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REPORT ON DEVELOPMENT ALTERNATIVES IN THE DILLY PASTORAL ZONE

BY

CHEMONICS INTERNATIONAL CONSULTING DIVISION

MINISTERE DE L'ELEVAGE
ET DES EAUX ET FORETS

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SECTION I

ABSTRACT

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The present study, requested by the Mali Livestock Development Project Director, examines development alternatives for the Dilly Pastoral Zone. Resource limitations made the gathering of detailed information difficult. Nevertheless, information is presented on conditions in the zone and on constraints on the development of livestock in the zone. The effects of various interventions on forage production are estimated, including fire control (prevention, firebreaks and suppression), water development (drilled wells, reservoirs and improved mares) and range management. Benefits and costs are calculated for a combined program using all these interventions, over a 20-year period. Based on the results of these calculations, it is concluded that (1) a full-scale program to improve livestock production in the Dilly Pastoral Zone outside of the Test Perimeter should not be undertaken at this time; (2) a significant effort should be made to continue the development of the Test Perimeter, but on a more ambitious level than has previously occurred; and (3) certain aspects of the Test Perimeter should be studied further as part of an expanded development program there. Specific recommendations include providing the full-time services of a Range Manager, a Sociologist and an Animal Husbandry expert, augmented by other short-term staff over a two-year period; providing adequate facilities and logistics at the Dilly Center; implementing, with some modifications, the original Management Plan for the Test Perimeter; continuing attempts to combat fire; continuing efforts to find and conserve water; and implementing a program of sociological and evaluative studies.

SECTION II

INTRODUCTION

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Range livestock production plays an important role in the agriculturally-based economy of Mali. The livestock are managed under centuries-old sedentary and nomadic (transhumant) systems. Efforts to increase livestock production must build on these traditional systems which, in turn, capitalize on the use of different climatic and ecological zones. Flexibility is built into the system to maximize seasonal supply utilization, while minimizing impacts of droughts and other uncertainties.

These production systems have served and will continue to serve the livestock breeders well until livestock numbers increase to a level that weakens one or more segments and then the whole system will be threatened.

During the Mali Livestock Development project planning stage, the ecological problems of the Sahel were identified as one of the limiting factors in increasing livestock production in Mali. The major problems were seen to be the deterioration of forage as a result of increasing livestock numbers, excessive concentration around permanent water points, decreased grazing land due to expanding cultivation and uncontrolled burning.

The Dilly Pastoral Zone (DPZ) was designated in 1977 as a principal project area. The zone encompasses approximately 1,550,000 hectares, with administrative headquarters at Dilly.

Among the goals identified for the project was increasing livestock production in the DPZ through application of improved methods of range management, animal husbandry, marketing and extension.

The GRM was aware that success or failure of any intervention in the DPZ would largely hinge on the involvement of the people living within and using the area for livestock grazing. Therefore, in order to get their involvement in the early stages of the project, OMBEVI, assisted by an earlier project financed by the FAO, undertook to build the Dilly Center. With personnel based at the Center, a program was carried out in parts of the zone to "sensitize" herders to the coming project and to changes in herding methods. Most of this work was done in areas of the DPZ near the Dilly Center.

With the launching of the Mali Livestock Development Project and the increased operations at Dilly Center, a smaller part of the zone was selected to the south of the Center, in an area which was very lightly occupied and "underutilized" because of a lack of drinking water for livestock. The purpose was to have an area of manageable size in which to develop, test and demonstrate management practices and development techniques. Therefore, in 1978 the "Test Perimeter," an area of approximately 157,000 ha., was designated for this purpose.

To generate support and local involvement in the design and implementation stage, grazing associations were established in the Test Perimeter. Association members were selected by the villages involved. They have since been working directly with the Dilly Center in designing and implementing the management and development program.

In August 1978 Mr. Mohammed Lamine Ba and Mr. James Naylor, local and expatriate project personnel, developed a Management Plan for the Test Perimeter. Since then, work has progressed on establishing and maintaining firebreaks and a fire prevention program was initiated.

In addition, subsurface water studies have been made and a number of water wells drilled to develop this source of livestock and village water. These underground sources are very limited and unevenly distributed. They have also proved to be extremely expensive. As a result, attention is now being directed toward the development of potential surface water sources by impounding rainfall and surface runoff.

The livestock in the DPZ are mostly managed under a transhumant system; however, substantial numbers remain in the DPZ year-long. Both milk and meat are important products. Small ruminants (i.e., sheep and goats) make up a large portion of the animals remaining in the area throughout the year, although cattle predominate.

The cattle are of the Zebu strain and are already protected by an established disease vaccination program. The area is free of tsetse flies, but there is some evidence that a limited amount of trypanosomiasis does exist via transmission by secondary vectors that acquire the trypanosoma sp. from infected animals passing through the area. Relatively few livestock predators inhabit the zone. A relatively small number of big game animals presently exist in the area. The probability that they present problems of disease transmission or external and internal parasites is minor.

An efficient system of livestock marketing does not now exist in the area, but market studies have been made as part of the project and these could be used in part to develop such a system.

In January 1980 Dr. Ferdinand Traoré, Director of the Mali Livestock Development Project, considered the program in the Test Perimeter far enough advanced that some attention should be directed toward planning for development of the entire DPZ. He therefore requested Chemonics International Consulting Division, the contractor for the project, to make a preliminary study of the DPZ that would

- identify and describe the principal production systems for livestock and livestock products in the zone,
- identify the constraints on improving the efficiency of livestock production in the zone and on the expansion of production, and
- assess those development activities for the zone that appear to be technically, economically and socially feasible.

An initial work plan was developed for the study that proposed an inventory of resources within the zone and a projection of the resource potential through implementation of alternative interventions. After further consideration it was realized that conducting a resource inventory of an area as large as the DPZ would require a commitment of manpower and funds beyond the capacity of the project.

It was agreed, therefore, that the study team would work with information currently available and would present a study report on the zone that would describe the physical conditions, current livestock practices, and the constraints on increasing livestock production. The study would also consider various development alternatives, including a discussion of their merits and disadvantages, the team's recommended alternative and an economic evaluation.

A team consisting of an engineer, a hydrogeologist and a range management expert was sent to carry out the study in Mali during the period of February through June 1980. The first two months were spent in Bamako, working with project management staff, obtaining and reviewing available documents. The team then spent three to four weeks at Dilly, where they systematicallly flew over and drove through the zone in order to obtain first-hand views of conditions there. Most importantly, they were to make an estimate of the present forage condition and the potential for future forage growth, given various interventions. They also obtained information on local conditions and cost from staff at the Dilly Center.

The team then returned to Bamako to write up the report. Since a USAID economist who had planned to be part of the team could only make a brief visit to Dilly and could not participate in analyzing the data, the economic evaluation was turned over to the Mali Livestock Development Project Land-Use Economist.

The team encountered some serious problems in carrying out the study. While some data were available, they generally were inadequate in both detail and reliability. For example, the methods and equipment used in collecting the information were sometimes rudimentary at best, and different local staff gave conflicting information. It also became apparent that not having a sociologist or an animal husbandry expert on the study team made it virtually impossible to obtain any useful information on these aspects of livestock development to include in the report. Finally, the short time that the project economist was available meant that a benefit/cost analysis could only be done for one development alternative, Alternative A, maximum investment in the entire DPZ.

These problems notwithstanding, each of the four team members produced a report on his or her assigned topic, and these individual contributions were integrated into a single document, with a first draft completed in January, 1981. During April and May 1981, that document was further refined, edited and updated in Chemonics' Washington, D.C. office to produce this report.

Following this Introduction (Section II), the report contains six more sections. Section III is a study of the Dilly Pastoral Zone, including a general description of the zone (physical, climatic, etc.), existing water sources (hand-dug wells, deep wells and natural *mares*) and current livestock practices and grazing patterns. Section IV describes the constraints on increased livestock production in the zone, which are principally fire, poor range condition and livestock water deficiencies. Section V lays out the development alternatives considered, which involve fire control (prevention, firebreaks and suppression), water development and range management. Section VI provides cost estimates for "high" and "low" versions of the full-scale range development alternative. Section VII presents the economic evaluation in the form of a benefit/cost analysis of the alternative that was costed. Section VIII gives the conclusions and recommendations of the study.

SECTION III

STUDY OF THE DILLY PASTORAL ZONE

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A. General Description of the Dilly Pastoral Zone

1. Physical and General

The Dilly Pastoral Zone (DPZ) extends from 7°30'E of the Principal Meridian of Longitude to 8°30'E and from the Mauritanian border (15°30'N) south to 14°30'N, encompassing an area of over 1,550,000 ha. It includes more than 200 villages, approximately 80,000 people and an estimated 133,000 cattle, which approximates its optimal carrying capacity. The ZPD has been the subject of fairly intensive study over the years. Physically, it is typically Soudano-Sahelian terrain. Dunes and valleys, aligned generally along the prevailing winds (northeast to southwest), roll gently as a traveler moves northward. The dunes, mostly stabilized, trend southwesterly over most of the northern two-thirds of the zone. Grasslands and typical scattered brush and trees stretch from horizon to horizon. Villages cluster around each permanent water source. Patches of badly over-grazed ground surround each village, lending credence to the widely-held belief that desertification and the spread of the Sahara southward will one day engulf the entire zone.

A few outcrops of dolorite pierce a generally sandy over-burden. In some areas the sand has been blown away, exposing a clay or laterite substrate, especially where fire or over-grazing has destroyed the vegetation. In the dry season, a pall of dust hangs over the area through which cattle wander while searching for forage or being herded from watering point to watering point.

2. Climate

The DPZ has three distinct seasons, each of approximately four months' duration. Rain begins about the middle of June and continues until the middle of October. It is followed by the "cold" dry season which lasts until the middle of February, succeeded by the "hot" dry season which lasts until the middle of June, at which time the rain storms come again and the cycle is completed.

Tables 1 through 3 show representative data for precipitation, temperatures, ar' evaporation and humidity. It is customary to refer to the DPZ, and indeed the entire Sahel, as a rain-deficient area. This statement is an oversimplification. With an average annual precipitation of 400-500 mm. in the north and about 700 mm. in the south, the DPZ receives more precipitation than most cattle-raising areas in the United States. The problem is the poor distribution of the rainfall, with 90 percent occurring during the four-month rainy season. In addition, the intensity of precipitation is very high and the torrential storms result in erosion, crop damage, and accumulation of surface runoff between the dunes and in the numerous shallow depressions or mares. This accumulation is significant because it points to the possibility of capturing and storing a portion of the runoff in properly constructed ponds, in spite of the sandy soil and high evaporation.

Maximum temperatures at Nara, in the shade, vary from 32.1°C in August to 40.1°C in April. The preceding are average values for seventeen years. Maximum monthly temperatures in the shade, recorded for 1978 only, averaged 45.6°C in December. Individual days may have temperatures in excess of 50°C during May and June.

The average annual evaporation for a seventeen-year period at Nara was 2.95 m. The months of highest evaporation were March and April (365.8 mm. and 375.0 mm.), which correspond with the period of lowest relative humidity (25.7 percent and 26.6 percent). The three rainy months, July through September, had the lowest evaporation and the highest humidity.

The prevailing wind is the Harmattan which blows from northeast to southwest from October to June. This hot, arid wind comes from the desert and increases both the rate of evaporation and plant transpiration. During the rainy season, the wind direction is reversed (SW to NE) and the so-called monsoon wind is humid and relatively cool. This explains the high humidity during the July through September period. Both the Harmattan and the monsoon are characterized by brief gusts of very high velocity.

3. <u>Soils</u>

The soils in the DPZ are mainly of alluvial origin. The Valley of the Serpent meanders west to east through the zone. The soils in the Valley of the Serpent are overlain by Eolian deposits and tend to be somewhat heavier than the other soils in the zone but they do vary in texture from fine sand to heavy clays.

North of the Valley of the Serpent, the land form is characterized by linear dune formations. Both active and stable dunes are present. In some areas the dunes flatten into a sandy silt plain of Eolian deposits with laterite and quartzite outcroppings.

The dune soils are brownish in color. They vary in texture from heavy sand at the base of the dune to fine silty sand or clay in the depressions between the dunes. These clay depressions receive runoff water from surrounding areas.

The soils are low in organic matter and without definite horizons. Geologically, they are considered young, immature soils. In most areas the soils are quite deep, and with the loose structure of the dune formations, moisture can penetrate easily. The water-holding capacity is good in most sites.

4. Vegetation

The vegetation of the Dilly Pastoral Zone can be divided into major groups based on the ligneous species that dominate the vegetational aspect.

In the northern part of the zone, small, thorny-leafed shrubs such as *Acacia*, *Balanites* and *Commiphora* dominate, while in the south, *Bombax*, *Terminalia* and *Prosopis* are dominant.

The grass cover is predominantly annual. The species vary from site to site depending on the soil characteristics and the degree of degradation caused by overgrazing, fire and farming. Common annual grass species include: *Cenchrus biflorus*, *Ctenium elegans*, *Dactylactenium aegyptium*, *Eragrastis tremula*, *Oryza breviligulata*, *Panicum lactum*, *Schoenefeldia gracilis*, *Sprobolus granularis*, *Diheteropogon hagerupii* and *Aristida mutabilis*.

Perennial grass species such as _Andrapogon gayanus_, _Aristida pallida_ and _Panicum turgidum_ can be found on isolated sites protected somewhat from the full impacts of grazing and annual burning.

Some of the grass species have important uses other than livestock forage. The long culms of _Andropogon_ are used to make mats for shade and sleeping. They are also used to make thatched roofs for huts. The grains of _Cenchrus_ and _Panicum_ are sometimes crushed and used for porridge by the local people.

Trees and shrubs supplement grasses for livestock feed during the dry season. In some situations the branches are cut and carried to the livestock, or they are cut and left or bent down so they are accessible to livestock.

Other common trees and shrubs in the DPZ include _Guieara Senegalensis_, _Terminalia avicennicides_ and _Tribulus terricatris_.

B. Existing Water Sources

Livestock production in the DPZ depends entirely on direct rainfall. For human consumption and cattle-watering, there are three types of water sources: traditional hand-dug, shallow wells; machine-drilled, deep wells; and the natural ground depressions, or _mares_, that collect surface runoff and store it for periods up to four or five months after the end of the rainy season.

For a detailed discussion of water sources, we refer in the next few pages to a map prepared from a thesis by Mr. Khalidou Diallo, "Aménagement - mise au point d'un système d'exploitation Dilly," in December 1977. The map is found in the annex to this report. Although it is the most complete inventory of DPZ water sources prepared to date, the information shown on the map is nonetheless approximate, due primarily to the size of the zone and the limited resources thus far available to gather such data.

The map indicates clearly, however, the so-called empty or underutilized areas, especially in the southeastern and northern parts of the region, where the absence of permanent water sources prevents the use of pasture. The map shows the location of both hand-dug wells and various mares as of the end of 1977. It also shows the deep wells which have been machine-drilled by the Service de l'Hydraulique from 1978 to 1980. It does not show the shallow wells which have undoubtedly been dug by the villagers since the survey was completed in late 1977.

Specifically, the map shows the following water sources in the zone:

- 48 permanent hand-dug wells of less than 20 m. depth;
- an estimated 1,025 non-permanent1/ hand-dug wells of less than 20 m. depth, and wells dug in sand, also non-permanent;
- 30 wells of more than 20 m. depth;
- 37 machine-drilled deep wells
- 74 shallow mares, lasting one to two months after the end of the rainy season;
- 75 shallow mares, lasting two to four months after the end of the rainy season;
- 17 shallow mares, lasting more than four months after the end of the rainy season.

1/ A "non-permanent" well means one which is dry during the dry season.

In order to analyze the variations in water supply within the DPZ, we divided the zone into sixteen equal sections, numbering them consecutively from left to right, beginning in the upper left (northwest) corner. Table 4 shows the number of water sources in each section during both the rainy season and the dry season. It also shows the number of dry-season and rainy-season water sources per hectare in each section and the percentage difference between the rainy and dry seasons.

While it is true that water requirements for livestock vary considerably, depending on the kind of stock, the nature of the forage and the weather conditions, some generalizations about water usage can be made. Mature Zebu cattle will drink from six to twenty liters of water per day, depending on the temperature, the humidity and feed conditions (i.e., whether the forage they are grazing on is succulent or dry). Sheep and goats will drink from 2.5 to 5 liters per day, depending on the same variables. When animals are herded, as they are in the DPZ, and can thus be distributed to areas of light utilization, one water source for every 7,000 to 8,000 hectares is probably adequate to achieve good results in animal production. (When animals are not herded, one water source should be available for every 1,500 to 2,000 hectares.)

Using these same generalizations, and the information in Table 4, we can make the following observations:

- The number of available water sources during the rainy season is well within acceptable levels (i.e., one source per 8,000 hectares) in all but two sections (numbers 15 and 16) in the southeasternmost part of the zone. Thus, water supply is adequate over 88 percent of the DPZ during four months of the year.

- Using the same requirement of one water source to every 8,000 hectares, barely 25 percent of the zone (sections 2, 7, 8 and 11) has adequate water during the dry season.1/

- During the dry season, the average number of hectares per water source over the entire zone is 11,742. This figure is misleading, however, because of the heavy concentration of water sources in a few areas. As an example, the four sections listed above (2, 7, 8 and 11) represent only 25 percent of the land area, but have more than 52 percent of the dry-season water sources in the zone. By contrast, in nearly 40 percent of the zone (sections 3, 4, 9, 13, 15 and 16) existing water sources would have to be increased from 400 to 1,200 percent to reach the minimum acceptable level of one source per 8,000 hectares.

- Even in those areas that have an adequate water supply during the dry season, the difference between dry-season and rainy-season sources is dramatic. One-third of the DPZ has a dry-season water supply which is only five percent or less of the rainy-season supply for the same areas. The average over the entire zone is only 10 percent.

- It must further be remembered that quantifying water supply in this fashion gives, if anything, a more optimistic picture than is truly the case, since many of the water sources listed in the study are either not used for livestock, or have a lesser utility, and can serve fewer numbers of animals than others. We did not attempt to weight each type of water source according to the numbers of animals it can accommodate. We believe it would be a useful approach, however, for assessing the water resources in a given area and for a given use. Should money become available for a detailed inventory of the DPZ, we would recommend incorporating some form of weighted system in such an inventory. We did note that the mares, for example, which can accommodate the largest numbers of animals, dwindle to a total of 17 during the dry season, i.e., they constitute only 13 percent of all dry-season water sources.

1/ Sections 7, 8 and 11 include Dilly and the area immediately to the northeast, northwest and southwest.

The following is a discussion of each of the three major water sources in the DPZ: (1) hand-dug wells; (2) machine-drilled, deep wells; and (3) natural _mares_.

1. _Hand-Dug Wells_

Hand-dug, traditional wells are currently of greatest importance in the DPZ because they are the only source of water for most villages during the dry season, after the shallow _mares_ have dried up. Most of these wells are 1 m. to 2 m. in diameter and from 5 m. to 25 m. deep. They are located close to the villages and generally in or around the borders of the _mares_. Many wells have their sides supported by sticks and branches to prevent caving in, and a few have a concrete lining. The yields of the wells are poor, especially during the dry season, when the local water table is only a little above the bottom of the well. Most of the wells are dug in sand and clay of low permeability, resulting in slow recharge when the water is dipped out. A number of wells, especially in the northern part of the DPZ, go down to rock, which is chipped out with a hammer and chisel in order to collect the water as it oozes out of the cracks and fissures of the rock.

The sanitary conditions of the open wells are often deplorable. Located helter-skelter in and around the _mares_ where many village activities take place, or where the animals concentrate, most wells have no protective walls or enclosures. Sand and dirt blow in without interference, and when the _mares_ fill up during the rainy season, fecal matter and garbage float into the wells and remain there after the _mares_ dry up and the wells are used again.

The wells also lack any mechanism to ease the labor of hauling water to the surface. Goatskin bags and buckets are dumped in with a rope and hauled up hand-over-hand. Considering that each head of cattle needs at least two bags of water at every watering, the labor to satisfy a herd of about 100 animals would be enormous. The simple method of a tripod with a pulley and rope, used in other areas of Mali and Africa, is not prevalent in the DPZ.

2. Deep Wells (Machine-Drilled)

Seismic and geophysical groundwater explorations have been carried out in the DPZ under a United Nations program since 1970. A number of reports on the geology and hydrogeology of the zone have been published. Some wells were drilled under other projects, but the majority were dry holes. A few wells produce fair yields, such as the FAO well at Dilly Center, which has been tested at 10.4 m^3/hr. and which is the only well in the area with an electric submersible pump.

In 1978, as part of the Mali Livestock II Project, the Service de l'Hydraulique du Mali started a well-drilling program which sank 45 test holes. Twenty holes were less than 50 m. deep and seven produced water. Twenty-five were from 50 m. to 91 m. deep and all produced water. Of the 32 water-producing test holes, 16 had adequate test pumping yields of 0.8 m^3/hr. to 13.5 m^3/hr. Only 13, however, were redrilled as production wells and are now being equipped with pumps. The main characteristics of these wells are shown in Table 5.

It is interesting to note that only 3 of the 16 good test holes encountered water in the dolorite intrusions.

The balance of the good test holes found water in fractures of the schist bedrock at depths of 20 m. to 45 m., or in sandstone at more than 50 m. depth. The frequently expressed theory that the dolorite intrusions in the DPZ may be promising groundwater sources appears to be untrue.

It is also worth noting that all productive wells are in the fossilized river beds, such as the Valley of the Serpent and its ancient tributaries, rather than in the so-called "empty" areas where forage goes unused. These former rivers can be clearly distinguished by their more abundant tree and brush cover. They are also the location of most villages because groundwater can be harvested from hand-dug wells at reasonable depths. As a result of the many villages and the shallow wells, the area of the old river beds is already overgrazed, and it is entirely possible that the new deep wells may actually aggravate the overgrazing problem.

A very recent study,2/ based on interpretation of Landsat satellite photography, proposes that there may be many more geological faults and anomalies in the DPZ than had been previously believed. These fault lines, superimposed on the ancient river valleys, might indicate the existence of groundwater where none had been expected or found before. The study and its interesting theory have not yet been verified by actual drilling. In general, it must be recognized that, through 1980, exploration for groundwater and drilling of deep wells in the DPZ has had only indifferent results at a very high cost.

2/ Lamine Bâ, "Contribution des images Landsat à l'étude des ressources pastorales du Périmètre test de Dilly," 28 April 1980.

3. Natural Mares

The rolling topography of the DPZ with its fixed (and occasionally live) dunes creates a very large number of ground depressions that have drainage basins of varying sizes. Many of these natural depressions fill up with runoff during the rainy season, creating shallow lakes or mares. Depressions covered entirely with sand lose the collected runoff almost immediately through exfiltration. Others that have a bottom cover of sandy clay and silt retain the water for periods of up to five months after the rainy season. Evaporation losses are, of course, very high due to the shallow depth. By the start of the hot, dry season, nearly all the mares in the DPZ have dried up and the villagers then depend on their hand-dug wells.

Villages tend to be located where the better, longer-lasting mares are found, and as long as the mares contain water they serve all human and livestock needs, including drinking water, washing, bathing and animal watering. Sanitary conditions can be as bad or worse than those described for the shallow wells since the bottoms of the mares are generally covered with animal droppings, human waste and refuse during the dry season.

After the mares dry up, the villagers resort to the shallow wells which are generally dug in or around the mares as described earlier. As the water of the mares recedes, the sandy clay bottom also furnishes the material for the mud bricks which are the basic building material for the village huts.

C. Current Livestock Practices and Grazing Patterns

The livestock production system in the DPZ is similar to that in other parts of the Sahel in that both meat and milk are important products of the system. Hides are tanned and used locally. When the animals are marketed through the abattoir, the hides then become an important commercial by-product. Milk is an important component of the family diet, and is bartered or sold at local markets.

The production of milk for sale and for family use detracts from maximum production of meat. With milk as the focal point, efforts are directed toward maintaining lactating cows throughout the year. To accomplish this goal, calves must be born throughout the year without a specific calving season. This practice has merit as far as milk production is concerned, but a high percentage of the calves born during the dry season die from malnutrition and disease as a result of sharing the milk before they are able to subsist on their own. Thus the number of young animals for meat production is limited. Calves born during the green season have a much better chance at survival.

Small ruminants (i.e., sheep and goats) play an important part in the production cycle by providing meat and some milk on a daily basis. Large numbers are marketed for special occasions such as Ramadan. These small ruminants are usually kept around the village all year long. As described above, livestock water during the dry season is very limited and may only exist at the village site. When forage is depleted near the village, the small ruminants and the sedentary cattle herd must spend a day or more without water in order to obtain sufficient forage to maintain themselves.

Dairy herds are kept by most, if not by all, villages in the DPZ. These sedentary herds usually graze around the villages during the year; they are corralled at night in or near the village. Dry and young animals are sometimes sorted from the herd and sent on transhumance during the dry season. They then return for the rainy-season grazing period.

Three distinct transhumant systems ("grand," "south" and "north") affect the livestock grazing patterns in the DPZ. Herds participating in the "grand" transhumance originate in the Mauritanian Sahel and graze through the DPZ on their way south at the beginning of the dry season. They sometimes spend short periods of time in the DPZ feeding on millet and sorghum stalks after the grain has been harvested. The farmers feel this practice of concentrating large numbers of animals on the grain fields adds fertility and improves their grain production. This "grand" transhumance returns to Mauritania through the DPZ again at the beginning of the rainy season to reach the natural salt licks and lush grazing lands north of the DPZ.

The timing of the transhumance depends on both water and forage conditions. In years when the early rains are light, the transhumance is delayed until the rains are sufficient for water to accumulate in the natural ponds along the transhumant routes. During dry years, livestock waters may be as far as 20 to 30 km. apart. Under such stress, livestock lose considerable weight and their death rate is high.

The "south" transhumance consists of local herds that graze in the DPZ during the rainy season. They leave the areas and spend the dry season in the southern part of Mali where both forage and water are more plentiful.

While these local herds are south during the dry season, a limited number of herds come from Mauritania and spend parts of the dry season in the DPZ and then return north during the rainy season. These herds are often referred to as the "north" transhumance herds.

The transhumant system of managing livestock has been criticized as being outmoded and inefficient, but it is a system of livestock management that offers the flexibility that is so necessary when forage and water conditions fluctuate from one year to the next as they do in the Sahel.

TABLE 1

AVERAGE MONTHLY PRECIPITATION

	Nara 1931-1968		Dilly 1966-1975		Balle 1956-1975		Mourdiah 1932-1975	
	mm.	days	mm.	days	mm.	days	mm.	days
Jan.	0.0	0.2	0.0	0.0	0.0	-	0.3	0.1
Feb.	0.1	0.1	0.0	0.0	0.0	-	0.0	0.0
Mar.	0.4	0.3	0.8	0.2	0.5	-	2.5	0.4
Apr.	3.4	0.8	2.5	0.4	0.7	-	6.9	1.4
May	10.7	5.4	13.8	1.4	12.1	-	20.4	3.9
June	53.6	5.1	30.8	3.0	33.7	-	81.7	8.0
July	137.6	9.6	122.2	9.4	131.5	-	192.2	11.4
Aug.	186.2	11.8	153.1	10.5	166.2	-	271.0	11.9
Sep.	91.6	7.3	83.9	6.8	77.4	-	125.2	9.2
Oct.	16.9	1.8	18.8	2.8	31.0	-	26.5	3.8
Nov.	1.9	0.2	0.0	0.0	1.2	-	0.4	0.8
Dec.	1.5	0.1	0.0	0.0	0.0	-	1.6	0.2
Annual	504.8	38.6	425.9	34.5	454.3	-	729.9	50.9

Source: Service Météorologique National, Division Climatologique.

Note: The quality of the data is doubtful. Data for Nara does not include the period of drought, which may explain the relatively high rainfall. Mourdiah is the most southerly station, which may account for the sharp increase in precipitation. Data on maxima, minima, intensity and duration of rainfall are not available.

TABLE 2

TEMPERATURES AT NARA

	Average Monthly Temperature in the Shade, 1951-1968		Average Monthly Temperature in the Sun (Top of Soil) 1978 Only
	Max. (°C)	Min. (°C)	Max. (°C)
Jan.	32.3	11.0	36.6
Feb.	35.4	13.3	40.8
Mar.	37.5	15.9	41.4
Apr.	40.1	20.3	43.2
May	38.9	21.4	45.6
June	39.0	22.5	43.6
July	34.3	20.4	38.2
Aug.	32.1	19.9	37.5
Sep.	33.5	19.7	38.5
Oct.	36.9	18.9	40.1
Nov.	36-3	15.1	37.3
Dec.	32.3	11.1	31.6
Annual	35.7	17.5	39.5

Source: Service Météorologique National, Division Climatologique.

Note: Quality of data doubtful. Maximum temperatures in the sun exceeded 50°C on individual days during May and June. Temperatures at Dilly in the sun, in the shade, and at varying soil depths have been recorded since 1977 but are not yet tabulated.

TABLE 3

AVERAGE EVAPORATION AND HUMIDITY

NARA, 1951 - 1968

	Evaporation		Humidity
	mm/Day	mm/Month	%
Jan.	8.4	260.4	36.2
Feb.	10.4	291.2	32.3
Mar.	11.8	365.8	25.7
Apr.	12.5	375.0	26.6
May	11.4	353.4	35.9
June	8.4	252.0	46.9
July	4.5	139.5	63.2
Aug.	2.9	89.9	73.4
Sept.	3.6	108.0	65.0
Oct.	6.4	198.4	54.9
Nov.	8.5	255.0	41.1
Dec.	8.2	254.2	33.9
Annual		2946.8 (≈ 2.95 m)	

Source: Service Météorologique National, Division Climatologique.

TABLE 4

ANALYSIS OF RAINY-SEASON AND DRY-SEASON WATER SOURCES BY SECTION IN THE DPZ

Section Number	No. of Water Sources, Rainy Season1/	No. of Water Sources, Dry Season2/	Dry-Season Sources as a Percentage of Rainy-Season Sources	No. of Hectares3/ per Water Source, Rainy Season	No. of Hectares per Water Source, Dry Season
1	57	10	18%	1,700	9,688
2	79	12	15%	1,226	8,073
3	136	2	1%	712	48,438
4	102	2	2%	950	48,438
5	99	4	4%	978	24,219
6	75	6	8%	1,291	16,146
7	106	17	16%	914	5,699
8	86	24	28%	1,126	4,036
9	60	3	5%	1,615	32,292
10	50	11	22%	1,938	8,807
11	64	16	25%	1,514	6,055
12	77	7	9%	1,258	13,839
13	113	3	3%	857	32,292
14	183	11	6%	529	8,807
15	8	1	12%	12,109	96,875
16	9	3	33%	10,764	32,292
Totals/ Averages	1,304	132	10%	1,189	11,742

1/ Includes all water sources shown on the Khalidou Diallo map.

2/ Includes only permanent, hand-dug wells less than 20 m. depth; wells more than 20 m. depth; machine-drilled deep wells; and mares lasting more than four months after the end of the rainy season.

3/ Based on a total of 1,550,000 hectares in the Zone, or 96,875 ha. per section.

TABLE 5

CHARACTERISTICS OF PRODUCTION WELLS IN DILLY PASTORAL ZONE 1/

Chemonics ID.	Hydraulic No.	District Secteur	Original TWL (M.)	TWL-BPI (M.)	WL-BPI (M.)	140 mm.C. (M.)	Capacity M^3/hr.	Pump at (M.)
A	7	Safintara	68	55	5.1	8.5	13.5	24
B	4	" - " S.W.	65	37	13.4	8.0	8.1	21
C	9	Demba W.	59	55	11.3	10.8	11.5	21
D	11	Demba S.	88	89	30.5	18.65	8.0	45
E	13	Dyelwa S.	91	31	14.3	9.5	4.8	24
F	14	N'tomikoro	38.5	60	15.4	29.5	7.0	27
G	15	" - " - "	45	41	15.5	20 ?	8.0 Est.	24
H	16	" - " - S	78	48 Est.	24.5	34.6	2.8	NF
	5	Safintara 2/						
	1	Demba towards Fallou 3/	50	?	?	15.65	1.0	
	2	N'galabougou 3/ South	85	?	?	18.65	1.5	
	3	N'galabougou 4/ South	86	?	?	24.5	0.8	
	17	N'galabougou 5/						

Abbreviations: Original TWL = Original Total Well Length (as drilled by H.S. in 1979).
TWL-BPI = Total Well Length just before pump installation.
WL-BPI = Water Level just before pump installation.
140 mm.C. = 140 millimeters (diameter) casing with welded-on cover.
Capacity m^3/hr: Estimated by Hydraulic Service after 1/2 to 2 hr. test.
Chemonics IDs: are permanently established at cement base of each pump as well as Hydraulic Service numbers. However, the latter were not established in 1975 right after the wells were drilled, so their accuracy cannot be guaranteed.

