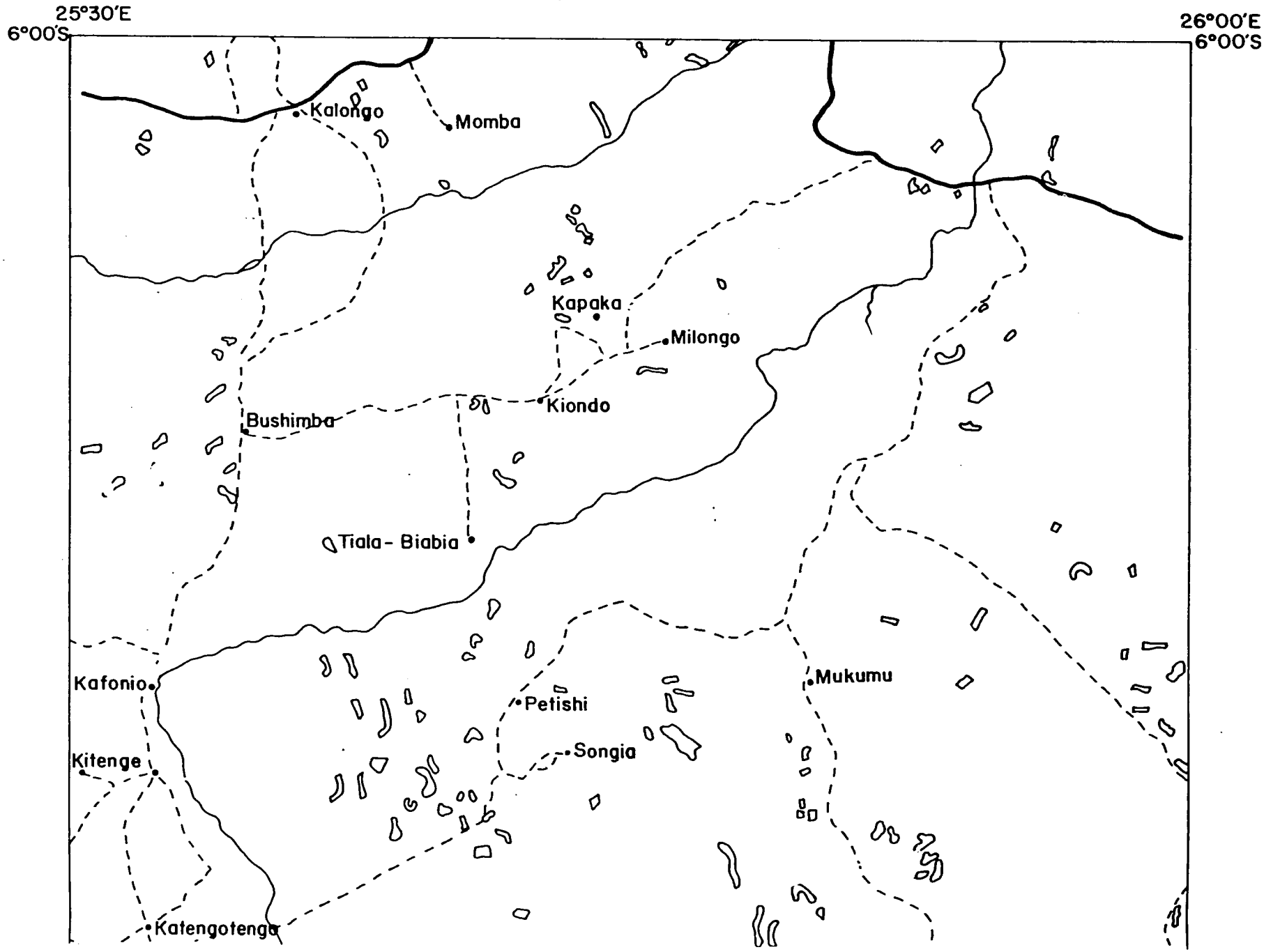
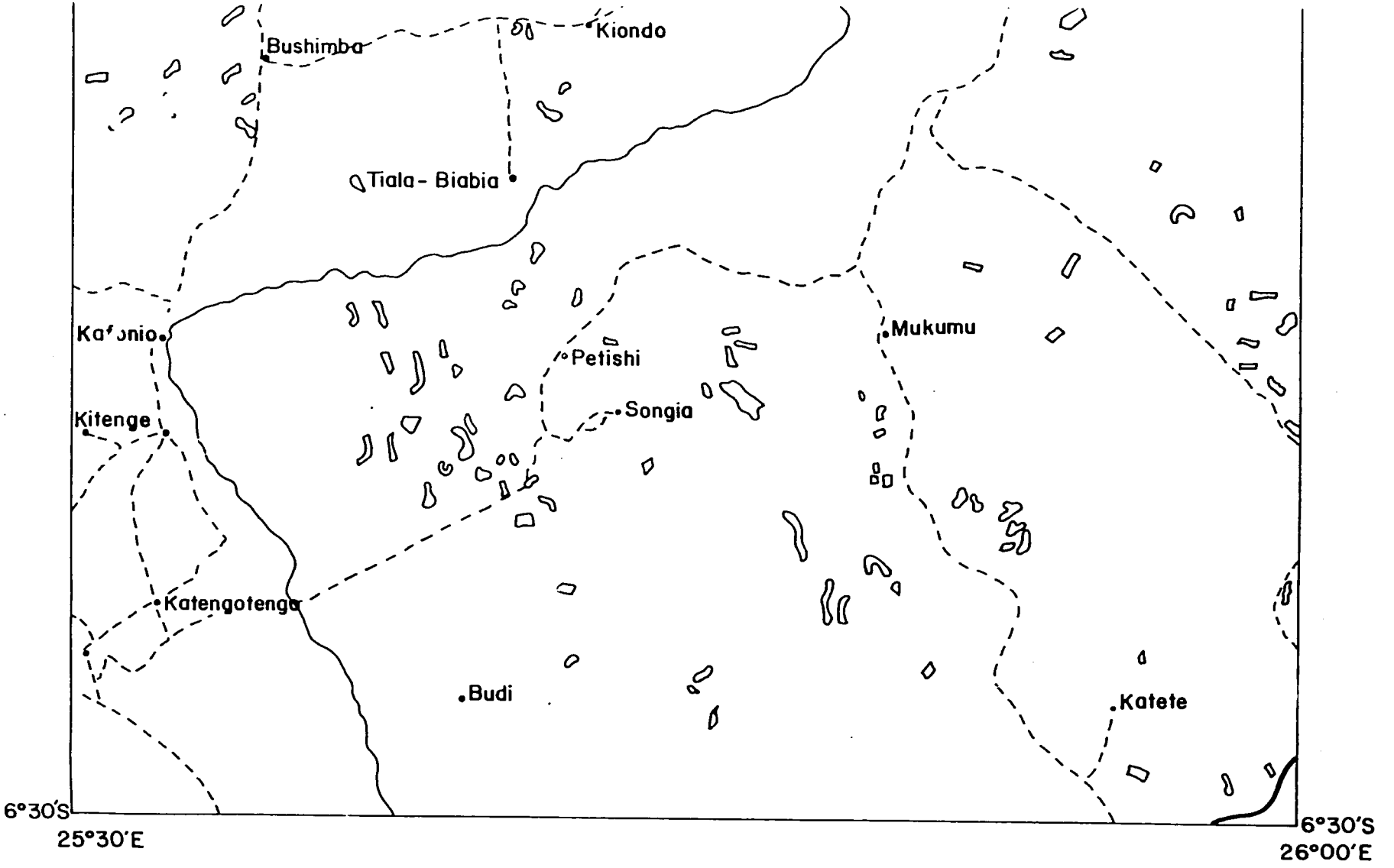


PLANCHE 6-M-1957

$\frac{1}{4}$° BLOC SONGIA





CARTE D'UTILISATION AGRICOLE DES TERRES

1980

Superficie Cultuvée :