Notes:
1/ As of March 1981. Further improvements were made in April-May 1981.
2/ Pump established by Hydraulic Service 1979-80.
3/ Probably not suitable for pump installation.
4/ Most probably not suitable for pump installation.
5/ Dry well found in approximate location of 17.

SECTION IV

CONSTRAINTS ON INCREASED LIVESTOCK PRODUCTION IN THE DILLY PASTORAL ZONE

SECTION IV

CONSTRAINTS ON INCREASED LIVESTOCK PRODUCTION IN THE DPZ

Livestock production in the DPZ, as elsewhere in Mali, is fully dependent on the native forage resource. While the supply of forage seems unlimited during the rainy season, i.e., June to September, there are many obstacles to overcome in developing an efficient livestock production system that provides ample forage and water on a daily basis throughout the year.

Palatability and nutritive content of the native range forage decrease during the dry season. Shortages develop during low rainfall years and each year fire destroys a high percentage of the forage that would otherwise be available for livestock. Limited livestock water sources during the dry season further curtails access to otherwise available forage, thus contributing to range degradation near the permanent water sources where livestock are forced to congregate. Nutritional deficiencies also weaken livestock, causing weight loss, lower offspring percentages, higher death losses and higher susceptibility to disease.

Although the constraints on improvement of efficiency and expansion of livestock production in the DPZ have many ramifications, these constraints can be summarized in a few words: lack of adequate water and forage on a continuing basis. For our discussion here, we sub-divide the constraints into three: fire, poor range condition and water. Fire and poor range condition contribute to the lack of adequate forage mentioned above.[1/]

1/ Obviously, significant weather variation, such as drought, can and should be listed as a major constraint on increased livestock production in the Sahel. We do not treat it in this report, however, but concentrate instead on those constraints which can be addressed by specific interventions, or combinations of interventions.

A. Fire

For livestock breeders and herders, fire generally represents a loss of forage that could have been grazed. Range fires destroy large amounts of forage each year. For example, Le Houeron reports that in the African Savanna, 80 million tons (enough forage for 25 million cattle for nine months) are destroyed by fire each year.

In the DPZ, approximately one third of the area (500,000 hectares) burned during 1979-80. Assuming an average production of 400 kg./ha., this represents a loss of 200,000 tons of forage, enough to meet a year's requirements for 50,000 cattle.

Fires occur mostly in lightly or ungrazed areas where vegetation is heavy enough to carry a fire. Most fires in the DPZ occur early in the dry season. Some are set accidentally or deliberately by transhumants; others are set by farmers to kill the larvae of crickets that invade their fields; some are set to control ticks that attach themselves to livestock as they graze the heavily vegetated areas; some are set to get rid of dry grass so the new green shoots that usually develop following burning of perennial grass species are more accessible to livestock; and some are started naturally by lightning. Whatever the cause, continuous burning can result in destruction of desirable vegetation and growth of less desirable plants; it sometimes leaves an area entirely denuded of vegetation and subject to erosion by both wind and water.

Once vegetation is burned, adequate forage may not be available to maintain the livestock. They must then travel longer distances for forage, which can be a factor in determining whether or not livestock in the DPZ are sent on transhumance.

A fire on grassland reduces the litter and mulch that protects the soil from wind erosion during the dry season. A bare or black surface left after a fire readily absorbs heat from the sun's rays and the soil temperature is usually much higher than on adjacent unburned areas. The fluctuation in soil temperature during the day is also much greater on burned than on unburned areas. Burning usually reduces soil moisture by causing higher soil temperatures in the surface layers resulting in higher evaporation from soil surfaces. Without vegetative cover the burned areas are more easily eroded by water when the rains begin, and the amount of rain that actually filters into the soil is usually less on areas that are burned. Fire damage to the individual plants varies depending upon the temperatures reached during the burn and the length of time high temperatures persist.

B. <u>Poor Range Condition and the Imbalance Between Wet and Dry Season Forage Supply</u>

Ranges deteriorate as a result of detrimental changes in the composition and productivity of range vegetation, caused in turn by weather variations, especially drought. Perennial plants that are weakened by heavy grazing, overgrazing and fire are more susceptible to further damage when droughts occur. The ground space vacated when desirable plant species are killed is taken over by less desirable plants or, in some cases, the area remains bare and subject to erosion.

Livestock production depends on the maintenance of desirable forage plants. Plants, like animals, require food for growth and sustenance. Plants manufacture their own food through the process of photosynthesis. In perennial plants, some of the food materials made by the plant each year are stored for future use. In perennial grasses, most of the reserve food materials are stored in the roots of the plant. In annual grasses, the food reserve for future years is concentrated in the seed. In woody plants, food storage occurs in the stems, branches, twigs and roots. This stored food is necessary for the plant to start growth after the dry season. Perennial plants usually store enough food to last several years. Therefore, they can withstand drought much better than annuals.

With uncontrolled and continuous grazing year after year, the leaves of the preferred plants (where most of the plant food is manufactured through photosynthesis) are greatly reduced in size and number and the plants' ability to manufacture food and store reserves is reduced. Eventually the reserve supply is depleted. With continuous, uncontrolled grazing the plant can become progressively weaker and smaller as the food supply is exhausted, and the plants actually die of starvation.

Livestock graze forage plants selectively by species. They consistently graze the plant species they like best, and, if uncontrolled, they will graze beyond proper limits for the plants to survive. They switch to less preferred species as the ones they like best are depleted.

When livestock are uncontrolled, they repeatedly graze easily accessible areas before moving to less accessible areas. Consequently the areas close to water points are denuded of vegetation before livestock move further from water.

This deterioration process occurs with annual grasses as well as with perennials, so that progressively larger areas of poor range condition develop and range sites become occupied by weeds and other plants that have little value in providing forage. When sites become completely denuded of vegetation they are usually damaged further by wind and water erosion, thus limiting their ability to support any kind of plant life.

The glaring imbalance between wet-season and dry-season forage supply is now recognized to some extent by some villages in the DPZ. This is shown by the attempts made to provide supplemental feed late in the dry season to sick and weak animals by feeding hay made from dry grasses. This practice is not as effective as it should be, however, since the grasses cut for hay late in the dry season are lacking in nutrients and have to be gathered from limited sources long distances from the villages.

C. Livestock Water Deficiencies

One of the most widely acknowledged constraints to increasing livestock production in the Dilly Pastoral Zone is the lack of water. More accurately speaking, it is the absence of water when and where needed. During the four-month rainy season, as discussed earlier, there is an abundance of water throughout almost 90 percent of the zone. By contrast, during the dry season, there is adequate water in only 25 percent of the zone. Thus, the absence of year-long water is a major contributing factor to the imbalance between wet-season and dry-season forage availability in the DPZ. In some places (the so-called "underutilized" areas, for example) water storage is not generally practiced. Further, the innumerable ground depressions which exist during part of the year dry up as a result of exfiltration and evaporation. The result is the dramatic difference shown in Table 4 in Section III, where the dry-season water supply is in some instances as little as 2 percent of the rainy-season supply.

Proper livestock distribution, and consequently increased production, is impossible under current conditions. Ranges within 10 km. of a water source have been seriously overgrazed. Areas in the DPZ which are 20 km. beyond a permanent source are currently very lightly grazed, with the effect that the density and population of desirable forage species increases as the distance from water sources increases, especially if these areas escape the annual burning practices. We believe that development of additional waters without control of animal numbers would only extend the area of overgrazing (see Section V, "Development Alternatives").

Poor water quality in the DPZ is a related constraint. The questionable condition of many of the hand-dug wells and the village mares is cited in Section III. Stock water which is not free from debris, decayed material and even decomposed dead animals is objectionable to livestock and in some cases toxic as well. Stagnant water, even if not poisonous, often decreases the amount of water the animals will drink.

Another constraint that may develop as additional permanent water points are developed is that of village expansion, i.e., the establishment of new villages around new permanent water points. This phenomenon could result in a reduction in grazing areas as cultivation is increased to support new or expanded village populations. It could also interfere to a degree with free access to the water points for the grazing herds.

SECTION V

DEVELOPMENT ALTERNATIVES

SECTION V

DEVELOPMENT ALTERNATIVES

The development alternatives considered in this section all address to some degree the constraints to increased livestock production mentioned in Section IV. It should also be noted that the list of alternatives which we have used, both in this section and in the graphs and tables of Section VII, is in fact a modification, or simplification, of the original list of alternatives found in the Terms of Reference. In carrying out the study, the team quickly determined that they lacked time and resources to handle the original list fully. Further, in the case of some of the original alternatives, the delineation between them was not always clear.

The list which we have derived below is believed adequate to cover the real alternatives for future livestock development efforts in the DPZ. They are as follows:

- Maximum Investment in the entire DPZ (combining fire control programs, water development, and range management, Alternative A;
- Fire Prevention, Alternative B;
- Fire Prevention and Suppression, Alternative C;
- Fire Prevention, Suppression and Firebreaks, Alternative D;
- Water Development, Alternative E;
- Do Nothing, Alternative F; and,
- Continued Development of the Test Perimeter, Alternative G.

The letters A through G have been assigned to the list of seven alternatives in order to facilitate their use in conjunction with the tables of Section VII. In the present section, however, we have found a different ordering more effective. The Do Nothing Alternative is discussed first because it was given only very brief consideration by the Study Team. Alternatives B, C and D all represent different combinations of fire control programs. They are therefore grouped together in this section. A discussion of water development is then followed by a discussion of range management. Even though range management does not constitute an alternative all by itself, it is important to treat its advantages and disadvantages in isolation before coming to a discussion of the

Maximum Investment Alternative. Finally, the Test Perimeter Alternative is treated last, after Maximum Investment, because it logically represents a smaller-scale version of Maximum Investment, and has the same combination of interventions: fire, water and range management.

A. Do Nothing (No Proposed Program)

This first alternative was quickly discarded by the study team as inappropriate for further consideration, since it would be likely to lead to further deterioration of the forage resource and associated livestock problems, and is fundamentally incompatible with the objectives of the Mali Livestock Development Program in which Chemonics, the GRM and AID have been jointly involved since 1977.

B. Fire Control

A fire-control program in the DPZ could do much to alleviate the existing forage shortage during the dry season. It is hypothesized that if a larger portion of man-caused fires could be prevented, and those that are set controlled within reasonable limits by firebreaks and fire suppression crews, a substantial portion of the 200,000 tons of forage that currently burn each year could be available for livestock production, provided additional water supplies are made available. A further advantage in pursuing a fire-control program is that the work has already been started in the DPZ, using the resources first of the FAO-financed Project 007 and then the Mali Livestock II Project. The need would be to expand and make more efficient the previous or ongoing efforts.

Fire control in fact includes three separate interventions: (1) fire prevention; (2) firebreaks; and (3) fire suppression. Each of these is treated below.

1. Fire-Prevention Campaign

a. General Description

A fire-prevention campaign would inform all land-users of the potentially harmful effects of fire on the vege-

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1/ Terms of Reference, Annex 2.

tative resource and the impact it could have on livestock production in the DPZ. The campaign would reach all livestock owners, herders, farmers, hunters and others that have occasion to travel through or work in the DPZ.

The fire-prevention campaign could be planned and organized by technicians at the Dilly Center, and could be designed to use every means available to inform the local population, transhumants and others, of the harmful effects of uncontrolled wildfire. The encadreurs working in the pastoral zone could help to increase the dissemination of fire prevention information, as they already do to an extent. Further, the Dilly Center technicians could meet with village groups, government leaders, schoolteachers, etc., to discuss fire problems and measures needed to reduce uncontrolled, man-caused wildfires in the DPZ. Village grazing committees, organized to work with the Dilly Center staff on other aspects of the grazing program, could also play a major role in the fire-prevention campaign.

The Sotuba Training and Communication Center could continue to assist with the campaign. They have the facilities and personnel to design and develop fire-prevention posters to place at village markets, public offices, and roads and trails leading into and through the zone. Pamphlets describing the effects of fire could be developed for distribution to schools, public offices and market centers; fire prevention radio messages could be developed for use in the campaign. The Training and Communications Center film on fire prevention and suppression could be used much more effectively than in the past to support the overall program.

b. <u>Advantages of a Fire-Prevention Campaign</u>

- Prevention or reduction of the number of man-caused fires through an effective fire-prevention campaign would assure availability of range forage when needed by livestock.

- Elimination of wildfire would result in improved forage quality.
- An efficient fire-prevention campaign in the DPZ would reduce the number of man-caused fires by 50 percent in three years.
- Fire-prevention campaigns could be planned, organized and implemented for a fraction of the costs involved in combatting or attempting to control wildfires once started.
- Fire-prevention campaigns could utilize existing communication networks such as radio stations, government offices and village organizations such as grazing committees, etc.
- Fire-prevention campaigns could be planned, organized, and implemented using existing staff at Sotuba and Dilly Center.

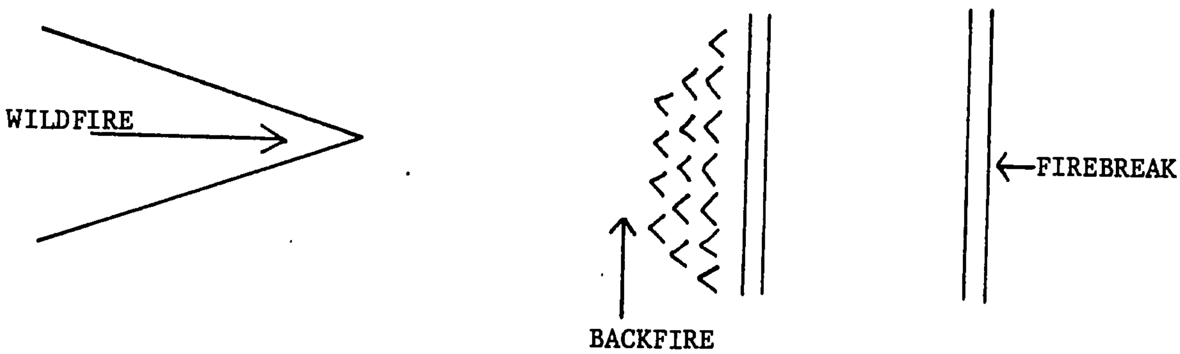
c. Disadvantages of Fire Prevention

- An effective fire-prevention campaign in the DPZ would require dedicated personnel to plan, organize and implement. An intensive training program for those individuals involved would be required to assure success.
- If existing staff at Sotuba and Dilly were used, the level of commitment of money and manpower for the program could detract from other priority programs.
- Sufficient attention has not yet been given to the benefits of certain kinds of controlled burning, as practiced by herders and farmers for centuries. A truly effective, fire-prevention campaign should not indiscriminately ban burning without some research into the traditional uses of fire under certain conditions. It is also doubtful whether a complete ban on deliberately set fires would meet with much success among local herders, since such a policy contradicts the weight of their own experience. This issue is admittedly controversial, but there are sufficient arguments on both sides to warrant further study as part of any fire-prevention program.

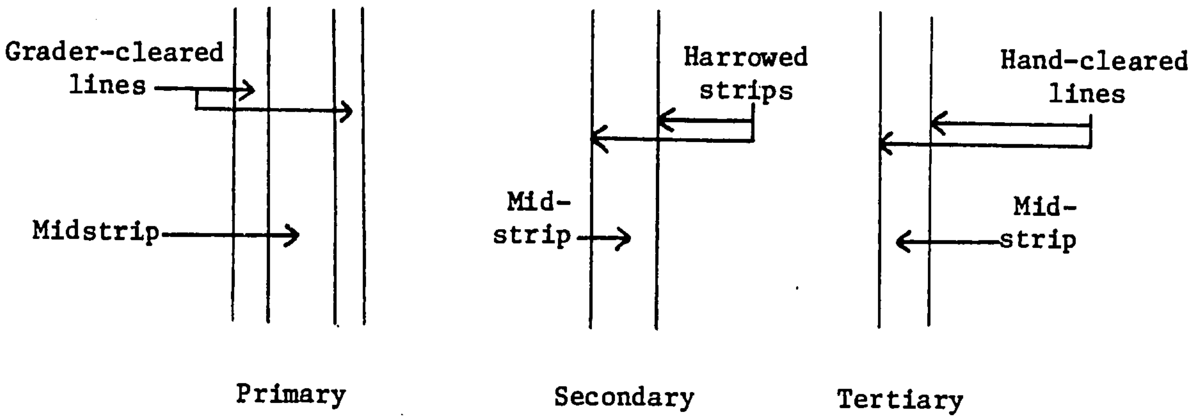
2. Firebreaks

a. General Description

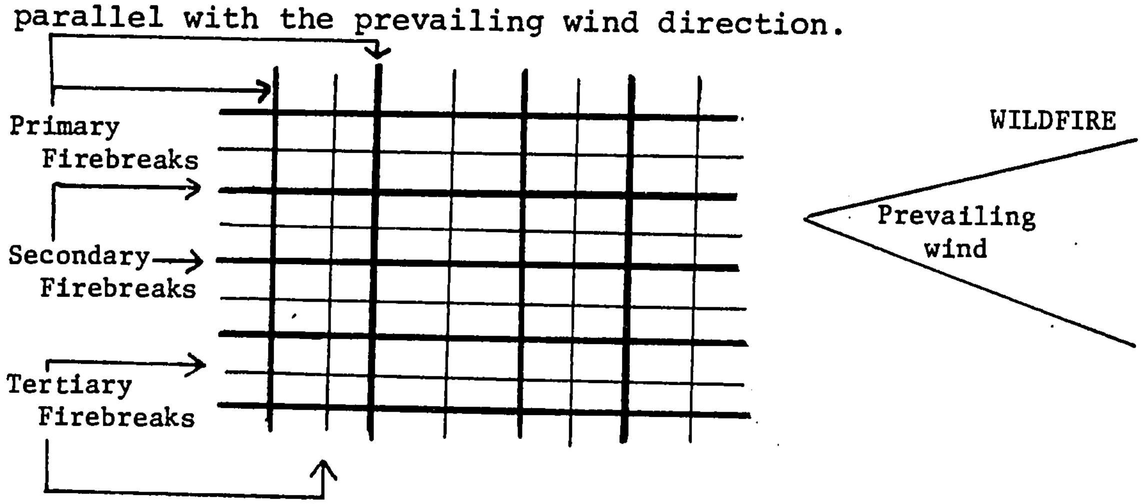
Firebreaks throughout the heavily vegetated areas in the DPZ are an effective means of limiting or controlling the number of hectares burned once a wildfire is started. Firebreaks are strips of land where the burnable materials have been removed before or at the beginning of the fire season. In light fuels, firebreaks need only be a few meters in width, but in heavy fuels, 10 to 20 meters in width are necessary to control fires when burning conditions are normal. Under extremely hazardous conditions, such as when strong winds occur and humidity is low, a fire can easily jump a firebreak 20 meters in width. The firebreak does, however, give the fire suppression crew a logical place to start fire control efforts by backfiring, thus widening the firebreak to 100 meters or more as the backfire burns toward the wildfire.



Firebreaks can be cleared in a number of different ways. When heavy equipment such as graders and bulldozers is available, a common practice is to clear two parallel strips the width of the grader or dozer blade 5 to 20 meters apart and then burn out the uncleared midstrip when burning conditions are favorable. Another method of constructing firebreaks is using oxen-drawn plows or harrows to clear the parallel strips. In light fuels, hand-clearing with shovels, then burning the mid-strips may be all that is necessary.



It is important that all firebreaks be cleared before the beginning of the high fire-danger season. The midstrips must be burned out before the fire hazard becomes so great that burning is inadvisable. Primary or major firebreaks should be placed perpendicular to the prevailing wind direction and should be spaced every 5 to 10 km. apart. The actual distance should be determined by fuel conditions and the losses that would be sustained if the area were to burn. Secondary firebreaks should be established at similar intervals but running parallel with the prevailing wind direction.



Firebreaks are most effective and easier to construct when they utilize natural features of the landscape. They should be placed on ridgetops when possible and should take advantage of roads and livestock trails where vegetation may be thinned out by livestock grazing, trailing, and vehicle travel. Firebreaks should also be planned where they can provide fast and convenient access to the area for fire suppression crews in case of wildfire.

Sometimes firebreak clearings are seeded with plants that are more attractive to livestock than those found naturally on the range. These plants attract livestock to the firebreak and they graze the firebreak area first, reducing the vegetative cover to the extent it will not carry a fire, thus effectively clearing the firebreak by grazing.

Firebreaks can serve another important function in a range management program. Generally, where fencing is not required to confine livestock to certain grazing areas and herding the livestock is a common practice, firebreaks are used to mark grazing unit boundaries. In this way, the firebreaks become an important part of a range management plan.

The DPZ contains several large areas with relatively heavy vegetative cover. A firebreak network in these areas along with a fire-prevention campaign could be effective in limiting the forage lost to fire every year.

An effective firebreak network in the DPZ will require 3150 km. of primary firebreak construction. The areas can be listed in priority consideration as follows:

- Test Perimeter, 330 km.[1/]
- Management Unit No. 1, 340 km.
- Management Unit No. 2, 830 km.

1/ Firebreaks in the Test Perimeter were partly cleared in 1978 and completed in 1979. Maintenance will be required each year to keep them operational. This figure also contemplates extending the Test Perimeter to the eastern boundary of the DPZ. Firebreaks have not been laid out or cleared in the extension area.

- Management Unit No. 3, 510 km.
- Management Unit No. 4, 640 km.
- Management Unit No. 5, 500 km.

b. Advantages of Firebreaks

- Firebreaks properly cleared and maintained each year, supplemented with a fire-prevention campaign could be effective in reducing forage loss due to wildfire by an estimated 50 to 75 percent in ten years.

- Controlling wildfires within a firebreak network and reducing the area burned each year contributes to the development of high-quality forage, reduces the area subjected to wind and water erosion, and assures forage availability when needed for grazing.

- Firebreak networks can serve a valuable function when used to delineate grazing unit boundaries as part of a range-management plan.

- Firebreaks provide cleared access routes to rangeland for fire suppression crews, and for other range management and development activities.

- Initial experience with firebreaks built under the Mali Livestock II Project in the Test Perimeter has clearly demonstrated the usefulness and effectiveness of firebreaks even when their construction and maintenance are less than ideal.

c. Disadvantages of Firebreaks

- Constructing and maintaining firebreaks is very costly and time-consuming.

- Man-caused fires can be started on both sides of a firebreak, thus making them ineffective in limiting the number of hectares burned.

- Firebreaks alone will not reduce the number of man-caused fires.

- To realize the full value of firebreaks, a fire suppression program should be developed and implemented at the same time. This entails organizing and training fire control crews, providing transportation, and fire control tools.

3. Fire Suppression Program

a. General Description

The most important feature of wildfire suppression is early detection and getting a fire control crew to the site as quickly as possible. Wind-driven fires move extremely fast and can easily jump a firebreak ten meters in width. In attempting to control wildfires, it is also more effective to fight them at natural barriers such as ridge tops, roads, livestock trails and firebreaks.

When winds are extremely strong and the fire is moving rapidly across the range, little can be gained by trying to control it. It is usually a better strategy to save the strength and energy of the fire-fighters until the winds have died down in the late evening and the air is cooler and more humid to make an organized attack on the fire. Fighting a range fire at night when burning conditions are less favorable is also a good strategy. Night fire-fighting can be extremely hazardous, however, and care must be exercised to provide for the safety of men and equipment.

When grasses are tall, a fire blazes high above ground level. Burning pieces of grass can float considerable distances through the air. Consequently, the fire crews must be constantly on the alert for spot fires outside the major burn area.

A very effective way to fight grass fires is to pull a light-weight harrow, using a small farm tractor or oxen or some other means, to disk the grasses down to ground level so that the fire can be controlled more easily . Sometimes grass fires can be effectively controlled by beating the flames down with tools available for beating, such as a densely-leafed tree branch, pieces of hide or leather, burlap sacks, and shovels.

The Dilly Center has for some years been carrying out *ad hoc* fire suppression work which has included mobilizing crews to fight large fires, using project vehicles and equipment to move crews to the site of the fire, and developing simple, improved equipment such as fire beaters. The experience has further demonstrated that it is difficult to mobilize resources effectively for fire suppression, and that fire prevention and the use of firebreaks are desirable first and second lines of defense.

Nonetheless, a more formal and better-financed and supported wildfire control or suppression program in the DPZ could be effective in limiting the number of hectares burned each year. The program could be conducted from the Dilly Center and would include organizing, training and equipping the village crews so they could respond and control fires burning in their grazing area.

If fire suppression programs were initiated, they should include training for technicians at the Dilly Center in fire behavior, crew organization and suppression techniques. The Dilly Crew could then organize and train village crews adjacent to the major potential burn areas. More fire tools could also be acquired or fabricated at the Dilly Center and distributed to the village crews.

b. Advantages of Fire Suppression

- An effective fire-suppression program in the DPZ could reduce the number of hectares burned each year by an estimated 20 percent of the area currently being burned.
- Training village crews in fire behavior and suppression techniques could develop an increased fire consciousness among the villagers, which could lead to a reduction in the number of man-caused fires.
- A balanced program of fire prevention, firebreaks and fire suppression could reduce the number of hectares burned in the DPZ by an estimated 90 percent within a ten-year period.

c. Disadvantages of Fire Suppression

- Fire suppression activities require sizable commitments of funds for fire fighting tools and equipment.

- Manpower requirements to organize and train the necessary crews each year can be substantial and very often divert resources from other priority activities.

- To be most effective, fire suppression activities must be combined with fire prevention and a firebreak network.

C. Water Development

The second alternative to be discussed is livestock water development. Maximum livestock production can be obtained only when both forage and water supplies are adequate on a year-long basis. Proper planning and implementation of a water-development program is therefore important to maximum livestock production.

Sections III and IV above describe the status of livestock water in the DPZ and the extent to which many areas of the zone are deficient in livestock water, especially in the dry season. The extent to which this water deficiency constrains livestock production is also suggested.

In this section, we describe various approaches to planning a water development program and three different types of water points which have been and/or can be established in the DPZ. We also list the advantages and disadvantages of embarking on a water development program.

1. Approaches to Planning Water Development

Three different approaches can be used in planning water development and balancing water and forage use. They are discussed briefly below.

a. <u>By Requirement, to Match Forage Resources</u>

Using this approach, the available forage (AUMs)[1/] is determined, and then the grazing season or the length of time the range will be grazed. Finally, the volume and distribution of water necessary to make the projected grazing use are computed.

For example, the estimated grazing capacity of a typical range site in the DPZ is about 1 AUM/hectare to 1.5 AUMs/hectare. A range area with 600 AUMs of production will support 100 cattle for six months, or 50 cattle for twelve months. In the Sahel, about 6 to 10 kg. of forage (air-dried) are required for each mature cow every day. Using 10 kg., an AUM would represent 300 kg. dry weight of forage.

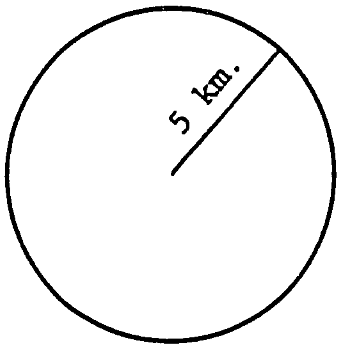
Using an estimated rating of 1 AUM/hectare, 12 hectares will be required to graze one head of cattle for one year. For 100 head, 1200 hectares would be required per year. The amount of water needed to graze the 1200 hectares would be 365,000 liters (100 head x 365 days x 10 liters/day = 365,000 liters). A reservoir or surface water catchment with a storage volume of 365 m^3 would be required to store this amount of water, not taking into account losses due to evaporation and seepage.

b. <u>By Locating Potential Water Points First</u>

Another approach to water development planning would be to locate the potential water points, then compute the amount of forage within the 5 km. radius and determine the volume of water necessary to graze the area properly.

1/ AUM = Animal Unit Month, or the forage consumed in one month by a standard animal unit. For the sake of simplicity, we can consider 12 AUMs equal to one <u>Unite de Betail Tropical</u>, or UBT, which in turn equals one head of cattle or five sheep and goats.

Example:



The number of hectares within a circle with a 5 km. radius = 7854.

If the grazing capacity is 1 AUM/hectare, the area will provide forage for 654 cattle year-long.

$$\frac{7854 \text{ AUMs}}{12 \text{ months}} = 654 \text{ cattle}$$

This number of cattle year-long will require 2,387,100 liters of water (10 liters/head/day). A reservoir with a storage capacity of 2387 m^3 would be required to store this amount of water, not taking into account evaporation and seepage losses.

c. By Storage Potential

Another approach is to locate the potential water points, determine the volume of water it is reasonable to collect and store and then compute the size of the grazing area based on the amount of water that will be available.

For example, we can hypothesize a potential water development site where we determine that it is feasible to construct a reservoir (to be filled each year) with the following dimensions:

20 m. long x 10 m. wide x 5 m. deep = 1000 m^3

This amount of water (1,000,000 liters) will supply the needs of 274 cattle year-long = 3288 AUMs. If the grazing capacity of the range is 1 AUM/hectare, the grazing area serviced by the water development would be 3288 hectares.

On areas with very coarse-textured or shallow soils, where enough surface runoff to fill a reservoir does not occur, a rainfall catchment apron may be required. The catchment apron may consist of a butyl rubber or plastic material placed on the soil surface near the reservoir. The rainfall collected is then piped into the storage reservoir. To illustrate the utility of such a practice, the following example may be helpful.

In the 400 mm. rainfall zone, an apron 30 m. x 30 m. will intercept 360 cubic meters of water or 360,000 liters. If properly stored in a reservoir, this amount of water can supply 36,000 cattle-days of grazing use or approximately 100 cattle for one year (10 liters/head/day).

The above examples show different approaches to planning grazing use and water requirements. The examples showing water storage capacities do not take into account evaporation and seepage losses, however, and these factors must be considered. The water loss from the surface of a reservoir through evaporation can be substantial in hot, dry climates such as the Sahel. The actual amount will vary depending on the ratio of water surface to the depth of the reservoir, temperature, humidity and wind conditions. Water losses through evaporation can be reduced by designing storage areas with maximum depths and as small a water surface area as possible. Evaporation can also be reduced by covering the water surface with grass mats, plastic, or some other material. Water losses due to seepage through the sides and bottom of the storage area can also be reduced by lining the storage area with heavy clay soils, bentonite, or with plastic or rubber materials.

Because of the many variables which cannot be predicted with accuracy, the computations given above should be considered rough estimates for planning purposes only. Once water developments are installed and put into use, refinements in livestock numbers and grazing season must be made based on actual livestock performance, range forage conditions, rainfall variations and other factors. For these reasons, range livestock operations must be planned with a margin of reserve built into the program and with considerable flexibility so the livestock operation can be adjusted to cope with conditions affecting both water and forage availability.

2. Methods of Providing Additional Water

Three methods of providing additional livestock water in the DPZ appear feasible and have been considered in this study: wells, Dupuy points (reservoirs named after the hydrogeologist who developed the design) and *mares* (surface water catchments).

In estimating the number of water points needed, we based our estimate on a situation where water would be provided at 10 km. intervals. Each water point would service 100 km^2. (10,000 ha.). Since there are 75 to 80 permanent sources existing now, some 75 more should be provided to meet this requirement. The study group feels that 1/3 should be wells (i.e., 25) and the balance reservoirs and *mares*. This suggested ratio assumes that 25 wells can be drilled in areas which are currently underutilized. If reservoir sites limit storage capacity to such an extent that adequate storage is not available at one site, additional sites could be considered within each 10,000-hectare block.

The distribution of additional water points in the proposed management units throughout the DPZ would be as follows:

Area	No.of Water Points
1	14 (Test Perimeter)
2	16
3	41
4	24
5	31
6	24
	150 Total

3. Advantages and Disadvantages in a Water Development Program

As noted, a water development program is essential to maximize livestock development in the DPZ. The specific advantages of such a program are given below. There are also definite disadvantages, several important examples of which are listed.

a. Advantages of Livestock Water Development

- Additional water developments will facilitate better distribution of livestock throughout the pastoral zone; consequently more uniform utilization of available forage will occur.

- The 500,000 hectares of rangeland now ungrazed, or lightly grazed because of livestock water deficiencies, can be grazed if protected from fire, thus providing the potential forage for approximately 50,000 additional livestock. If used only during the dry season by existing livestock, this additional forage will help alleviate the imbalance between wet-season and dry-season forage supply.

- The landform in the DPZ is such that many natural sites exist for potential reservoir construction.

- Development of reservoirs, even though some may only be a temporary source of livestock water, can facilitate a water-rotation program wherein the temporary sources can be used first and the forage around permanent sources saved until later in the year when the temporary waters are no longer available, thus extending the time of livestock grazing.

b. Disadvantages of Livestock Water Development

- Reservoirs are not a fully dependable source of livestock water. The amount of water collected, stored and available for livestock is dependent on fluctuations in rainfall, evaporation and seepage.

- Wells can only be situated on sites where underground water can be reached at a reasonable depth. They are also very costly to drill and maintain.

- Water development without livestock management and control will undoubtedly contribute to further range deterioration. The latter disadvantage is crucial, and has led to disaster in many arid-land grazing and water-development programs. Range management must accompany water development. Range management, in its comprehensive sense, is covered in the following subsection.