Echèlle: 1/200.000

5 0 5 10 15

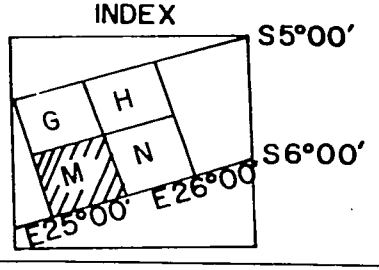


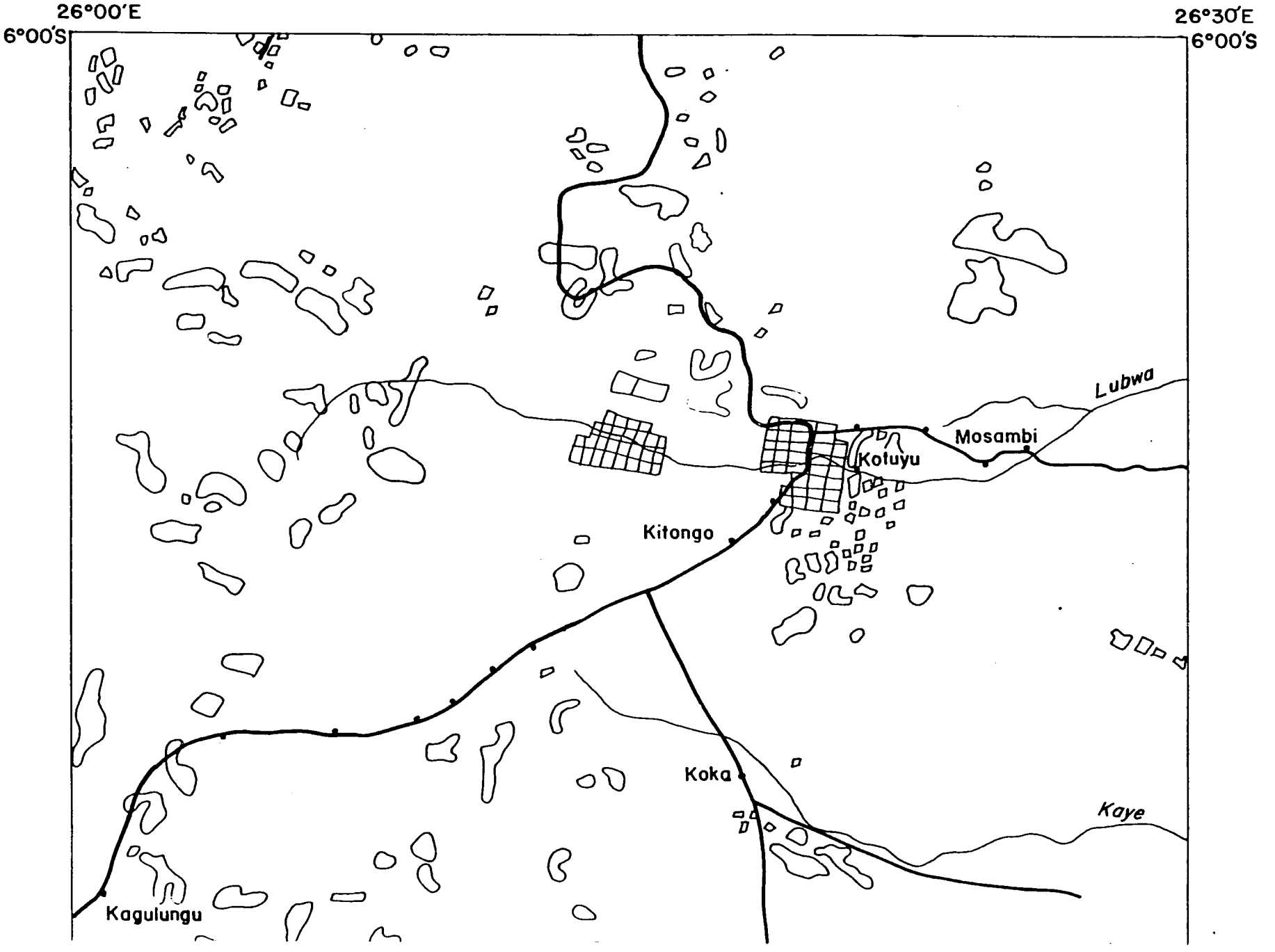
PLANCHE 6-M-1980

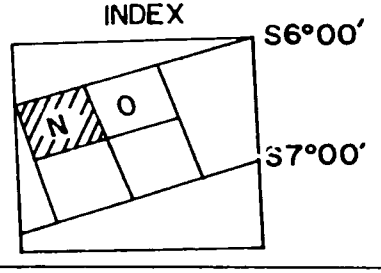
b

P 6-11-1957

2

$\frac{1}{4}$° BLOC MOSAMBI





CARTE D'UTILISATION AGRICOLE DES TERRES

1957

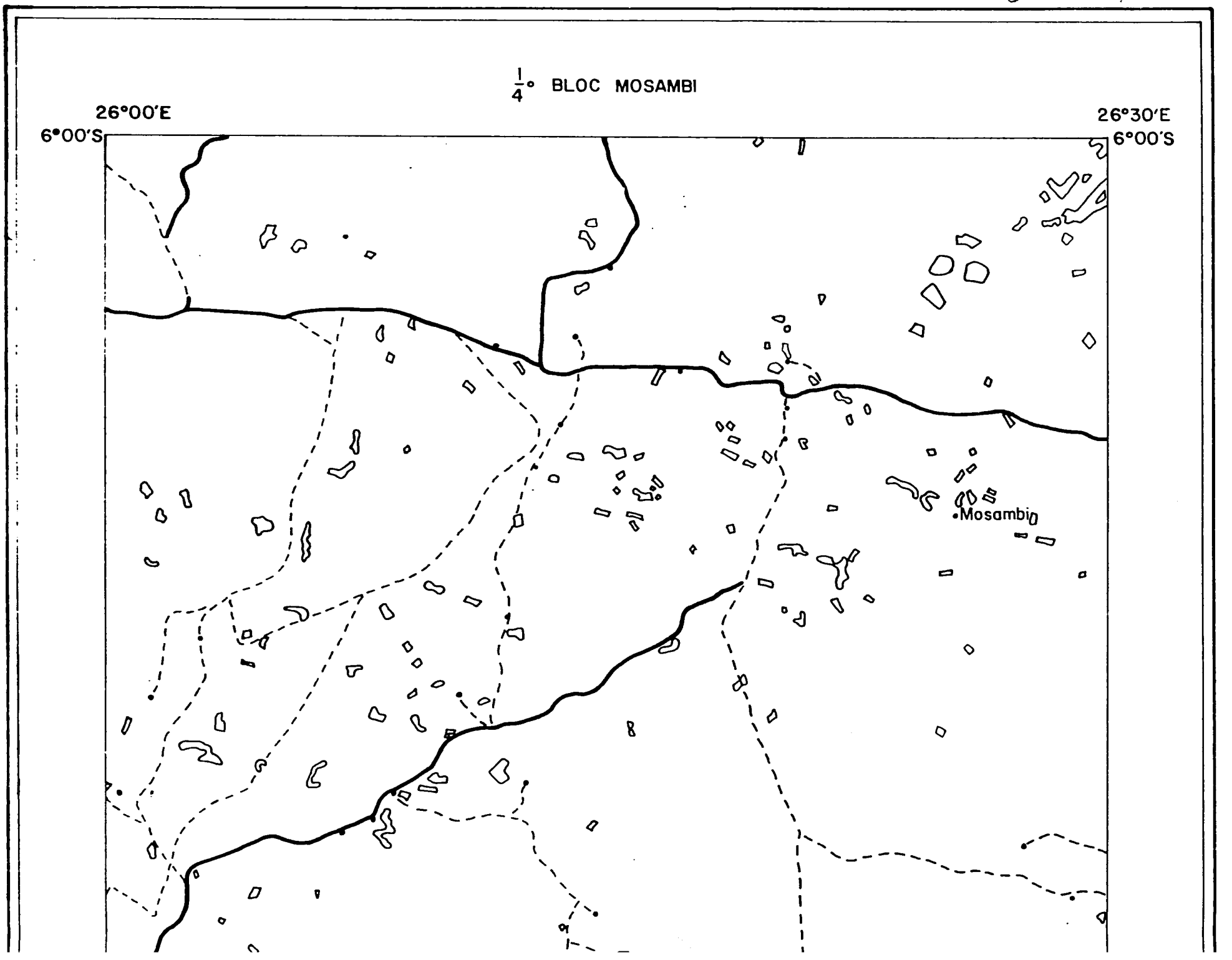
Superficie : 18300 Has

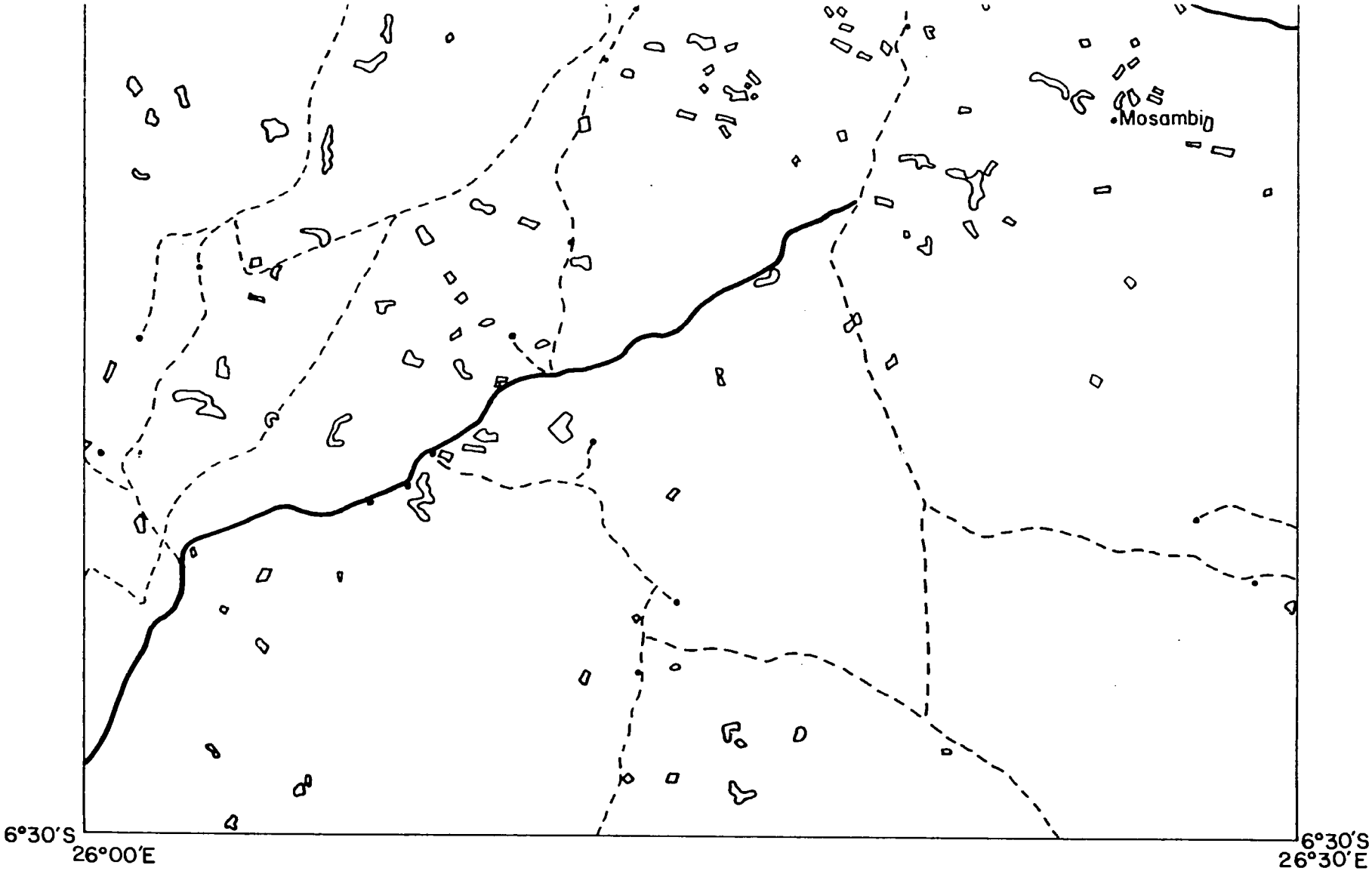
Echelle: 1/200.000

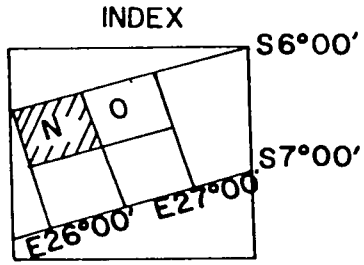
5 0 5 10 15

PLANCHE 6-N-1957

P 6-N-10,0 a







CARTE D'UTILISATION AGRICOLE DES TERRES

1980

Superficie Cultuvée

Echelle: 1/200.000

5 0 5 10 15

PLANCHE 6-N-1980

b

P 6-0-105

a

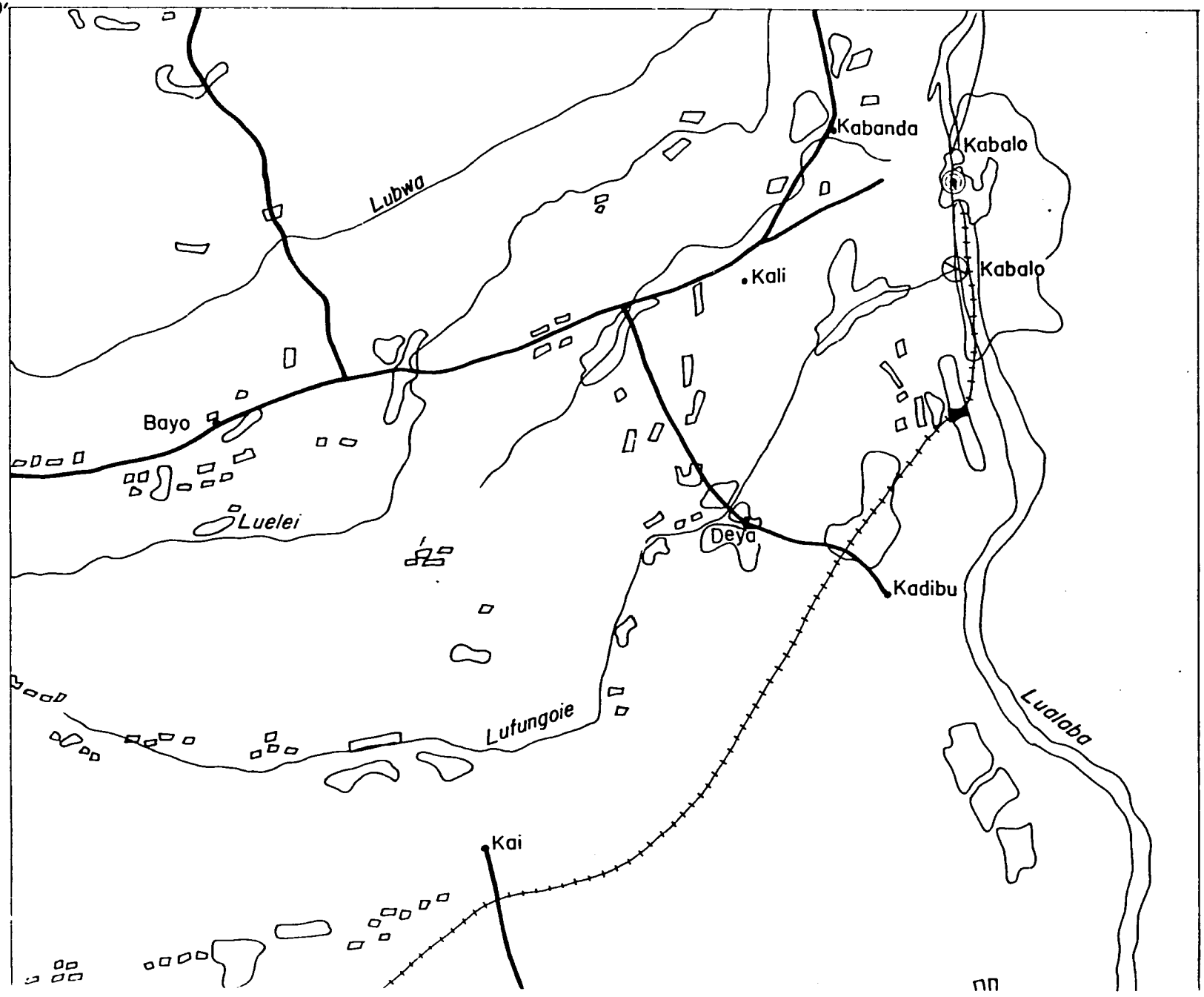
1/4° BLOC KABALO

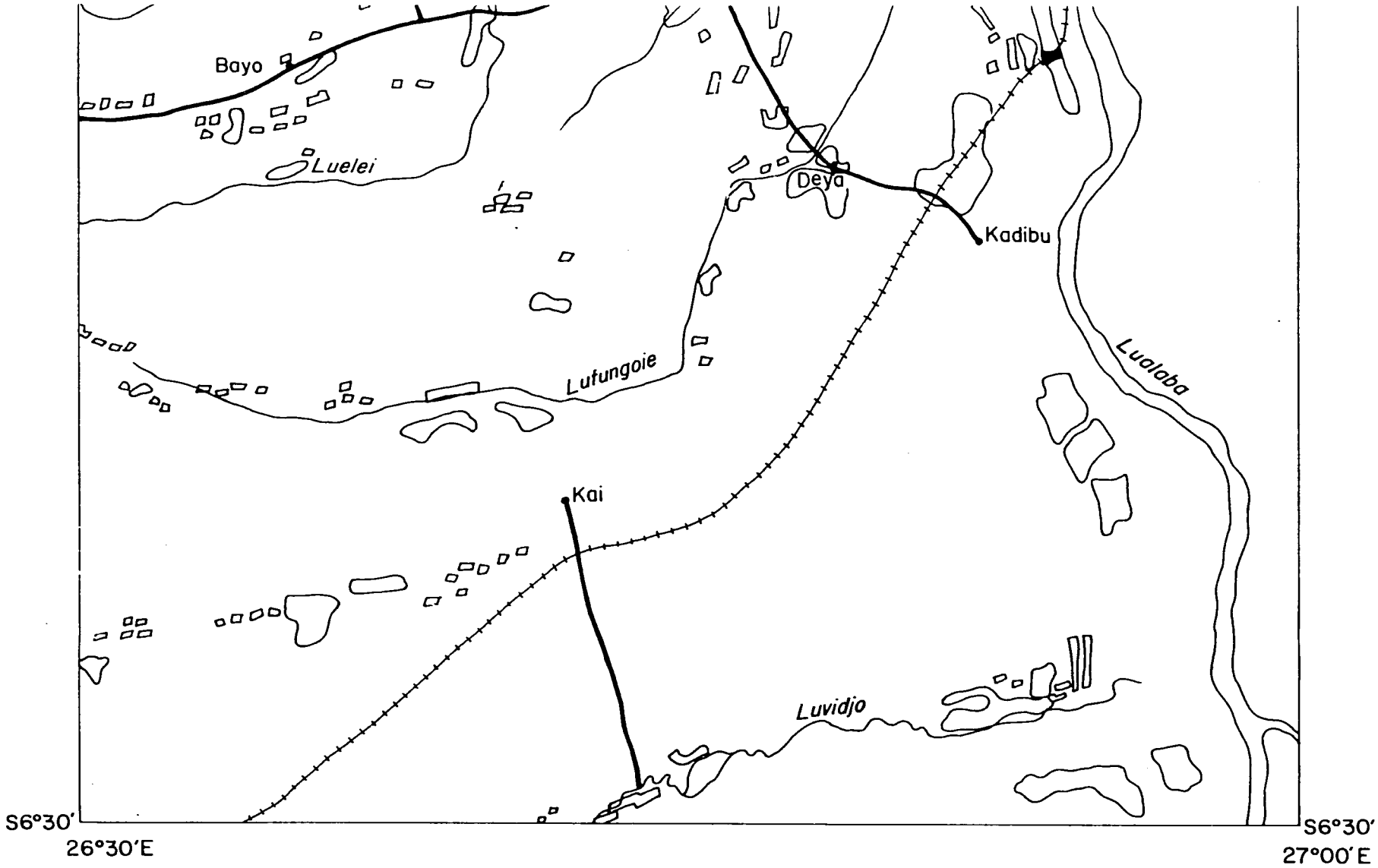
26°30'E

27°00'E

S6°00'

S6°00'



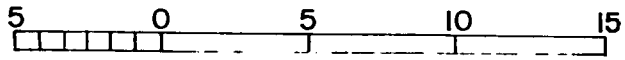


CARTE D'UTILISATION AGRICOLE DES TERRES

1957

Superficie Cultuvée : 13925 Has

Echèlle : 1/200.000



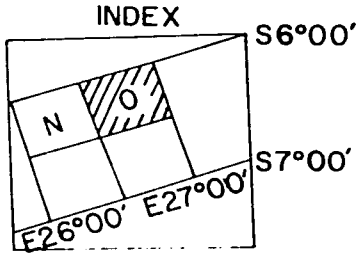
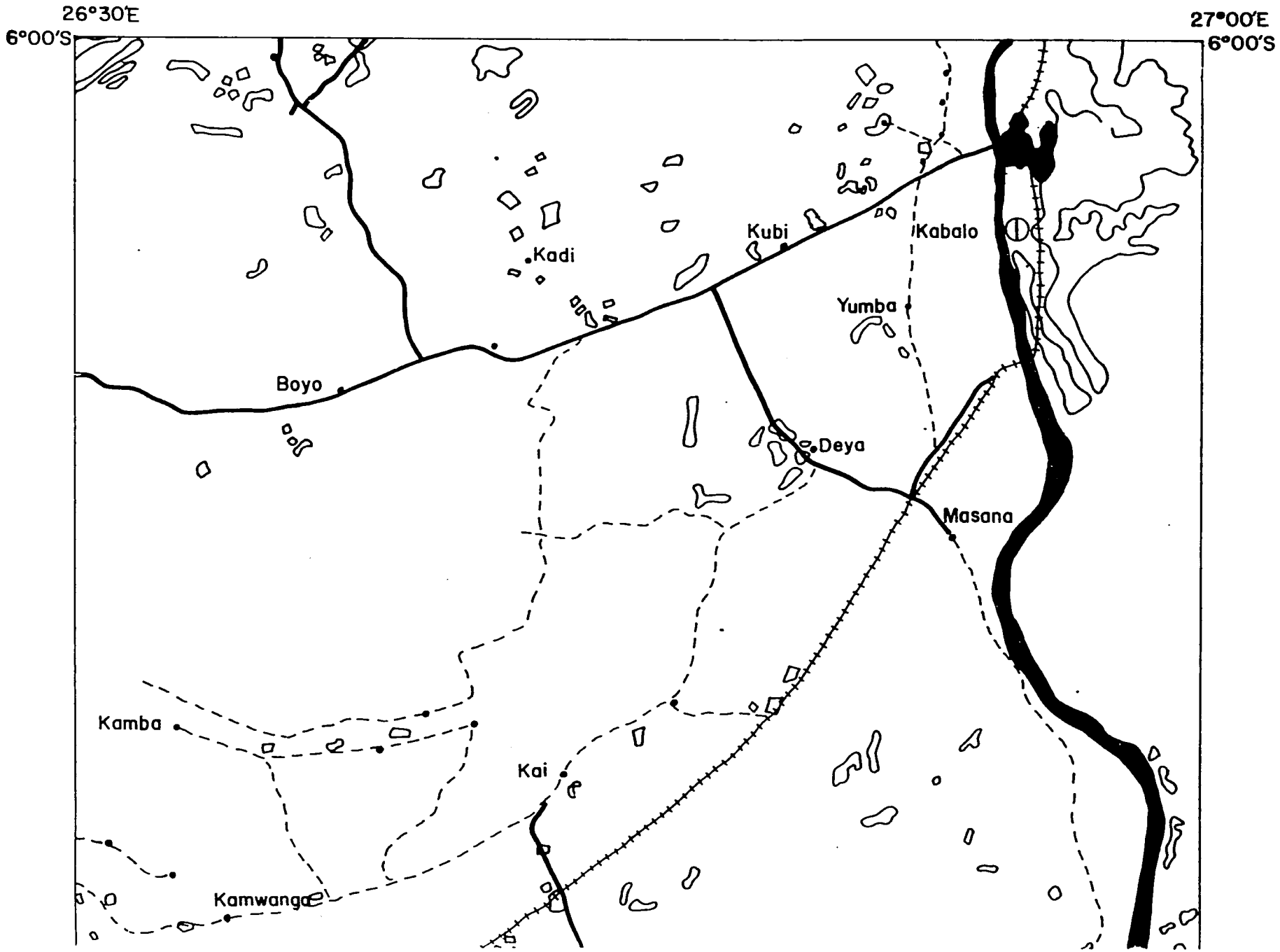


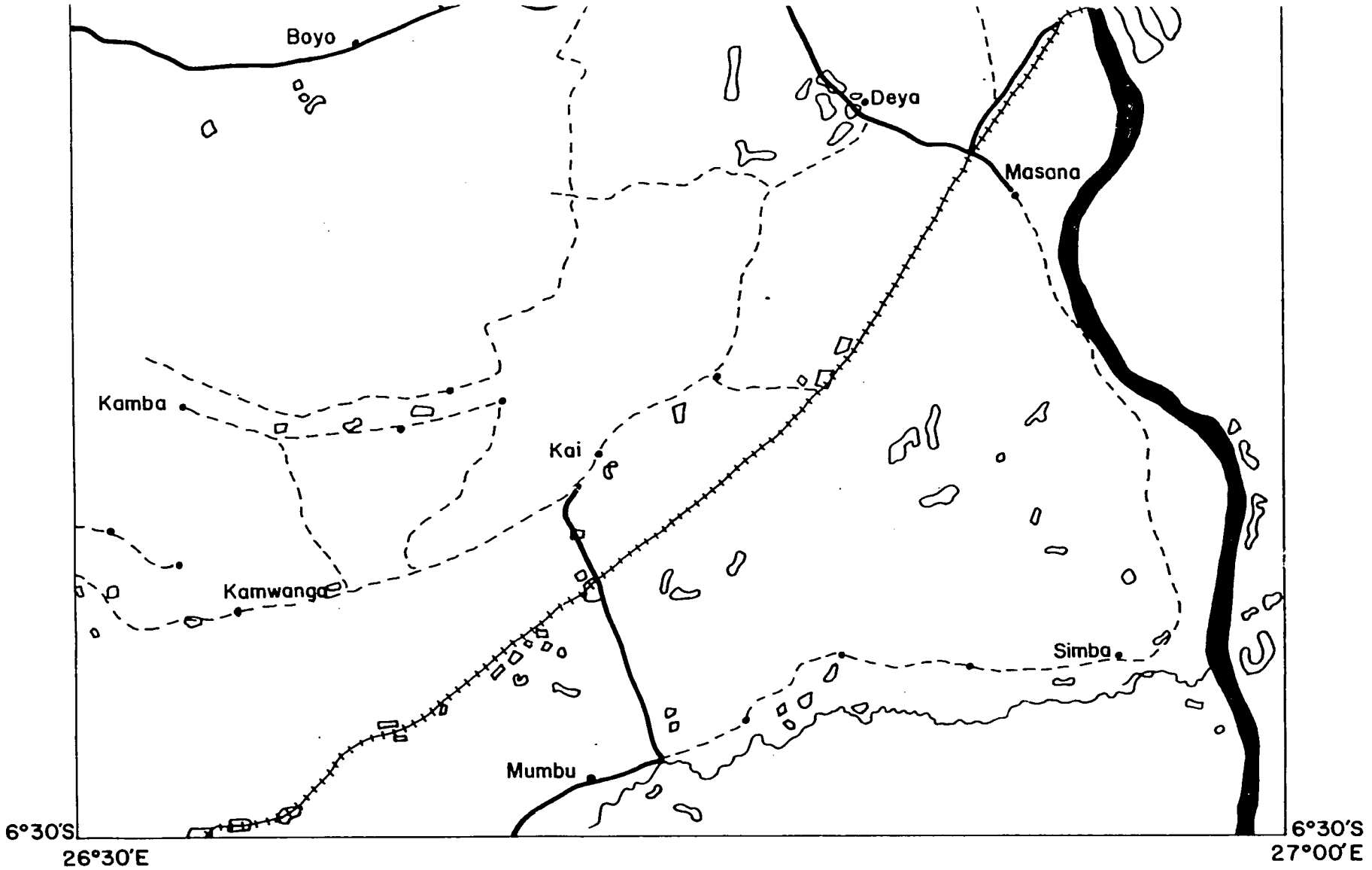
PLANCHE 6-0-1957

b

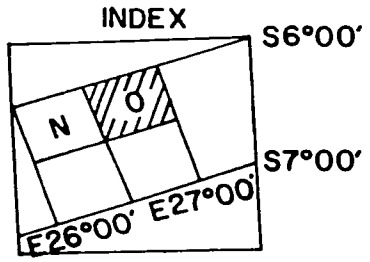
P 6-0-1980 a

$\frac{1}{4}$° BLOC KABALO





CARTE D'UTILISATION AGRICOLE DES TERRES
1980
Superficie Cultuvée
Echèlle : 1/200.000