D. Range Management

1. Description of Range Management as Applied to the DPZ

Range Management is the science and art of obtaining maximum sustained use of the forage crop without damage to the other resources or uses of the land. In its broadest sense, therefore, range management is not a concept foreign to the herdsmen in the DPZ. On the contrary, the transhumance is itself a highly evolved range management "plan" designed to make use of, and yet preserve, the water and forage resources in the Sahel. Changes which have occurred, however, particularly in the last decade, in climate, ecology and the demand for increased food supply, have resulted in a disruption of traditional migration patterns, and the ability of the transhumance to survive these changes is seriously in question. The complexity of these issues, however, is well beyond the scope of this report. What we mean to treat below are a number of specific interventions, under the rubric of range management, which have been shown to be effective in certain areas of the world.

2. Range Management Plans

The actions necessary to apply range management principles are generally set forth in a range management plan. The plan describes the specific management area, states the management objectives, outlines a grazing system and livestock control measures. It may also describe a monitoring system, in the form of studies, to be used in evaluating the effectiveness of the plan.

As demonstrated by the work performed to date in the Test Perimeter, range management plans are not short-range plans. They involve tasks that require careful design, implementation and monitoring year after year. Only through strict attention to these details and proper emphasis can deteriorated rangeland be restored to its productive potential. In implementing a range management plan, some control of livestock is a must; success of the program depends on it. Such livestock control measures must regulate numbers within the limits of the grazing capacity of the range and assure that the livestock are grazed within the designated area scheduled for use within the grazing system.

Although little if anything can be done to prevent selective grazing by the livestock when the range is being used, the harmful effects of grazing can be counteracted by rest from grazing at appropriate intervals so the desirable forage plants have an opportunity to grow and reproduce normally throughout the entire grazing area. These safeguards are taken into account when designing the grazing system component of the range management plan.

As range management plans are implemented, concern for the imbalance between wet-season and dry-season forage supply can be further alleviated by expanding the efforts to provide supplemental feed or hay. To be most effective, the grasses used for hay must be cut while green and nutritious, properly cured and stacked until needed. The amount collected can be increased by reserving an area close to the villages for this purpose and providing a more efficient means of cutting. Providing scythes as a substitute for the currently-used small machetes should help.

A range management program properly designed and implemented in the DPZ would do much to alleviate the current imbalance between wet-season and dry-season forage supply. It would also provide the necessary livestock and fire-control measures to improve range conditions to an acceptable level. A long-term commitment, however, on the part of the Malian government, the villagers in the pastoral zone and the donor countries would be required to attain these goals.

a. Advantages

- Range management plans, properly developed and implemented, incorporating grazing systems and designed to increase perennial grass species, can improve livestock production in the DPZ by extending the time nutritious forage is available, which will help alleviate the present imbalance between wet-season and dry-season forage supply. (Perennial grass species generally stay green and maintain their nutrients 2 to 4 months longer than annual grasses.)

- Range management and development applied throughout the DPZ would do much to improve range conditions to an acceptable level and provide forage on a sustained basis once the potential level of production is reached.

- Grazing systems that incorporate periods of rest from grazing build up forage reserves that can be used during emergency drought periods.

- Range management plannning in the DPZ could be scheduled over a period of years on a priority area basis to gain experience, train personnel and select practices and techniques proven effective in the Test Perimeter.

b. Disadvantages

- To develop and implement range management plans throughout the DPZ would require a very large commitment of scarce resources: money, manpower, and equipment.

- Trained technicians required to develop, implement and monitor a range-management program throughout the DPZ are not currently available.

- Inventory data on forage production and livestock population within each management unit would be required before specific range management plans can be developed.

E. Maximum Investment in the DPZ, Combining Fire Control, Water Development and Range Management

It is the view of the Study Team that implementation of a fire control program would, in and of itself, provide protection for currently ungrazed or lightly grazed areas in the DPZ. Although protecting the vegetation from fire would no doubt improve ecological conditions, very little additional livestock forage would in fact become available unless additional livestock water sources were developed in these same areas.

Combining a fire control program and a livestock water development program would make additional forage available for increased livestock production, but only on a short-term basis. It is believed by the team that without the necessary range management and corresponding livestock control measures, the area around newly developed water sources would quickly deteriorate to the same conditions as are currently found around existing water sources.

1. Advantages to Maximum Investment in the DPZ

As a result of the above considerations, the study team recommended that Alternative A, Maximum Investment, be thoroughly analyzed with respect to its benefits and costs, because it offers the only systematic approach to livestock production on a sustained basis, with full consideration for improved range condition in the zone.

2. Disadvantages to Maximum Investment in the DPZ

The Study Team nonetheless recognized that implementation of the combined program, Alternative A, Maximum Investment throughout the DPZ would be an overwhelming undertaking even under the best of conditions, and would certainly not be warranted without a sufficiently favorable benefit/cost ratio. (The results of the benefit/cost analysis are found in Section VII.) Even if one assumes a sufficiently positive ratio, rather massive amounts of (foreign) donor assistance would be required, over an approximate 20-year period, before tangible benefits could begin to be realized.

F. Continued Development of the Test Perimeter

In the earliest stages of the Mali Livestock II project, Mssrs. James Naylor and Lamine Bâ devised a Management Plan dividing the DPZ into six management units. The first of these to receive assistance was the so-called Test Perimeter, of an area roughly 1/10 that of the entire Zone. The five additional management units within the zone were to receive project resources on a priority basis, based to some extent on successes and failures in the first unit (the Test Perimeter). This plan was dictated by the reality of scarce project resources and was in effect throughout the life of the Mali Livestock Development project. The Test Perimeter was not to be considered as a pilot sub-project, however, in that systematic data collection for the purposes of monitoring specific interventions was deliberately not done. This policy was followed as a result of the overall development approach established by the GRM, which is discussed further in Section VIII, "Conclusions and Recommendations."

1. Advantages of Continued Development of the Test Perimeter

In the context of the present report, Alternative G, Continued Development of the Test Perimeter, would essentially mean combining fire control, water development and range management, on more restricted geographic basis than in A above, i.e., in roughly 1/10 of the DPZ rather than in the entire DPZ. This alternative was regarded by the Study Team as having much to recommend it in the event the benefit/cost analysis for maximum investment in the entire DPZ should prove unfavorable. Like the maximum investment alternative, it represents an integrated approach to livestock production on a sustained basis. Furthermore, it is the belief of the Study Team that an experimental emphasis can (and should) be incorporated into continued development of the Test Perimeter to make the program more effective than it has previously been. This aspect of the proposed alternative is taken up again in Section VIII.

2. Disadvantages of Continued Development of the Test Perimeter

Whereas continued development of the Test Perimeter could be undertaken on a significantly smaller scale than maximum investment in the DPZ, its impact in terms of livestock numbers, increased forage availability, etc., will obviously be correspondingly smaller as well. Also, no benefit/cost analysis was performed to determine the viability of such a program, again because of time constraints and lack of personnel. If the proposed program is regarded as largely experimental, then benefit/cost considerations become somewhat less important. The question of the long-range objectives of the program, however, has yet to be worked out on a joint basis between the GRM and AID.

SECTION VI

COST ESTIMATES

SECTION VI

COST ESTIMATES

A. Introduction

In this section we provide rough cost estimates for a long-term development program for the entire DPZ, which is Development Alternative A, Maximum Investment (see Section V). As noted, this alternative combines the fire control and water development activities with the range management activities, a combination we believe is necessary to make the overall effort effective.

In building up our estimated costs, we show the fire prevention and water development activities separately, thus allowing the reader the opportunity to see the proportion of expenditure for these individual activities. In the benefit/cost analysis that follows in Section VII, however, we calculate only the benefits of the combined program and compare them with the total costs for that program. This method is used first because we believe that financing the entire program is necessary to achieve the desired benefits, and secondly, because it was not possible to estimate the potential benefits of the individual water-development activities, which would, in theory, permit a benefit/cost analysis to be done activity by activity. In addition, as mentioned earlier, there was not sufficient time available for the economist to calculate the benefits and the discounted costs of the other alternatives considered.

The task of estimating costs for livestock development practices is difficult under the best of circumstances, even with a long history and previous experience under similar conditions. Standard cost figures have been developed for many common practices in some locales, but such is not the case for the Sahel. Consequently, our estimates are very broad. We have, however, used experience gained through previous work in the Dilly area (e.g., in drilling wells and constructing firebreaks) in making our cost estimates.

B. Assumptions

In estimating costs, we have assumed that the expatriate personnel furnished will be relatively junior, that needed improvements in the Dilly Center will be carried out under other financing and that logistic support for the Dilly Center and the overall operation, including a "rear base" in Bamako and vehicle and equipment maintenance, will also be provided under other financing.

There are nonetheless certain minimal administrative costs (clerical costs, office supplies, etc.) that have been included in both the fire and the range management activities. No similar costs were included for the water development activities, on the assumption that Service de l'Hydraulique would provide the needed support.

Finally, the estimated costs do not include inflation.

C. Methodology

First, we present in Table 1 a summary of the costs over 20 years for Alternative A, Maximum Investment. Following Table 1, we give a breakdown of costs by program activity, which was the basis for the summarized costs in Table 1. The activities fall under three headings: fire (fire prevention, fire suppression and firebreaks), water (wells, Dupuy points and improved mares) and range management. The estimated total cost for the first year is $1,692,300, which includes $495,700 and $486,600 for construction, maintenance and operation of the fire and water activities, respectively, and $710,000 for the range management component. The total cost increases in the second year and then decreases to a level of $791,500 for years six through twenty.

Next, for purposes of the benefit/cost analysis that follows in Section VII, we take these undiscounted costs over 20 years and compute the discounted costs for implementing the maximum investment program in Table 2. Discount rates of 12 percent and 16 percent were chosen as representing a reasonable span. For both costs and benefits, the time horizon of 20 years has been used as a realistic limit beyond which projections could hardly be accurate.

TABLE 1

SUMMARY OF COSTS FOR IMPLEMENTING DEVELOPMENT ALTERNATIVE A, "MAXIMUM INVESTMENT"1/

Activity	Cost (US$)					
	1st year	2nd	3rd	4th	5th	6th - 20th
1. Fire						
Fire Prevention	175,000	115,000	115,000	115,000	115,000	115,000
Fire Suppression	65,000	130,000	130,000	130,000	130,000	130,000
Firebreaks	255,700	260,200	264,700	149,900	32,500	32,500
Sub-total, Fire	495,700	505,200	509,700	394,900	277,500	277,500
2. Water						
Wells	263,400	307,300	307,300	307,300	307,300	43,900
Dupuy Points	127,500	139,000	139,000	139,000	139,000	11,500
Improved Mares	95,700	104,300	104,300	104,300	104,300	8,600
Sub-total, Water	486,600	550,600	550,600	550,600	550,600	64,000
3. Range Management						
Expatriate	660,000	660,000	440,000	440,000	220,000	220,000
Local	36,000	72,000	108,000	144,000	180,000	216,000
Clerical and Supplies	14,000	14,000	14,000	14,000	14,000	14,000
Sub-total, Range Mgmt.	710,000	746,000	562,000	598,000	414,000	450,000
TOTAL COST2/	1,692,300	1,801,800	1,622,300	1,543,500	1,242,100	791,500

Notes: 1/ A breakdown of the costs for each activity is given in the following pages.

2/ Total cost, years 1-5 = \$ 7,902,000
Total cost, years 1-20 = \$19,774,500

D. Breakdown of Costs for Table 1 (in US$)

1. Fire

a. Fire Prevention

1st Year

3 expatriates (Range Manager, Sociologist and Hydrologist) at Dilly for 3 months each	82,500
3 local technicians for 4 months each	6,000
10 encadreurs for 2 months each	2,200
2 expatriates (Communications Specialist and Range Manager) at Sotuba for 2 months each	37,000
Materials and printing (posters, pamphlets, etc.)	1,500
Training of technicians for 4 months	4,500
Clerical	3,000
Office equipment (typewriter for 1,000 and adding machine for 500)	1,500
Office supplies	1,000
Transportation (10,000 km.)	5,000
Sub-total	144,200
Administration and Contingencies	30,800
Total	175,000

2nd-20th Years

3 expatriates for 3 months each	82,500
3 local technicians for 3 months each	6,000
10 encadreurs for 2 months each	2,200
Transportation (10,000 km.)	5,000
Sub-total	95,700
Administration and Contingencies	19,300
Total	115,000

b. Fire Suppression

1st Year

2 expatriates (Range Fire and Communications experts) for 3 months each	55,000
3 local technicians for 3 months each	2,500
Equipment and supplies for 25 crews (one per village) @ US$100 per crew	2,500
Transportation (10,000 km.)	5,000
Total	65,000

2nd-20th Years

Twice 1st year costs (for maintenance, repair and replacement of equipment, and training and retraining of crews)	130,000

(Note: To train crews for 50 villages will take 2 years and will provide adequate coverage for the entire zone.)

c. Firebreaks

1st Year

Construction of 900 km. of primary firebreaks	217,000
Construction of 3,400 km. of secondary firebreaks by harrowing	17,000
Administration and Contingencies	21,700
Total	255,700

2nd Year

Construction of 900 km. of primary firebreaks	217,000
Maintenance by harrowing of 4,300 km. of firebreaks	21,500
Administration and Contingencies	21,700
Total	260,200

3rd Year

Construction of 900 km. of primary firebreaks	217,000
Maintenance of 5,200 km. of firebreaks	26,000
Administration and Contingencies	21,700
Total	264,700

4th Year

Construction of 400 km. of primary firebreaks	97,700
Maintenance of 6,100 km. of firebreaks	30,500
Administration and Contingencies	21,700
Total	149,900

5th - 20th Years

Maintenance of 6,500 km. of firebreaks	32,500

2. Water

a. Wells

1st Year

Explore for 10 wells, drill 10 exploratory holes and drill 5 wells	263,400

2nd - 5th Years

Explore for 10 wells, drill 10 exploratory holes and drill 5 wells	263,400
Maintenance and repair	43,900
Total	307,300

6th - 20th Years

Maintenance and repair	43,900

b. Dupuy Points

1st Year

Build 5 Dupuy points	115,850
Contingencies	11,650
Total	127,500

2nd - 5th Years

Build 5 Dupuy points	115,850
Maintenance	11,500
Contingencies	11,650
Total	139,000

6th - 20th Years

Maintenance	11,500

c. Improved Mares

1st Year

Build 5 improved mares	87,000
Contingencies	8,700
Total	95,700

2nd - 5th Years

Build 5 improved mares	87,000
Maintenance	8,600
Contingencies	8,700
Total	104,300

6th - 20th Years

Maintenance	8,600

. Range Management

a. Expatriate (@ US$110,000 per person per year)

1st and 2nd Years

1 Project Manager (Range Management expert), 3 additional Range Managers, 1 Hydrologist and 1 Animal Husbandry expert	660,000

3rd and 4th Years

1 Project Manager (Range Management expert), 2 additional Range Managers and 1 Animal Husbandry expert	440,000

5th - 20th Years

1 Project Manager (Range Management expert) and 1 Animal Husbandry expert	220,000

b. Local (@ US$6,000 per person per year)

1st Year

6 person-years of technicians	36,000

2nd Year

12 person-years of technicians	72,000

3rd Year

18 person-years of technicians	108,000

4th Year

24 person-years of technicians	144,000

5th Year

30 person-years of technicians	180,000

6th - 20th Years

36 person-years of technicians	216,000
c. Clerical and Supplies each year, Years 1-20	14,000

TABLE 2

ESTIMATED COSTS DISCOUNTED AT 12% AND AT 16% OVER TWENTY YEARS

Year	Total Costs	Discounted at 12%	Discounted at 16%
1	1,692,300	1,692,300	1,692,300
2	1,801,800	1,608,750	1,334,667
3	1,622,300	1,297,840	1,201,704
4	1,543,500	1,102,500	983,121
5	1,242,100	791,147	682,473
6	791,500	449,716	375,118
7	791,500	401,777	323,061
8	791,500	358,145	278,501
9	791,500	319,153	240,087
10	791,500	284,712	206,972
11	791,500	254,502	178,424
12	791,500	227,443	153,814
13	791,500	202,949	132,598
14	791,500	181,121	114,309
15	791,500	161,715	98,452
16	791,500	144,389	84,950
17	791,500	128,919	73,233
18	791,500	115,106	63,132
19	791,500	102,773	54,424
20	791,500	91,762	46,917
Totals	19,774,500	9,916,719	8,318,257

Source: Table 1, "Summary of Costs"

SECTION VII

BENEFIT/COST ANALYSIS

SECTION VII

BENEFIT/COST ANALYSIS

A. Introduction

Section VI gave the estimated costs for carrying out Alternative A, maximum investment in the entire DPZ. In the present section, we provide a benefit/cost analysis of Alternative A, using the cost estimates previously provided and comparing them with estimates of the benefits that would be derived from the program. The Section further describes the processes used to arrive at these estimated benefits, including the assumptions and limitations involved.

B. Assumptions

Because the economist was not a member of the original study team, as explained earlier, and thus had limited time to spend on the study, the benefit/cost analysis treats only the Alternative A, maximum investment in the DPZ (described in Section V, "Development Alternatives"). Both cost and benefit estimates were developed using the limited information available, supplementing it where necessary with information based on the experience and judgment of the study-team specialists--both Malian and expatriate.

The basic approach in determining the level which benefits could reach is to estimate increased forage available to livestock if maximum investment is undertaken, as compared to a decline in forage production if nothing is done. This approach is then applied to current livestock numbers to determine possible results with respect to growth-rate depending on whether or not the development project is undertaken. Both high and low estimates of the benefits are calculated.

The low estimate of benefits assumes that the project would increase animal population growth to an annual rate of four percent instead of the present estimated rate of three percent until the optimum (sustainable) carrying capacity is reached, after which it is assumed that numbers remain constant and growth is converted into extra offtake. Under the low-benefit estimate, the decline in forage which is predicted if development is not undertaken would not affect livestock numbers, since it is assumed that the animals would likely emigrate to other areas presently less densely populated than the DPZ.

The high-benefit estimate assumes that a decline in forage would affect one half to one third of the animals in the DPZ. Other sources of benefits included are reduced losses to cattle herds passing through the zone on transhumance and reduced losses from the expected periodic droughts.

All these benefits are quantified using current production parameters: offtake rate, carcass weight, and the current (1980) retail price for meat. No changes in the traditional production system are assumed, except for the increased offtake rate in the last years mentioned and for the assumption that because of better water supplies, 60 percent of the livestock would remain in the area during the dry season instead of the current estimated 30 percent. All benefits are due to reduced mortality, presumed to follow from better forage and water supplies particularly for calves. Benefits are valued solely in terms of marketed meat products. (Milk and nomadic income were not included as they are considered too complex to estimate in a study of this nature.)

The benefits represent an estimate of the maximum response possible within the traditional system to a significant improvement in forage and water conditions. The benefits cannot be accurately estimated, however, until several critical areas are clarified where exact, detailed knowledge is now lacking. These are the current animal husbandry system, the estimated flexibility within that system (especially regarding migratory habits) and strategies and practices of resource allocation.

C. Human and Livestock Populations in the DPZ

To determine the carrying capacity and potential benefits of full-scale development, it is necessary to have baseline data on both human and livestock populations in the DPZ. In Mali these data are reported by arrondissement and cercle. Figure 1 shows the arrondissements and cercles that are contained within and/or overlap the boundaries of the DPZ. Tables 1a and 1b give the cattle and sheep and goat populations, respectively, for 1979 for the cercle of Nara (which largely encompasses the DPZ) from two sources. These are the "Recensement Administratif" and the "Estimation Vétérinaire." The former is based on tax figures and, therefore, is much lower than the latter, which is based on reporting by livestock officers in the field who vaccinate and treat livestock. Generally, the latter are considered to provide reasonably accurate data and these numbers are the ones that are used for calculating the livestock population of the DPZ in Table 2b.

Table 1c shows how the cattle population in the cercle of Nara changed over the period 1973 to 1979, demonstrating the effect of the drought and the recent recovery in cattle numbers. Table 1c also compares these changes with those in the neighboring cercles of Nioro and Niono. Table 2a shows the total area and 1976 populations for the arrondissements within the cercle of Nara and for an arrondissement of the cercle of Diema that overlaps the DPZ. In Table 2b, using a weighted average, the 1980 human and livestock populations for the DPZ are calculated.

D. Land Use in the DPZ

1. Basic Calculation of Available Grazing Land versus Animal Population

In this sub-section we compare the availability of grazing land in the DPZ, assuming no degradation, with projections of animal population to show that even under this optimistic assumption, the population will soon outstrip resources.

Land use in the DPZ is divided between farming and pastoralism, there being no forest reserves or mountainous, rocky areas that have to be discounted from use. Agricultural land consists of land currently cultivated plus fallow land; the latter can be regarded as available for grazing. From the "Rapport Enquête Agricole," the average cultivated area per rural inhabitant in the regions with a high proportion of Sahelian land is 0.35 hectares. When this figure is subtracted from the total area, the remainder left for grazing can be derived. This data is presented in Table 3.

Currently, due to the general water shortage in the dry season, some of the area is grazed only during the wet season. In the dry season, at least 70 percent of the cattle must go south (leaving in January/February and returning in June/July), since it is estimated that only 40 percent of pasture can then be used. At these times, cattle from other areas (notably further north in Mauritania) also pass through the DPZ. Sheep and goats leave about a month later than cattle. Since they are more resistant to reduced water and food supply and are more likely to be village-based, a higher proportion (say about 40 percent) stay behind. Of the cattle that stay behind, some are village cattle and some are the good milkers from the nomadic herds, maybe 10-15 percent of the total.

Various estimates of the carrying capacity and of current demand on that capacity in the DPZ can thus be made. With the current year-round grazing potential usually estimated at eight hectares per UBT[1/], and only 40 percent of the area usable for the six dry months of the year, there is thus an average 70 percent utilization year-round, which can be calculated as shown in Table 4.

The figures in the second and third columns of Table 4 would apply if no degradation and no increase in dry-season grazing took place, so that the only reduction in land available would be due to land newly used for agriculture.

Current cattle and small ruminant populations, which show evidence of recent immigration (Table 1c), are already pushing against this carrying-capacity limit. Given one UBT to eight hectares, year-round, and counting a small ruminant as one fifth of a UBT, the following can be deduced from the data in Table 2b.

There are 133,200 cattle (equal to 133,200 UBT) and 307,500 small ruminants (equal to 61,500 UBT) or an estimated total of 1^4,700 UBT present in the DPZ during the wet season. Of the cattle, 100 percent spend 6/12 of the year there (equal to 66,600 UBT) and in the dry season 30 percent spend 6/12 of the year (20,000 UBT). Of small ruminants, 100 percent spend 7/12 of the year there (equal to 35,900 UBT) and in the dry season 40 percent spend 5/12 of the year (10,200 UBT). Adding the four together, the current year-round load in the DPZ is about 132,700 UBT (compared to the current carrying capacity of 133,200 UBT derived from Table 4).

If the 132,700 UBT grow at the current estimated rate of three percent per year, they will outstrip the available grazing land in four years; at the end of 20 years, there would be 230,000 UBT, with the area's carrying capacity reduced slightly to 132,000 UBT (Table 4). Thus, even without degradation, the DPZ can support only the present animal population.

1/ One UBT (Unite Bovine Tropicale) equals one head of cattle or five sheep or goats.

In Table 4, the figures for current and projected carrying capacity in columns 4 and 5 were derived via Table 5 from Graph 1. Assuming ten kg. of forage eaten per animal per day, the neutral carrying capacity in column 3 of Table 4 (133,200 UBT) was derived from Table 3 on the basis of extrapolating current trands in human populati growth so as to calculate the amount of land going over to agriculture and the residual available for grazing. Despite the different origins of these figures, the estimates of current carrying capacity obtained are remarkably similar and compatible with the current number of year-round UBT estimated above at 132,700.

It is important to keep in mind, however, that the DPZ apparently did hold larger animal populations before the drought. Even with the consequent disruption in grazing patterns, one could over-estimate the potential degradation, real though the threat is.

2. <u>Carrying Capacities Under Various Assumptions and Programs</u>

The above calculation, which assumes no degradation caused by overgrazing, and no increase in carrying capacity due to development programs, we have called the "neutral" projection.

We have made other projections based on other assumptions. In Graph 1, we present our estimates of the potential forage production in the DPZ which would result in response to various development alternatives discussed earlier. Naturally, the largest amount of forage production results from the maximum investment program, Alternative A. The assumptions used in preparing Graph 1 are also summarized.

The forage production figures given in Graph 1 are translated into carrying capacity of the DPZ in Table 5. In Table 5, column a gives the carrying capacity that would result from full implementation of Alternative A. The final column,

column f, gives the carrying capacity that would result from doing nothing, on the assumption that serious degradation would take place and that there would be a sharp reduction in carrying capacity from the present level. (The slight difference between the current carrying capacity of 137,000 UBT in Table 5 and the figure 133,200 in Table 4 results from using two slightly different methods of calculation, as explained above.) Of the middle columns, b gives the carrying capacity that would result from implementation of Alternative D, and c through e, the carrying capacities that would result from implementation of the other alternatives.

The extreme projections from Table 5 might be called the "optimistic" and the "pessimistic" assumptions, the pessimistic giving the worst possible result of inaction, and the neutral projection (no program but no degradation) in the middle. The optimistic projection (column a) would improve carrying capacity to year 16 and assumes an increase in capacity from the current eight hectares per UBT per year to 5.5 per UBT per year.

E. Benefits

The benefits for livestock living in the DPZ due to implementing Alternative A are assumed to result from better water supplies and better nutrition, which should increase fertility, decrease mortality and hence lead to higher growth rates for the animals. The benefits should occur in three ways: (1) it is expected that numbers and offtake of cattle and of sheep and goats in the DPZ would be higher than they would be in the absence of a project; (2) there should be fewer losses among the herds of cattle and small ruminants that pass through the area on their annual migration; and (3) it is expected that cattle and small ruminants in the DPZ would be better able to survive the periodic droughts that affect the area. In the subsections that follow, each of these three categories of benefits will be converted into dollar values for a high estimate and a low estimate of benefits.

1. <u>Changes in Growth Rates of Animals in the DPZ</u>

As indicated earlier in this section, there are pessimistic, neutral and optimistic views of what may happen to animal numbers in the DPZ in the absence of project interventions. We calculate potential benefits by comparing a projected result due to the project with one of these baseline projections. Positive changes in animal growth rates are valued as benefits via the offtake rate in terms of the market price of the extra meat produced (as given in Table 7).

For the low estimate of benefits, we assume a neutral view of the future in the absence of a project. This neutral view is that there is no change in forage available and that animal numbers continue to grow at the current estimated rate of three percent per year until the carrying capacity constraint is reached. We further assume that the project interventions are only sufficient to produce a change in forage availability such that the annual growth rate in animal numbers increases from three to four percent. These calculations appear in subsection <u>a</u> below.

For the high estimate of benefits, we assume a pessimistic view of the future in the absence of a project. This is represented by the "do nothing" alternative in Graph 1 and Table 5, column <u>f</u>. It involves a decline in absolute forage availability in the DPZ so that, with a lower carrying capacity, fewer animals can survive in the area. The project is assumed to be sufficient both to counteract this decline, the results of which are calculated as benefits in subsections <u>b</u> and <u>c</u>, and to produce the benefit calculated in subsection <u>a</u>.

Table 6 shows the implications over 20 years of the assumptions used in calculating the high and low estimates of benefits. In the table, in order to simplify the calculations, the figure of 10,000 UBT was chosen as the basis. Thus, in the calculations below, the totals obtained from Table 6 are multiplied by an appropriate number in order to convert them to results applicable to the number of UBT in each case. The conversion factor is the actual number of UBT divided by 10,000.

The main problem in applying to the DPZ the assumptions made about how changes in forage availability affect carrying capacity and hence numbers of UBT as expressed by changes in growth rates is in determining what allowances to make for emigration and immigration. As a result of immigration, the area has a far higher population density than surrounding areas or even arrondissements (Table 2b). Thus a decline in forage availability, rather than resulting in death from starvation, could simply result in an outflow of cattle and small ruminants from the area into immediately neighboring areas that appear to be less densely populated or even into areas farther afield. Different assumptions with respect to how this would affect meat production are made below.

The price and production parameters used in these calculations are given in Table 7.

a. <u>Increase in Growth Rate from 3 to 4 Percent and Increase in Dry-Season Use of DPZ by Animals</u>

An assumed increase in dry-season use of the DPZ by animals brings the initial number of UBT up to 157,000, since the number of year-round UBT is then equal to 80 percent of those using the DPZ in the wet season (i.e., of the 194,700 calculated in sub-section C 1, above). This increase further assumes that 60 percent instead of 30 to 40 percent of animals (as estimated above in the absence of a project) spend the dry season in the DPZ. An annual offtake of 15 percent (Table 7) equals 23,700 UBT. The whole of the increase in offtake due to the increase in growth rate is counted as a benefit.

Thus, when discounted at 12 percent (from Table 6, column A') and adjusting the result from 10,000 animals, the benefit is

(23,700/10,000) x 4929 x US$250 = US$2,920,400

and discounted at 16 percent (from Table 6, column A") it is

(23,700/10,000) x 3478 x US$250 = US$2,060,700.

To this benefit must be added the extra offtake in years 17 to 20, when the whole of the annual increase in animal numbers is taken as offtake, since the optimum carrying capacity has been reached, and it is assumed that herders are willing to sell the extra animals so as to keep numbers within the carrying capacity. From Table 6, 10,000 UBT growing at four percent per year become 17,500 UBT in 16 years, and thus 157,700 UBT (multiplied by 17,500/10,000) become 276,000 UBT. If the growth rate continues at four percent but numbers are kept constant by increasing offtake, then the extra annual offtake is four percent of 276,000, or 11,000 UBT. If this extra number is slaughtered from year 17 through year 20 in order to keep animal numbers within the carrying capacity, then (if one discounts these extra numbers slaughtered at the appropriate rates of interest to determine their present value in year 0) the present value of this increase in meat production discounted at 12 percent is 6097, which must be multiplied by US$250 to give a benefit of US$1,524,300 ; discounted at 16 percent, the present value of the increase in meat production is 3316 multiplied by US$250 for a total of US$828,900 .

The totals obtained by adding the effect of the increase in growth rate of offtake for years 1 to 20 to the increase in offtake for years 17 to 20 thus become, when discounted at 12 percent, US$4,444,700 and when discounted at 16 percent, US$2,889,600. These constitute the low estimates of benefits.

b. Decline in Growth Rate from 3 to -1.3 and then to -4.3 Percent

As noted above, the high estimate of benefits includes counteracting an absolute decline in forage availability, which would cause a decrease from the current estimated three percent annual growth rate in animal numbers in the DPZ.

It is assumed that the growth rate could decrease over 20 years, first to -1.3 and then to -4.3 percent. For ease of calculation, three columns have been included in each part of Table 6. As a result, this decrease is calculated in two parts: from 3 to -1.3 and then -4.3 percent, which is obtained by subtracting the C columns from the B columns and the value of which is calculated in this subsection; and from 3 to 0 percent, which is obtained from the C columns alone and the value of which is calculated in the next subsection.

The estimated present value of an offtake rate of 10,000 UBT over 20 years when discounted at 12 percent (from Table 6, columns B' and C') is 25,578 minus 17,485, which equals 8093 UBT. The 15 percent offtake (from Table 7) from 132,700 UBT is 19,905 (say, 20,000), so the figure from Table 6 is doubled to 16,186. Thus, a total offtake of about 16,000 present value is lost at US$250 per UBT giving a total of US$4,000,000 for the lost production.

Discounted at 16 percent, the numbers become (from columns B" and C") 17,673 - 12,413 = 5260 , which doubled equals 10,500 UBT at US$250 each for a total of US$2,625,000 as the value of potential production lost.

By emigrating to neighboring areas, however, some herds would probably not experience this decline in numbers (and hence in offtake). If it is assumed that only half of this decline in offtake occurs (though the whole decline would appear to have taken place in the DPZ), the presumed benefits due to the project would be halved, so that the 12 percent discount rate value would be US$2,000,000 and the 16 percent discount rate value would be US$1,312,000.

c. Decline in Growth Rate from Three to Zero Percent

In this case, the restricted carrying capacity will also force animal numbers (and therefore offtake) within the DPZ to decline. But, again, since ample opportunities for emigration exist, it is assumed that some herds will leave the area and continue to increase, while others will stay and keep growing to fill the gaps left by those that had departed. As a result, it is assumed that only one third of the projected decline will actually occur. This amount is less than the one half assumed in b above, since with a less acute decline in forage, it is assumed that it will be easier for animals to avoid suffering actual losses in numbers. Thus, with 132,700 UBT as the base number, the benefits at each discount rate are calculated by doubling the amounts from columns C' and C" as follows:

At 12%: 2 x 17,485 = 35,000 x US$250 divided by 3 equals approximately US$2,917,000; and,

At 16%: 2 x 12,413 = 24,800 x US$250 divided by 3 equals approximately US$2,067,000.

d. Calculation of High Estimate of Benefits

The high estimate of benefits is determined by adding the results from subsections a, b and c. For a discount rate of 12 percent, this is US$4,444,700 plus 2,000,000 plus 2,917,000, which equals US$9,361,700. For a discount rate of 16 percent, the value is US$2,889,600 plus 1,312,000 plus 2,067,000, which equals US$6,268,600.