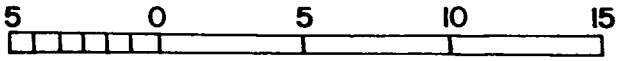
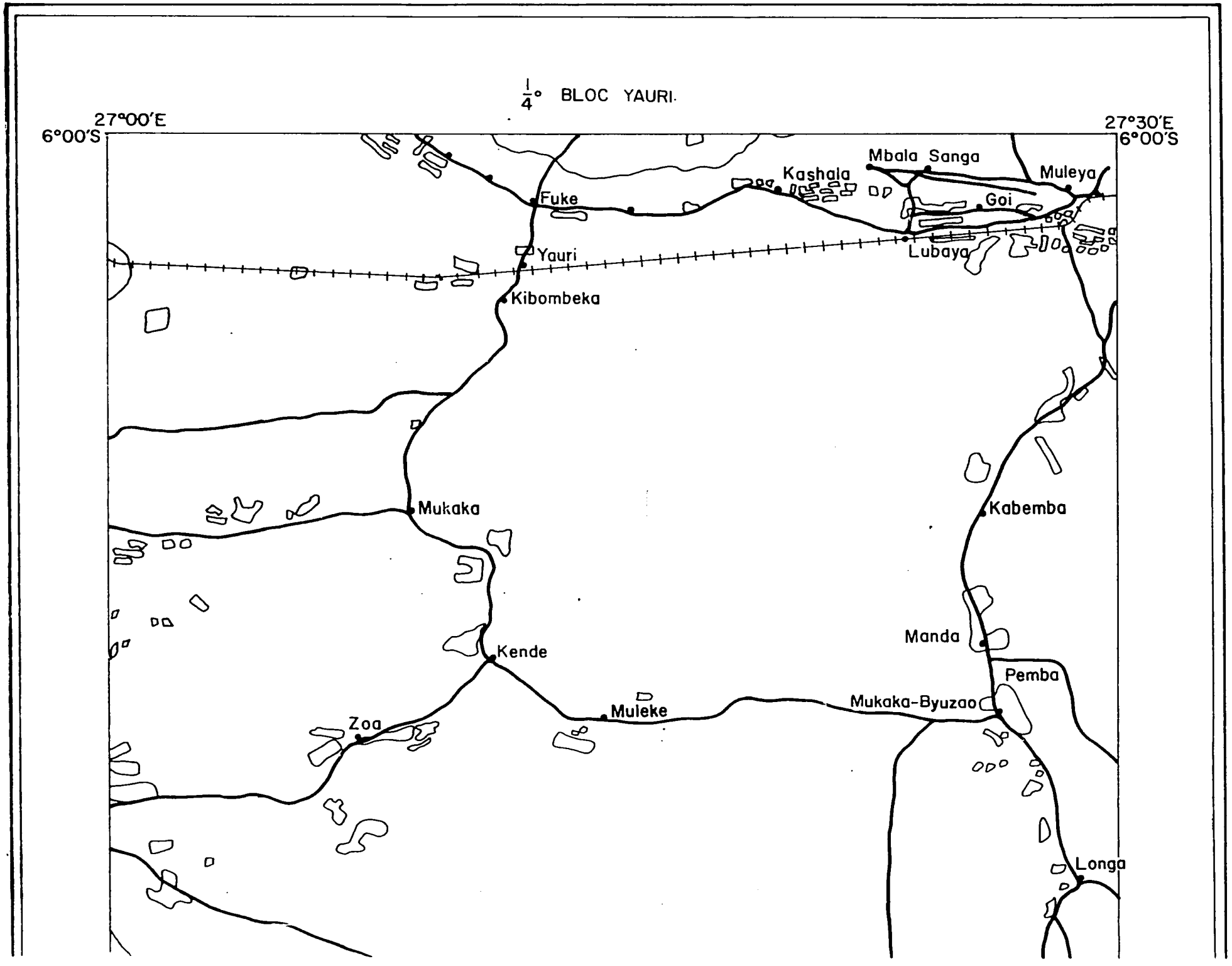
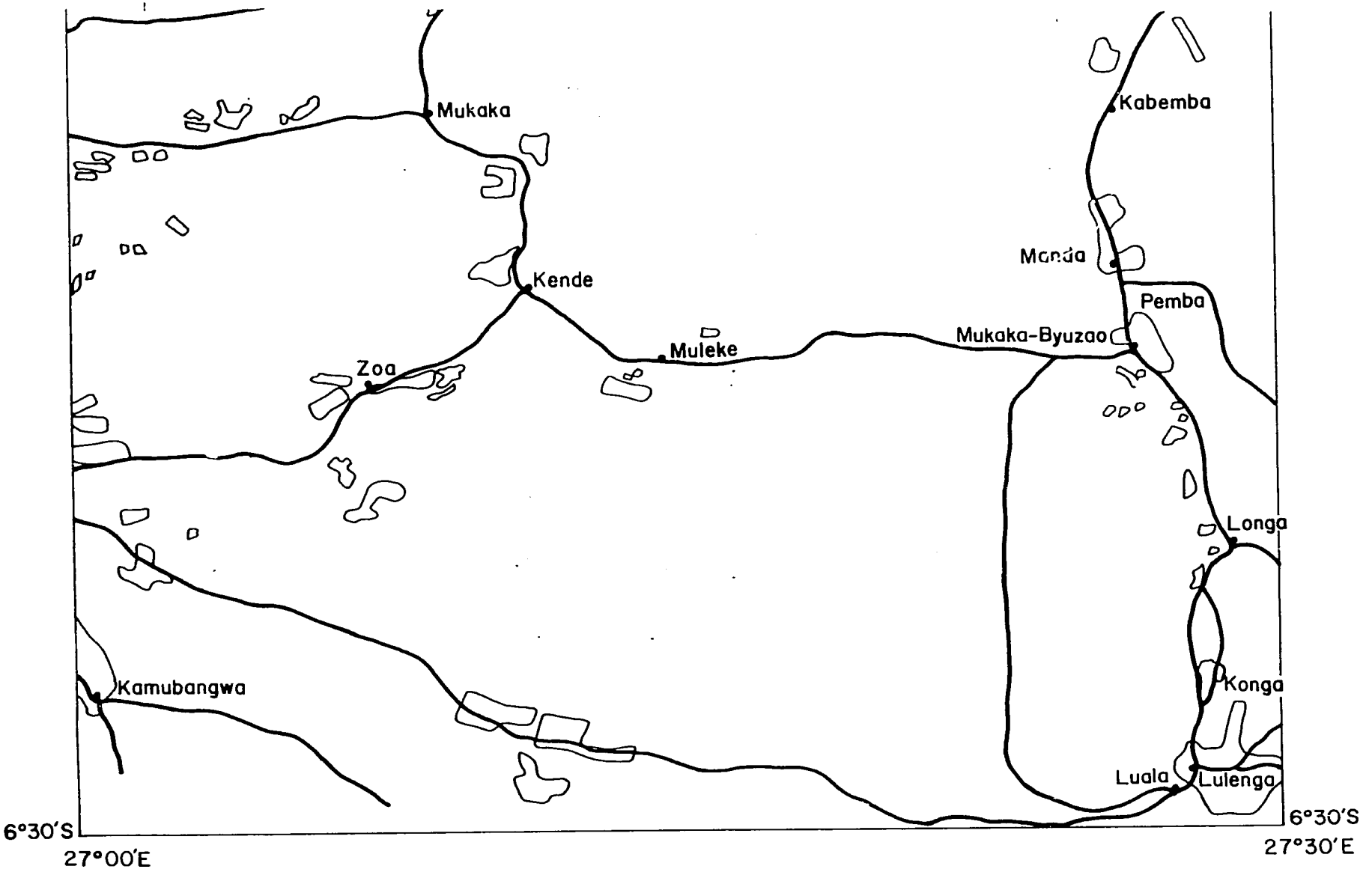


PLANCHE 6-0-1980

b

P 6-P-1957 a


1/4° BLOC YAURI.
27°00'E
6°00'S
27°30'E
6°00'S
Mbala Sanga
Muleya
Kashala
Goi
Fuke
Yauri
Lubaya
Kibombeka
Mukaka
Kabemba
Manda
Kende
Pemba
Mukaka-Byuzao
Muleke
Zoa
Longa

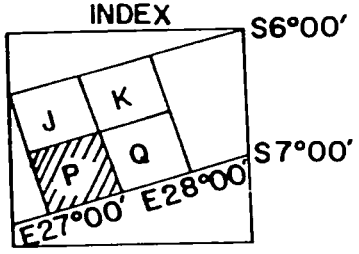


CARTE D'UTILISATION AGRICOLE DES TERRES

1957

Superficie : 9625 Has

Echèlle : 1/200.000



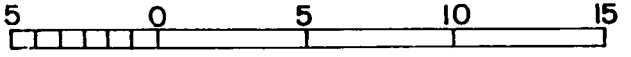
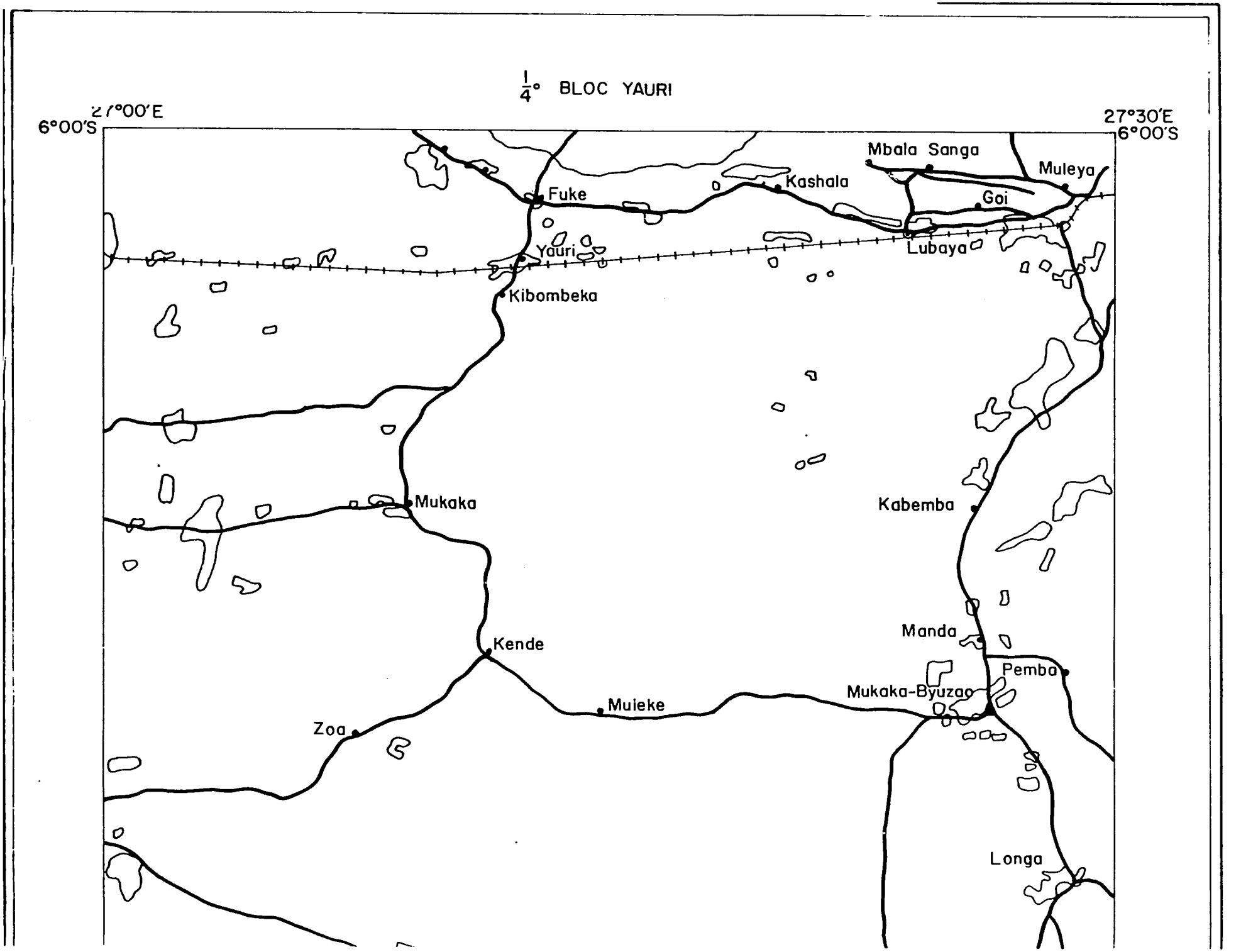
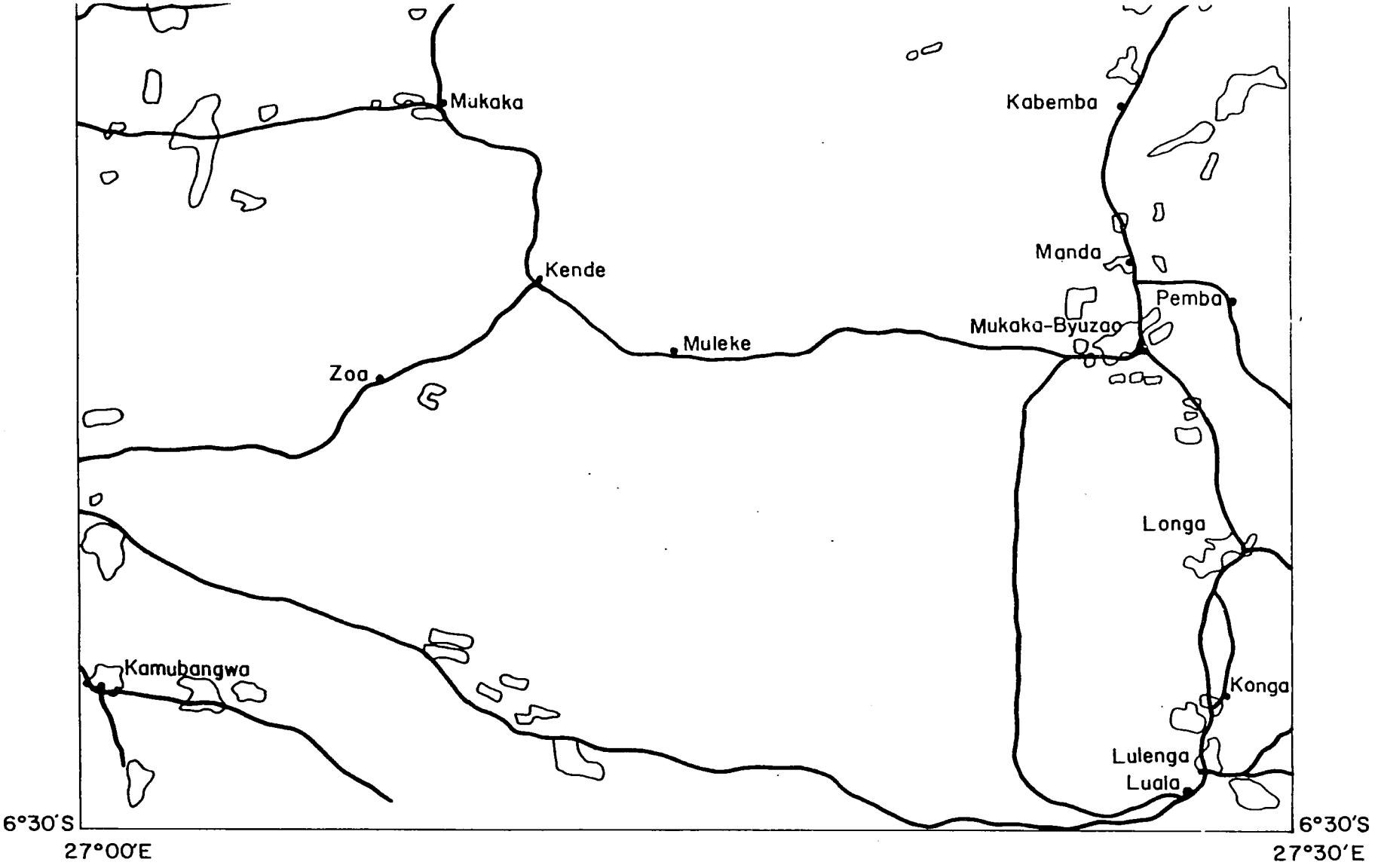


PLANCHE 6-P-1957

b

P 6-F-1910 a


1/4° BLOC YAURI
27°00'E
6°00'S
27°30'E
6°00'S
Mbala Sanga
Muleya
Kashala
Fuke
Goi
Yauri
Lubaya
Kibombeka
Mukaka
Kabemba
Manda
Kende
Pemba
Mukaka-Byuzao
Muieke
Zoa
Longa



CARTE D'UTILISATION AGRICOLE DES TERRES

1980

Superficie Cultuvée: 6800 Has

Echelle : 1/200.000

5 0 5 10 15

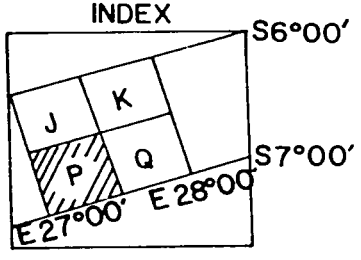
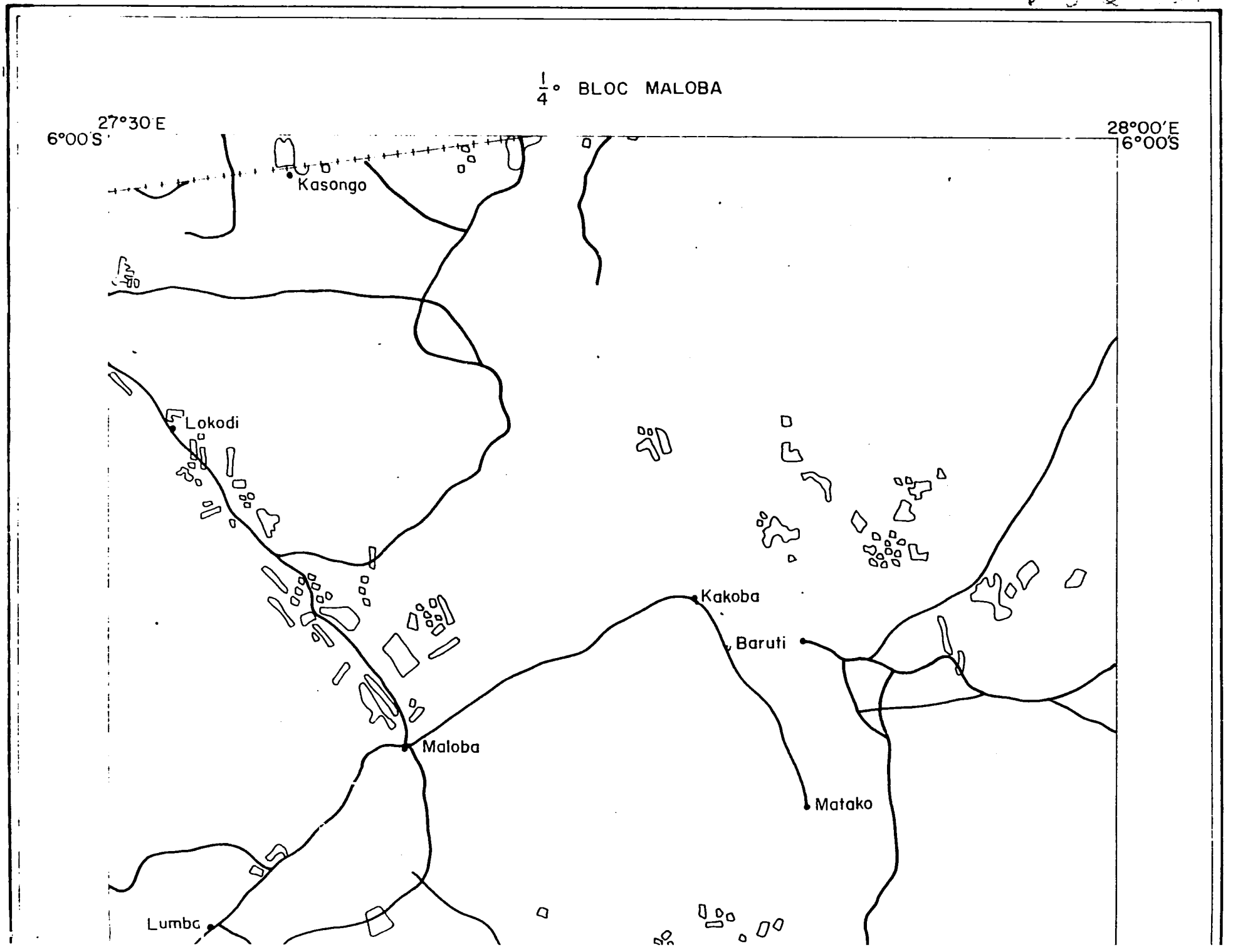
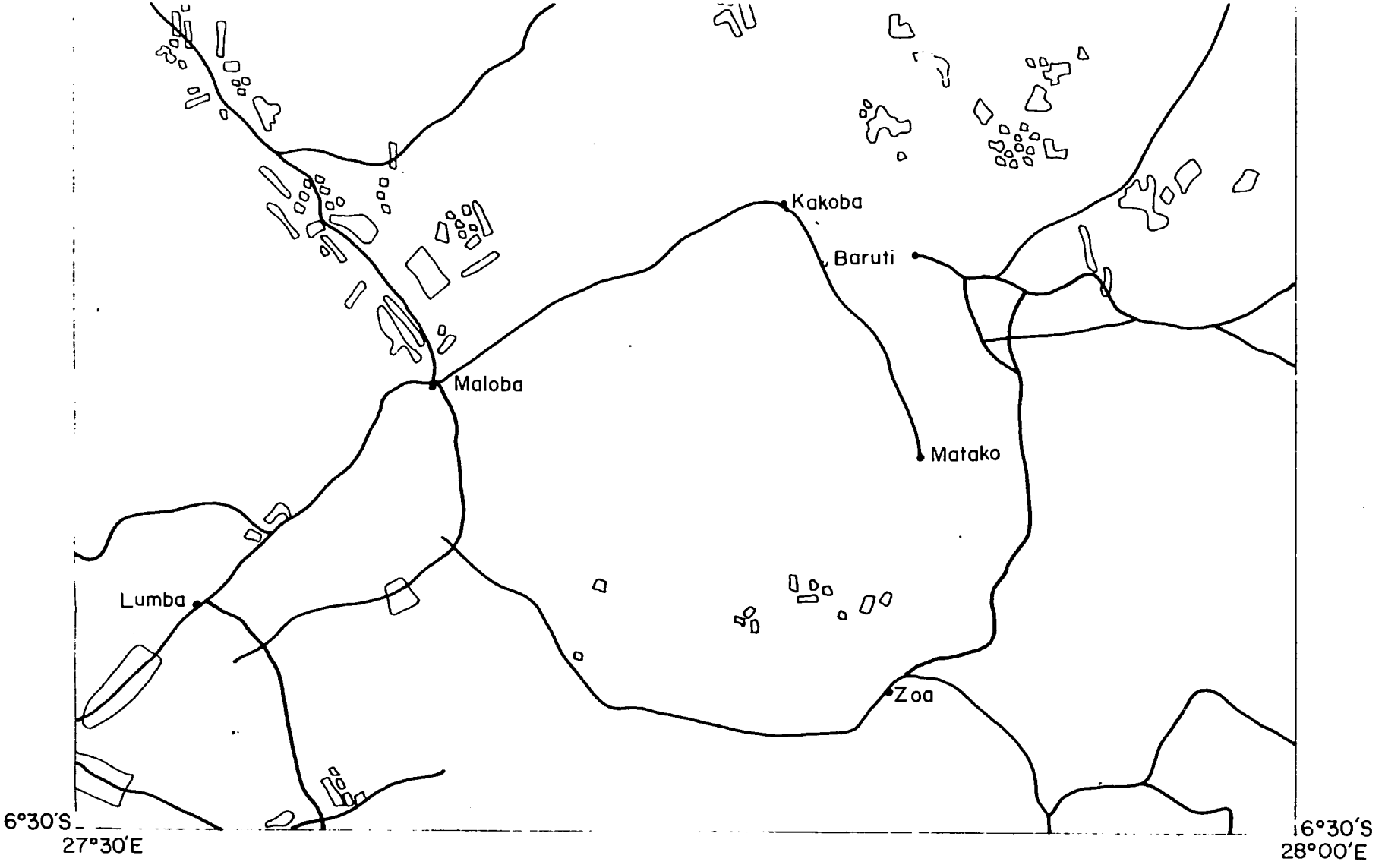