2. Reductions in Losses on the Transhumance

a. Cattle

About 50,000 to 100,000 cattle are said to traverse the DPZ coming from further north and east or west and going south towards the Bamako and Kolokani areas. From the herd composition figures (source: OMBEVI in Delgado), it can be calculated that each herd has had 15 mortalities per 100 animals per year. Of these, 11 are calves less than one year old. Most calves are born July/August and most of these deaths occur within the first three to six months of life. Let us assume that about six months later, seven of these calf deaths have already occurred by the time the cattle transhume south (January/February). They return north in June/July before most births occur. Transhumance occurs relatively quickly between established grazing areas, say over two weeks. Assuming traversing the DPZ takes one fourth of this time, and that one fourth of the two remaining annual deaths occur during transhumance, i.e., 15 - 7 = 8, of which 1/4 equals 2 , then better water supplies in the DPZ could help avoid 0.5 (i.e., 1/4 of 2) deaths per 100 cattle.

From the age distribution of mortalities, it can be calculated that the average female death would occur at about age one to two, valued at 35,000 FM (1978/9 prices), or at age 0 to one if male, valued at 15,000 FM (1978/9 prices). For males, the price was obtained from the average wholesale price for meat of male animals; for females, the price also includes an imputed milk and calf value in addition to the meat value. These prices were discounted by current mortalities and an implicit social time discount rate of 15 to 17 percent. The result is equivalent to that obtained by using a weighted average of deaths by age and value. Since the males and females in the above age groups occur in about equal numbers, the average price is $\frac{15,000 + 35,000}{2} = 25,000$ FM.

This wholesale price must be adjusted for inflation and to a retail price, which implies adding about 50 percent to the total. In dollars, this becomes $\frac{25,000 \times 1.5}{400} = 93.75$, say US$90.

The loss is assumed to be total, since little salvage of dying animals is done on transhumance because of difficult access to markets.

In line with other herds, these transhumant groups are growing at three percent, so the numbers of mortalities avoided will increase at this rate. When discounted at 12 and 16 percent, this is equivalent to an approximate result of discounting by 9 and 13 percent, respectively. One thousand annually discounted over 20 years at nine percent has a present value of 9949, at 13 percent of 7937.

With 0.5 animals dying per 100 passing through the DPZ, the values for 100,000 animals are, at 12 percent:

0.5 x 9949 x US$90 = US$447,700

and, at 16 percent:

0.5 x 7937 x US$90 = US$357,200.

These are the high estimates of potential benefits. These benefits are halved if only 50,000 animals are assumed to pass through the area. Thus, discounted at 12 percent, they equal US$223,800, and discounted at 16 percent they equal US$178,600. These are the low estimates of potential benefits.

b. Sheep and Goats

Probably 100,000 to 200,000 sheep and goats pass through the DPZ each year. Little is known about their mortality pattern, except that it is much higher than the mortality of cattle, probably double. So, assuming one death per 100 animals (avoidable via the program) at a value equivalent to their relative carcass weights (13/120) multiplied by US$90 (i.e., U.S.$9.75--say US$10), the benefit from this source would be, for a low estimate of 100,000 animals and 1,000 deaths avoided:

At 12%: 9949 x US$10 = US$99,500; and,
At 16%: 7937 x US$10 = US$79,400.

Doubling these for the high estimate of 200,000 animals and 2000 deaths avoided, the benefit would be US$199,000 at a 12 percent discount rate and US$158,800 discounted at 16 percent.

c. Combined Cattle and Sheep and Goats

The combined cattle and sheep and goat figures for benefits due to losses avoided in the transhumance therefore are:

	12%	16%
High estimate	US$646,700	US$516,000
Low estimate	US$323,300	US$258,000.

3. Effects of Reduced Losses Due to an Ability to Withstand Drought

Water supplies and extra forage should help to mitigate significantly the effects of drought in the DPZ. Investigation into the effects of the 1972/73 drought found it was responsible for a 60 percent reduction in the number of cattle in the DPZ (Table 1). Sheep and goats probably suffered a similar loss. Assuming that only half (i.e., 30 percent) of these actually died, with the rest simply leaving the area, and that such a drought had about twice the severity of those occurring regularly every seven to ten years, implying a 15 percent mortality, the program could perhaps reduce by one half or one third such losses. These assumed reductions in losses are the basis for calculating the high and low estimates, respectively, of benefits below.

Assuming a drought in ten years with an equal probability of occurring each year, this would be $\frac{15\%}{10}$ = 1.5 percent per annum reduced by half (i.e., 0.75 percent) or 1/3 (i.e., 0.5 percent) for the 132,700 UBT in the area. The value of this loss, as usual assuming about 1/3 sheep and goats and 2/3 cattle, and five sheep and goats per UBT, is calculated (using a weighted average) to be approximately US$75. (The US$90 and US$10 values of a mortality derived in subsection 2 above were used for cattle and sheep and goats, respectively.)

The herds in the DPZ hopefully should be growing at four percent per year, as indicated earlier; therefore, discounting at 12 percent less four percent annual growth is approximately equal to discounting at eight percent, and 16 percent is approximately equal to 12 percent.

The present value of 1000 animals at eight percent is 10,602 for 20 years. With the 0.75 percent (equal to 0.0075) loss avoided annually, for 132,700 animals:

10,602 x 132.7 x 0.0075 x US$75 = US$791,400.

The present value of 1000 animals at 12 percent is 8367; thus:

8367 x 132.7 x 0.0075 x US$75 = US$624,500.

These are the high estimate amounts (i.e., assuming a reduction by half in potential mortalities). The low estimate amounts (1/3 reduction) are two-thirds of these.

Thus potential drought losses avoided are:

	12%	16%
High estimate	US$791,400	US$624,500
Low estimate	US$527,600	US$416,300.

F. Comparison of Benefits with Costs

Table 8 shows the results of comparing total costs (from Section VI) with total benefits for high and low estimates of benefits. Only in the case of the high-benefit estimate discounted at 12 percent is the benefit/cost ratio greater than 1.0, and then only modestly so at 1.09. Discounted at 16 percent, the figure is 0.89. The low-benefit ratios are 0.53 and 0.43 for the 12 percent and 16 percent discount rates, respectively. The 16 percent discount rate estimates give relatively lower valuations mainly because the high offtake rates which occur when a three to four percent increase in growth is assumed happen only in the last four years of the project.[1/]

1/ It should be noted that the use of high discount rates (which are considered realistic because they reflect risk and approximate acceptable returns on capital) do, however, discriminate against projects such as this one which have high initial costs but have benefits that gradually increase and continue over a long period of time. Internal rates of return (ROR) were not calculated, but it can be inferred from Table 8 that the ROR for the high

Given the great number of assumptions that had to be made and the lack of data on livestock numbers, it is questionable whether the project could even come close to covering costs in the single case where the ratio is positive. In other words, much higher benefit/cost ratios would be necessary to justify implementing the maximum investment program in the DPZ. The lack of data is particularly crucial on the subjects of movement patterns, the relation between wet and dry-season grazing and, of course, absolute numbers of animals.

The projections made show basically what the maximum response within the traditional herding system might be to this project, which has interventions aimed at forage and water development but not at improving animal health. The assumption of an increase in herd growth rate from three to four percent is roughly equivalent to a ten percent increase in calf survival to age 1 (or a 25 percent reduction in current mortality of about 40 percent). The main change in the grazing pattern is that of an increase in year-round grazing in the area.

Consequently, these projections should be considered a preliminary estimate of the expected level of benefits. The estimate was obtained by manipulating the limited data available and by following the projections of increased forage in Table 5. All benefits are expressed in terms of offtake of meat. Whether these projections are found to be accurate over time depends, on the "optimistic" side, on whether it is really possible to increase carrying capacity from one animal per eight hectares to one animal per 5.5 hectares and, on the "pessimistic" side, on whether and to what extent overgrazing would otherwise occur and to what extent herders would emigrate from this area of presently higher livestock population density to surrounding areas to mitigate the effect of overgrazing. A more detailed estimate will require further research into grazing demands on the area at different times of the year, the flexibility of these demands and the system of animal husbandry currently being practiced.

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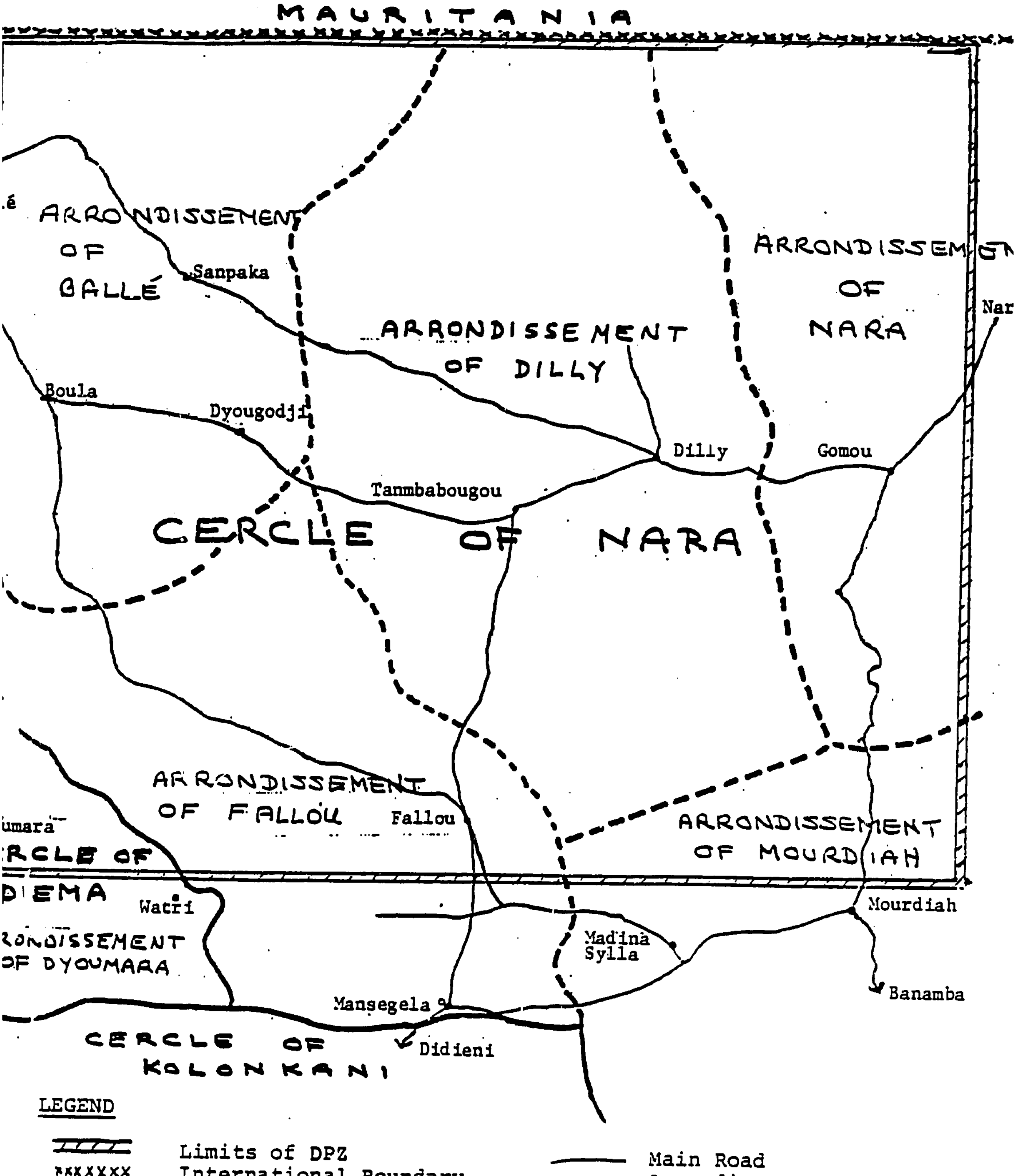
level estimates is probably just over 12 percent, while that at the low level is very much lower.

FIGURE 1

SKETCH MAP OF THE DILLY PASTORAL ZONE
SHOWING ADMINISTRATIVE BOUNDARIES

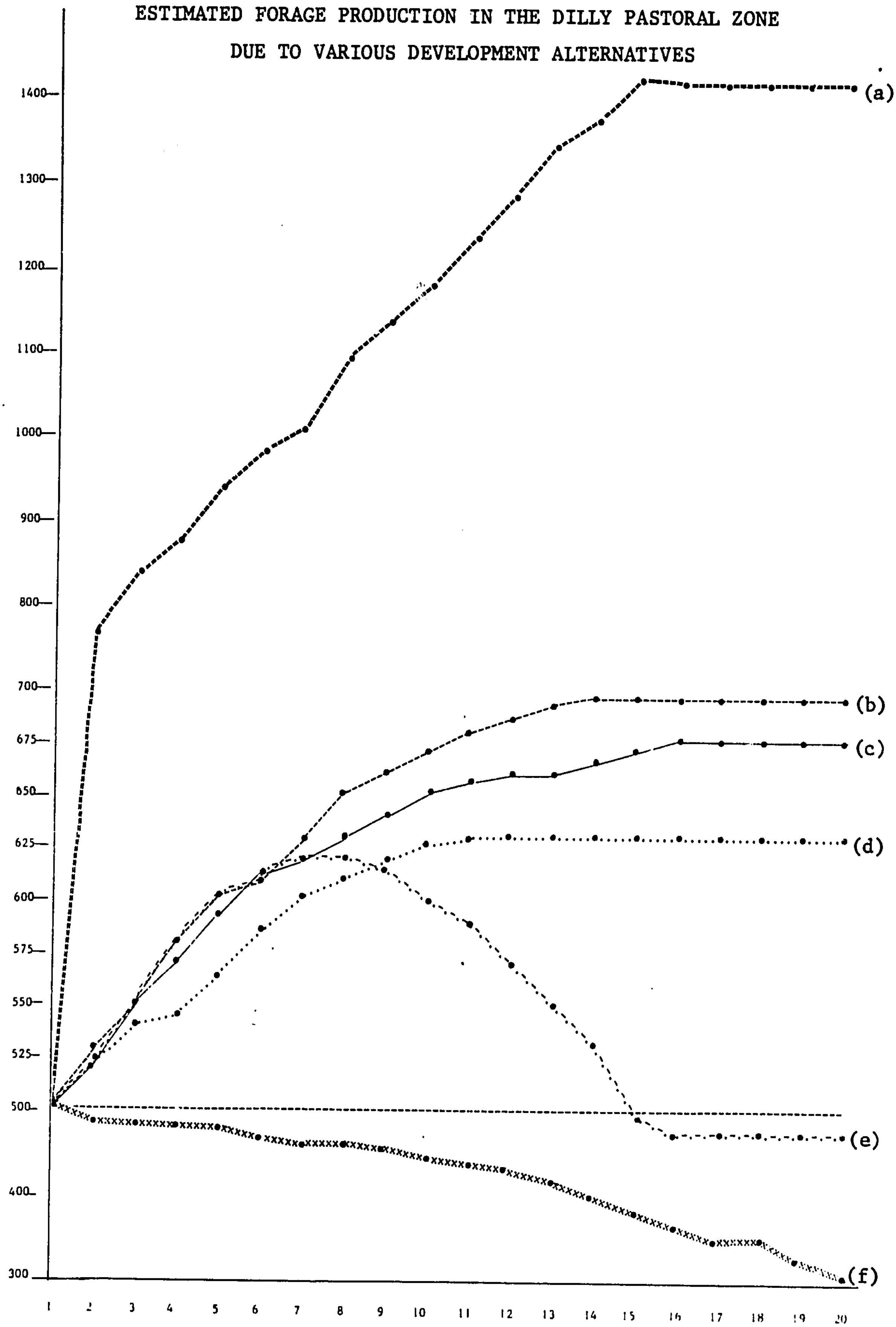


Source: Map 'Nara' 1:500,000, BCR Archives.

GRAPH 1

ESTIMATED FORAGE PRODUCTION IN THE DILLY PASTORAL ZONE

DUE TO VARIOUS DEVELOPMENT ALTERNATIVES



(a) Maximum investment.
(b) Fire prevention, suppression and fire breaks.
(c) Fire prevention and suppression.
(d) Fire prevention.
(e) Water development
(f) Do nothing.

ASSUMPTIONS USED IN PREPARING GRAPH 1

Dilly Pastoral Zone = 1,550,000 hectares (15,500 km^2)
Current estimated production = 450 kg/ha (approximately 700,000 tons of forage. Current estimate of forage burned = 200,000 tons.

A. Maximum Investment Alternative

The Maximum Investment Alternative would include fire prevention, fire suppression, a firebreak network, water development, grazing systems and livestock control, (i.e., range management), as components of a Management Plan for each of the management areas in the DPZ. The projections are based on the assumption that the program will be implemented over a five-year period. We estimate that forage production could be doubled within a fifteen-year time frame and sustained at that level by implementing the Maximum Investment Alternative.

B. Fire Prevention Alternative

The Fire Prevention Alternative implemented by itself could reduce the number of man-caused fires by 90 percent in 10 years. The number of hectares burned should be reduced by 65 percent.

C. Fire Prevention and Suppression Alternative

By implementing a fire suppression program to accompany the fire prevention campaign, the cumulative results of the Fire Prevention and Fire Suppression Alternative would be a reduction of the number of hectares burned by another 23 percent, for a total reduction of 88 percent.

D. Fire Prevention, Suppression and Firebreak Alternatives

By implementing a firebreak network to accompany the fire prevention and suppression programs the cumulative effect of a Fire Prevention, Suppression and Firebreak Alternative would be a reduction in the number of hectares burned by another 10 percent, for a total of 98 percent.

E. Water Development Alternative

Fires occur mainly in the ungrazed or lightly grazed areas where vegetation is heavy enough to carry a fire. Most of these areas are lightly grazed because of inadequate water sources. If the Water Development Alternative were implemented, the forage protected by fire control (i.e., prevention, suppression and firebreaks) could be grazed in the short run, and would result in a slight increase in available forage over the long run. Without proper range management however, it is believed that the forage condition in the newly developed areas would deteriorate fairly rapidly.

F. <u>Do Nothing Alternative</u>

The results of the Do Nothing Alternative would be continuing deterioration of forage resources, i.e., a significant net decrease from present conditions, largely as a result of continued growth in herd numbers, and to some extent, as a result of increase land brought under cultivation.

TABLE 1

LIVESTOCK POPULATION DATA FOR CERCLE OF NARA

(a) Cattle in 1979

Arrondissement	Recensement Administratif	Estimation Vétérinaire
Ballé	10,223	35,000
Dilly	43,493	80,000
Guiré	5,246	10,000
Fallou	1,976	9,000
Mourdiah	4,456	12,000
Central (Nara)	12,100	36,000
Total for Cercle of Nara	77,494	172,000

(b) Sheep and Goats in 1979

Arrondissement	Recensement Administratif	Estimation Vétérinaire
Ballé	8,396	60,000
Dilly	40,096	180,000
Guiré	4,877	60,000
Fallou	6,316	17,000
Mourdiah	9,601	50,000
Central (Nara)	19,586	90,000
Total for Cercle of Nara	88,872	457,000

(c) Changes in Cattle Population During 1973-1979 (Comparison of Cercles of Nara, Niono and Nioro

Year	Number (Cercle of Nara)	Difference from Previous Year (%)		
		Cercle of Nara	Cercle of Nioro	Cercle of Niono
1973	210,000			
1974	81,500	-61.19	4.50	-71.1
1975	84,760	4.00 *	3.97	4.00 *
1976	88,150	4.00 *	4.03	3.99 *
1977	91,676	4.00 *	4.00 *	4.00 *
1978	146,000	59.25	2.94	9.41
1979	172,000	17.81	-	-

* figures evidently derived by applying growth rate of 4% per annum.

Source: Rapports annuels du Service de l'élevage, Nara Secteur.

TABLE 2

(a) Area and Human Population of Cercle of Nara in 1976

Arrondissement	Area (km^2)	Human Population
Nara Central	7,224	31,969
Ballé	5,137	27,149
Dilly	[illegible],673	24,700
Fallou	[illegible],891	13,302
Guiré	4,790	6,513
Mourdiah	4,985	13,787
Total for Cercle of Nara	30,700	117,420
Dioumara (Cercle of Diema)	3,478	9,208

Source: BCR

(b) Calculation of Human and Livestock Populations in Dilly Pastoral Zone (Using a Weighted Average)

Arondissement	Proportion of DPZ Occupied by each Arron-dissement	Population Density (#/km^2)			Population per km^2 of DPZ in Arrondissement		
		Human	Cattle	Sheep + Goats	Human	Cattle	Sheep + Goats
Dilly	0.35	5.3	17.1	38.5	1.855	5.985	13.475
Ballé	0.22	5.3	4.9	11.7	1.166	1.078	2.574
Mourdiah	0.05	2.8	2.4	10.0	0.140	0.120	0.500
Nara	0.20	4.4	5.0	12.5	0.880	1.000	2.500
Fallou	0.16) 0.18	3.4	2.3	4.4	0.544	0.414	0.792
Dioumara	0.02)	2.6			0.052		
Total per km^2 of the DPZ	1.00	4.6	8.6	19.8	4.637	8.597	19.841

* Information available only on human population for Dioumara, so for the animal populations the parts included in the DPZ are assumed to be similar in density to Fallou. The population density of each category times the area of the DPZ gives the total number, as follows.

TABLE 2 (continued)

Category	#/km^2	km^2	Total Number in DPZ	
Human	4.637)		71,900	(1976)1/
Cattle	8.597)	x 15.500 =	133,250	(1980)
Sheep + Goats	19.841)		307,500	(1980)

1/ In 1980 the human population is estimated at 78,000, based on a 2.0 % growth rate from the 1976 number of 71,900.

Source: BCR, Elevage Nara

Note: 1 km^2 = 100 ha.

TABLE 3

CALCULATION OF LAND AVAILABLE FOR GRAZING

Year	Human Population (growing at 2.0% per year)	Km^2 cultivated (Pop. x 0.35 ha.)	Potential Grazing Land km^2 (15,500 less area cultivated)
Now	78,000	273	15,227
+ 5 years	86,100	301	15,199
+ 10 years	95,100	333	15,167
+ 15 years	105,000	368	15,132
+ 20 years	115,900	406	15,094

TABLE 4

PROJECTION OF CARRYING CAPACITIES

Year	Potential Grazing Land x 0.7 = Utilizable Land (km^2)	Carrying Capacity Assuming no Degradation (1,000 UBT)1/	Carrying Capacities from Table 5	
			With Program Proposed (1,000 UBT)	If Nothing is Done (1,000 UBT)
Now	10,659	133.2	137.0	137.0
5	10,639	133.0	175.5	131.5
10	10,617	132.7	221.9	124.6
15	10,592	132.4	265.8	104.1
20	10,566	132.1	271.3	82.2

Note: 1/ Obtained by taking utilizable land in column 1 and dividing by 8 (the estimated number of hectares per UBT).

TABLE 5

CARRYING CAPACITY IMPLICATIONS OF GRAPH 1 (IN 1,000 UBT)1/

Year	Development Alternative (described below)2/ a3/	b	c	d	e	f
1	137.0	137.0	137.0	137.0	137.0	137.0
2	145.2	145.2	142.5	142.5	143.8	134.3
3	156.7	150.7	150.7	147.9	150.7	132.8
4	164.8	158.9	156.2	149.3	158.9	131.5
5	175.5	164.8	161.5	154.8	164.4	131.5
6	186.3	167.1	167.2	160.3	167.1	128.7
7	191.8	172.6	169.8	164.4	169.8	127.4
8	205.5	178.1	172.6	167.1	169.8	127.4
9	213.7	180.8	175.4	169.8	168.5	126.1
10	221.9	183.6	178.1	171.3	164.4	124.6
11	232.9	186.3	179.5	172.6	161.6	120.5
12	241.1	187.7	180.8	172.6	156.2	119.2
13	249.3	189.1	180.8	172.6	150.7	113.7
14	257.6	190.4	182.2	172.6	145.2	109.6
15	265.8	190.4	183.6	172.6	136.9	104.1
16	271.3	190.4	184.9	172.6	134.3	98.6
17	271.3	190.4	184.9	172.6	134.3	95.9
18	271.3	190.4	184.9	172.6	134.3	90.4
19	271.3	190.4	184.9	172.6	134.3	87.7
20	271.3	190.4	184.9	172.6	134.3	82.2

1/ Assumes 10 kg. of forage eaten per animal per day. For example, 500,000 tons of forage currently available (after burning) ÷ 10/head/day = 500,000 ÷ 3650 = 137,000 UBT.

2/ Development Alternatives by Column:
(a) Maximum Investment: range management, fire prevention and suppression and firebreaks, water development, and range management (Alternative A).
(b) Fire prevention, suppression and firebreaks (Alternative D).
(c) Fire prevention and suppression (Alternative C).
(d) Fire prevention (Alternative B).
(e) Water development Alternative E).
(f) Do nothing (Alternative F).

3/ Assumes an increase in capacity from the current ha/per UBT/year to 5.5 ha/UBT/year.

TABLE 6

CALCULATION OF CHANGES IN GROWTH RATES OF ANIMALS

Year	10,000 growing at 4% up to year 16	10,000 growing at 3% per year	10,000 decreasing at 1.3% (yrs 1-10) and 4.3% (yrs 11-20)	Differences: Increase from 3% to 4% A	Differences: Decrease from +3% to -1.3% and -4.3% B	Differences: Decrease from +3% to 0 % C	Differences Discounted at 12% A'	Differences Discounted at 12% B'	Differences Discounted at 12% C'	Differences Discounted at 16% A"	Differences Discounted at 16% B"	Differences Discounted at 16% C"
1	10,000	10,000	10,000	0	0	0	0	0	0	0	0	0
2	10,333	10,300	9,873	33	427	300	29	381	268	28	368	257
3	10,712	10,609	9,747	103	862	609	82	687	485	77	641	423
4	11,141	10,927	9,623	214	1304	927	153	928	660	137	835	594
5	11,586	11,255	9,500	331	1755	1255	211	1115	798	183	969	693
6	12,050	11,593	9,378	457	2215	1593	259	1257	904	217	1054	758
7	12,531	11,940	9,260	591	2680	1940	299	1358	983	242	1100	796
8	13,033	12,299	9,142	735	3157	2298	332	1428	1039	260	1117	813
9	13,554	12,688	9,025	886	3663	2668	358	1479	1078	270	1117	814
10	14,097	13,048	8,910	1049	4138	3048	378	1492	1099	276	1088	801
11	14,660	13,439	8,546	1221	4893	3439	393	1575	1107	277	1109	780
12	15,247	13,842	8,197	1405	5645	3842	404	1623	1104	274	1103	751
13	15,857	14,258	7,862	1599	6396	4258	411	1642	1093	269	1077	717
14	16,491	14,685	7,541	1806	7144	4685	414	1637	1074	262	1037	680
15	17,151	15,126	7,232	2025	7894	5126	414	1615	1049	253	988	642
16	17,500	15,580	6,937	1920	8643	5580	351	1579	1019	207	933	602
17	17,500	16,047	6,654	1453	9393	6047	237	1532	986	135	874	563
18	17,500	16,528	6,382	972	10146	6528	142	1478	951	78	814	524
19	17,500	17,024	6,121	476	10903	7024	62	1418	913	33	754	486
20	17,500	17,535	5,871	0	11664	7535	0	1354	875	0	695	449
Totals							4,929	25,578	17,485	3,478	17,673	12,413

Notes: Declines of 1.3% for the first ten years and 4.3% for the next ten years are approximations of the rates which were derived from the "do nothing" alternative of Table 5.

The increase from 3 to 4% occurs gradually over the first three years; in year 16, when the carrying capacity limit is reached, animal numbers cease to grow and the increase is converted into extra offtake.

10,000 is used as convenient figure for these calculations. It must be multiplied by an appropriate number to convert it to an offtake number for the DPZ. This number, as noted in the text, is the actual number divided by 10,000.

TABLE 7

PRODUCTION PARAMETERS AND PRICE USED IN PROJECTIONS

A. Production Parameters Used

1 UBT = 1 head of cattle, liveweight, 250 kg

1/5 UBT = 1 sheep or goat

For cattle and for sheep and goats, a growth rate in total numbers of 3 percent per year is considered average to low while a growth rate of 4 percent per year is considered good.

Meat production per animal is defined as offtake (the percentage of animals slaughtered or sold per year) times carcass weight.

	Meat Production per animal (kg.)	Offtake (%)	Implied Carcass weight (kg.)
Cattle	13.2	11	120
Small ruminants	3.6	28	13

All information for sheep and goats varies far more than that for cattle; nevertheless, these are reasonable middle-range estimates.

Source: Delgado

B. Production Parameters for the DPZ

For a herd whose UBTs are composed of roughly one-third sheep and goats and two-thirds cattle, meat production per animal is approximately 15 kg. per year. This is calculated as follows.

For the 1/3 sheep and goats	1 x 5 x 3.6 kg./animal	=	18.0 kg.
For the 2/3 cattle:	2 x 1 x 13.2 kg./animal	=	26.4 kg.
	Total	=	44.4 kg.

When divided by 3, this gives approximately 15 kg. per year.

Similarly, the average carcass weight is about 100 kg., calculated as follows:

For the 1/3 sheep and goats:	1 x 5 x 13 kg./animal	=	65 kg.
For the 2/3 cattle:	2 x 1 x 120 kg./animal	=	240 kg.
	Total	=	305 kg.

When divided by 3, this is approximately 100 kg.

The offtake for the DPZ (i.e., meat production divided by carcass weight) is, therefore, about 15 percent per year.

C. Price

The sale price for all meat is chosen to be 1000 FM per kg. This is slightly lower than current (1980) Bamako beef-with-bone prices and reasonably representative of meat prices in the country in 1980. It equals US $2.50 per kg. or US $250 per carcass.

TABLE 8

SUMMARY OF BENEFITS AND COSTS FOR HIGH AND LOW ESTIMATE PROGRAMS
(IN US $1,000)

Present Value Item	Discounted at 12%		Discounted at 16%	
	High Estimate	Low Estimate	High Estimate	Low Estimate
1) Benefits Due to Increase in Herd Growth	9,361.7	4,444.7	6,286.6	2,889.6
2) Benefits due to Reductions in Losses on the Transhumance	646.7	323.3	516.0	258.0
3) Benefits Due to Drought	791.4	527.6	624.5	416.3
Total Benefits (B)	10,799.8	5,295.6	7,409.1	3,563.9
Total Costs (C)	9,916.7	9,916.7	8,318.3	8,318.3
Net Present Value (B-C)	883.1	-4,621.1	-909.2	-4,754.4
Benefit/Cost Ratio (B/C)	1.09	0.53	0.89	0.43

SECTION VIII

CONCLUSIONS AND RECOMMENDATIONS

SECTION VIII

CONCLUSIONS AND RECOMMENDATIONS

A. Introduction

This study is an important milestone in the history of the Mali Livestock Development Project. Since it comes at the end of a three-year period of activity, it can draw on the experience acquired during that time. Using that experience and the new information it provides, this study affords the opportunity to make some judgments about the feasible next steps for the development of the Dilly Pastoral Zone (DPZ).

B. Limitations of the Study

The study was undertaken with some limitations that were recognized at the outset. In particular the Terms of Reference called for an inventory of current forage production, water resources, grazing use patterns (range condition), livestock use, fire problems, erosion hazard and wildlife situation. They also called for a projection of the potential for expanding or dealing with each of these elements. It quickly became apparent that the Mali Livestock Development Project did not have the resources to field a team that would have the size and time to do the inventory and projections. It was agreed, therefore, that in lieu of a full-scale "inventory," the study team would attempt to evaluate current forage production, water resources, etc., using the data already available in the Mali Livestock Development Project, in a manner more comprehensive than previous reports had done.

Another limitation became apparent after the team went into the field and began to collect and analyze information, namely, the serious lack of sociological and livestock production data. In the field the team consisted of an engineer, a hydrogeologist and a range management expert. Cost and forage production estimates were later given to the Mali Livestock Development Project economist working in Bamako to do the benefit/cost analysis. The lack of empirical sociological and livestock information made it necessary to make a number of assumptions that greatly increased the uncertainty associated with the benefit/cost calculations. It also underlined the importance of having such information for future project planning and implementation.

Despite these limitations, the study team was able to take a first cut at laying out what a "maximum" program would be ideally and what the comparative benefits and costs of such an effort would be. As a result, the team has come to three basic conclusions and can make a number of specific recommendations (drawing also on previous work in the area) for future activities.

C. Conclusions

The Study Team's first conclusion is that a program to improve livestock production in the DPZ outside of the Test Perimeter should not be undertaken at this time. This conclusion is based on the results of the benefit/cost analysis for Alternative A, which is maximum investment in the DPZ. In only one case was the ratio greater than 1. Given the limitations on the data available and the assumptions that were made (as noted above and in Section VII), a ratio far higher than 1 would be required to provide the necessary margin of confidence and to warrant making the financial investment that was projected.

The second conclusion is that a significant effort should be made to continue the development of the Test Perimeter, but on a more ambitious level than has previously occurred. For various reasons, the Test Perimeter has never received the infusion of resources (both human and material) necessary to make it a true test area. Although some improvements have been made, there has been only intermittent expatriate involvement over the course of the Mali Livestock Development Program. Many of the improvements have not been carried through to completion and virtually no evaluative data have been collected.

There is now a base of activity in the Test Perimeter, nevertheless, that can be built on. The results of such a renewed effort should give much better information so that the benefit/cost calculation for moving ahead with development of the overall DPZ can be made again in a couple years' time.

In the meantime, all the original arguments for doing a test of appropriate interventions in this area still hold and ought to be acted on. The May 1975 Mali Livestock Sector Grant Program Proposal, which was developed by AID in close cooperation with the Government of Mali (GRM), introduced the Sahel Grazing Activity as a principal activity of the proposed program. The stated objective was

> to develop modalities for modifying rangeland use in the Western Sahelian Zone of Mali which will increase production and producer incomes working through, as much as is possible, herder institutions and society and which will protect the fragile land resource for future generations. The site for the activity is centered on Dilly.... The activity will focus upon improving the migratory and semi-migratory production systems while retaining extensive land use patterns.

The Grant Program Proposal went on to state that

> This is admittedly a difficult activity to plan and execute. The area being isolated, costs are higher, management more complex, and the benefits hard to quantify by traditional yardsticks. However, the activity is a key element in the strategy for the sector proposed by the GRM which includes conversion of the Sahel to a zone for breeding and rearing young stock to be fed out in higher rainfall zones. The activity will directly affect the migratory pastoralist, whose income opportunities we are concerned about. It permits a measure not only of how one may contribute to his survival, but also of how one may improve revenue-producing opportunities for him.

The original GRM proposal for implementing this activity, as described in this early document, was that there should be "an extensive approach rather than intensive, i.e., a relatively light spread of physical and management inputs over a large area." The main reason given for this approach was that the GRM felt the administrative capacity to institute an intensive range management effort would be lacking. This position was de facto later modified when the GRM agreed in about 1977 to the establishment of the Test Perimeter within the DPZ, in other words that there should be a limited area in which a comparatively intensive mix of interventions should be tried. A new effort focussed on the TP would require a clear commitment by the GRM to this concept.

The third basic conclusion of this report is that certain aspects of the Test Perimeter need further study as part of an expanded development program there. There is notably a lack of a comprehensive body of sociological information (notwithstanding occasional studies in the past)[1/] necessary to understand the dynamics of village and transhumant life, the changes that any interventions may produce, and what modifications in interventions might be necessary. This kind of information must be collected if a continual effort in the Test Perimeter is to produce an understanding of what happens and why that can be applied in the DPZ and elsewhere.

1/ H. Breman, A. Diallo, G. Traoré and M.M. Djiteye, "The Ecology of the Annual Migration of Cattle in the Sahel," CABO, P.B. 14, Wageningen, The Netherlands, approx. date 1978, prepared for the Malian-Dutch project "Primary Production Sahel."

Bureau Africain de Recherches Appliquees (BARA), "Impacts du Projet Mali - Livestock II (Developpement de la Zone Pastorale de Dilly - Cercle de Nara) sur la Vie Economique et Sociale des Femmes" B.P. 1806, Bamako, January-February 1980, prepared under subcontract with Chemonics International Consulting Division.

Michael M. Horowitz, "The Sociology of Pastoralism and African Livestock Projects," Institute for Development Anthropology, May 1979, submitted initially under Contract No. AID/otr-147-78-48 and revised for distribution to participants in AID Workshop on Livestock in Africa.

John Lewis, "Sociological Working Paper on Mali Livestock Evaluation and Design," Bamako, August 1978.

Marianne Rupp, "Anthropology of the Maures, Peul, Guera, Bambara, and Soniuke in the Nara-Niono Plain," 1975, prepared under UNDP project Mali 523.

In addition, little baseline information relating to livestock has been collected. This is necessary to provide a comparison of their condition before and after the interventions. While some of the "before" information can no longer be collected, much still can be and the effects of the interventions should be documented and evaluated.

An essential part of the Sahel Grazing Activity (stated in detail in the Sector Grant Program Proposal, in the September 1976 Request for Proposals (RFP) for Mali Livestock II and in the November 1976 Chemonics Consulting Division Proposal to Provide Technical Assistance to the Mali Livestock II Project) was the conduct of research and evaluation. The eleven tasks identified in the RFP included, for example, identifying and evaluating specific successful herd, range and water management practices; evaluating available research information on techniques to improve herd and range production; evaluating the incentives and constraints that affect the willingness of herders to cull young cattle and to sell mature cattle; and participating with the GRM and USAID in the preparation of an annual evaluation of the status of the project and of the modifications, if necessary, to accommodate problems encountered or to change the scope of objectives.

In practice, during the course of the Mali Livestock II project, a significant barrier to carrying out research and evaluation activities in the Test Perimeter has been the unwillingness or inability of the GRM to provide the necessary support. This lack of support was caused in part by lack of resources and in greater part by inefficient use of resources. Further, it should be noted that the GRM project managers, believing that (1) previous research done in Mali was adequate to the needs of the project, (2) that expatriates tend to gravitate toward research in preference to actual development work and (3) that the GRM's and the project's credibility in the DPZ demanded concentration on "results," deliberately downplayed "research" and resisted efforts to divert resources to it.

However, we believe that if the Test Perimeter is to serve its purpose and pave the way for rational investment in the development of the DPZ, resources must be allocated for this research.

D. Recommendations

Based on these conclusions, the study team believes that a number of specific steps should be taken to develop the Test Perimeter. These imply an infusion of a larger amount of resources than in the past. While no costs have been attached to these activities, it is assumed that the most intensive effort would be during the first two years, a consolidation of gains would be made during the following two years (during which time interventions in other parts of the DPZ might be planned and/or begun), and a maintenance level of activity would be carried on for a number of years thereafter.

The recommendations are as follows.

1. Staffing

Experience in the DPZ generally and in the Test Perimeter in particular has shown that provision of adequate expatriate and local staff is essential to carrying out a work program. We recommend that there be a three-person core staff stationed at Dilly full-time for two years to work in the Test Perimeter. They would be supplemented, as needed, with short-term research and technical specialists equivalent to an additional three person-years. The responsibilities of the long-term and short-term expert staff (generally considered to be expatriate) would be as follows. There should also be adequate local staff to work in the project office and to assist in the studies, in extension work and other activities.

a. Long-term Staff

The primary purposes of the long-term staff would be to carry out a coordinated program of study and intervention so that after two years, decisions could be made on whether and how development efforts should proceed both in the Test Perimeter and in other parts of the DPZ. The core staff would consist of a range manager (who would most likely be the activity chief), a sociologist (or someone with appropriate disciplinary and field experience to direct and carry out the necessary studies) and an animal husbandry expert. They would have the following responsibilities.

(1) Range Manager (Activity Chief)

The range manager (activity chief) should have a broad enough view to encompass all the areas of project activities. He would (a) make sure that the Management Plan (see below) is implemented and make appropriate modifications in the plan as experience and study show are warranted, (b) ensure that the short-term specialists are used when and as needed, (c) see that the facilities and logistics (see below) are kept to an adequate standard to enable the staff to function effectively, (d) oversee local staff, (e) coordinate the project with local and foreign agencies that may be involved and (f) make sure there is a proper balance between study and intervention.

(2) Sociologist

The sociologist should be a person with the training and experience necessary to (a) direct and carry out studies of the dynamics of village and transhumant life that would add to the store of knowledge on which project interventions are based, (b) direct and assist in carrying out evaluations of the effects of the interventions used, (c) assist to the degree that it is ethically and practically possible in implementing the project interventions and (d) train local staff and villagers, as appropriate, to collect and analyze information that would be useful for the purposes just described. There are examples in subsection 3 below of studies for which the sociologist would be responsible.

(3) Animal Husbandry Expert

The animal husbandry expert would (a) make a detailed study of the health and other physical characteristics of the animals that live in and pass through the Test Perimeter, (b) work with the sociologist in designing and implementing studies of the practices and knowledge of villagers and transhumants relating to animals, (c) coordinate his work with the Veterinary Service and assist them in trying new interventions that may be appropriate, (d) assist in evaluations of such interventions and (e) assist in designing and implementing appropriate activities related to livestock production.

b. Short-term Staff

Since the purpose of this project would be to make a concerted effort to have the interventions planned, implemented and evaluated as effectively as possible, it will be necessary to have a significant number of short-term specialists to help carry out these functions. Since any given need may require one or more people for one to six months, it is estimated that the project would require the equivalent of three man-years of short-term staff effort. These staff would include the following specialties.

(1) Hydrogeologist(s)

Since water is a major element in development of the Test Perimeter, a hydrogeologist will be needed to work with the Service de l'Hydraulique in determining water requirements, working on construction of water points (and, possibly, wells) and to advise and assist in the maintenance of water points.

(2) Engineer(s)

There should be one or more engineers who can assist in water catchment design and construction, in pump installation and maintenance, in production and procurement of equipment for use in constructing firebreaks and in fire suppression, in similar functions for farming, and in maintenance and operation of facilities, vehicles, and equipment.

(3) Evaluator(s)

The design, implementation and analysis of evaluations will require special skills given the variety of interventions, the lack of a history of such efforts in the area, and the need to produce data that can be used in the benefit/cost analysis that will be done at the end of the project. One or more evaluation specialists will be needed for varying periods of time throughout the project to achieve these results.

(4) Other Specialists

There will be a number of other areas in which specialists will be required for research and/or intervention in both social and technical fields. Some examples are social anthropology, agrostology, training, extension and marketing.

2. Facilities and Logistics

Chemonics has very detailed views on this subject, based on efforts since 1977 to maintain expatriate personnel in the Dilly area and to support them in such a way that they could accomplish the tasks assigned to them. It has been a difficult and frustrating experience. The Dilly area's isolation and primitive conditions are, of course, important reasons for initiating and continuing the effort to use it as a testing ground for intervention, but adequate facilities and logistics are necessary to maintain effective expatriate and Malian professional staff working efficiently in the area.

Here we summarize the requirements, with the further comment that the costs of many of the requirements have not been fully included in our cost estimates in Section VI.

a. Housing

Inadequate housing for expatriates and Malian professionals has long been a problem at Dilly. The current housing is barely adequate for short-term use and totally inadequate for long-term use. A number of new houses would have to be provided to include reasonable cooking and sanitary facilities now lacking in all but the three "grand-standing" houses, and air conditioning or desert coolers, furniture and equipment.

b. Work and Storage Facilities

The Dilly Center does have office and storage space, but it is used for a variety of purposes and is not satisfactory to support the program recommended. Separate work and storage space, under the control of the personnel assigned to the Test Perimeter activities, are required.

c. Vehicles and Maintenance

Clearly, vehicles are vital to the accomplishment of the work in the Test Perimeter. The availability and allocation of vehicles has always been a point of contention at the Dilly Center, as there are always more requirements than operating vehicles. We strongly recommend that the project not be undertaken unless adequate vehicles, assigned specifically to personnel working on the Test Perimeter and under their control, can be made available. An adequate number would be at least one per expatriate and his/her counterpart operating as a team, one for the Malian Chief of the Activity, and at least one spare vehicle for emergencies.

Further, vehicles must have fuel supplies and be maintained if they are to operate under conditions which prevail in the Dilly area. We have made many recommendations on this subject in the past. Basically, the project requires a well-stocked maintenance facility under the direction and control of a trained expatriate expert in vehicle maintenance and management, who would have the authority to carry out a proper vehicle management and maintenance program.

d. Landing Strip

A landing strip was constructed under the Mali Livestock II project. It has been very helpful in supporting the operations in the Dilly area. It must be maintained if it is to continue to serve that vital function.

e. Management

The Dilly Center represents a very significant investment on the part of the GRM and the donors. It provides an excellent and necessary base for interventions in range management, animal husbandry and animal health in this vital area of Mali. However, to maintain that investment, and to permit the Center to operate in a way which will allow its use as a base of operations for the recommended work in the Test Perimeter as well as for the several other development activities which are based at the Center, the Center must have adequate management. It has not had adequate management in the past, with the result that the facilities which have been made available at great expense have not provided the necessary support to the project activities. Management has been so bad that at times it has proved to be the major obstacle to project activities.

Chemonics has made many recommendations on this subject in the past. We offer here a brief summary. The Center needs as its Chef du Centre a Malian official who is an experienced manager of a complex facility which must function under difficult conditions, 350 km. away from the source of most supplies, equipment and additional personnel. He must have a small but well-trained support staff in the areas of maintenance, logistics, personnel, etc. Since the facility serves several groups of users, he must establish and maintain a system of regular consultation with the users regarding management matters. The expatriate personnel must also be allowed to take an active part in the management of the Center and control the use of some of the resources, including the garage and some warehouse and office space.

f. Bamako Support Facility: Rear Base

The proper management of the Dilly Center, and any project activity which is run out of the Center, requires a strong rear base in Bamako. There has been such a rear base in Bamako since 1977, but it has not been adequately run to support the operations at the Center. It requires, for example, secure and frequent radio communications between Bamako and Dilly; the current radio system, based on two schedules per day, is subject to frequent outages whenever there is a power cut in Bamako. A secure power supply for the Bamako rear base, via batteries such as are used at Dilly, is a simple and obvious solution which has not been implemented. More important, the rear base must also be well staffed and equipped, with vehicles for example, and be under the direct supervision of the management of the Center. The Management of the Center, using its own budget and funds, must be able to demand prompt action on the part of the rear base for the acquisition and transport of supplies and equipment to Dilly, supplemental personnel and the like. This rear base would also, of course, be responsive to the needs of personnel working on the Test Perimeter, working presumably with a separate budget.

3. Management Plan

The authors of this report recommend that the original Management Plan for the Test Perimeter be implemented with appropriate modifications. The Plan was developed by Mr. Mohamed Lamine Bâ and Mr. James Naylor in August 1978 under the Mali Livestock II Project and is entitled "The Management Plan for the Test Area, Sahel Grazing Activity, Dilly, Range Management Section." Furthermore, the four original objectives of the Plan should still guide activities in the Test Perimeter. The only change is that the planned importation of perennials is probably not necessary. Management improvements have already led to the reappearance of indigenous perennials and forbs (broad-leafed herbaceous plants) that were not apparent in over-grazed areas. The objectives should now read as follows.

> (1) To increase the area and forage available for use by domestic animals without deterioration of the range, through proper grazing management and fire control.
>
> (2) To improve the quality of the range within the area, particularly the dry-season forage, through proper management.
>
> (3) To improve animal condition, reproduction rate, and young animal survival within the area by providing ample and high quality water and forage.
>
> (4) To use the area to demonstrate what can be accomplished through application of sound range livestock management and development practices.

The primary elements of the Management Plan should now be range management, fire control, water provision and studies. The recommendations concerning each of these elements are discussed in the following sub-sections. In the future, other distinct elements--e.g., animal husbandry and marketing--could be added.

4. Range Management

The range management component of the Management Plan contains several components. These include:

a. Rest-Rotation System

The eight pastures that have been marked in the Test Perimeter should be maintained for as long as possible in order to see the effects of alternately taking two out of use for two-year periods. Consideration should be given to including the villages in the northern part of the Test Perimeter in the upper tier of pastures, as well as to extending the Test Perimeter to the eastern and southern borders of the DPZ. (It will be necessary to weigh the possible added integrity of the Test Perimeter by including these areas against the need for more resources or the dilution of a given amount of resources devoted to the Test Perimeter.)

b. Grazing Committees

The village grazing committees and their representative grazing association should be maintained and possibly extended to include other villages in the Test Perimeter. This is a relatively low-cost, essential management element and one that the villagers have readily supported.

c. Herders

A somewhat minor but essential activity is the appointment of one or two herders for each village (depending on its size) to keep livestock from wandering into the pastures that are in rest status. One of the results obtained so far from improved forage due to fire control has been that village livestock have been found to move up to 20 km. across the area one day and return to the village the following day. Since the pastures are or will be marked only by painted trees (fencing is prohibitively expensive), herders are a necessity.

d. Reforestation

The DPZ is a bush savannah, not a forest area, so "reforestation" is not really appropriate. As indicated in the Management Plan, however, there are some purposes for which planting trees would be useful. One use is that around villages that have wells from which some water is wasted, trees can be planted to provide fruit, shade and other benefits. Another is in areas of water erosion, where planting trees can help keep soil in place.

e. Haycutting

Villagers now look for unburned and ungrazed areas at the end of the dry season to get straw for feeding livestock. This straw has a far lower nutritive value than hay cut early in the season and stored as a supplemental feed. Haycutting is a good way to make existing firebreaks effective, if people are willing and available to do it. Growing hay is not recommended, however, since it is a much less efficient use of the land than growing crops for direct human consumption.

5. Fire Control

There has not been agreement among different sources on the most effective methods for combatting fire in the Test Perimeter. Nevertheless the following efforts should be continued simultaneous with the conduct of studies (below).

a. Firebreaks

The existing network of firebreaks in the Test Perimeter should be maintained to the extent possible at modest cost. Most effort should be given to those that follow natural land features, since they are easiest to maintain. Also, existing roads and trails should be used; they should be improved by burning out just after the end of the rainy season.

b. Fire Prevention

Fire prevention programs have been dramatically effective in reducing the incidence of fires in some locales, but have been untested over time in the Test Perimeter. Some resources should be devoted to this approach to see what effects it has.

c. <u>Fire Suppression</u>

Some further provision should be made to have locally-produced fire-fighting implements used by villagers, to have organization and training of and by local staff, and to have some motorized transport available for use against fires. This is probably the least cost-effective way of combatting fires, however, and should only be considered a limited component.

6. <u>Water Provision</u>

There has already been considerable work done on water exploration and exploitation in the Test Perimeter. This should be continued and extended in the following ways.

a. <u>Drilled Wells</u>

The thirteen wells drilled by the Service de l'Hydraulique that produced water in the Test Perimeter should be maintained. Pump installation in these wells (including construction of troughs and of barbed wire fences) should be completed. Maintenance capabilities should be provided thereafter both for the pumps and for the surrounding areas (e.g., keeping up the fences that prevent animals and large objects from getting close enough to the wells to cause them to cave in)

b. <u>Location of Water Points</u>

Most of the drilled wells are located near villages in the area of the Valley of the Serpent. Each of the eight pastures, however, should have two or three water points. These points can be on the boundary between pastures and serve more than one pasture, but they will be necessary for testing grazing in the previously unused areas. Additional test drilling should be tried and/or other types of water points should be developed.

c. <u>Hand-dug Wells and Mares</u>

Hand-dug wells and improved <u>mares</u> should be further tested as alternatives or supplements to drilled wells.

They are less expensive, less complicated and more common than drilled wells, although they normally do not provide water year-round and are easily contaminated. They may prove most cost-effective for inducing and regulating livestock use of the pastures.

7. Studies

A variety of studies should be carried out, both sociological and evaluative, that are coordinated with the planning, implementation and evaluation of the various interventions. Much of this effort needs to be worked out, especially what would constitute a desirable and feasible set of sociological studies. The following are several topics that should be studied.

a. Villages

A rather detailed description of the villages in the Test Perimeter should be developed to provide elementary descriptive data, some information on villager knowledge and attitudes about the effects of the various interventions, and observations on their way of life and interactions with others (e.g., people from other villages, transhumants, government officials and project staff). The work of the grazing committees and association should be examined.

b. Transhumants

For at least a year, one or more studies should be made of transhumants. For example, all movements into, within and out of the Test Perimeter should be monitored. Also, the movements and activities of transhumant groups should be studied on a continuous basis throughout the year, especially including their reactions to the interventions (e.g., use of water points and of pastures) and their interactions with villagers.

c. Livestock

Studies of livestock should be carried out to see what the effects are of the interventions. For example, comparative data should be collected on the rate of starvation (death) of cattle during the dry season and loss (death) of young cattle in improved versus customarily used areas.

d. Forage

There should be documentation on the nature, type and location of forage (and of crops) throughout the Test Perimeter on a regular basis throughout the year. This would help evaluate the effects of the interventions and determine more precisely the carrying capacity of the Test Perimeter.

e. Water Points

The use of the various water points should be studied. Now that pumps have been installed in many of the wells, the effects of those located in village and non-village locations should be compared with what happens in similar places that do not have drilled wells with pumps. There should also be assessments of the effects of hand-dug wells and improved mares.

f. Firebreaks

The effects of the firebreaks in the Test Perimeter should be examined through at least another dry season, including the costs and effectiveness of various means of maintaining them. Fire prevention and fire suppression efforts should also be studied.

g. Marketing

Since one of the ultimate purposes of producing more livestock is to sell the cattle, a study should be made of the various efforts to market livestock in Mali to see what might be tried in the Test Perimeter.

h. Extension and Training

Because expatriate involvement in the development of the Test Perimeter and thereafter possibly in the rest of the DPZ should only last for a limited period, the training and extension methods used should be evaluated to see what would most likely leave a solid base for continued activity once the expatriates depart.

ANNEX I AND II

I. SOURCES

II. TERMS OF REFERENCE

ANNEX I

SOURCES

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ANNEX II

TERMS OF REFERENCE

PROJECT MALI LIVESTOCK II
STUDY GROUP
DILLY PASTORAL ZONE
MARCH 1980

1. TERMS OF REFERENCE

The Project Mali Livestock II Study Group has been formed for the purpose of assessing the situation in the Dilly Pastoral Zone with the purpose of determining what efforts in range management should be undertaken to improve livestock production. To be included in the study will be the collection of data pertaining to existing conditions and resources and the analysis of that data with the view to making recommendations for action in the Dilly Pastoral Zone.

a. To identify and describe the principal production systems for livestock and livestock products in the Dilly Pastoral Zone.

b. To identify the constraints to improving the efficiency of livestock production in the Dilly Pastoral Zone and to the expansion of production.

c. To assess those development activities for the Dilly Pastoral Zone which appear to be technically, economically and socially feasible.

2. COMPOSITION OF STUDY GROUP

The Study Group will be composed of the following Chemonics and USAID personnel.

PROJET MALI LIVESTOCK II
GROUPE D'ETUDE
ZONE PASTORALE DE DILLY
MARS 1980

1. TERMES DE REFERENCE

Le Groupe d'Etude du Projet Mali Livestock II a été constitué dans le but d'analyser la situation de la Zone Pastorale de Dilly afin de définir les moyens d'actions en aménagement pastoral qu'il faudrait entreprendre pour y valoriser la production animale. L'étude comportera la collecte des données relatives aux conditions et ressources existantes et l'analyse de ces données devant aboutir à des recommandations sur les mesures à prendre dans la Zone Pastorale de Dilly.

a. Identifier et faire état des principales méthodes de production utilisées dans la Zone Pastorale de Dilly pour le bétail et ses produits.

b. Déterminer les facteurs qui empêchent de dynamiser et d'élargir la production animale dans la Zone Pastorale de Dilly.

c. Définir les sphères d'action de développement qui semblent techniquement, économiquement et socialement réalisables.

2. COMPOSITION DU GROUPE D'ETUDE

Le Groupe sera composé des membres de Chemonics et de l'USAID qui suivent:

Mr. Thomas Griffin	Eng.-Team Leader/Ingénieur - Chef de Groupe
Mr. John Topik	Hydrogeologist/Hydrogéologue
Mr. J. Hall	Economist (USAID)/Economiste (USAID)
Mr. Kay Wilkes	Range Management/Expert Gestion des Pâturages
GRM personnel	As assigned by the Director of the Project/ Affecté à l'étude par le Directeur du Projet

3. WORK PLAN

a. The initial effort in the Dilly Pastoral Zone will be to make an inventory of the Zone with respect to:

Current forage production
AUMS, kg/ha, species composition,

Current Water Sources
Kind, number, volume and quality,

Current grazing use patterns
(Range condition)
Transhumant trails
Location and area of overused areas - underutilized areas,

Current livestock use
Village livestock - numbers, time, and area grazed - transhumant livestock - numbers, time, and area grazed, average weights, calving and lambing percentages, sex ratio, age classification, death losses, and number marketed.

Current fire problems
Average number of man-caused fires and area burned
Average number of lightning fires and area burned
Forage lost to fire

Current erosion hazard
Percentage of area and location of active dunes
Water erosion hazard areas and trends.

3. PLAN DE TRAVAIL

a. L'étape initiale dans la Zone Pastorale de Dilly consistera à faire un inventaire de la Zone dans les domaines suivants:

Production habituelle de fourrage
Unité de Bétail/Mois, composition des espèces,

Sources d'eau actuelles
Genre, quantité, volume et qualité

Méthodes habituelles d'utilisation des Pâturages (Etat des pâturages)
Pistes de transhumance
Emplacement et zones surpâturées - zones sous-pâturées,

Utilisation présente du bétail
Cheptel du village - quantité, zone pâturée et durée de pâturage - bétail transhumant - quantité, zone pâturée et durée de pâturage - poids moyen, pourcentage de natalité, pourcentage animaux par sexe, classe d'âge, mortalité, quantité commercialisée.

Problèmes courants d'incendie
Moyenne de feux occasionnés par l'homme et zone touchée
Moyenne de feux provoqués par la foudre et zone touchée
Perte de fourrage due au feu de brousse

Eventualité d'érosion
Surface et emplacement - pourcentage des dunes mouvantes dans la zone
Erosion par ruissellement, zones et tendances.

Current wildlife situation
Wildlife species, numbers, importance.

b. The above information, when collected, will serve as the base from which to project resource potentials in the zone. Later it can serve as a basis for evaluating any programs which may be undertaken to develop those resources. At this point, the Study Group lists the following as potential resources in the zone:

Potential forage production
AUMs, kg/ha, species composition,

Potential water developments
Number, volume, locations, type,

Potential livestock use
Number, area, time, village herds,
Number, area, time, transhumant herds,
Weights, lambing and calving percentage, death loss, sex ratio, number marketed.

Potential improvement in grazing use patterns
Shifting use from over-used areas to under-used areas - improvement in range condition.

Potential for protecting forage by firebreak network
Kilometers of primary and secondary breaks,
AUMs of forage protected - reduction in area burned.

Potential for reducing number of man-caused fires - presuppression
Reduction in number of man-caused fires, reduction in area burned - AUMs of forage protected

Situation présente de la faune
Espèces de faune, quantité, importance.

b. Les données ci-dessus une fois réunies, serviront de base à la définition des potentialités de la zone. Plus tard, elles pourront servir de base à l'évaluation de tout programme de développement desdites potentialités. Pour le moment le Groupe d'Etude recense ce qui suit comme ressources potentielles de la zone:

Production fourragère potentielle
Unité de Bétail/Mois - kg/ha - composition des espèces

Potentiel d'aménagement des sources
Nombre, volume, emplacement, type,

Utilisation potentielle du bétail
Quantité, superficie, durée, cheptel du village,
Quantité, superficie, durée, troupeaux transhumants
Poids, pourcentage de natalité, de mortalité, d'animaux par sexe, quantité commercialisée.

Possibilités d'amélioration des méthodes d'utilisation des pâturages
Changement d'utilisation des zones surpâturées vers celles sous-pâturées - amélioration de l'état des pâturages.

Potentialité de protection de fourrage par un réseau de pare-feux
Dimension (km) des pare-feux primaires et secondaires,
Unité de Bétail/Mois de fourrage préservé, réduction de superficie touchée.

Possibilité de limitation d'incendie provoqué par l'homme - mesures préventives
Limitation des incendies provoqués par l'homme, limitation de la superficie touchée - Unité de Bétail/Mois de fourrage préservé.

Potential for reducing erosion hazard
% of area with active dunes - location.

Potential wildlife development
Species, numbers, importance, etc.

It is intended that the data collected and the potential for development will be presented in the form of maps, graphs, tables, and narrative.

4. LIMITATIONS

To undertake an exhaustive inventory of the entire Dilly Pastoral Zone is beyond the capability of the present Study Group considering the number of participants and the limited amount of time available to the Group. However, within the means available the Group proposes to initiate the survey and inventory immediately. It may have to recommend an increase in both manpower and time or the acceptance of alternative courses of action.

5. ALTERNATIVES TO FULL DEVELOPMENT OF PASTORAL ZONE

To undertake an inventory and analysis program as set forth will require commitment of substantial manpower and funds.

The Project Direction may want to consider the limited alternatives already identified and select one or a combination that would require less intensive inventory and analysis, and one that is felt to be within the existing manpower, funding and management capability.

Possibilités de limitation de l'érosion
Pourcentage en superficie des zones ayant des dunes mouvantes - emplacement.

Potentialité de développement de la faune
Espèces, quantité, importance, etc.

On prévoit de présenter les données collectées et les potentialités de développement sous forme de cartes, schémas graphiques et rapports.

4. FACTEURS DE RESTRICTION

Inventorier de manière exhaustive la totalité de la Zone Pastorale de Dilly est au-dessus des forces du Groupe d'Etude, compte tenu du nombre des participants et du laps de temps qui lui est imparti. Toutefois, dans la mesure des moyens dont il dispose, le Groupe se propose d'entamer aussitôt l'étude et l'inventaire. Il pourrait avoir à recommander un surcroît d'effort et de temps ou l'adoption d'autres voies et moyens.

5. SOLUTIONS ALTERNATIVES A LA MISE EN VALEUR TOTALE DE LA ZONE PASTORALE

Un inventaire et un programme d'études tels qu'on les prévoit, nécessitent un apport substantiel d'effort et un engagement considérable de fonds.

La Direction du Projet voudrait peut-être examiner les quelques alternatives déjà trouvées et opter pour l'une d'elles ou une combinaison qui nécessiterait un peu moins d'intensité dans l'inventaire et l'analyse, solution qui semblerait être appropriée à la dépense d'énergie, au financement et à la capacité de gestion dont on dispose.

To this end the Group proposes, following its field work to present with appropriate maps, tables, graphs and narrative the various alternatives that it perceives to be appropriate. Included in the analysis of the various alternatives would be costs and benefits. The Study Group considers that among others, the following alternatives exist:

(1) Fully develop Test Perimeter to determine feasible and practical practices for broad application throughout the Dilly Pastoral Zone.

(2) Develop water to utilize present ungrazed areas.

(3) Establish management units throughout the Pastoral Zone based on village community of interest, ethnic groups, topography, traditional grazing areas, etc.

(4) Combination or alternatives (2) and (3)

(5) Firebreak system and presuppression program

(6) Establish management units, alternative (3) and develop range management plan.

- grazing system
- firebreaks - presuppression program
- water developments

(7) Establish management units, alternate (3) and develop range and livestock management pla for each unit.

- grazing systems
- water developments
- firebreaks and presuppression program
- livestock management

A cette fin, le Groupe se propose après évolution sur le terrain de présenter avec cartes, diagrammes et schémas et rapports à l'appui, les différentes solutions qu'il trouverait adéquates. On incluera les coûts et bénéfices dans l'analyse des diverses solutions. Le Groupe d'Etude croit qu'entre autres il existe les solutions suivantes:

(1) Mettre en valeur la totalité du Périmètre test pour déterminer les méthodes réalisables et pratiques pour une application plus large dans la Zone Pastorale de Dilly.

(2) Aménager les ressources en eau pour les zones non pâturées qui existent.

(3) Instituer des unités de gestion sur l'étendue de la Zone Pastorale partant de la communauté d'intérêts des villages, des groupes ethniques, de la topographie des zones traditionnelles de pâturages, etc.

(4) Combinaisons des solutions (2) et (3)

(5) Système de pare-feux et programme de prévention.

(6) Etablir des unités de gestion, solution (3) et élaborer un plan d'aménagement pastoral.

- système de pâturage
- pare-feux - programme de prévention
- aménagement des sources d'eau

(7) Instituer des unités de gestion, solution (3) et élaborer un plan de gestion des pâturages et du bétail pour chaque unité.

- système de pâturage
- aménagement des sources d'eau
- pare-feux et programme de prévention
- gestion du bétail

(8) Do nothing.

6. DISCUSSION OF ALTERNATIVES

Alternative (7) represents the most intensive management and development program. It will achieve the full potential within the shortest time frame; however, the investment costs and manpower requirements to develop and implement the program would be considerable and would require substantial management capability to continue the program once implemented.

Alternative (2) represents a simple approach, and if favored by management at this time, it could be implemented with limited supporting inventory and analysis. Water development could be planned to control the amount of grazing to the capacity of the range. No regard would be necessary as to whose cattle grazed or the time they remained in the area.