PLANCHE 6-P-1980

b


1/4° BLOC MALOBA
27°30'E
6°00'S
28°00'E
6°00'S
Kasongo
Lokodi
Kakoba
Baruti
Maloba
Matako
Lumba

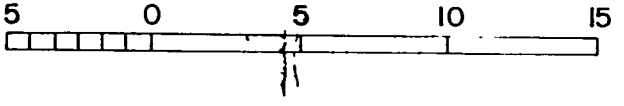


CARTE D'UTILISATION AGRICOLE DES TERRES

1957

Superficie : 6375 Has

Echèle : 1/200.000



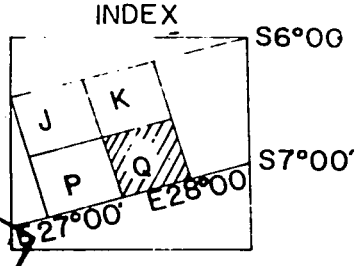
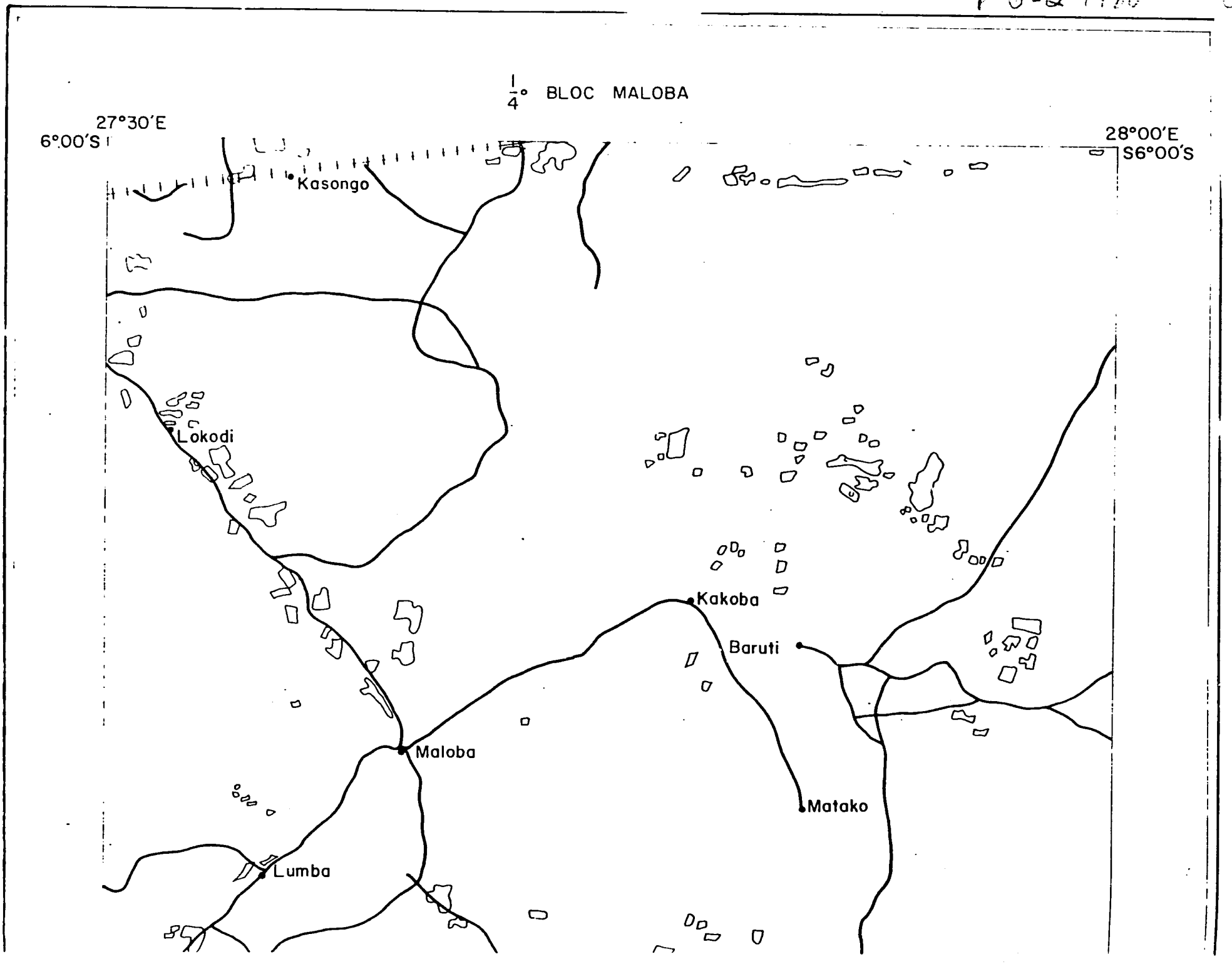
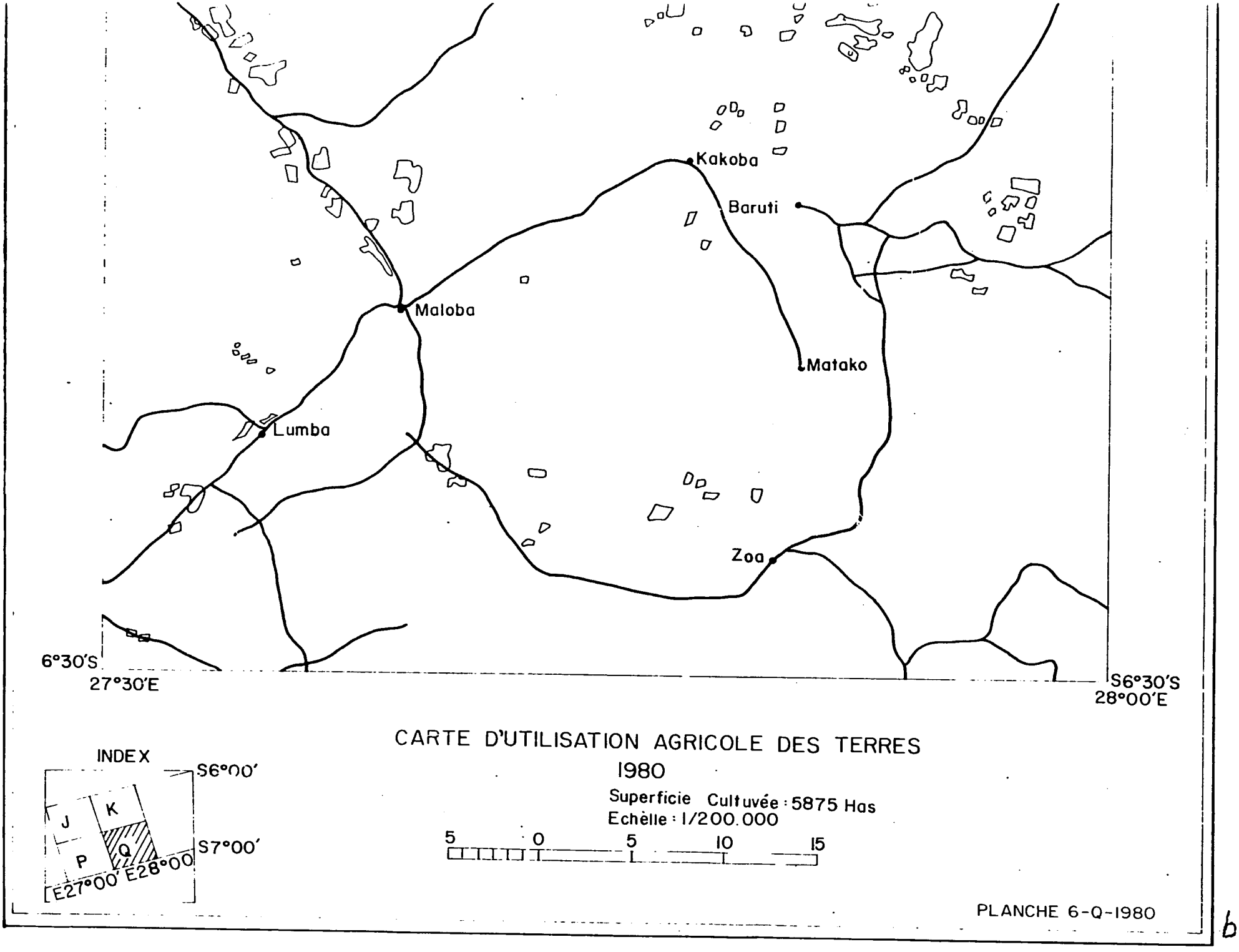


PLANCHE 6-Q-1957

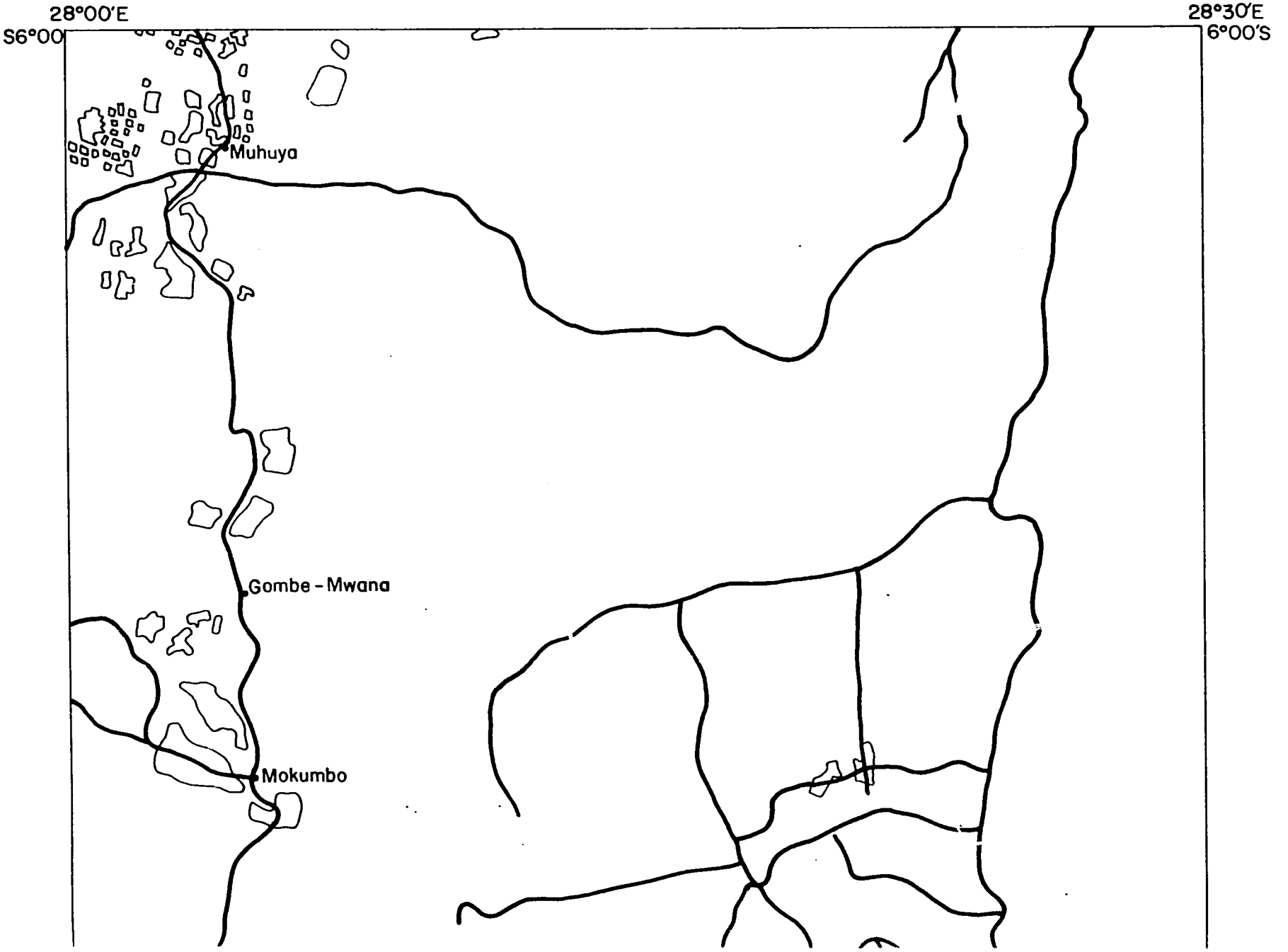
P 6-Q-1990

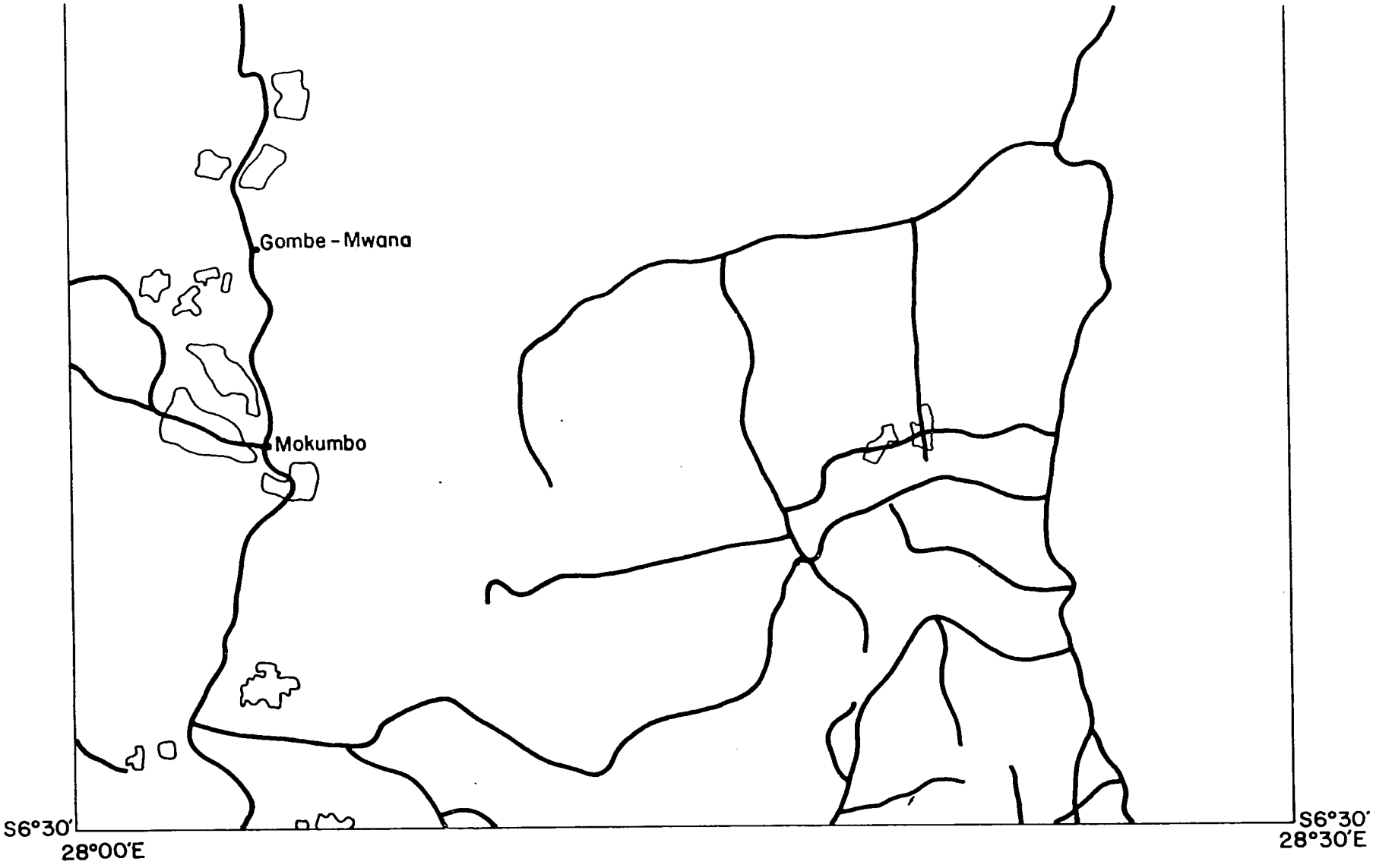

1/4° BLOC MALOBA
27°30'E
6°00'S
28°00'E
S6°00'S
Kasongo
Lokodi
Kakoba
Baruti
Maloba
Matako
Lumba


Kakoba
Baruti
Maloba
Matako
Lumba
Zoa
6°30'S
27°30'E
S6°30'S
28°00'E
CARTE D'UTILISATION AGRICOLE DES TERRES
1980
Superficie Cultuvée : 5875 Has
Echèlle : 1/200.000
5 0 5 10 15
INDEX
S6°00'
S7°00'
J
K
P
Q
E27°00'
E28°00
PLANCHE 6-Q-1980

b

$\frac{1}{4}$° BLOC GOMBE-MWANA





CARTE D'UTILISATION AGRICOLE DES TERRES

1957

Superficie : 5525 Has

Echèlle : 1/200.000

5 0 5 10 15

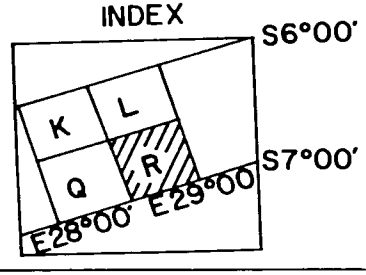
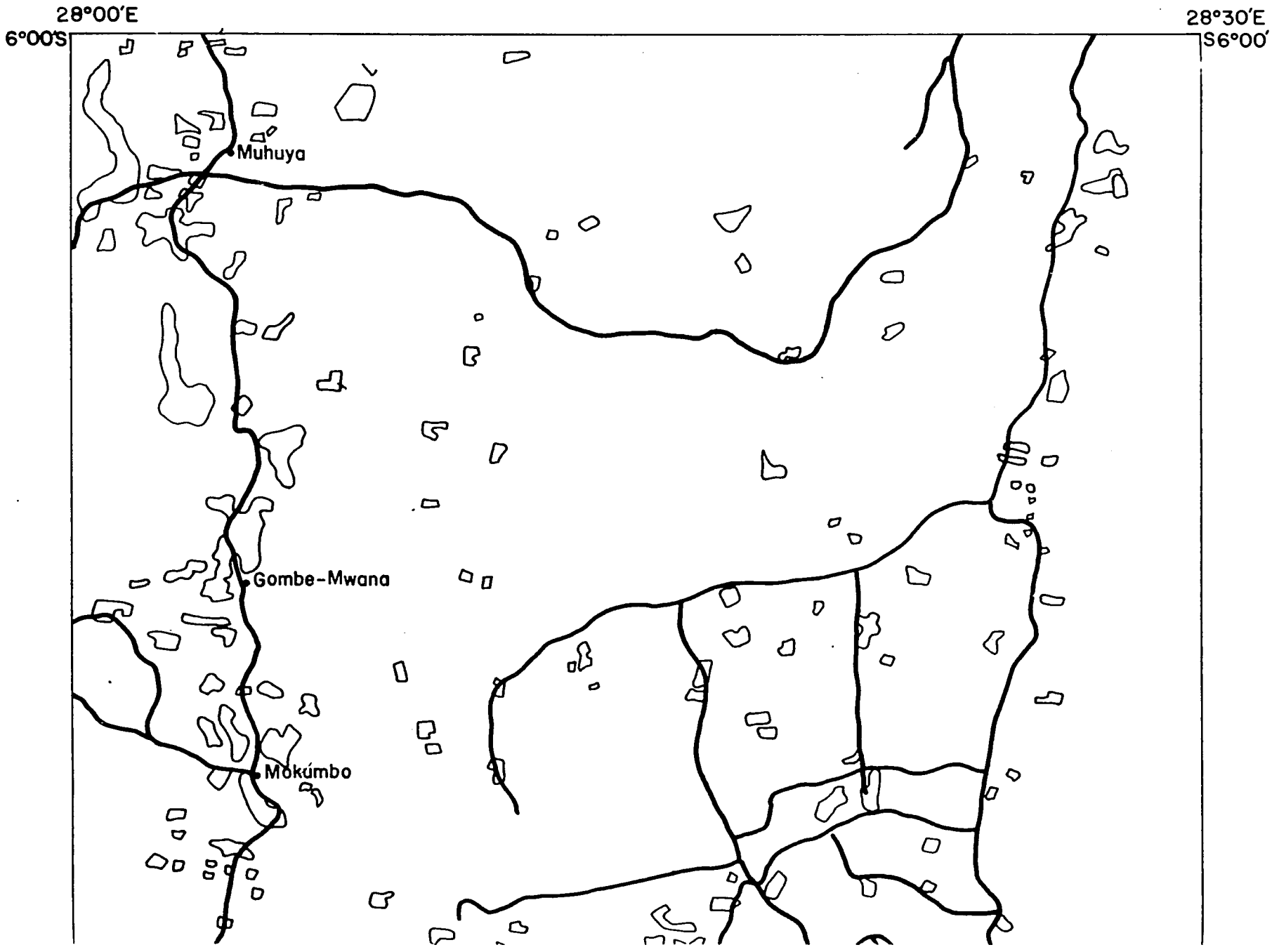
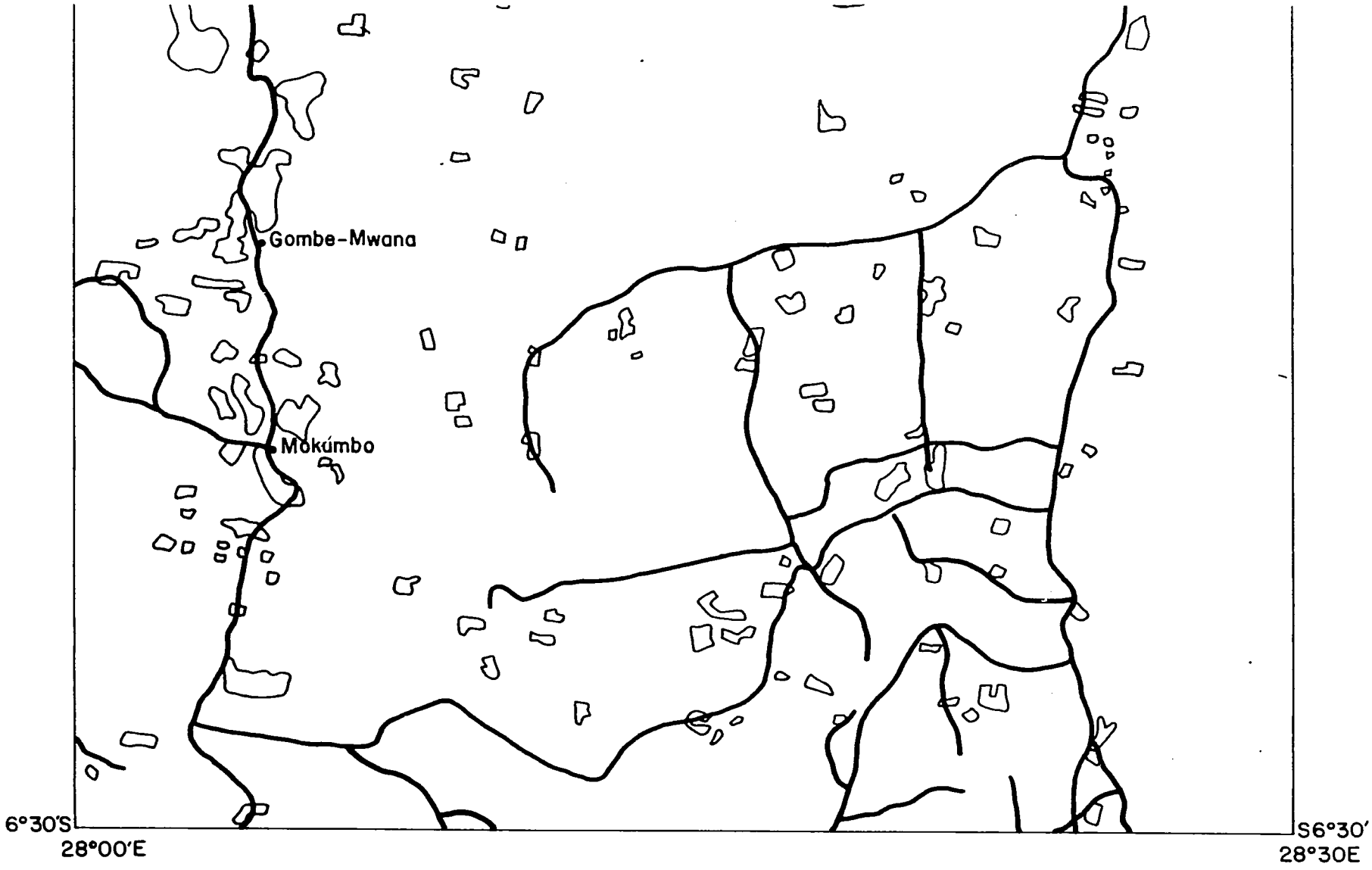
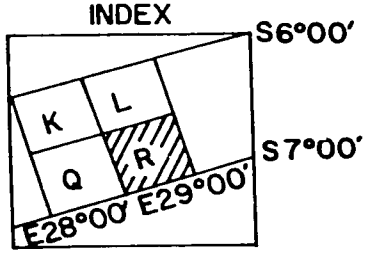