Alternative (3) would assign various management units to specific villages resulting in more orderly grazing use eliminating competition to use best areas first. If this alternative were selected at this time very little inventory and analysis would be required. It could be implemented with little commitment of manpower and funding. No additional grazing use would be feasible.

Combination of alternatives (4) and (5) would be more costly and complex and would require some management capability but should produce favorable results. Limited inventory required.

(8) Ne rien faire.

6. DISCUSSION DES ALTERNATIVES

L'alternative (7) représente le programme de gestion et de développement le plus intensif. Elle permettra de réaliser le potentiel maximum dans le plus court délai, cependant les coûts des investissements et la main d'oeuvre nécessaires pour l'élaboration et la mise en oeuvre du programme seront très élevés; cette alternative implique aussi une capacité de gestion substantielle pour la poursuite du programme après sa mise en oeuvre.

L'alternative (2) représente une approche simple et, au cas où la Direction lui accorde un intérêt en ce moment, il est possible qu'elle puissent être réalisée en utilisant un inventaire et une analyse d'appui réduits. On pourrait aménager des points d'eau de façon planifiée afin d'adapter la charge de pâturage à la capacité de la zone. Il ne sera plus nécessaire de tenir compte de l'appartenance du troupeau ou de la durée de séjour du troupeau dans la zone.

L'alternative (3) propose diverses unités de gestion pour des villages spécifiques, ce qui aboutira à une utilisation plus disciplinée du pâturage, éliminant ainsi la compétition pour l'utilisation des meilleures zones d'abord. Si cette alternative était retenue en ce moment, elle ne nécessitera que très peu d'inventaire et d'analyse. Elle peut être exécutée sans une main d'oeuvre et des fonds importants. On ne pourrait pas faire une utilisation supplémentaire de pâturage.

La combinaison des alternatives (4) et (5) serait plus coûteuse et plus complexe et exigerait une certaine capacité de gestion, mais elle donnera des résultats plus avantageux. Un inventaire restreint sera nécessaire.

Alternative (6) would result in a program throughout the pastoral zone similar to that proposed for the Test Perimeter but without the experimental features.

A word of caution - once a lower cost alternative is selected and implemented, a more intensive alternative may not be selected later without redoing or realizing previous work that may not exactly fit a more intensive program, thus resulting in greater overall costs and manpower commitments. Range management programs are long-term programs requiring maintenance and management for the full term.

Benefit/cost will be estimated for various investment levels. The following items will be analyzed separately and in various combinations.

a) Firebreaks only

b) Management only
   i) Controlled grazing only
   ii) technical support only (health review, etc.)
   iii) technical advice only (advising on cow-calf operation, etc.)

c) Various numbers and sizes of surface water collecting points. For example - given a 10 sq. kilometer area, vary the number of water points on estimated % area utilized.

Investment and recurring costs will be estimated for each alternative.

L'alternative (6) aboutirait à un programme global pour toute la zone pastorale similaire à celui proposé pour le Périmètre test, mais sans les aspects d'expérimentation.

Mise en garde - Une fois qu'une alternative de moindre coût est choisie et mise en oeuvre, on ne pourrait pas choisir une alternative plus intensive plus tard sans refaire le travail accompli précédemment, travail qui pourrait ne pas s'appliquer dans un programme plus intensif, ce qui aboutira à un coût total plus élevé et à une main-d'oeuvre plus importante. Les programmes de gestion du pâturage qui réussissent sont des programmes à long terme qui requièrent de la continuation dans la gestion pendant toute la période prévue.

Le rapport bénéfice/coût sera estimé pour divers niveaux d'investissement. Les éléments suivants seront analysés séparément et dans diverses combinaisons.

a) Pare-feux seulement

b) Gestion seulement
   i) pâturage contrôlé seulement
   ii) support technique seulement (contrôle sanitaire, etc.)
   iii) conseil technique seulement (conseil sur opération de naissage, etc.)

c) Divers points d'eau de surface d'étendue variées. Par exemple, une superficie de 10 km^2, varie le nombre de points d'eau sur une estimation en % de terres utilisées.

L'investissement et les coûts de revient seront calculés pour chaque alternative.

The value-article under each lternative will be estimated at:

a) the herder level
b) the export level

Internal rates of return will e calculated for each alternative.

ANALYSIS RESULTS

At the conclusion of the analsis of all the pertinent informaion the Study Group will recomend to the Project Direction the referred course of action in its eport. However, the Project Diection can review the alternaives presented and can then hoose the most appropriate alterative considering the resources vailable.

SCHEDULE

The Study Group proposes an nmediate departure for Dilly enter following approval of this ork plan.

GISTIC ANNEX

ransport - A minimum of two Landovers or other 4 wheel drive veicles are required by the Study roup for full time use upon arival in Dilly Center. Unless hese vehicles can be made availble full time there is little oint in undertaking the survey.

odging - The three guest units at ne Center will be required for a inimum of two weeks.

erial Reconnaissance - To save ime and effort the Study Group ecommends strongly that the inital reconnaissance of the entire illy Zone be done by air. This ill permit the entire group to btain a clear overview of the ntire zone.

La valeur unitaire de chaque alternative sera évaluée:

a) au niveau de l'éleveur.
b) au niveau de l'exportation

Le taux interne de revient sera calculé pour chaque alternative.

7. RESULTATS D'ANALYSE

En fin d'analyse de toutes les informations pertinentes le Groupe d'Etude, dans son rapport, fera des recommandations à la Direction du Projet quant à l'action à mener de préférence. Cependant la Direction du Projet pourra passer en revue les alternatives présentées et choisir celle qui est la plus appropriée compte tenu des ressources disponibles.

8. PROGRAMME

Le Groupe d'Etude propose un départ immédiat pour le Centre de Dilly dès que ce plan de travail sera approuvé.

ANNEXE LOGISTIQUE

Transport - A l'arrivée du Groupe d'Etude au Centre de Dilly il lui faut deux Landrovers à plein temps. A moins que ces véhicules soient disponibles à plein temps, cela servirait à peu de choses d'entreprendre ces études.

Logement - Les trois logements du Centre seront requisitionnés pour un minimum de deux semaines.

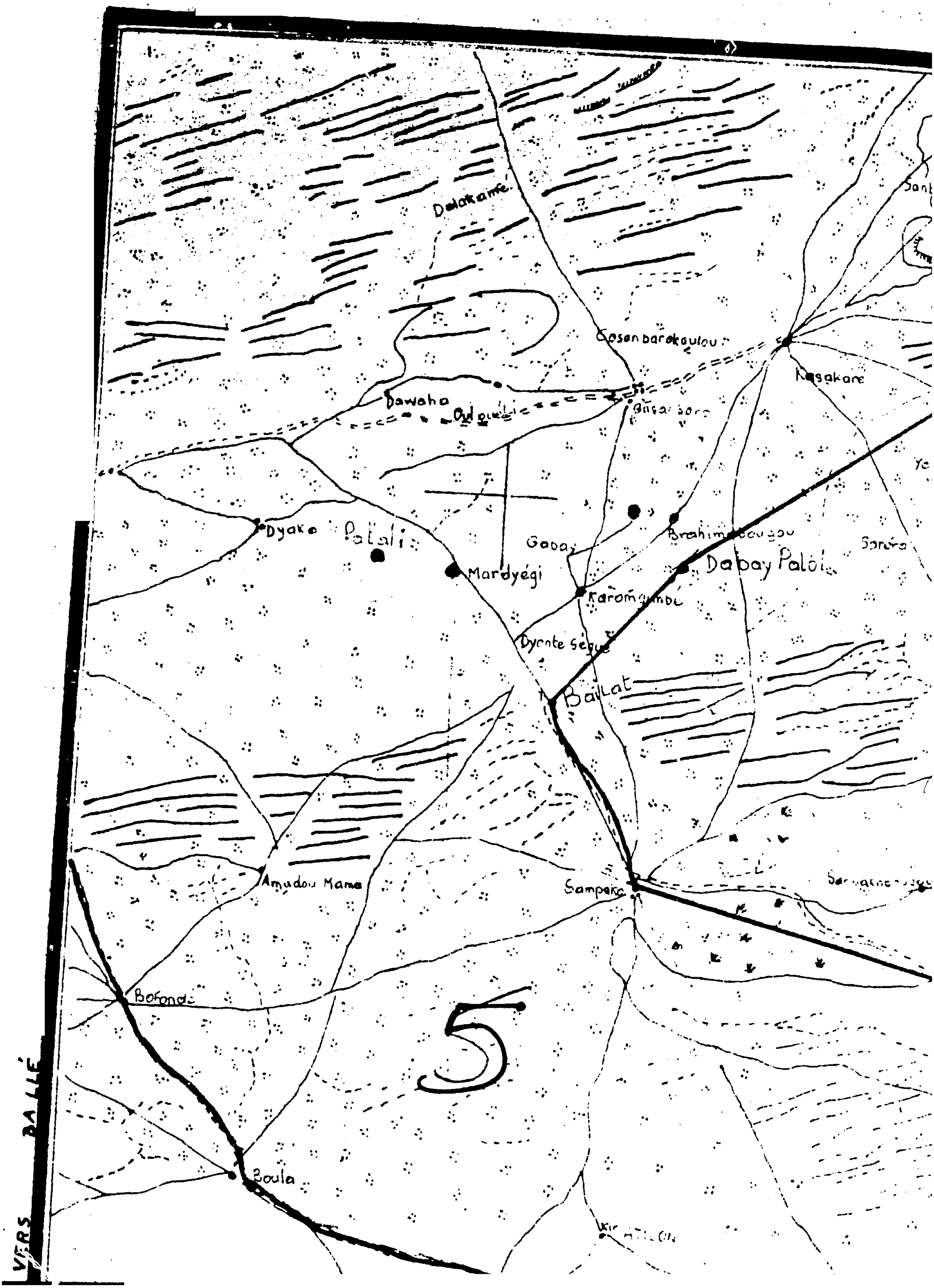
Reconnaissance aérienne - Pour gagner du temps et économiser des efforts le Groupe d'Etude recommande fermement que la reconnaissance initiale de toute la zone de Dilly soit effectuée par avion. Ceci permettra à tout le groupe d'avoir une vue d'ensemble claire de toute la zone.

Secretarial Assistance - Upon return to Bamako for the analysis and report writing phase the Group will require the services of two bi-lingual secretaries for at least one week.

Food - The group will provide for its own foodstuffs at Dilly but will require transport of some items from Bamako.

Travail de Secrétariat - A son retour à Bamako pour la phase d'analyse et la rédaction du rapport le Groupe aura besoin des services de deux secrétaires bilingues pendant au moins une semaine.

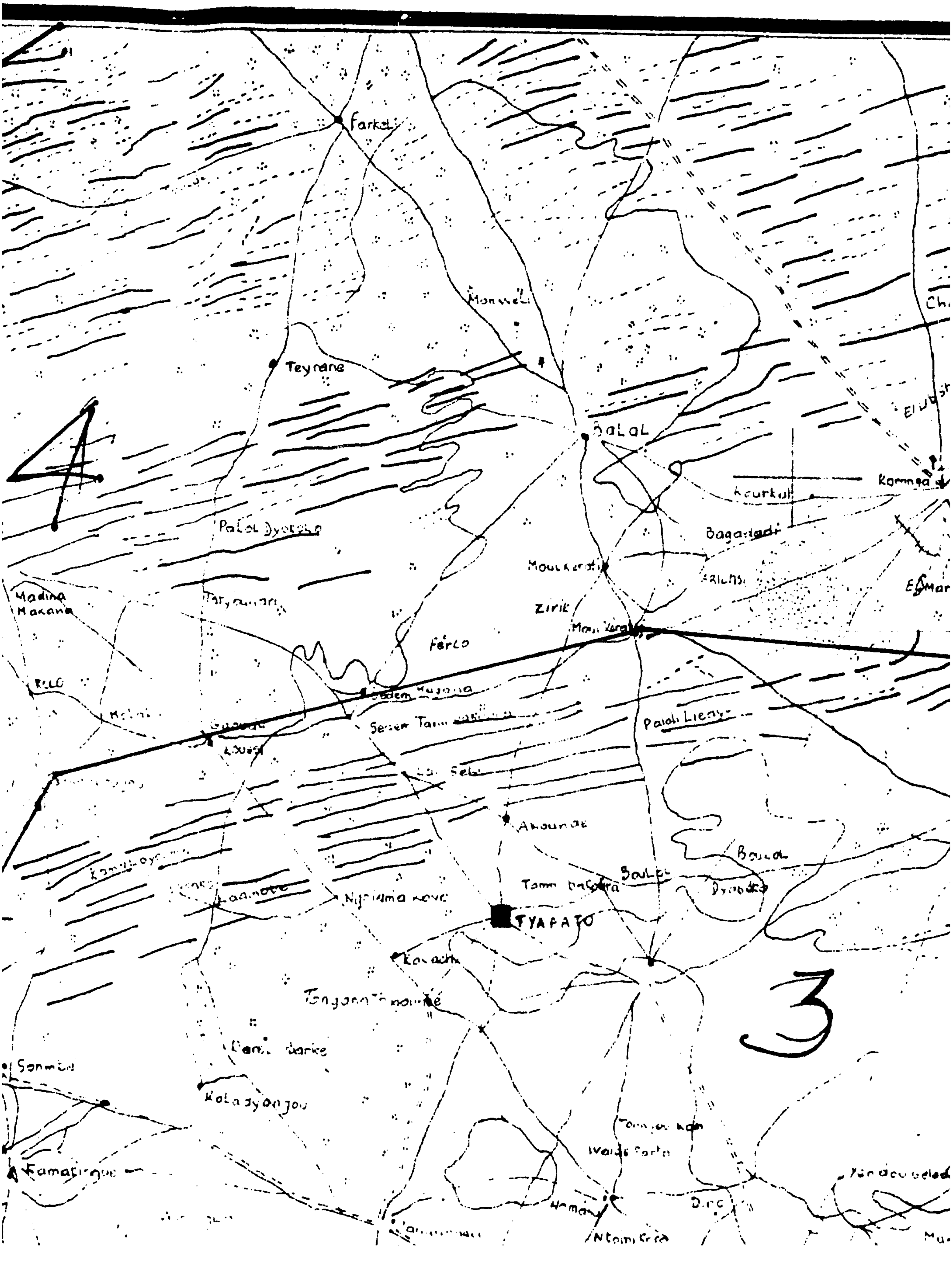
Nourriture - Le groupe se chargera de sa nourriture pendant qu'il est à Dilly mais aura besoin de moyens de transport pour acheminer certains articles de Bamako.

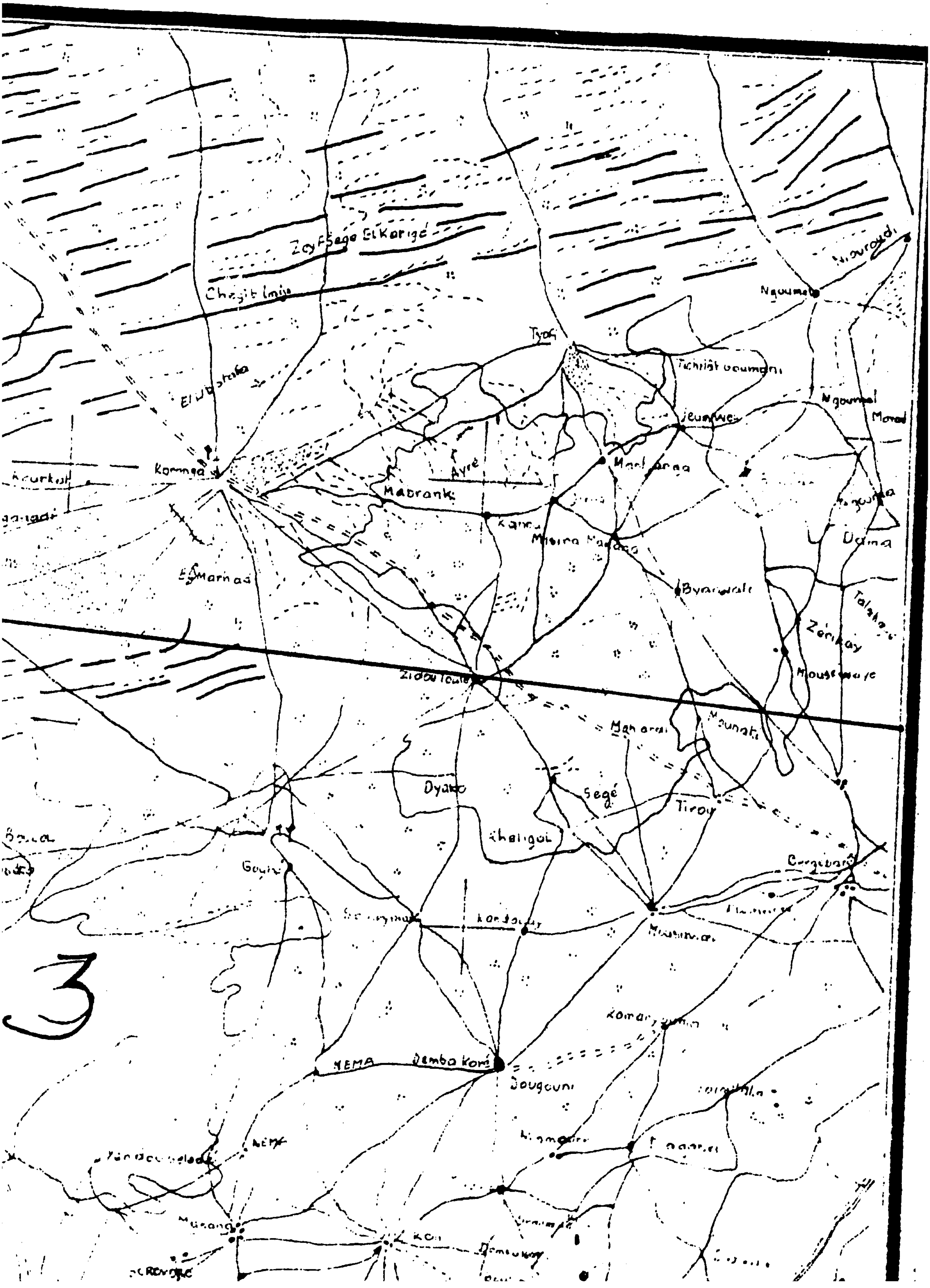


Dalakanfe
Kasakare
Dawaha
Dyako
Patali
Mardyégi
Gabay
Dabay Palol
Ballat
Amadou Mama
Sampeka
Bofona
5
Boula
VERS BALLIÉ

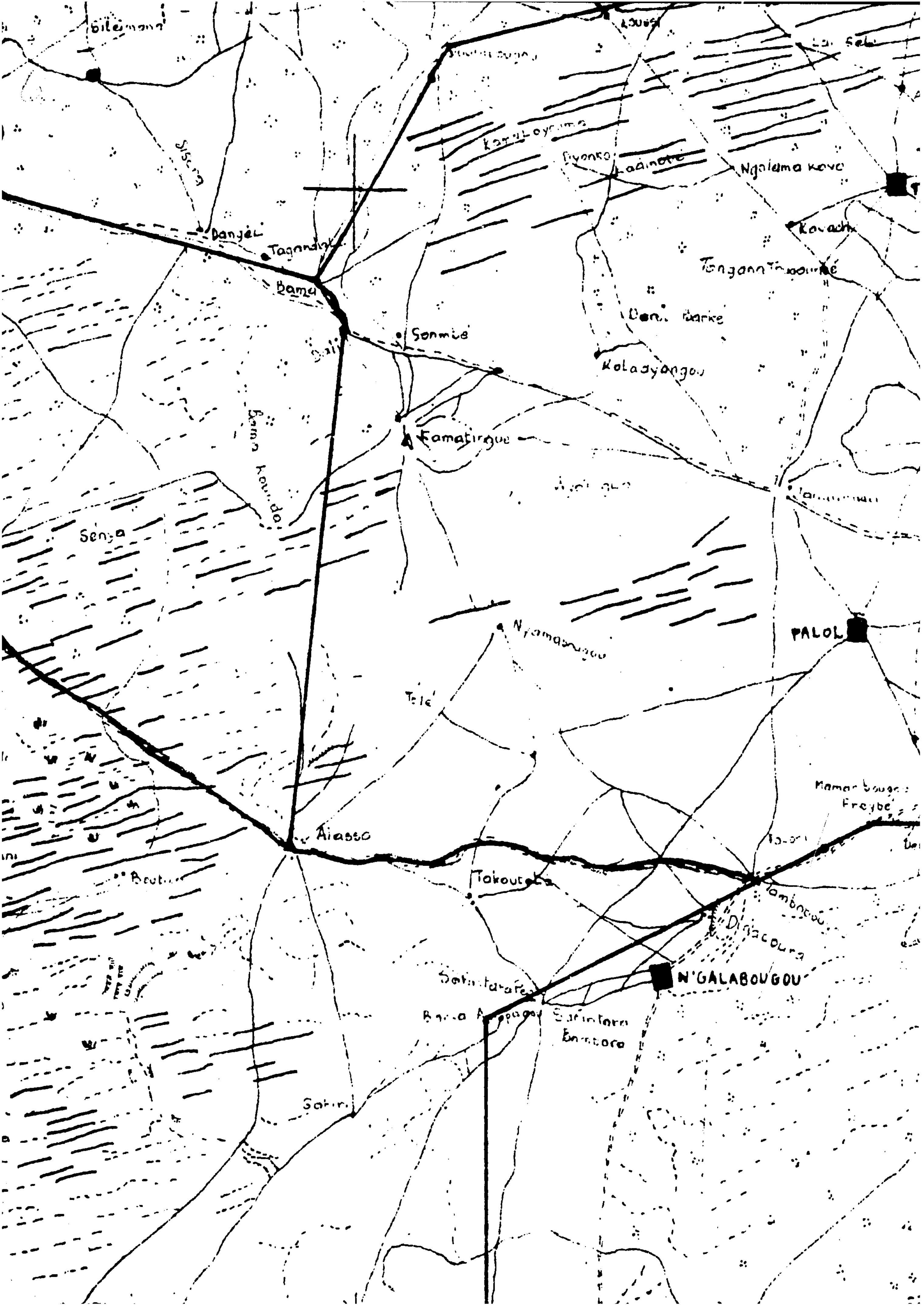
ZONE PASTORALE

PASTORALE DE DILLY

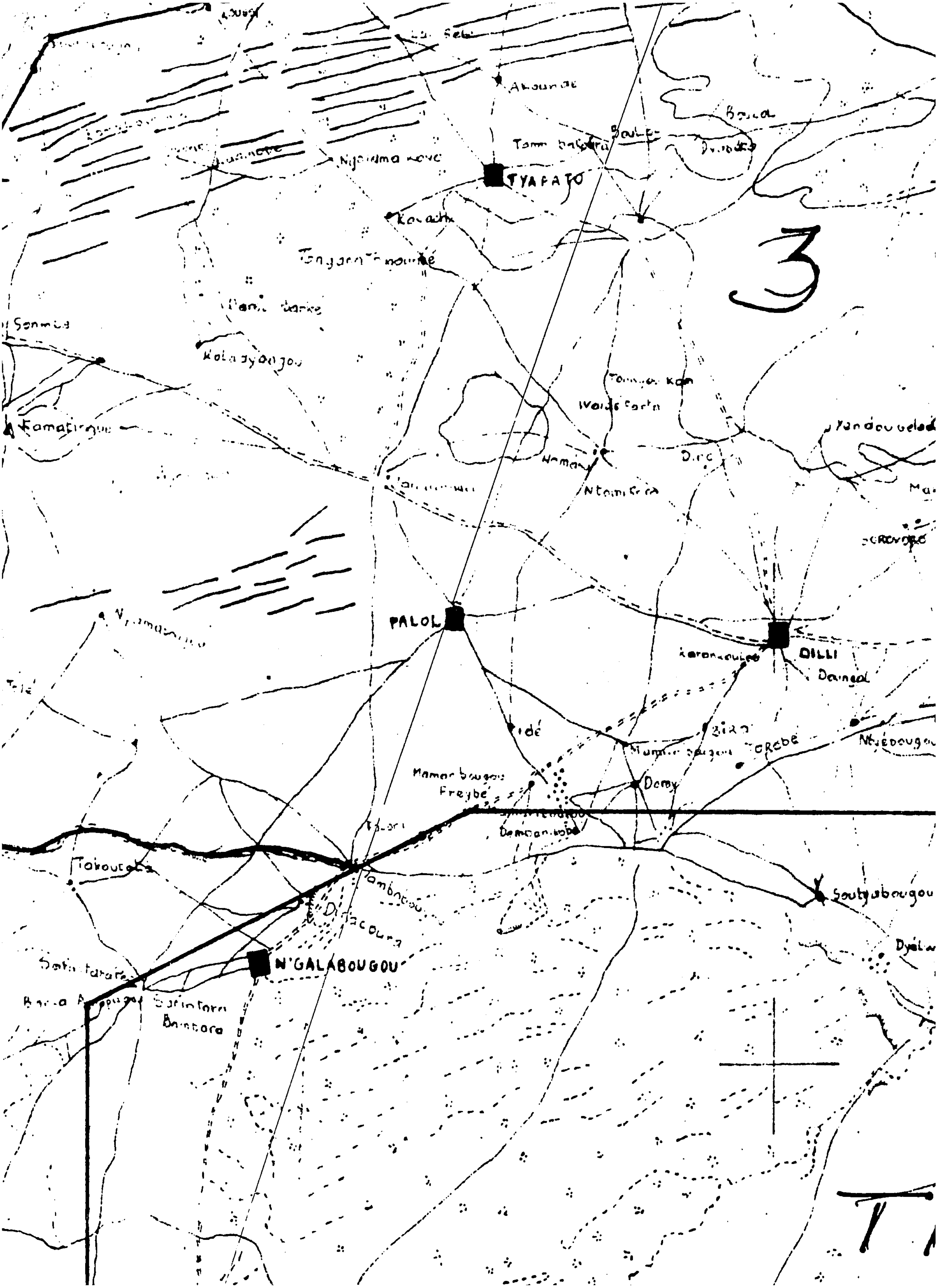


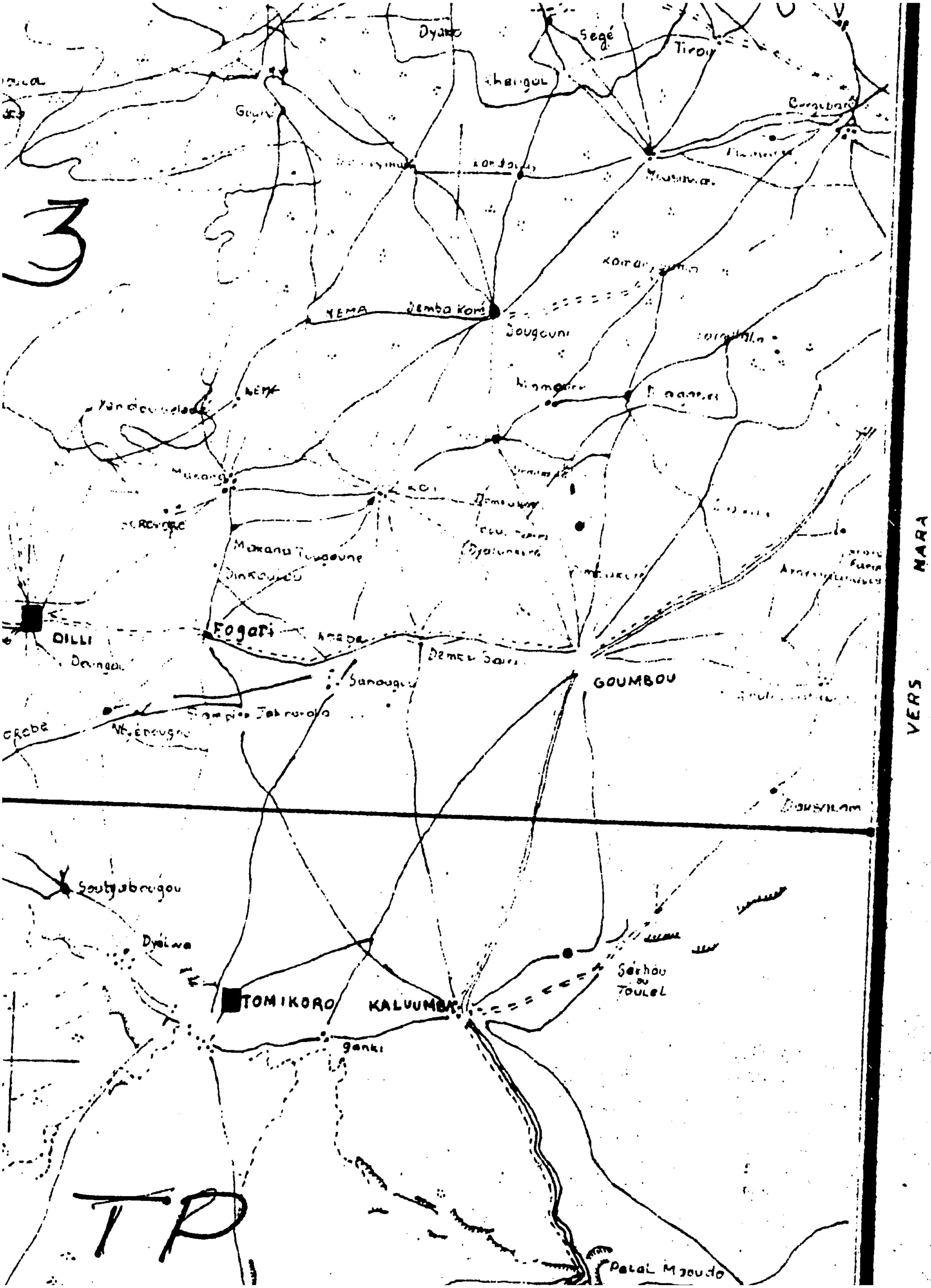

Zeyf Sege El Karigé
Ngouma
Tichrilt Goumani
Mabrank
Ayré
Dyako
Segé
Tirou
NEMA
Demba Koré
Zerikay
3

VERS BALIÉ
Amadou Mama
Sampeka
Boula
5
ATILON
Tiofingbougou
Mamaribougou
TJIRIKI
Awegna
FALAKATI
Kowari

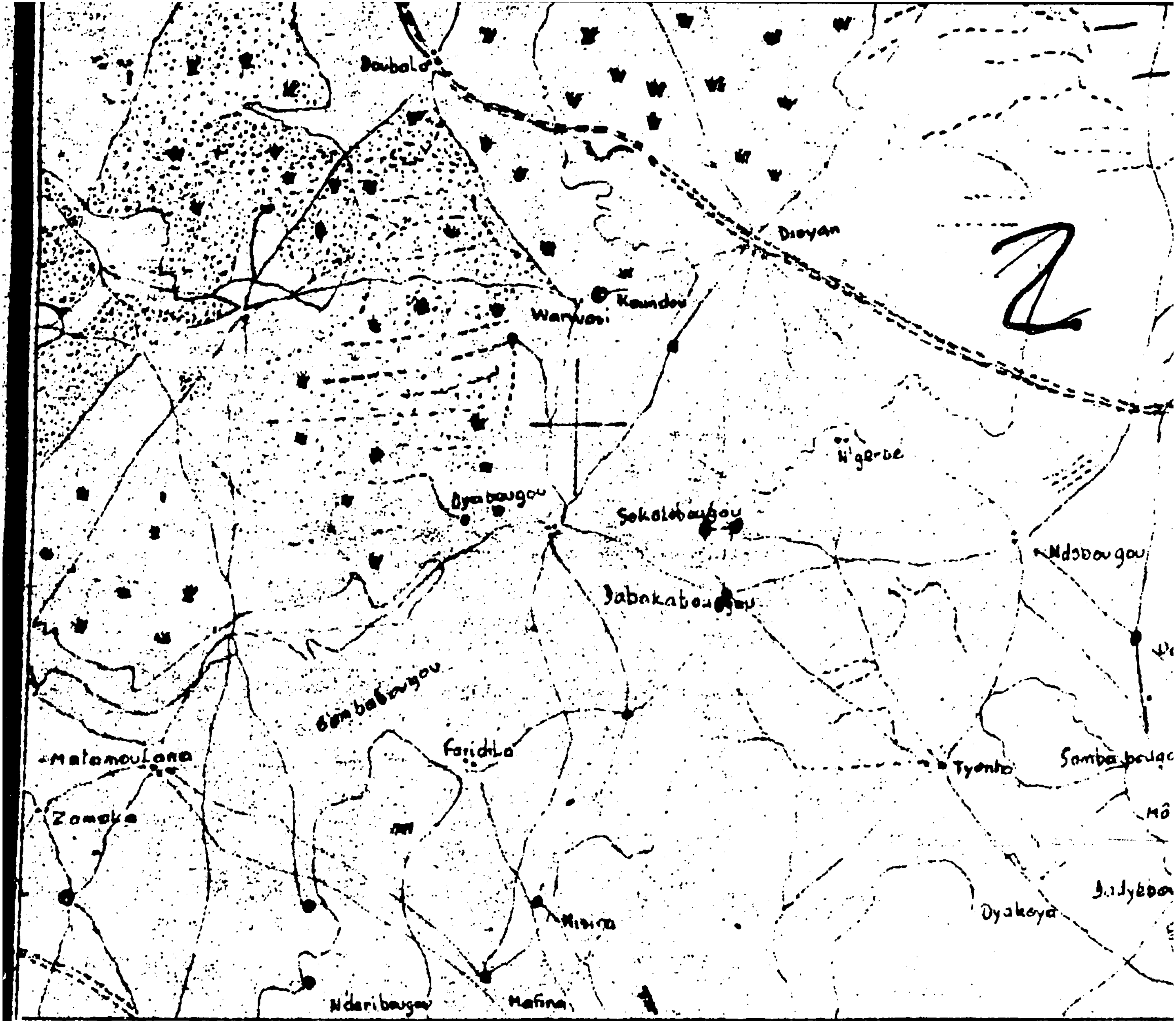


Ngalema kova
Bama
Sonmié
Kaladyangou
Kamatirgue
Senga
PALOL
Aiasso
Freybé
Diacoura
N'GALABOUGOU
Sakin