PLANCHE 6-R-1957

$\frac{1}{4}$° BLOC GOMBE-MWANA







CARTE D'UTILISATION AGRICOLE DES TERRES

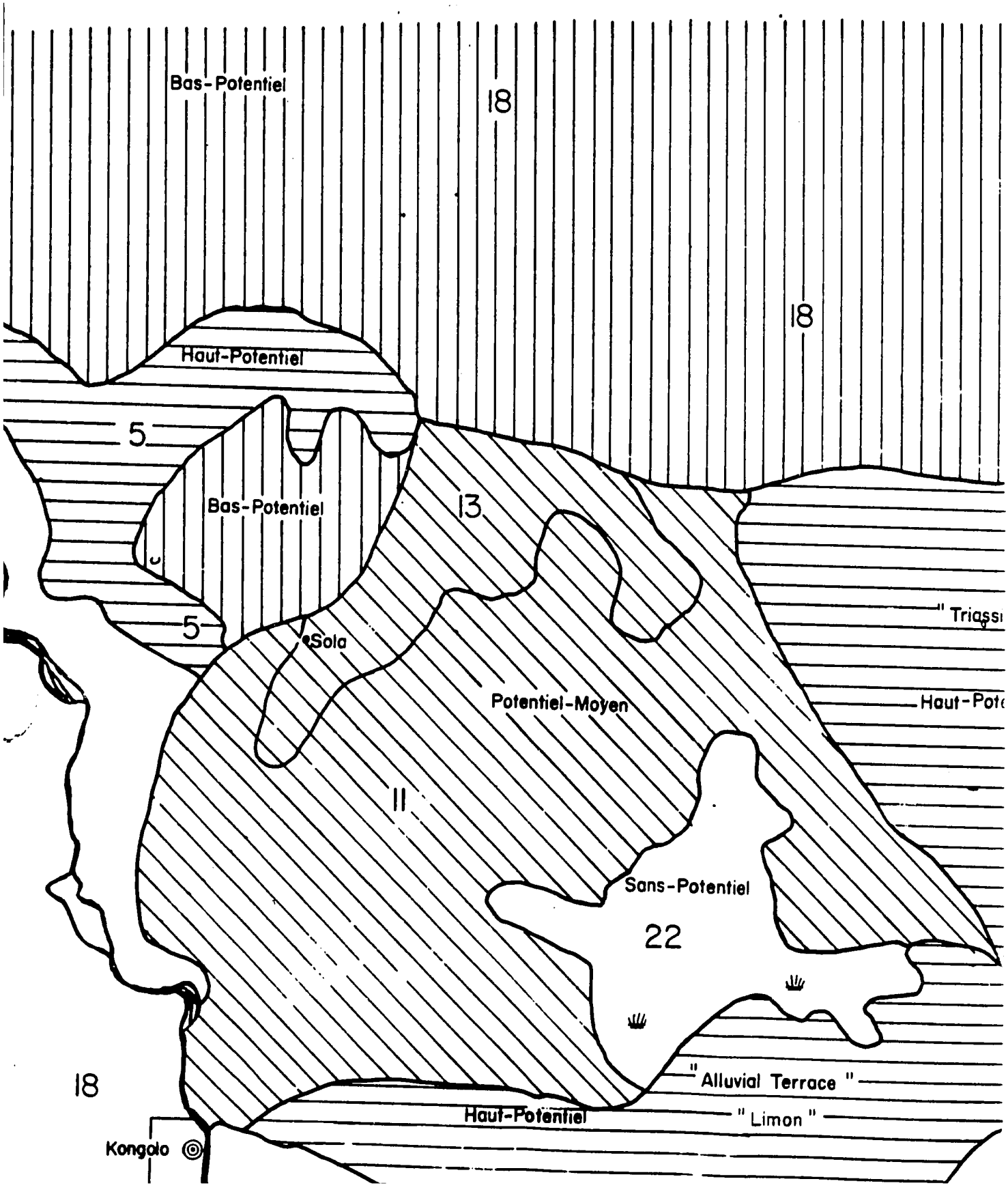
1980

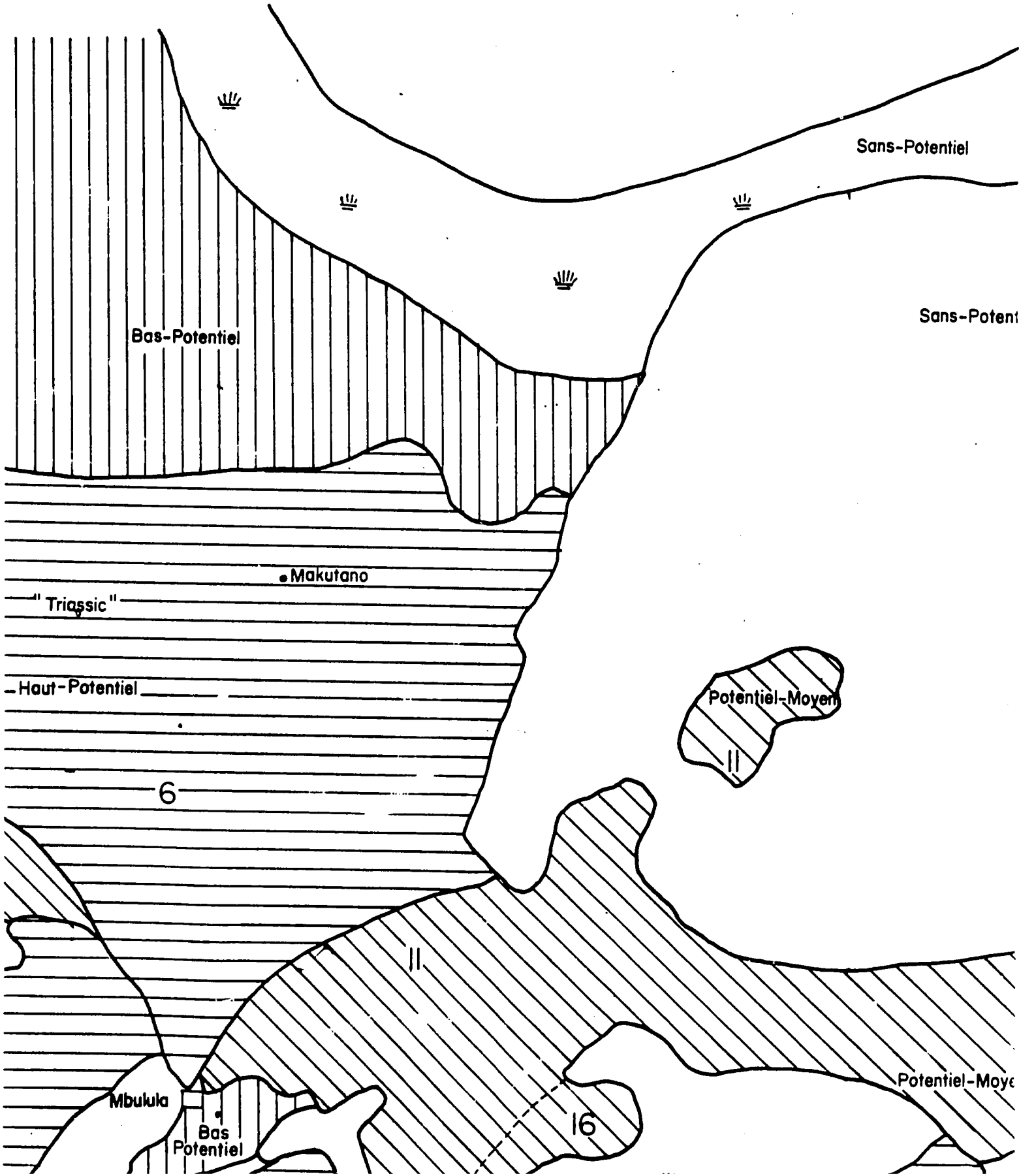
Superficie : 7.900 Has

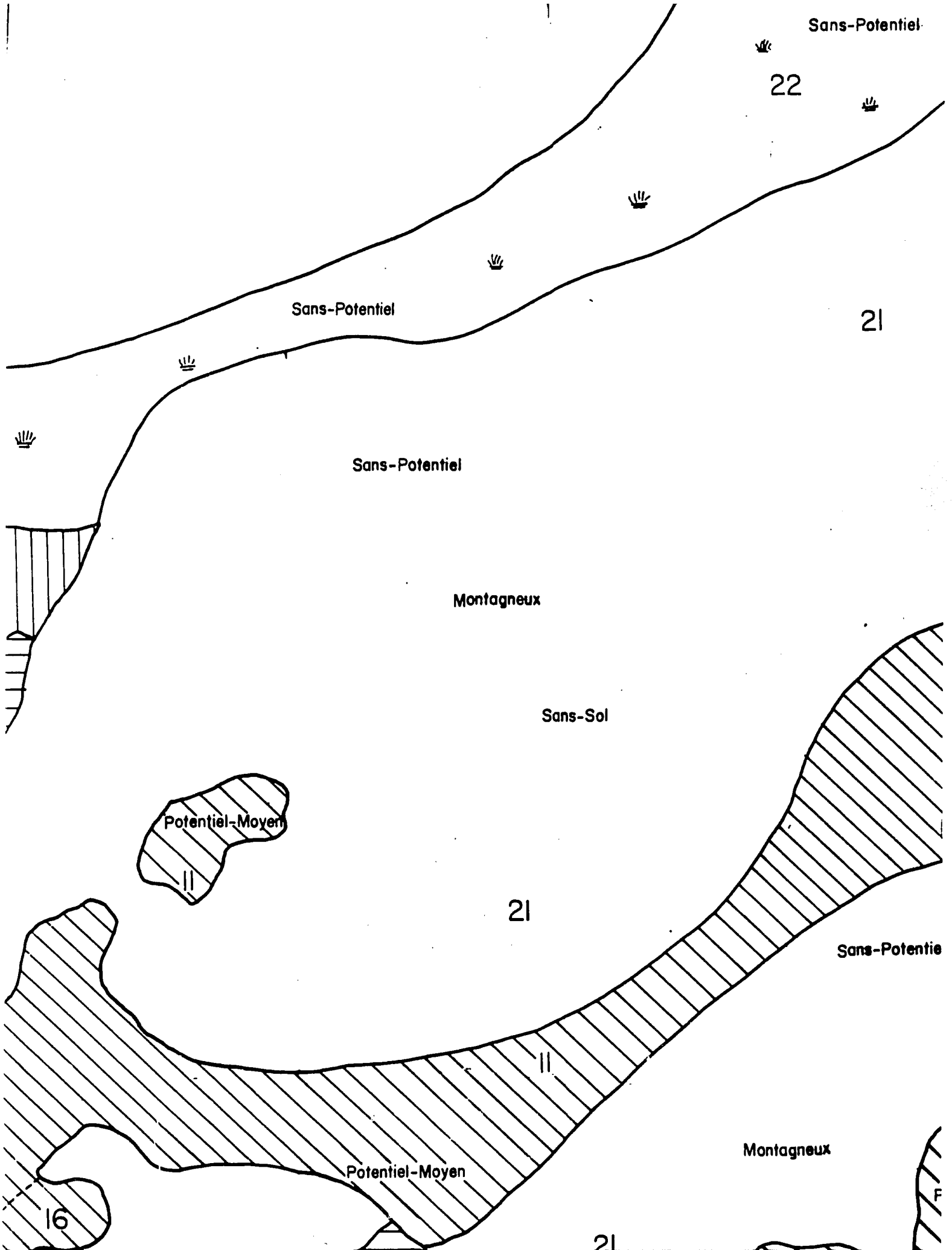
Echèlle : 1/200.000

5 0 5 10 15

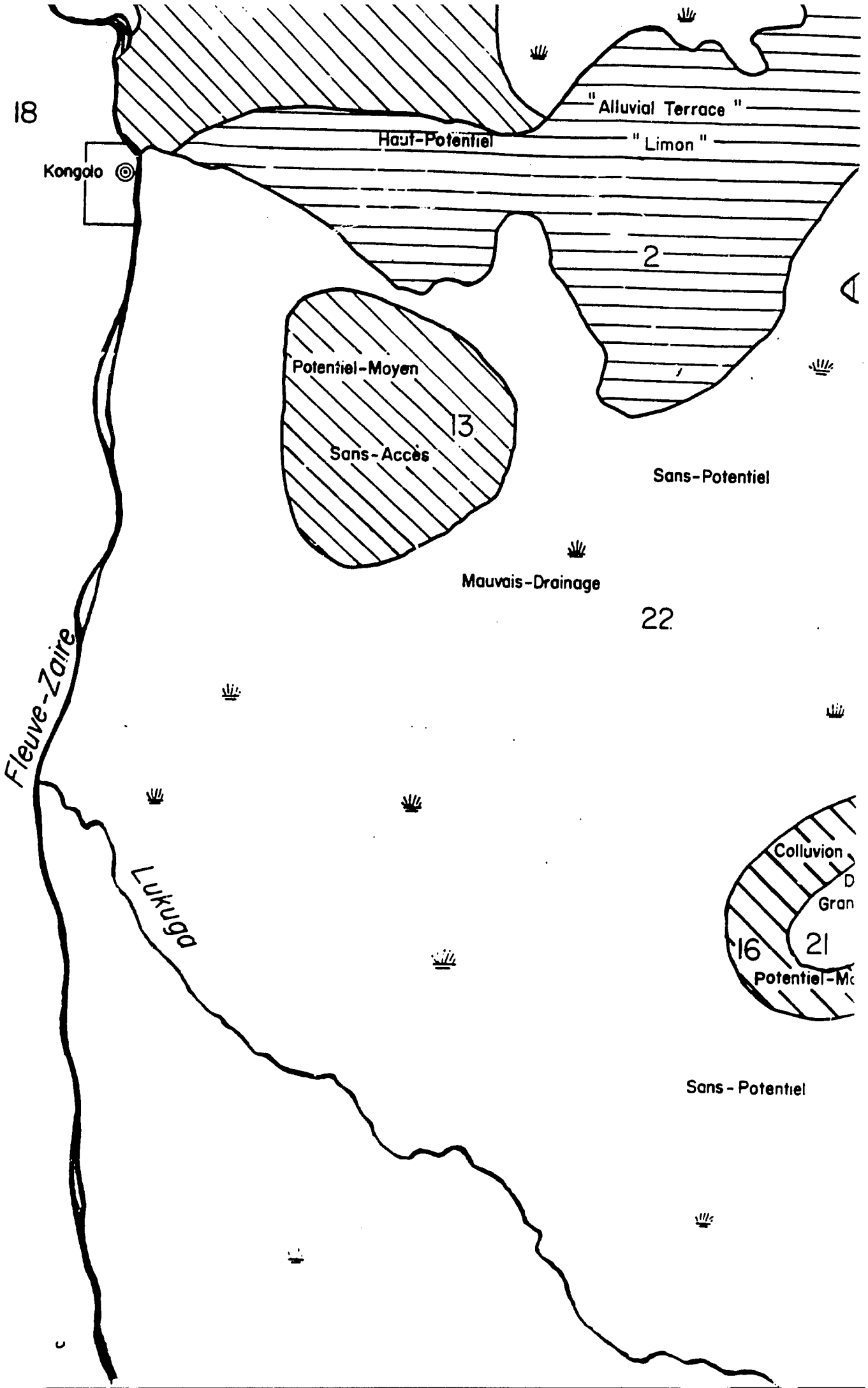
PLANCHE 6-R-1980

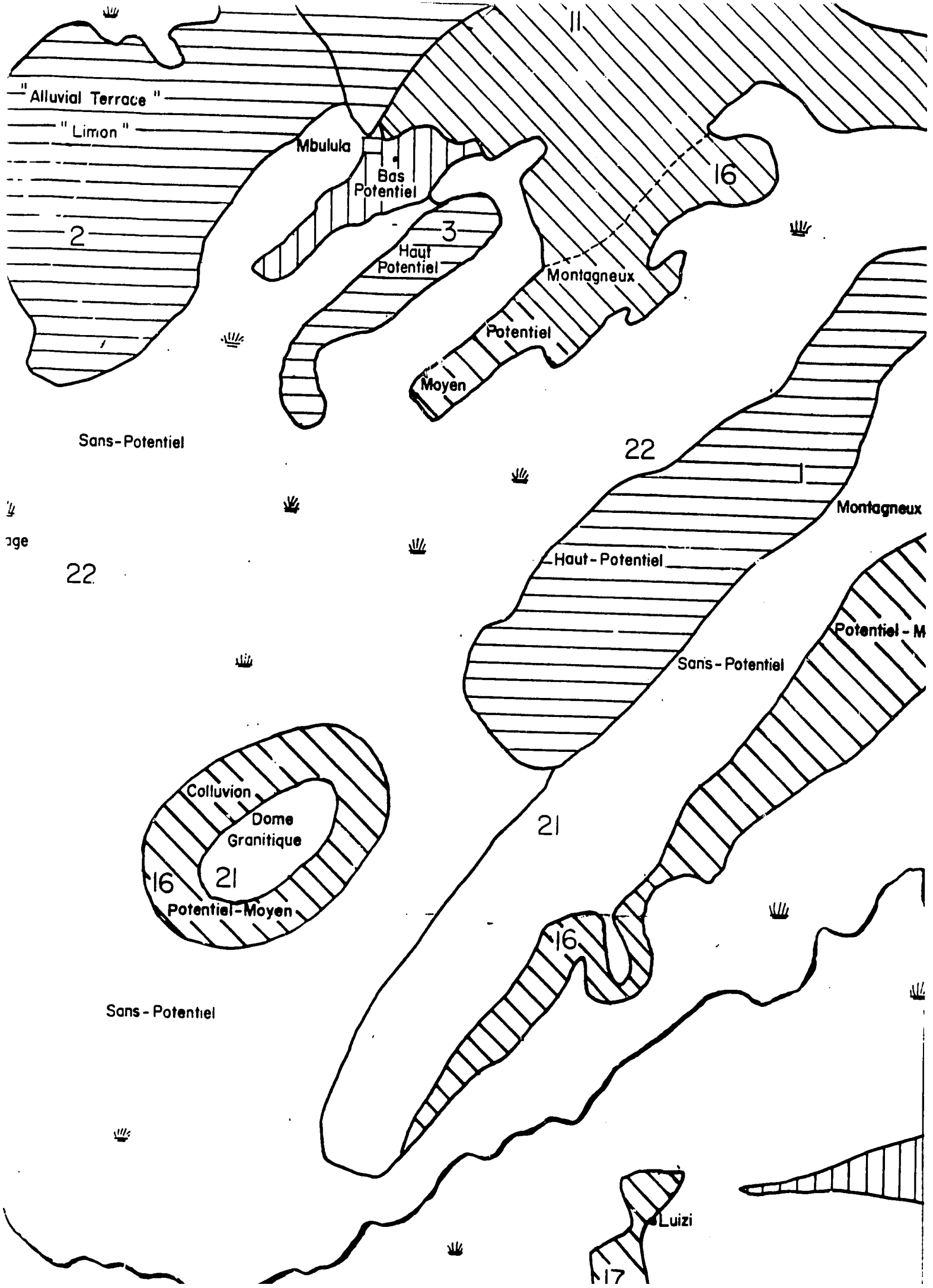

Bas-Potentiel
18
18
Haut-Potentiel
5
Bas-Potentiel
13
5
Sola
Potentiel-Moyen
11
Sans-Potentiel
22
18
"Alluvial Terrace"
Haut-Potentiel
"Limon"
Kongolo

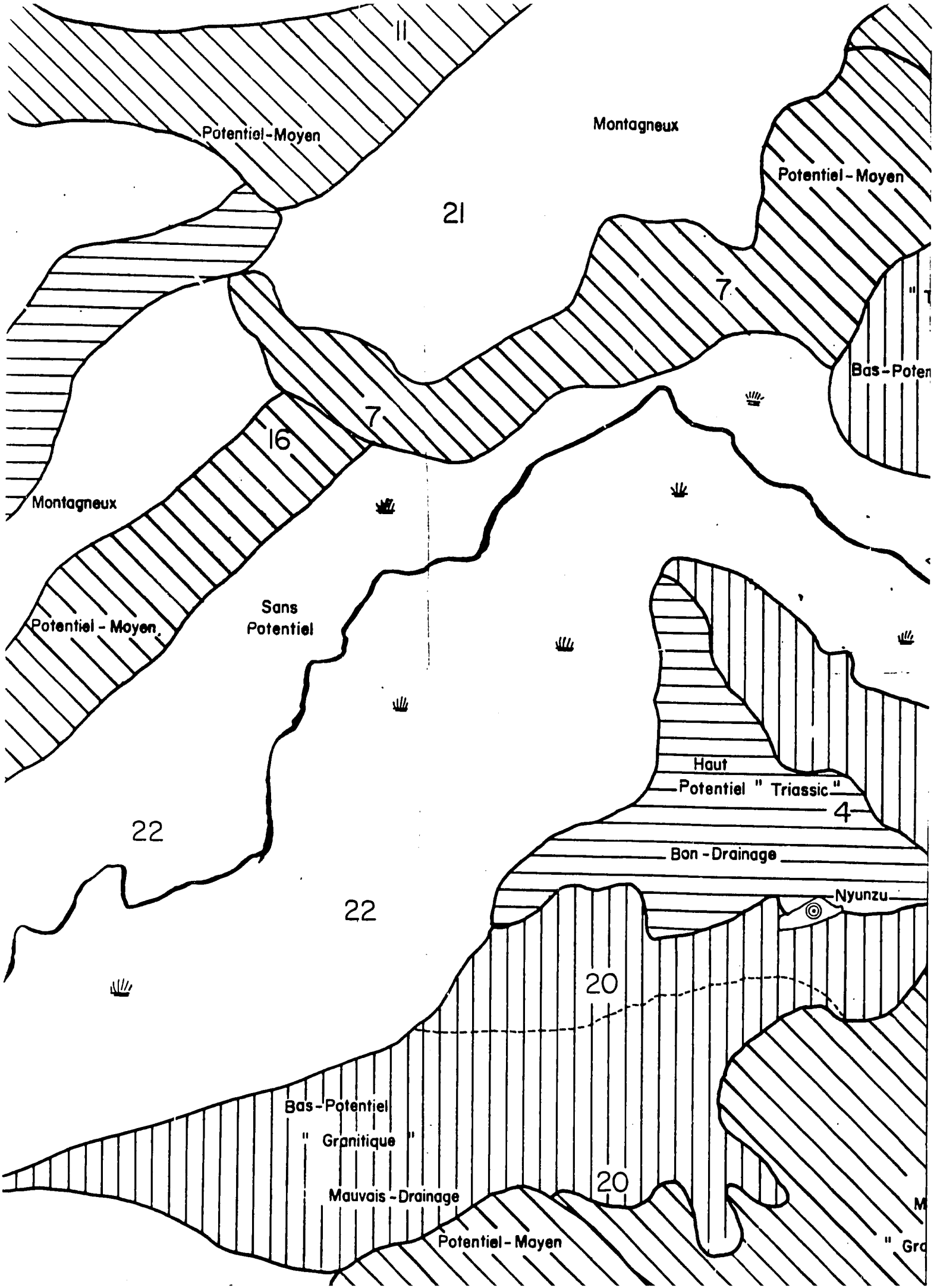

Sans-Potentiel
Sans-Potent
Bas-Potentiel
Makutano
"Triassic"
Haut-Potentiel
6
Potentiel-Moyen
11
11
16
Potentiel-Moye
Mbulula
Bas
Potentiel


Sans-Potentiel
22
Sans-Potentiel
21
Sans-Potentiel
Montagneux
Sans-Sol
Potentiel-Moyen
11
21
Sans-Potentie
11
Montagneux
Potentiel-Moyen
16
21

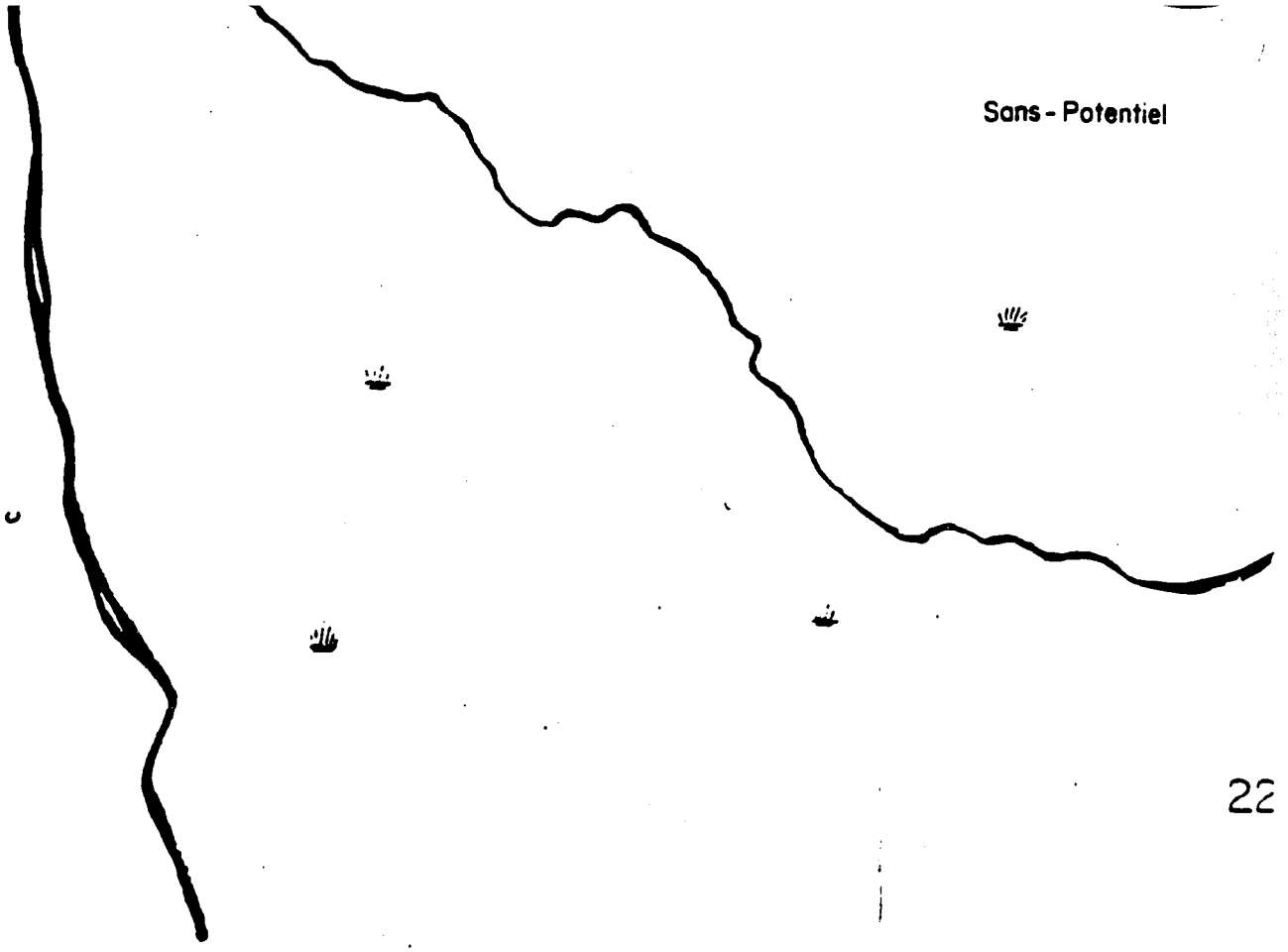
ntiel
II
Potentiel-Moyen
II
entiel
Bas-Potentiel
Mauvais-Drainage
Potentiel-Moyen
22


18
Kongolo
"Alluvial Terrace"
Haut-Potentiel
"Limon"
2
Potentiel-Moyen
13
Sans-Accès
Sans-Potentiel
Mauvais-Drainage
22
Fleuve-Zaire
Lukuga
Colluvion
Gran
16
21
Potentiel-Mo
Sans-Potentiel


"Alluvial Terrace"
"Limon"
Mbulula
Bas Potentiel
Haut Potentiel
Montagneux
Potentiel
Moyen
Sans-Potentiel
Montagneux
Haut-Potentiel
Sans-Potentiel
Potentiel-M
Colluvion
Dome Granitique
Potentiel-Moyen
Sans-Potentiel
Luizi
11
16
2
3
22
1
22
21
16
21
16
17


11
Potentiel-Moyen
Montagneux
21
Potentiel-Moyen
7
Bas-Poten
7
16
Montagneux
Sans
Potentiel
Potentiel - Moyen
Haut
Potentiel " Triassic "
4
22
Bon - Drainage
Nyunzu
22
20
Bas-Potentiel
" Granitique "
20
Mauvais - Drainage
Potentiel-Moyen

Mauvais-Drainage
22
Potentiel-Moyen
" Triassic "
Bas-Potentiel
Mauvais-Drainage
Lukuga
20
Sans
Potentiel
Triassic"
4
20
ge
Nyunzu
16
Materiel
" Granitique "

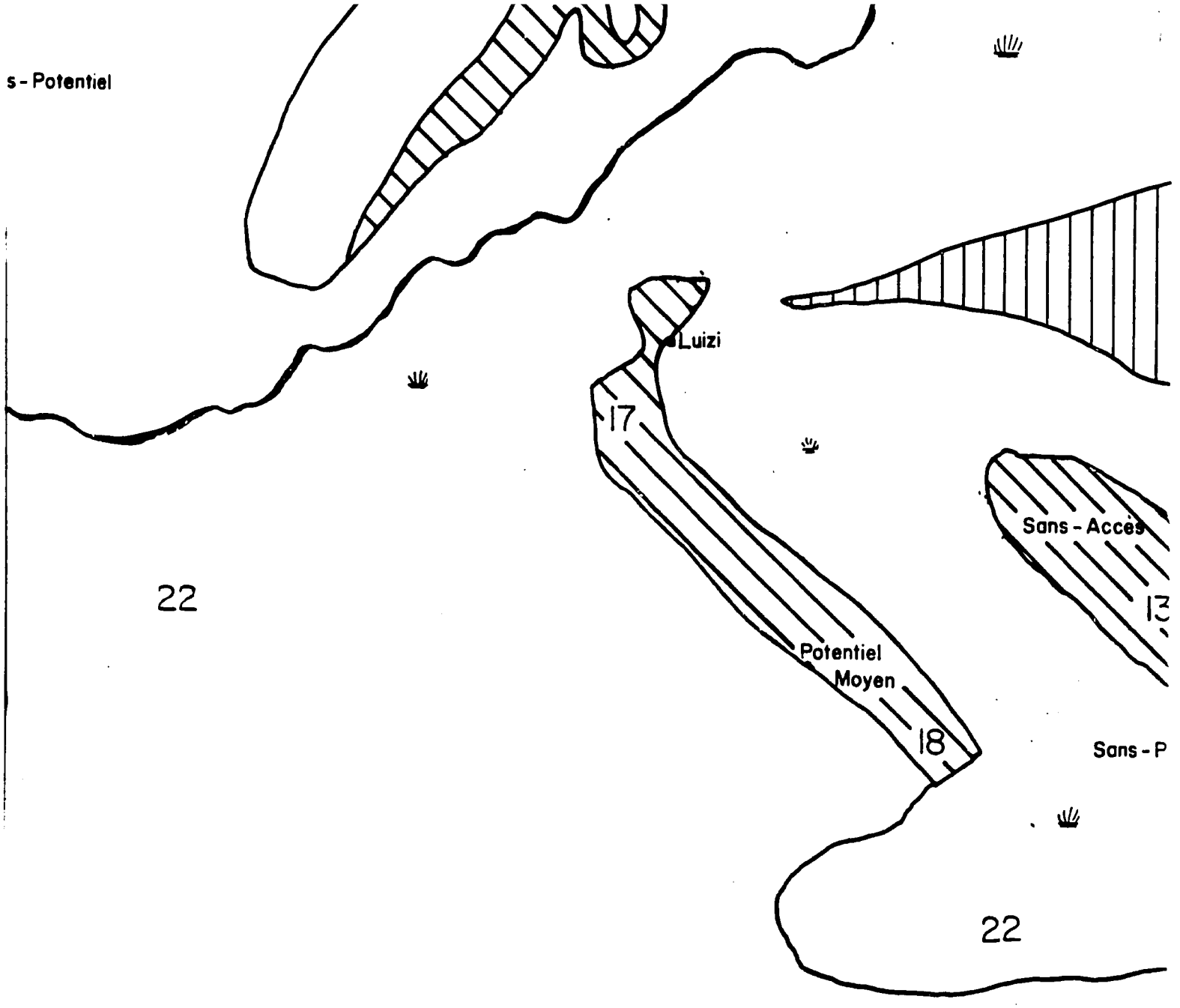


LEGENDE

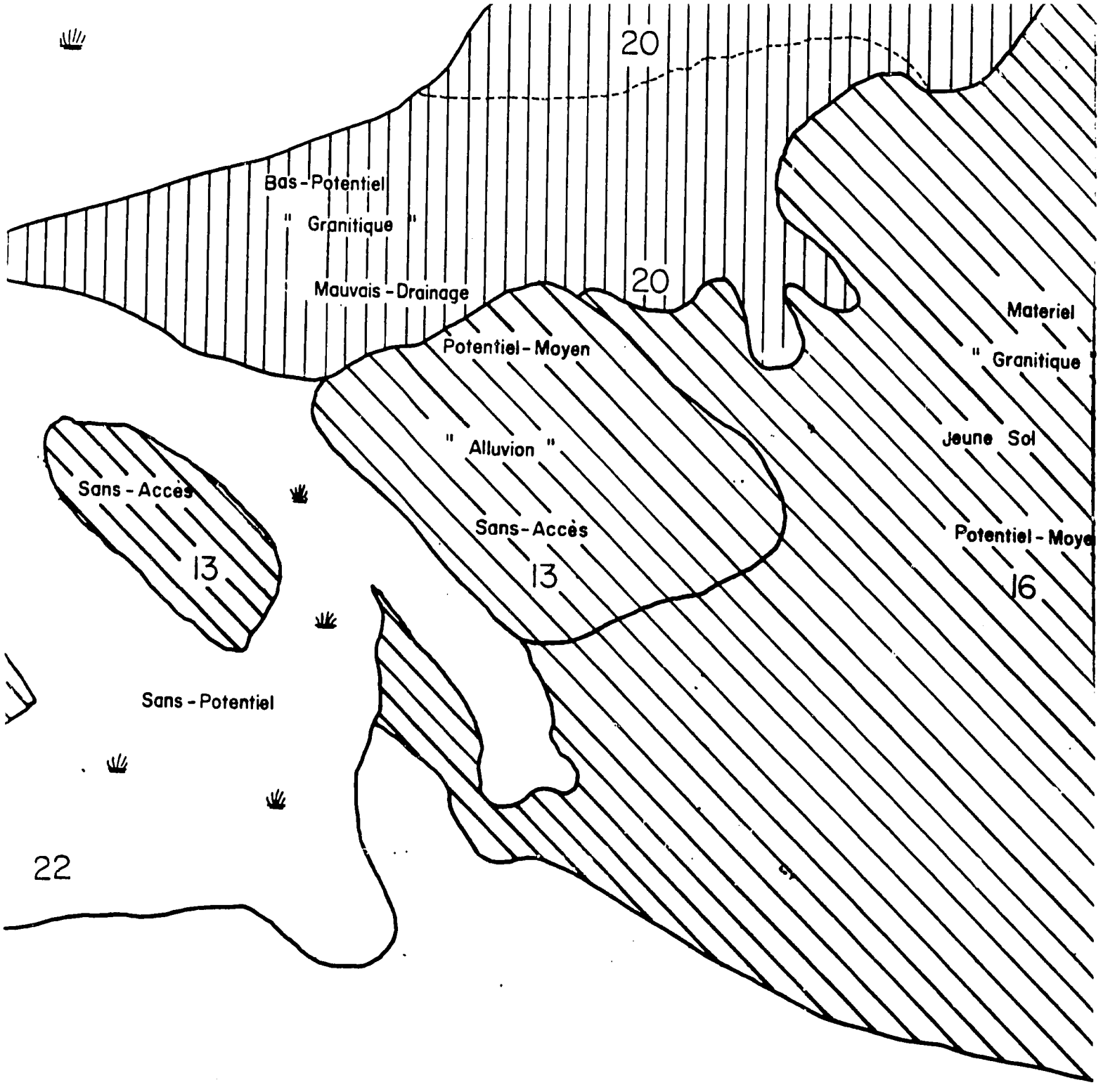
- Haute Potentialité
- Basse Potentialité
- Potentialité Moyenne
- Sans Potentialité

P O T E

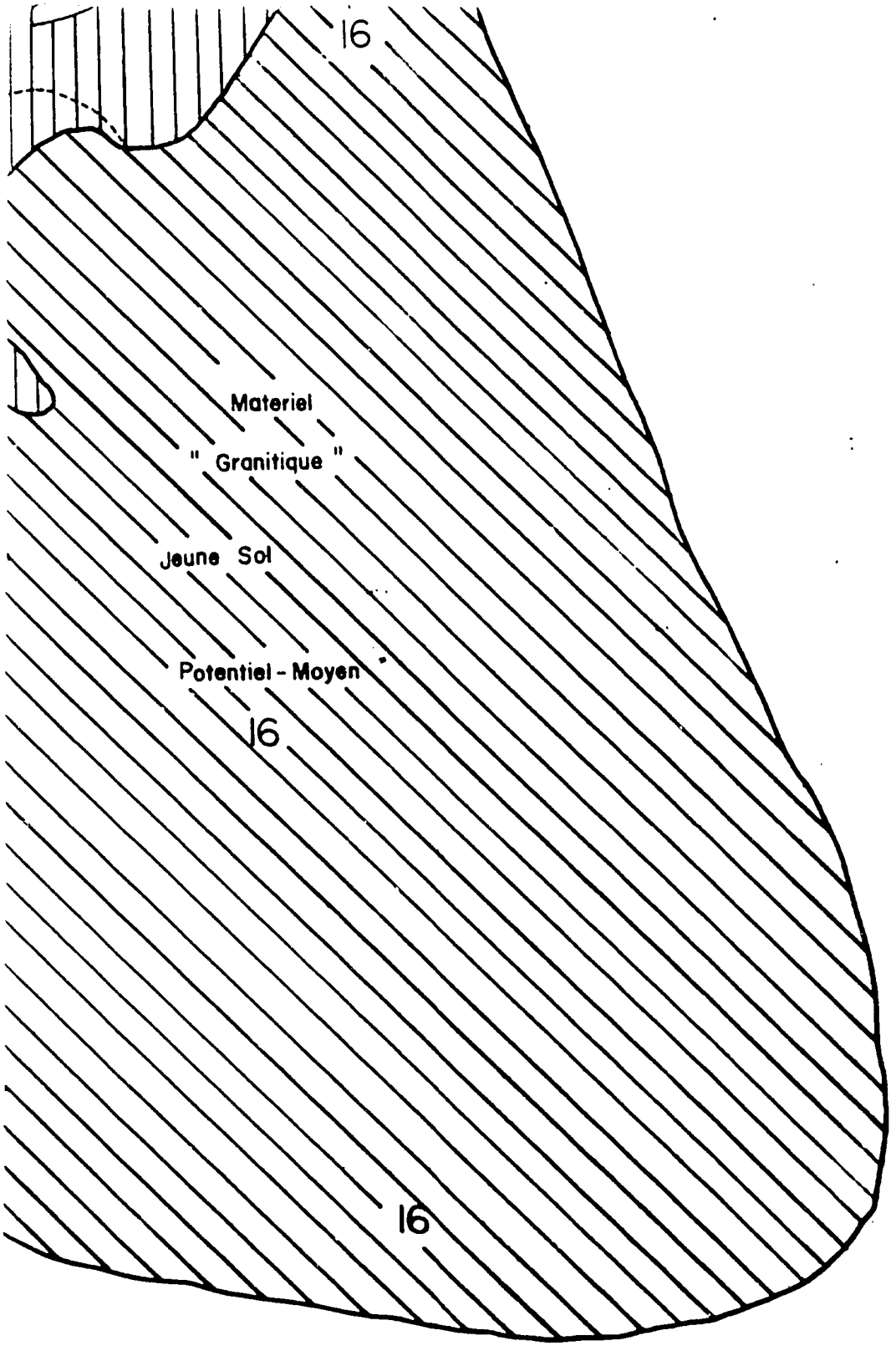
Planche N°7


s - Potentiel
Luizi
17
22
Sans - Acces
Potentiel
Moyen
18
Sans - P
22

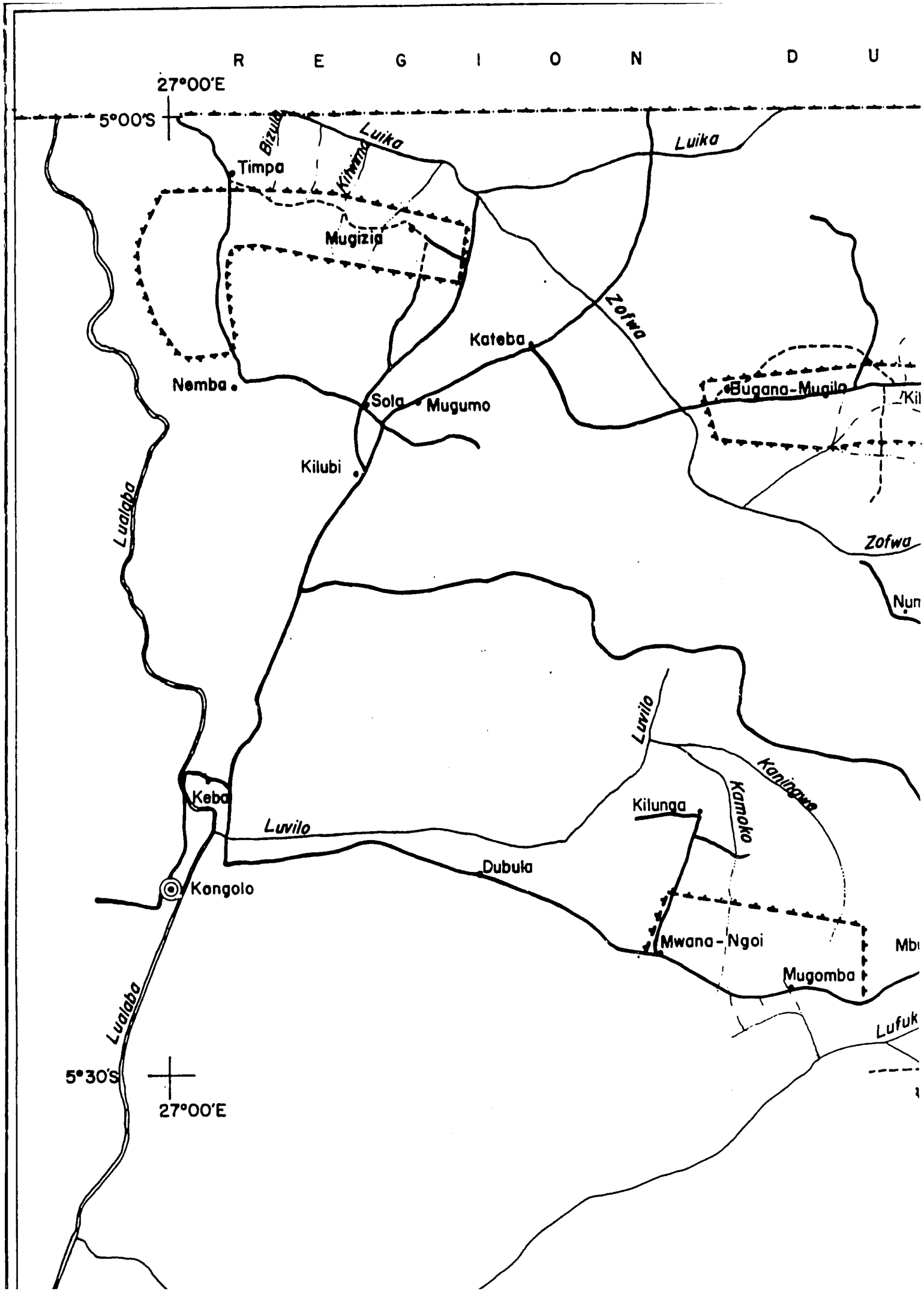
T E N T I A L I T E

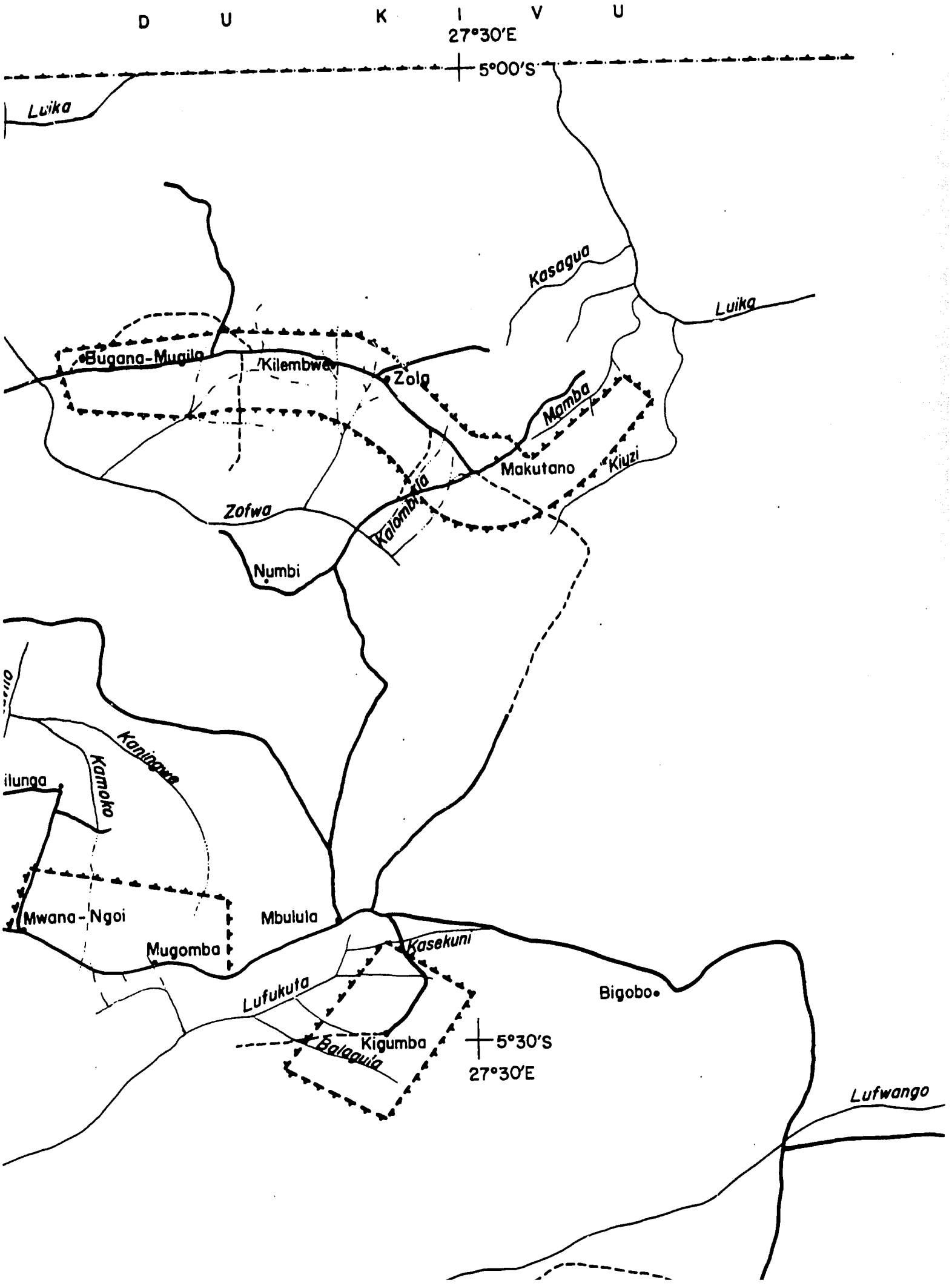

20
Bas - Potentiel
" Granitique "
Mauvais - Drainage
20
Potentiel - Moyen
" Alluvion "
Sans - Accès
13
Sans - Accès
13
Sans - Potentiel
22
Materiel
" Granitique "
Jeune Sol
Potentiel - Moye
16