3
TYAFATO
PALOL
DILLI
N'GALABOUGOU
Kolodyougou
Mamarbougou
Freybé
Soutyabougou
Diacoura
Ntomisfora



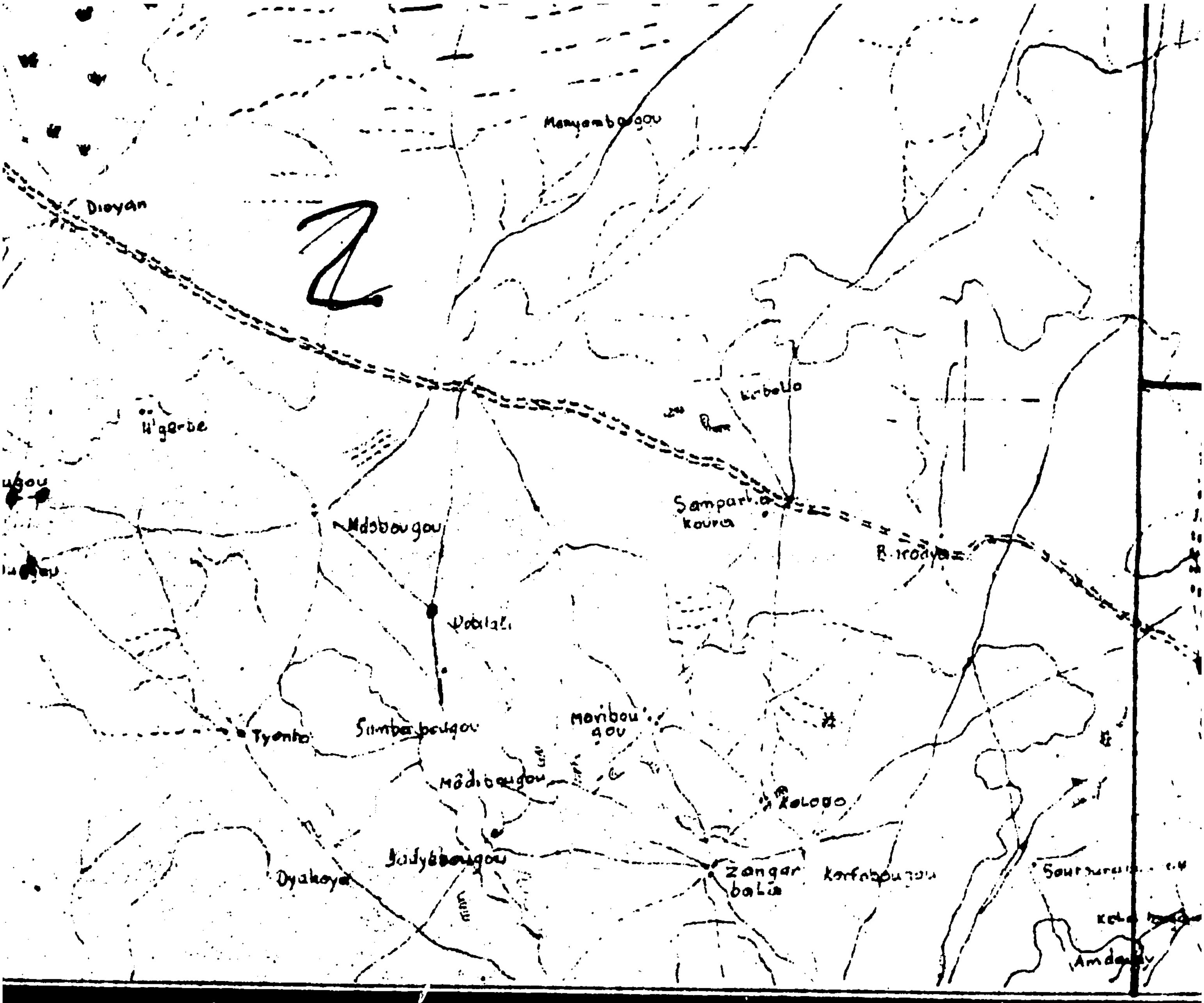
Dyako
Segé
Tiroi
Gouni
YEMA
Dembo Koré
Sougouni
Makana Tougoune
DILLI
Fogari
Demba Sara
Sanougou
GOUMBOU
Soutjabougou
Dyéwa
TOMIKORO
KALUUMBA
Sérhou ou Toulel
Ganki
Petal Maoudo
VERS NARA
3
TP



1 SCARPEMENT 2 TALUS

RIZIERE INONDABLE

ZONE INONDABLE



VERS MOURDIA

LEGEND

I SCARPEMENT 2 TALUS

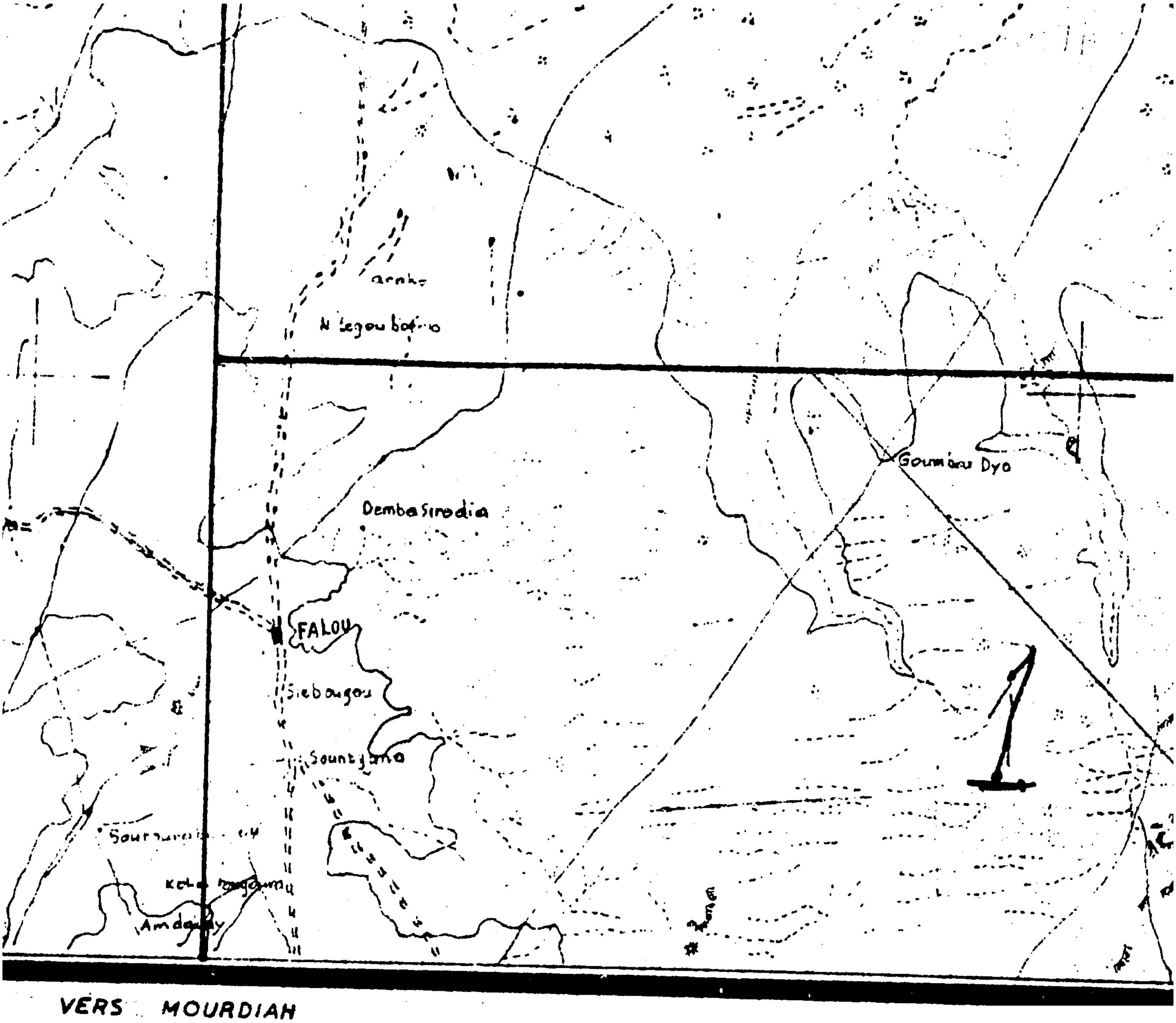
RIZIERE INONDABLE

ZONE INONDABLE

CO

SA

DU



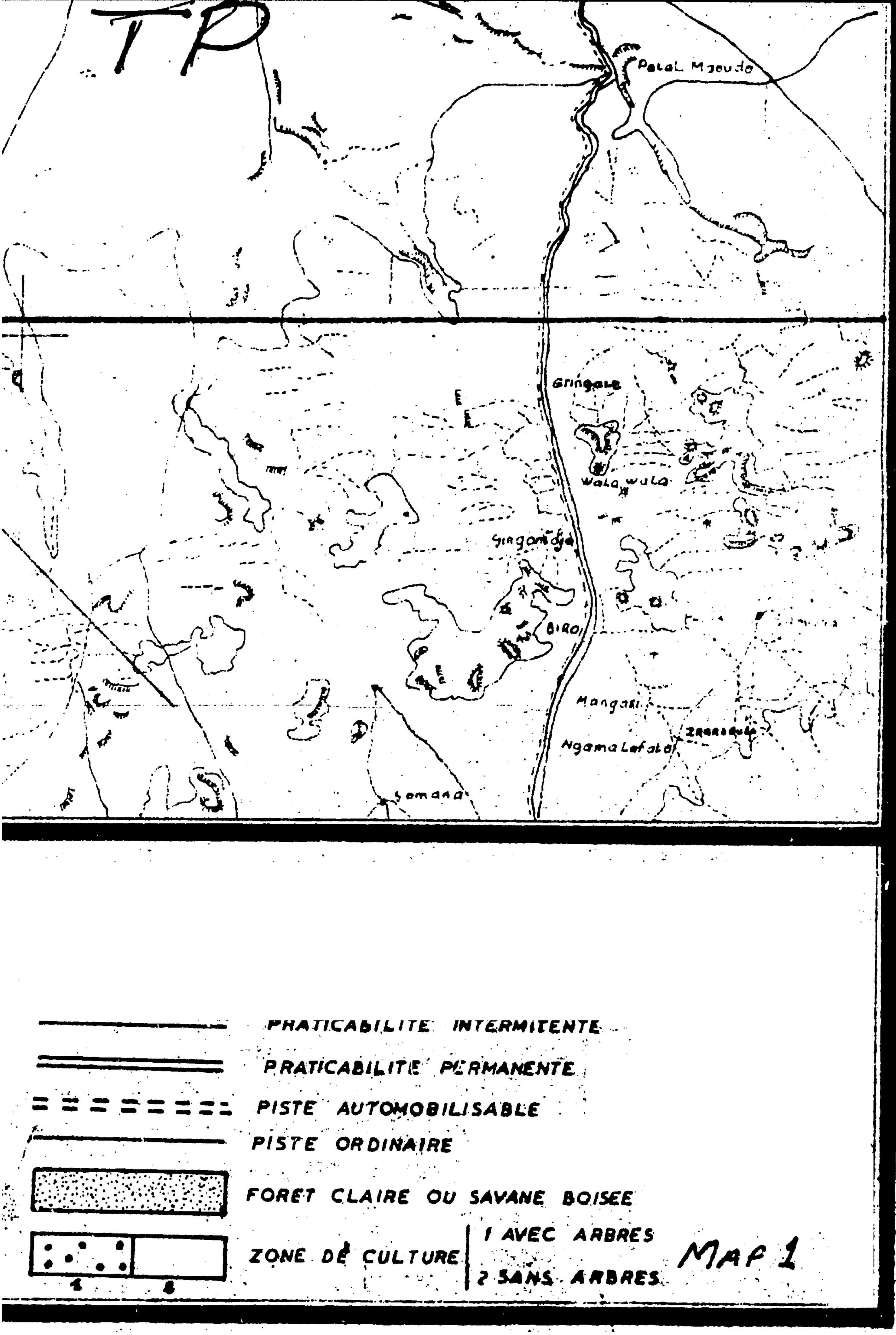
VERS MOURDIAH

LEGENDE

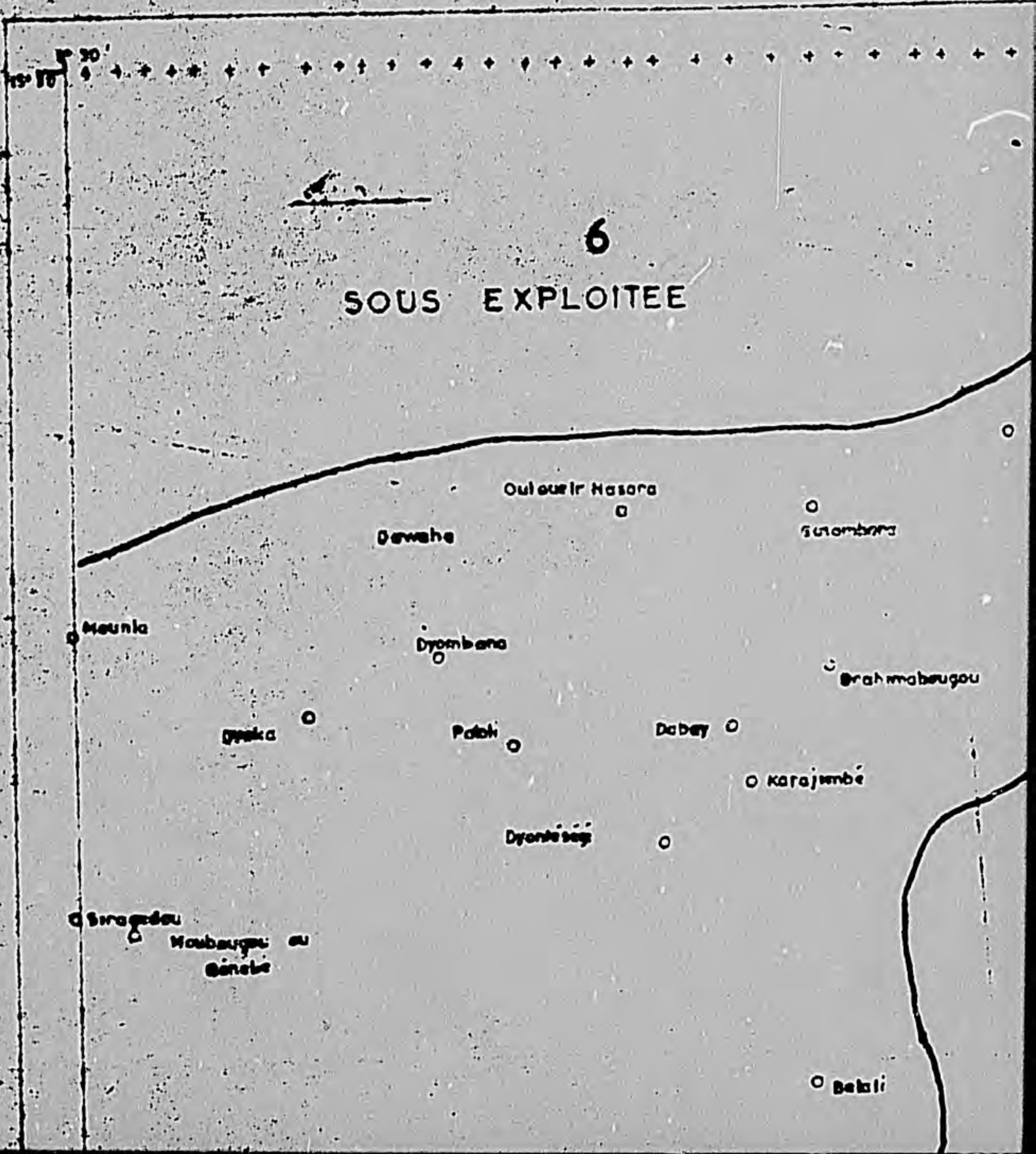
COURS D'EAU A SEC UNE PARTIE DE L'ANNEE

SABLES HUMIDES ET ALLUVIONS

DUNES ET SABLES VIFS

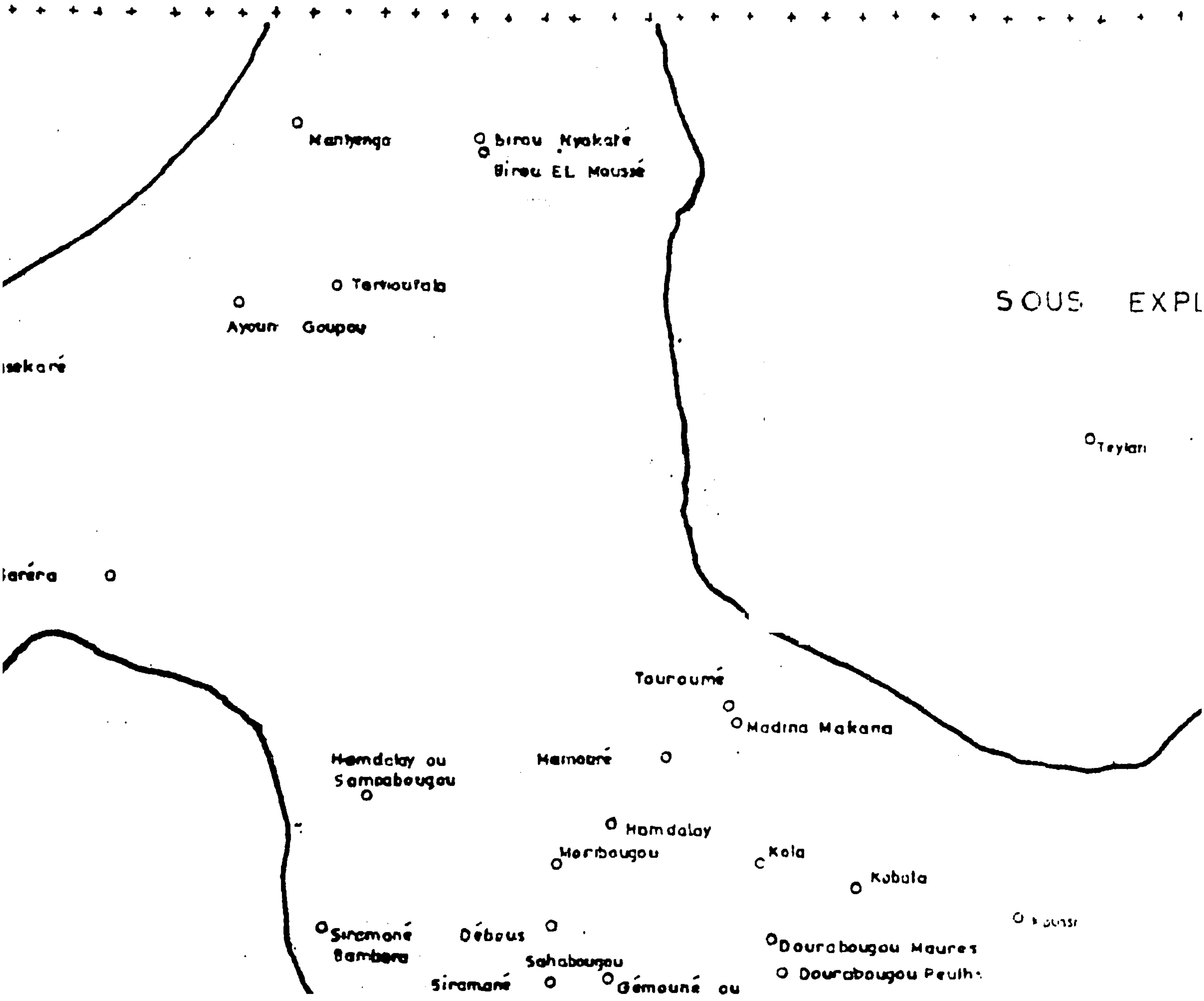


TP
Gringale
Wala wula
BIRO
Mangasi
PRATICABILITE INTERMITENTE
PRATICABILITE PERMANENTE
PISTE AUTOMOBILISABLE
PISTE ORDINAIRE
FORET CLAIRE OU SAVANE BOISEE
ZONE DE CULTURE
1 AVEC ARBRES
2 SANS ARBRES
Map 1


6
SOUS EXPLOITEE
Ouloueir Hasora
Dewahe
Mounia
Dyombana
Palok
Dabey
Karajembé
Belali

ZONE PASTORALE DE
ZONES SOUS-EXPLOITE

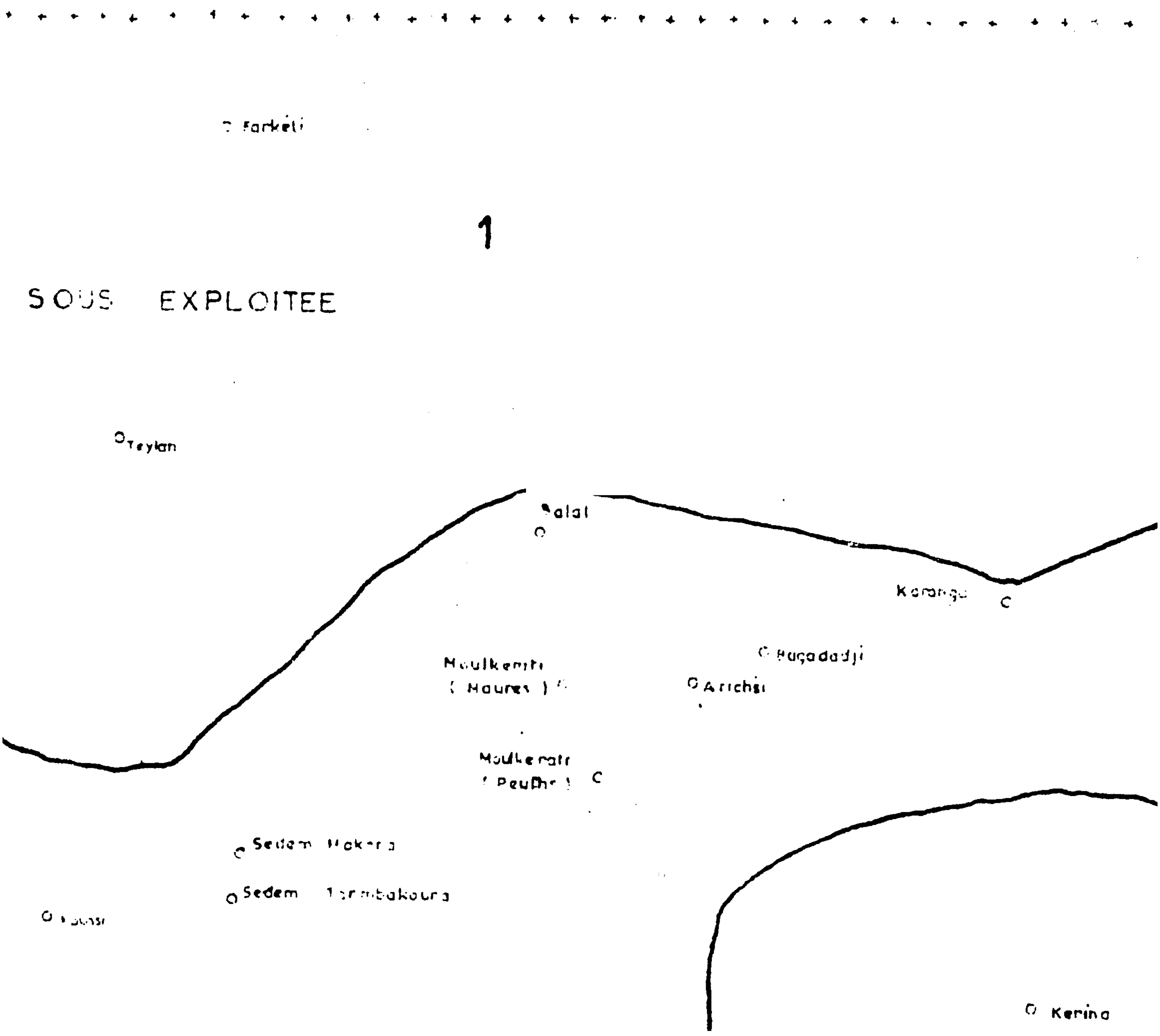
PASTORAL ZONE OF DILLY
UNDER UTILIZED AREAS

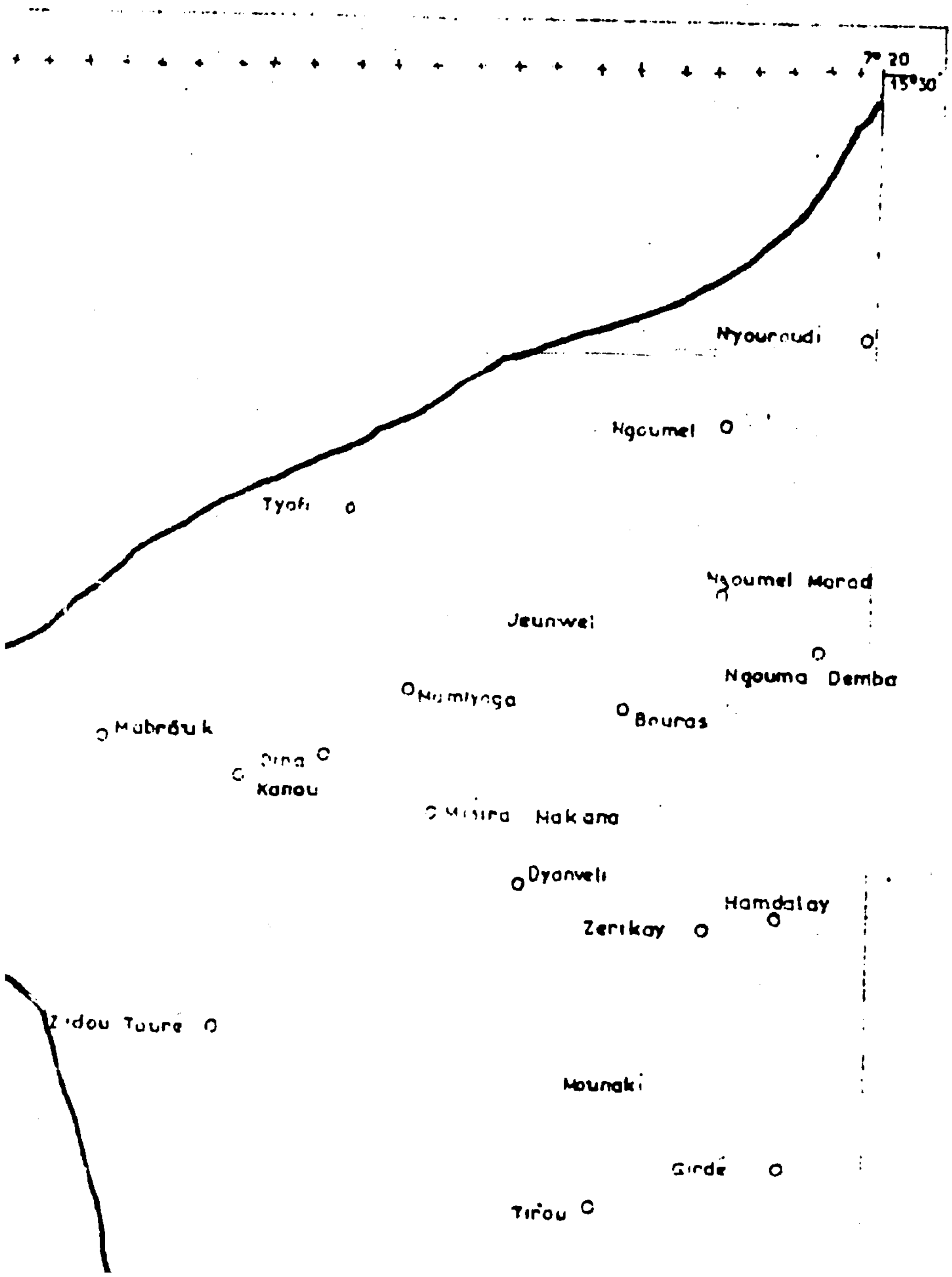


DE DILLY

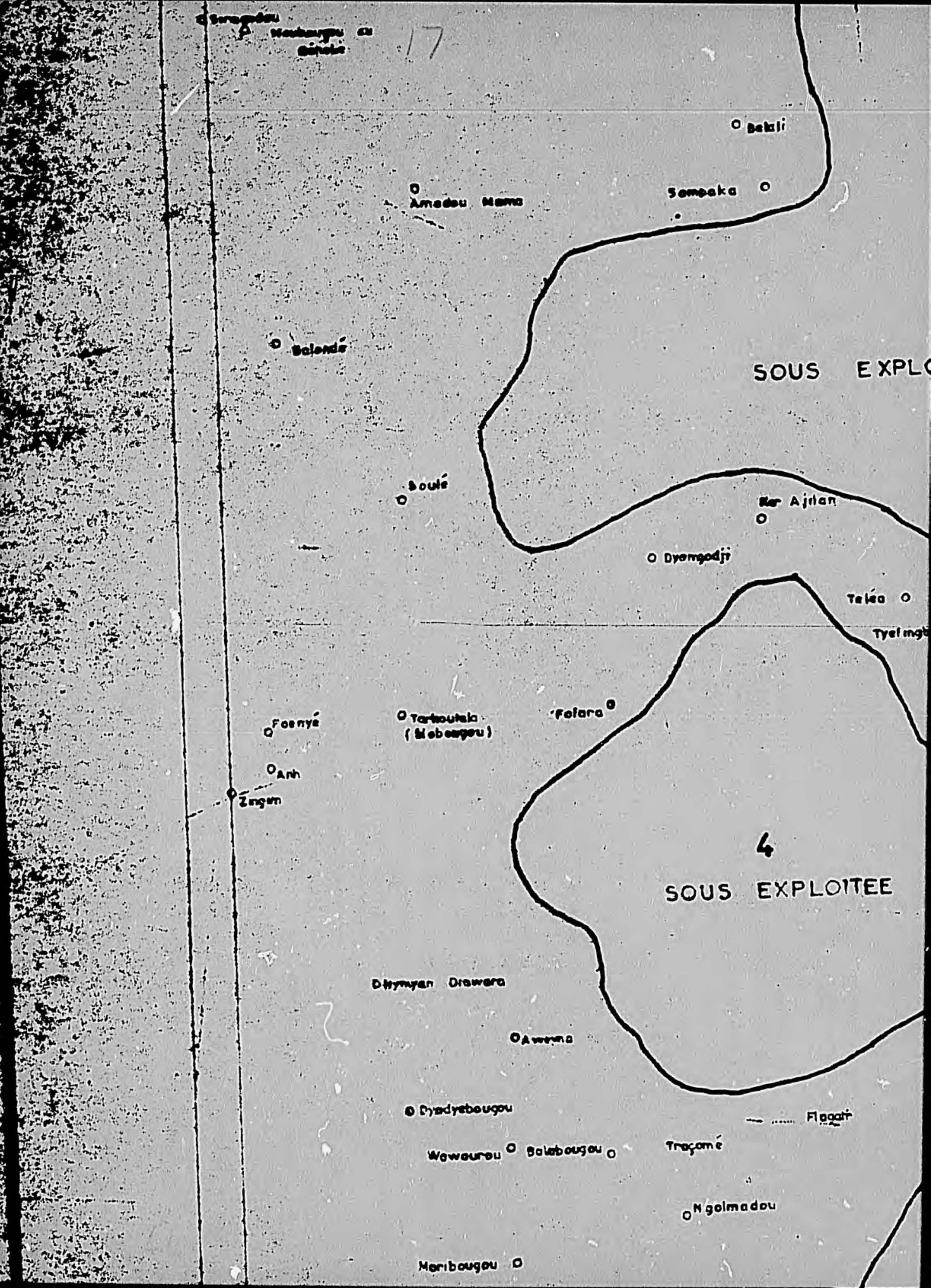
PLOITEE

LY

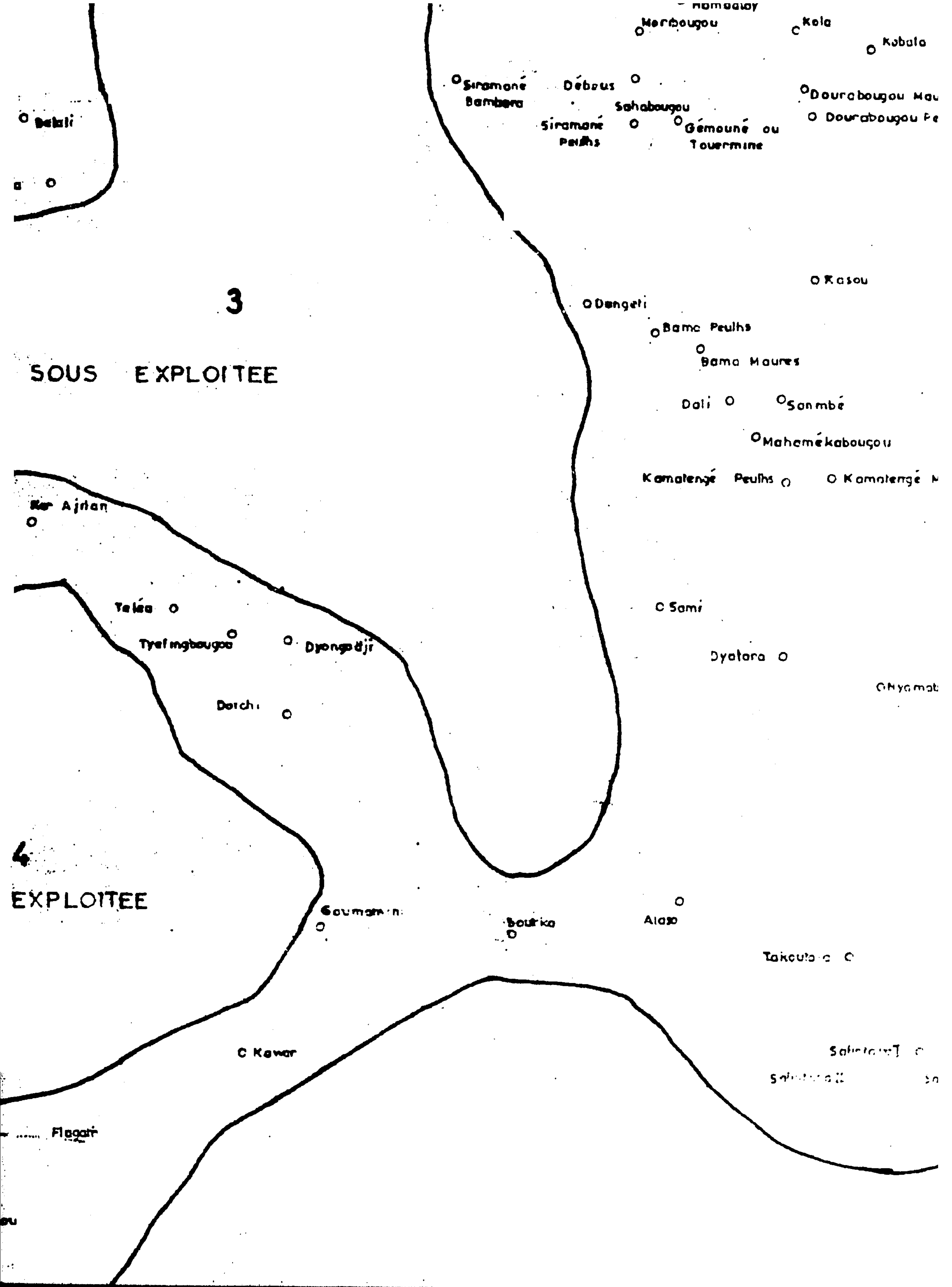



7° 20
15°30
Nyournudi
Ngoumel
Tyofi
Ngoumel Morad
Jeunwel
Ngouma Demba
Bouras
Mabrouk
Kanou
Makana
Dyanveli
Hamdalay
Zerikay
Zidou Toure
Mounaki
Girde
Tirou