T E S D E S T E

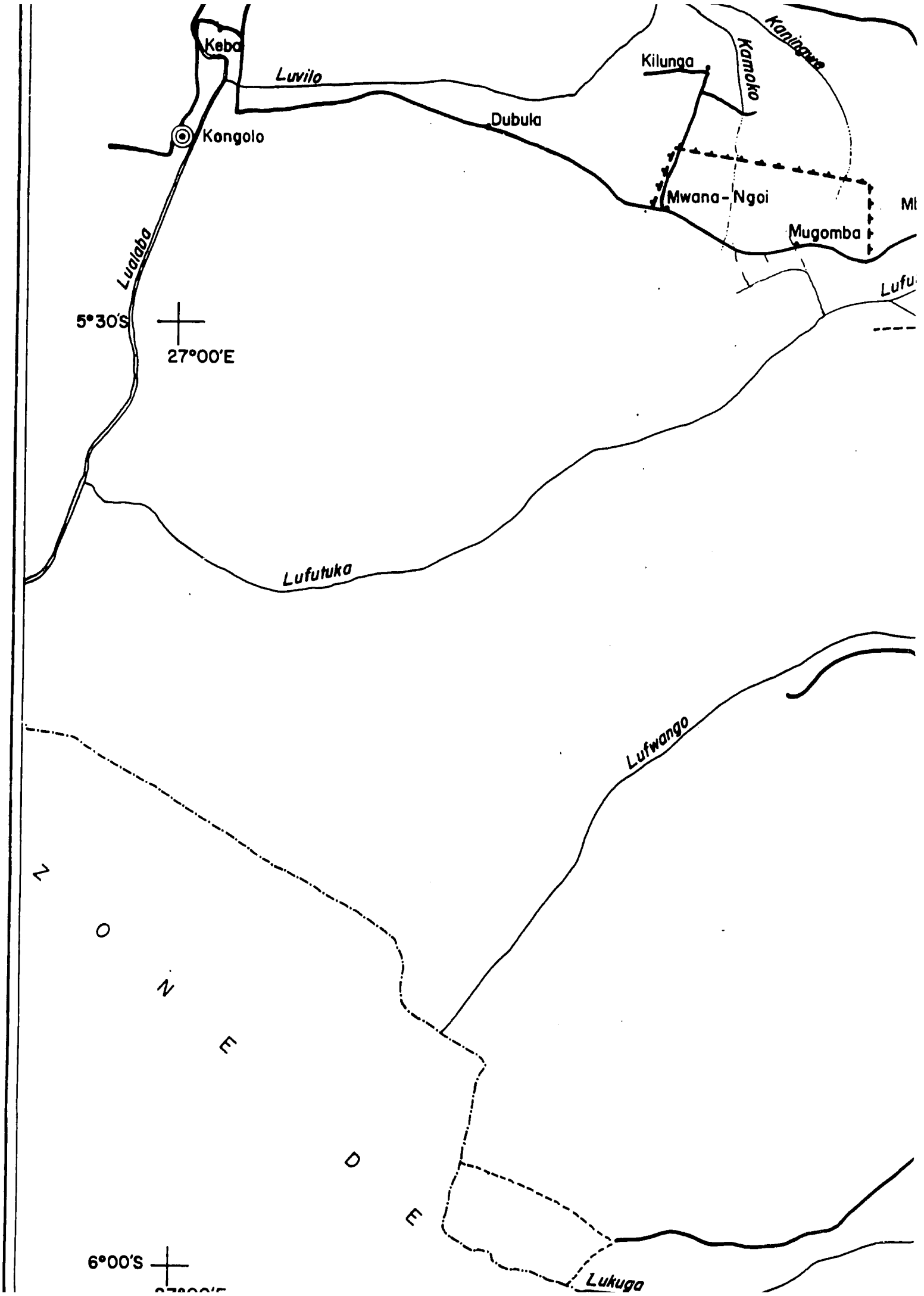


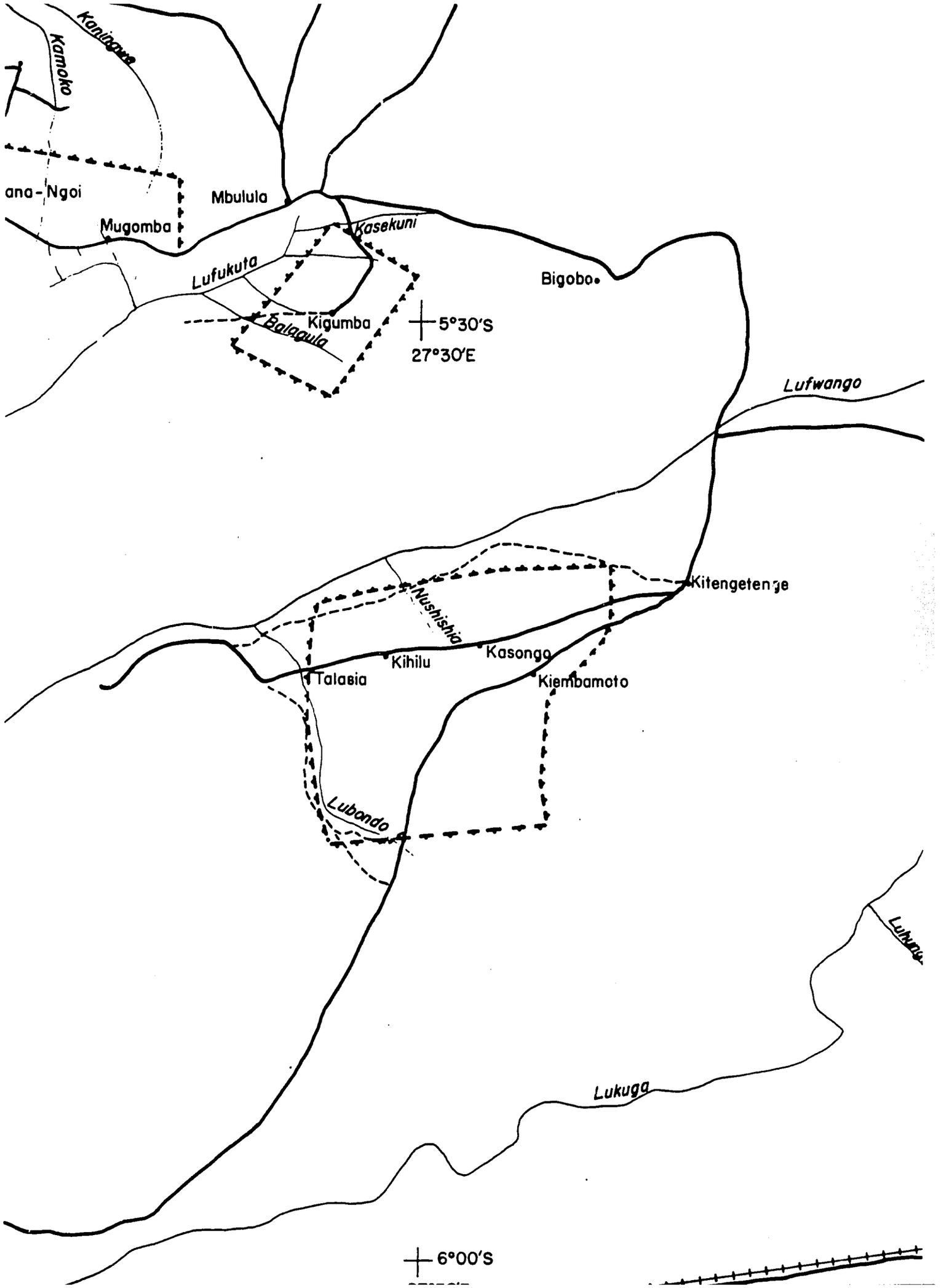
T E R R E S

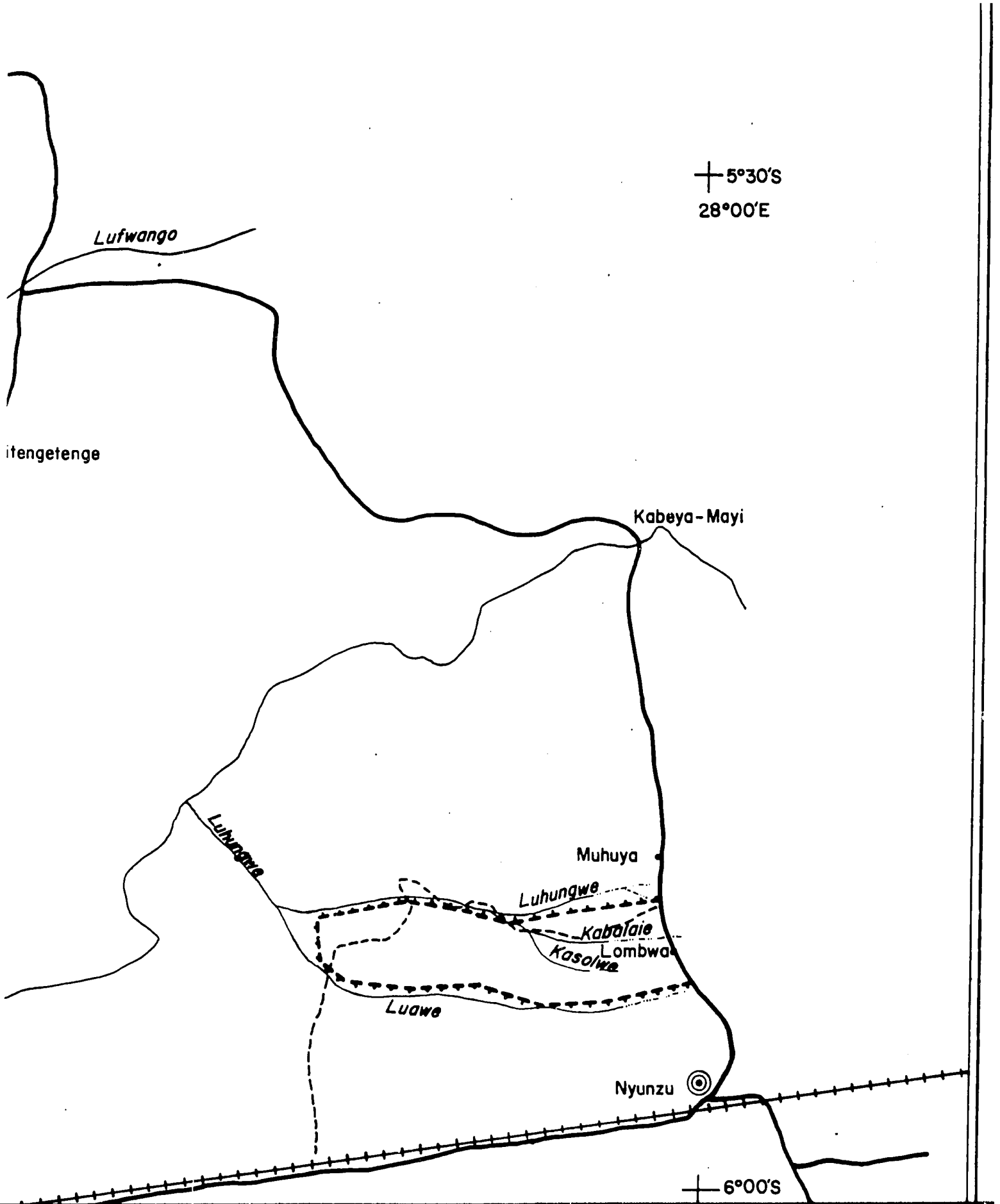

R E G I O N D U
27°00'E
5°00'S
Bizula
Kitwanda
Luika
Luika
Timpa
Mugizia
Zofwa
Kateba
Nemba
Sola
Mugumo
Bugana-Mugila
Kilubi
Lualaba
Zofwa
Luvilo
Kaningwa
Kamoko
Keba
Kilunga
Luvilo
Dubula
Kongolo
Mwana-Ngoi
Mugomba
Lualaba
Lufuk
5°30'S
27°00'E


D U K I V U
27°30'E
5°00'S
Luika
Kasagua
Luika
Bugana-Mugila
Kilembwe
Zola
Mamba
Makutano
Kiuzi
Zofwa
Kalombola
Numbi
Kaniagwe
Kamoko
ilunga
Mwana-Ngoi
Mbulula
Mugomba
Kasekuni
Lufukuta
Bigobo
Kigumba
Balaguila
5°30'S
27°30'E
Lufwango

Lufwango
5°30'S
28°00'E


Kebo
Luvilo
Kilunga
Kamoko
Kaningwe
Dubula
Kongolo
Mwana-Ngoi
Mugomba
Lualaba
5°30'S
27°00'E
Lufutuka
Lufwango
Z O N E D E
6°00'S
Lukuga


Kamoko
Kanigowa
ana-Ngoi
Mbulula
Mugomba
Kasekuni
Lufukuta
Bigobo
Kigumba
Balagula
5°30'S
27°30'E
Lufwango
Kitengetenge
Nushishia
Kasonga
Kihilu
Talasia
Kiembamoto
Lubondo
Lukuga
6°00'S


5°30'S
28°00'E
Lufwango
itengetenge
Kabeya-Mayi
Luhungwe
Muhuya
Luhungwe
Kabalaie
Kasolwe
Lombwa
Luawe
Nyunzu
6°00'S

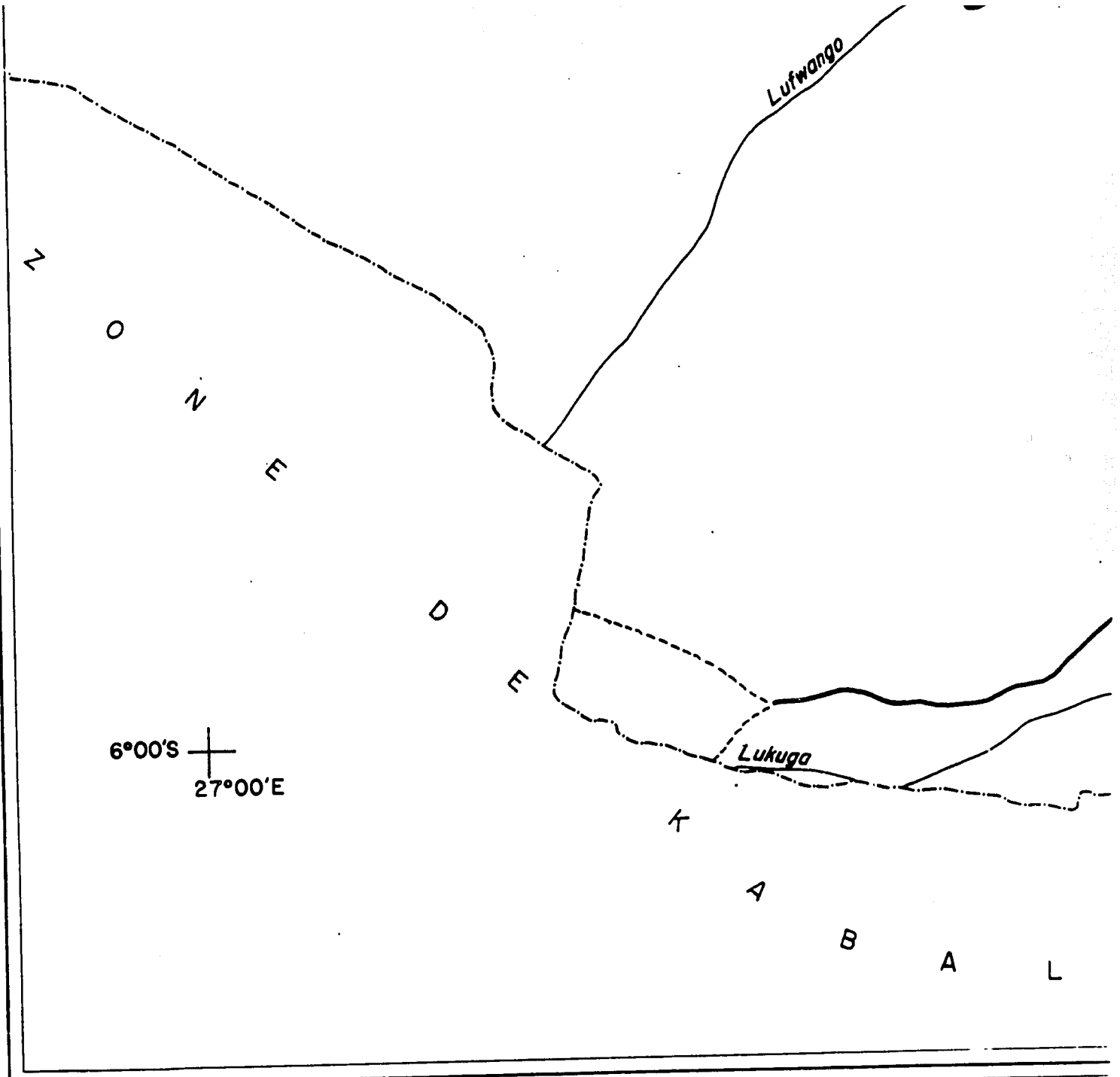


Planche N° 8

T E R R E S

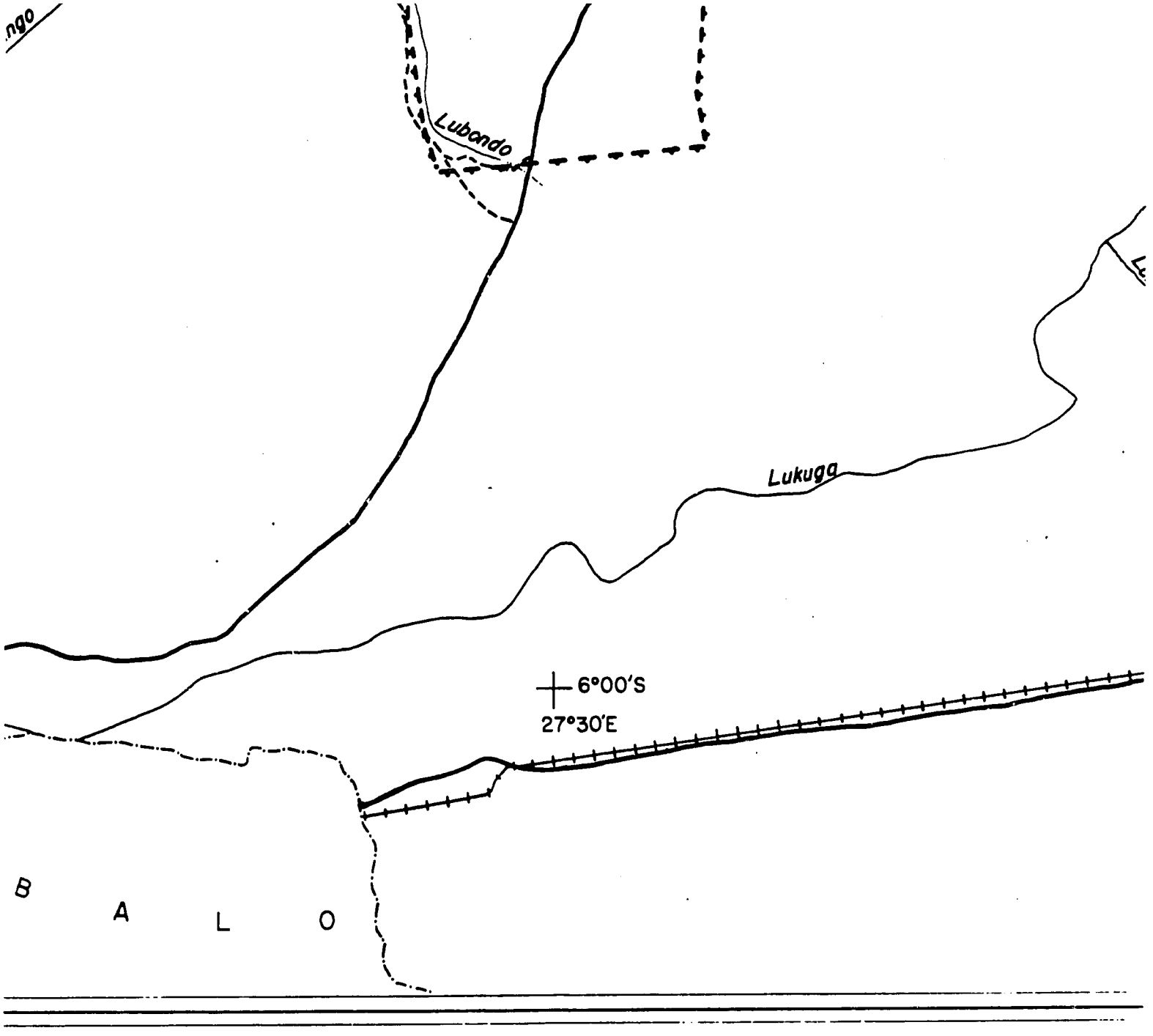
D E V E L O P

LEGENDE

Limite entre Régions

Terres Recommandées pour le Développement de l'Agriculture

Limite entre Zones

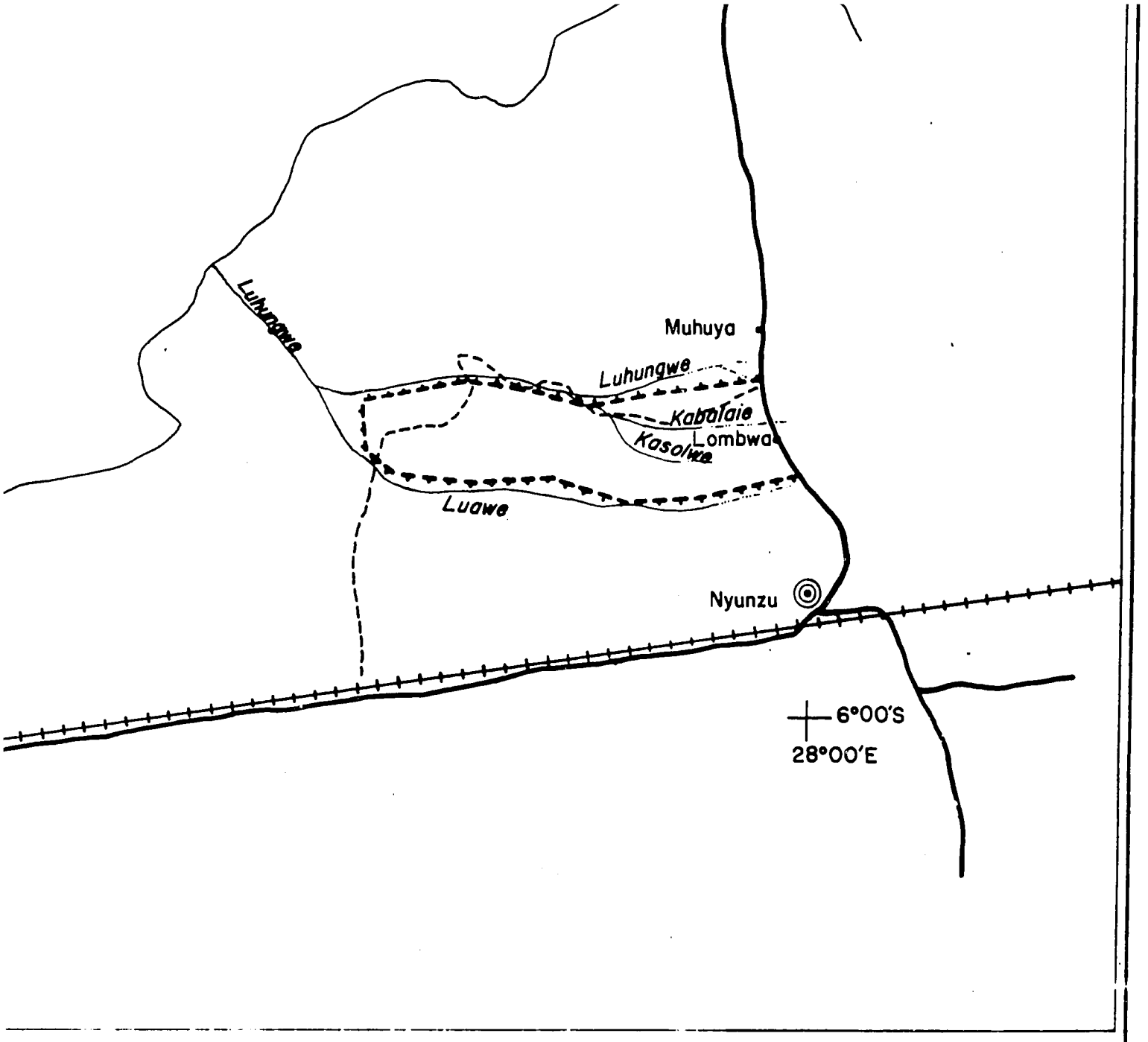


TERRES RECOMMANDEES POUR LE DEVELOPPEMENT DE L'AGRICULTURE

lture

Echèlle : 1/200.000

5 0 5 10 15


Luhungwe
Muhuya
Luhungwe
Kabolaie
Lombwa
Kasolwe
Luawe
Nyunzu
6°00'S
28°00'E

R L E

L T U R E