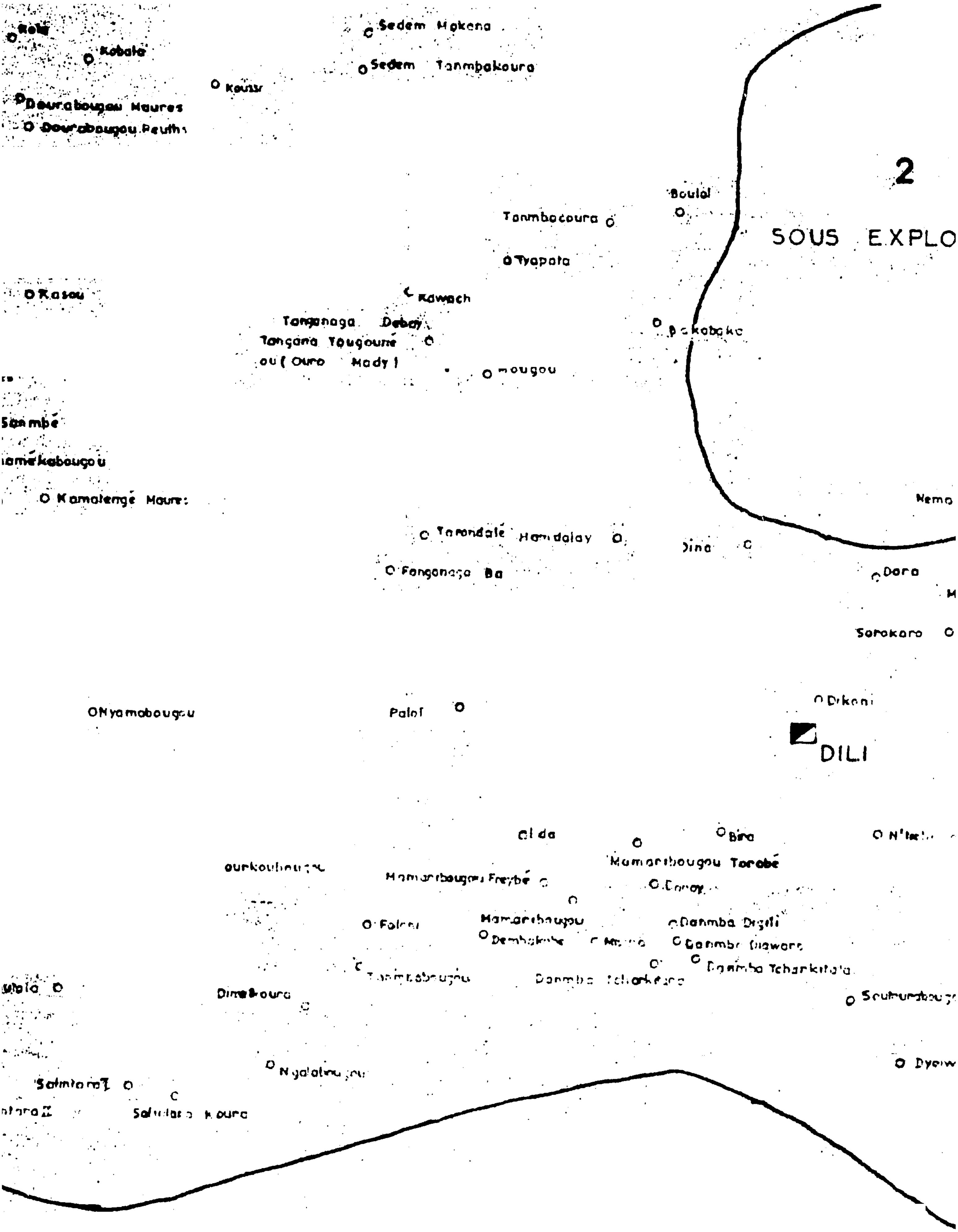
17



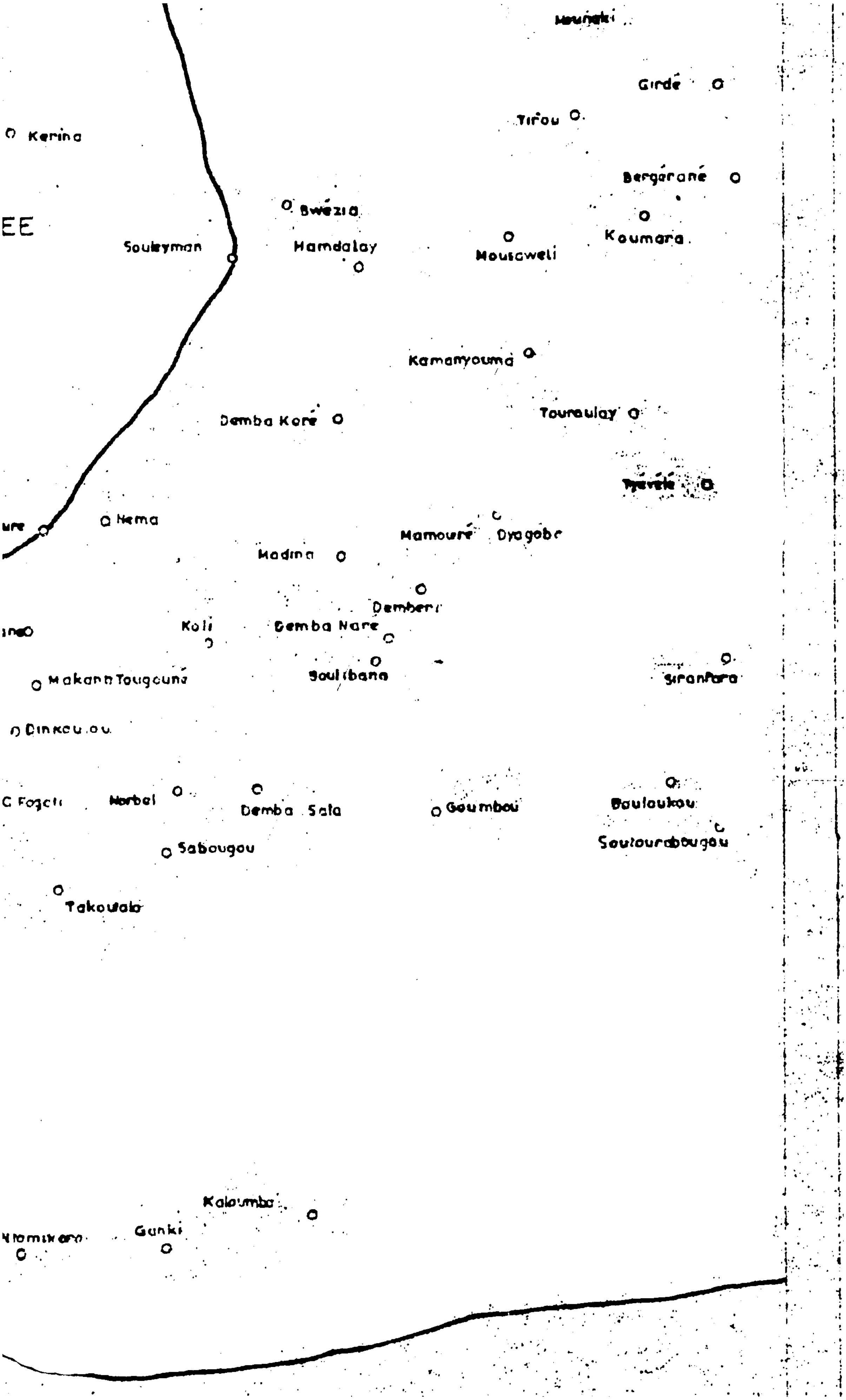
Amadou Mama
Sempaka
SOUS EXPLO
Soulé
Dyomgodji
Teléa
4
SOUS EXPLOITEE
Foenyé
Anh
Zingen
Diaymyan Drawara
Dyadyebougou
Wowourou
Balabougou
Traçomé
Ngolmadou
Maribougou

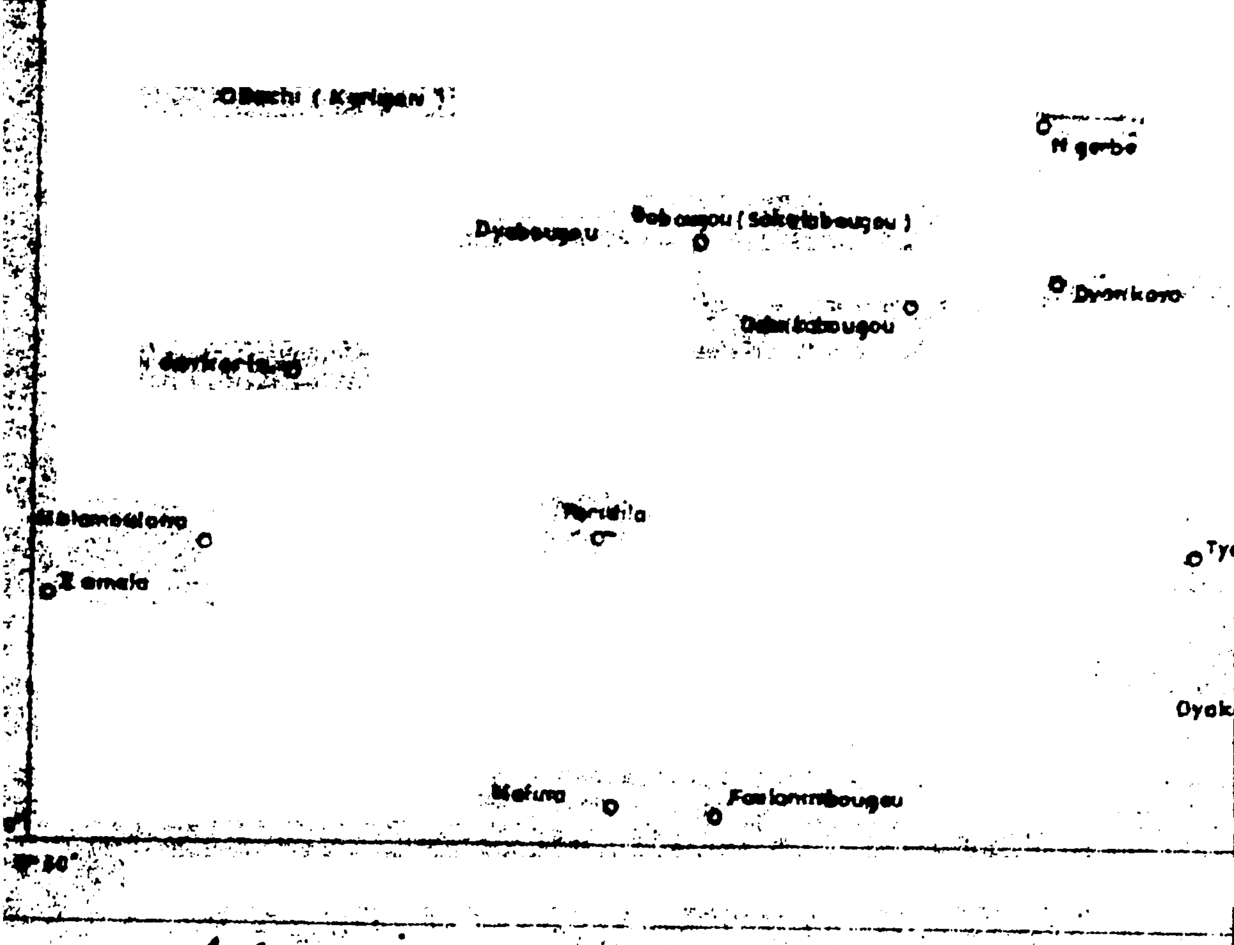


Merbougou
Kola
Kobala
Siramané
Bambara
Débous
Sahabougou
Siramané
Peulhs
Gémouné ou
Touermine
Belali
3
SOUS EXPLOITEE
Kasou
Dangeli
Bama Peulhs
Bama Maures
Dali
Sanmbé
Mahemékabougou
Kamatengé Peulhs
Telea
Tyefingbougou
Dyongodji
Darchi
Sami
Dyatara
4
EXPLOITEE
Boutika
Alaso
Kawar



Kobala
Sedem Mokena
Sedem Tanmbakoura
Dourabougou Maures
Dourabougou Peuths
2
Boulal
Tanmbacoura
SOUS EXPLO
Tyapala
Kasou
Kawach
Tanganaga Debay
Tangana Tougoune
ou (Ouro Mady)
Sambé
Kamalenge Maures
Tarandale
Hamdalay
Fanganaga Ba
Dara
Sorokara
Nyamabougou
Palal
DILI
Bira
Mamarribougou Torobé
Mamarribougou Freybe
Mamarribougou
Danmba Digili
Dimébourou
Danmba Tcharkitala
Salntara I

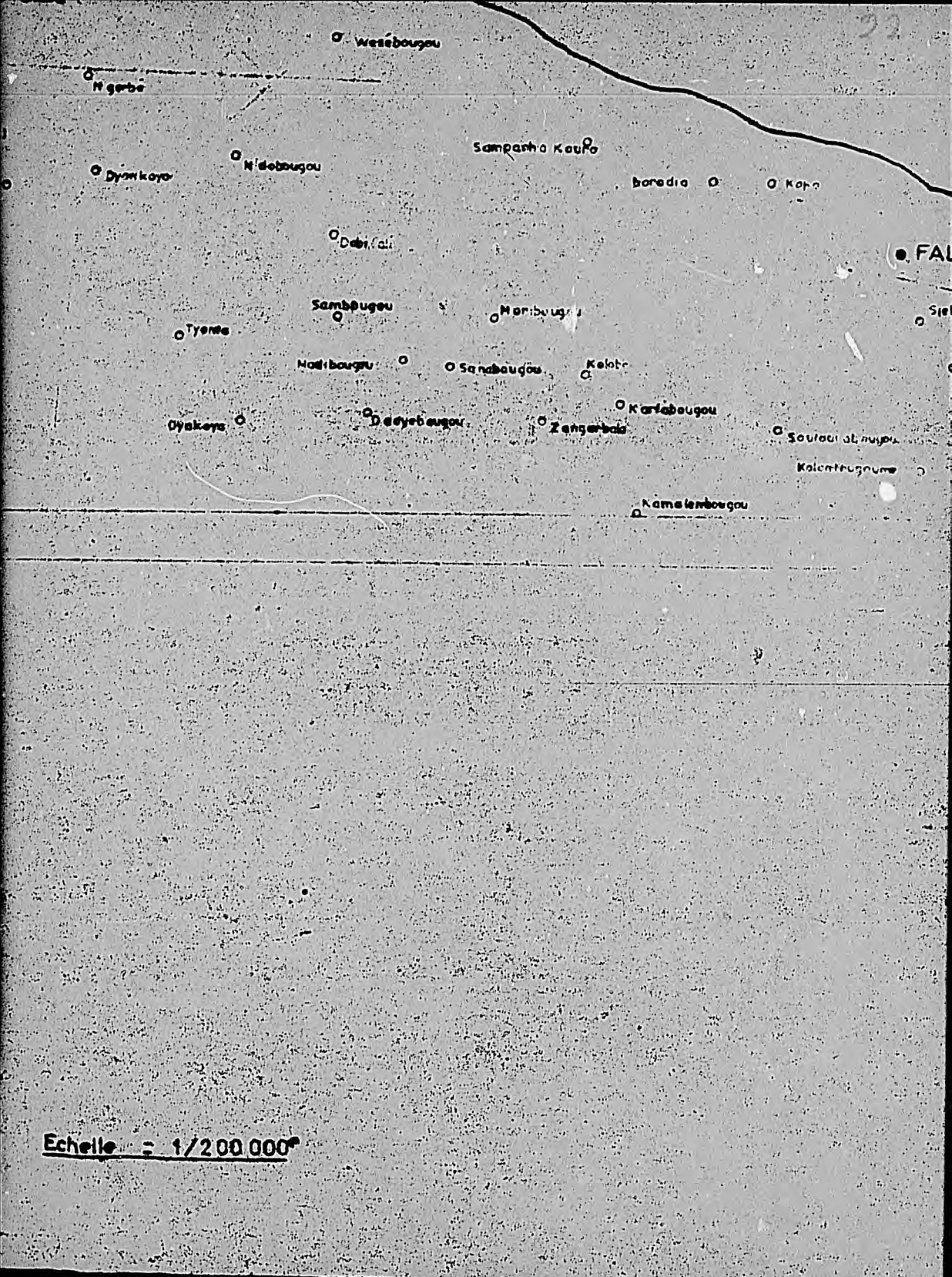

Girde
Tirou
Kerina
Bergorane
EE
Bwezia
Souleyman
Hamdalay
Mousaweli
Koumara
Kamanyouma
Touraulay
Demba Kore
Nema
Mamoure
Dyagobe
Madina
Koli
Demba Nare
Soulibana
Siranfara
Norbel
Demba Sala
Goumbou
Soutourabougou
Sabougou
Takoutala
Kaloumba
Gunki

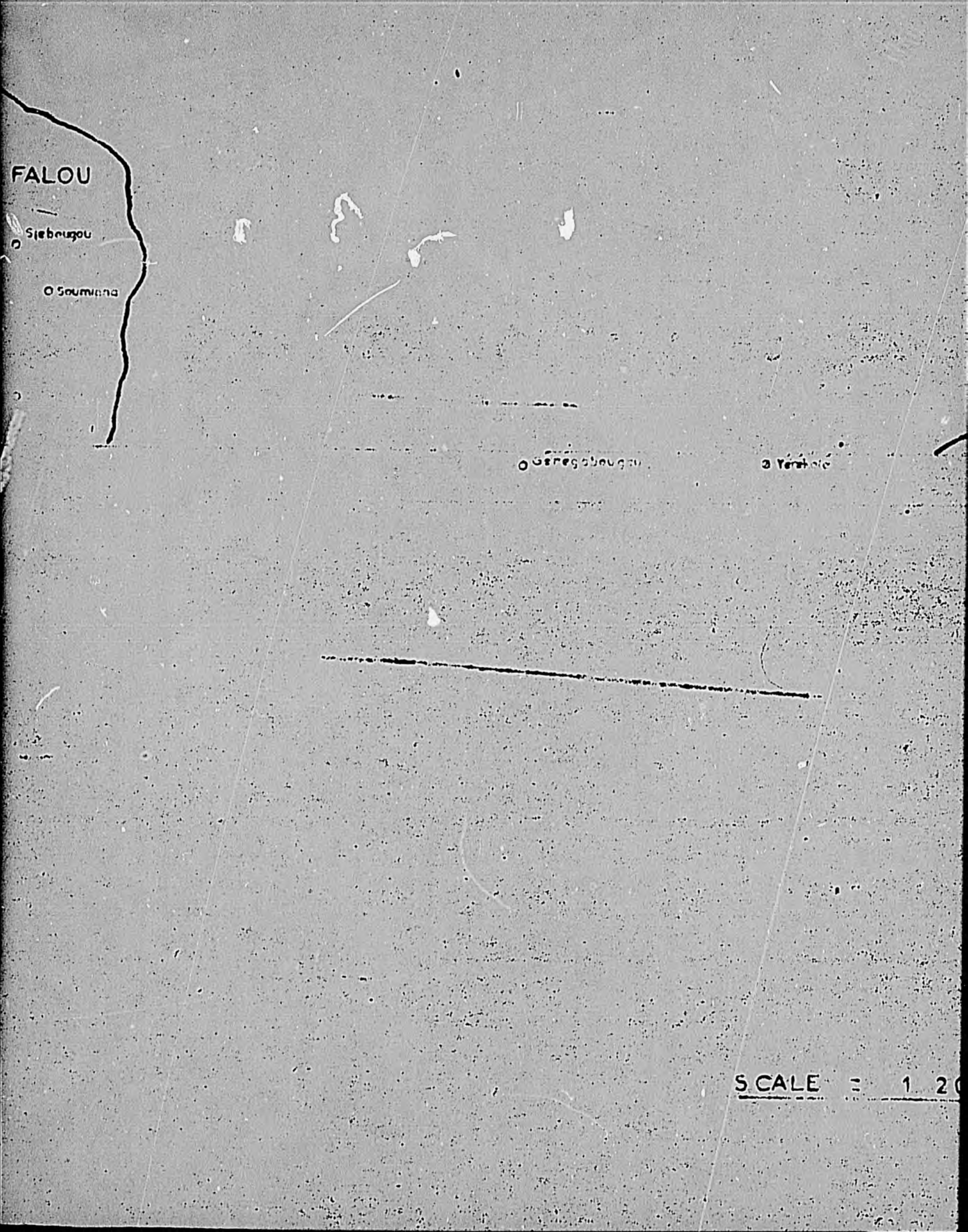


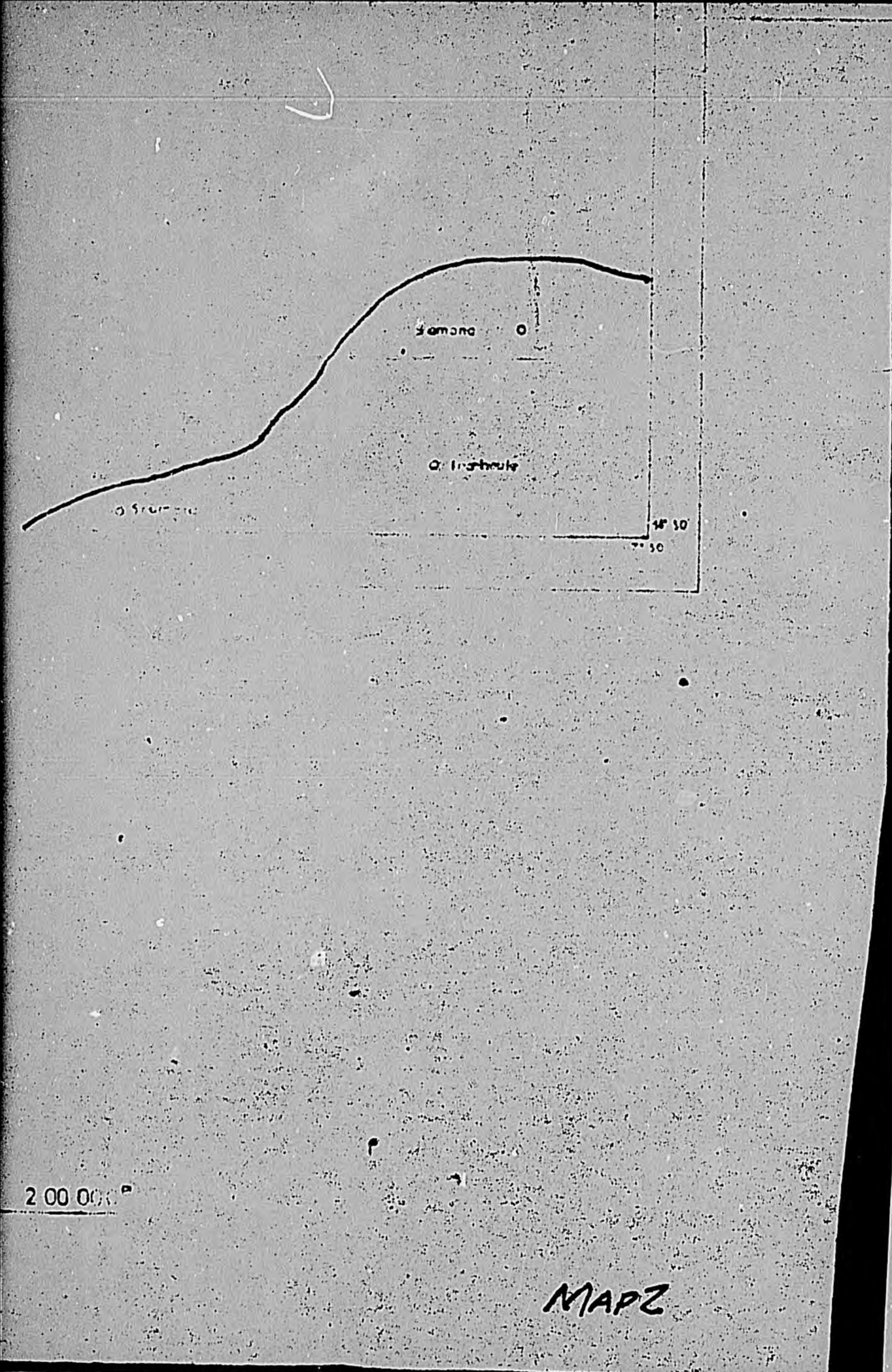
Compilé
Compiled MLBa

DECEMBRE 1977
DECEMBER 1977

Echelle = 1/

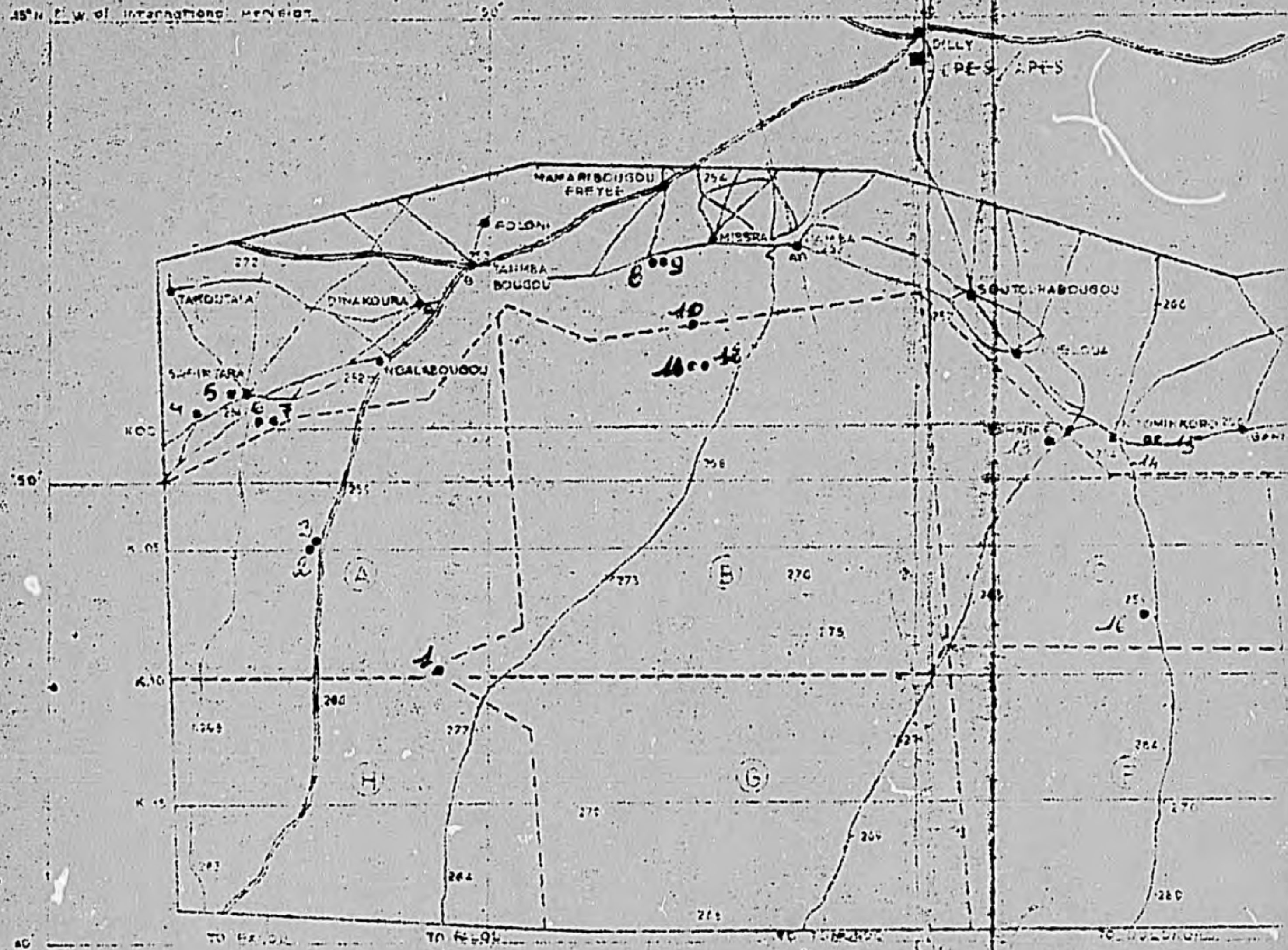

Wesébougou
N'gerbe
Sampanha Kouro
N'dobougou
Dyonkoyo
Baradia
Koro
Dabifali
FAL
Sambougou
Maribougou
Tyente
Sanabougou
Kolobo
Karlabougou
Dyakoya
Dadyebougou
Zangarbala
Kolontrugoume
Kamalembougou
Echelle = 1/200 000°


FALOU
Sjebougou
SCALE = 1 2


2 00 00
MAP 2

125

WATER DEVELOPMENT: TEST PERIMETER -APS-DILLY



SCALE 1: 200.000

0 5 10 15 20 Km

CONTROL

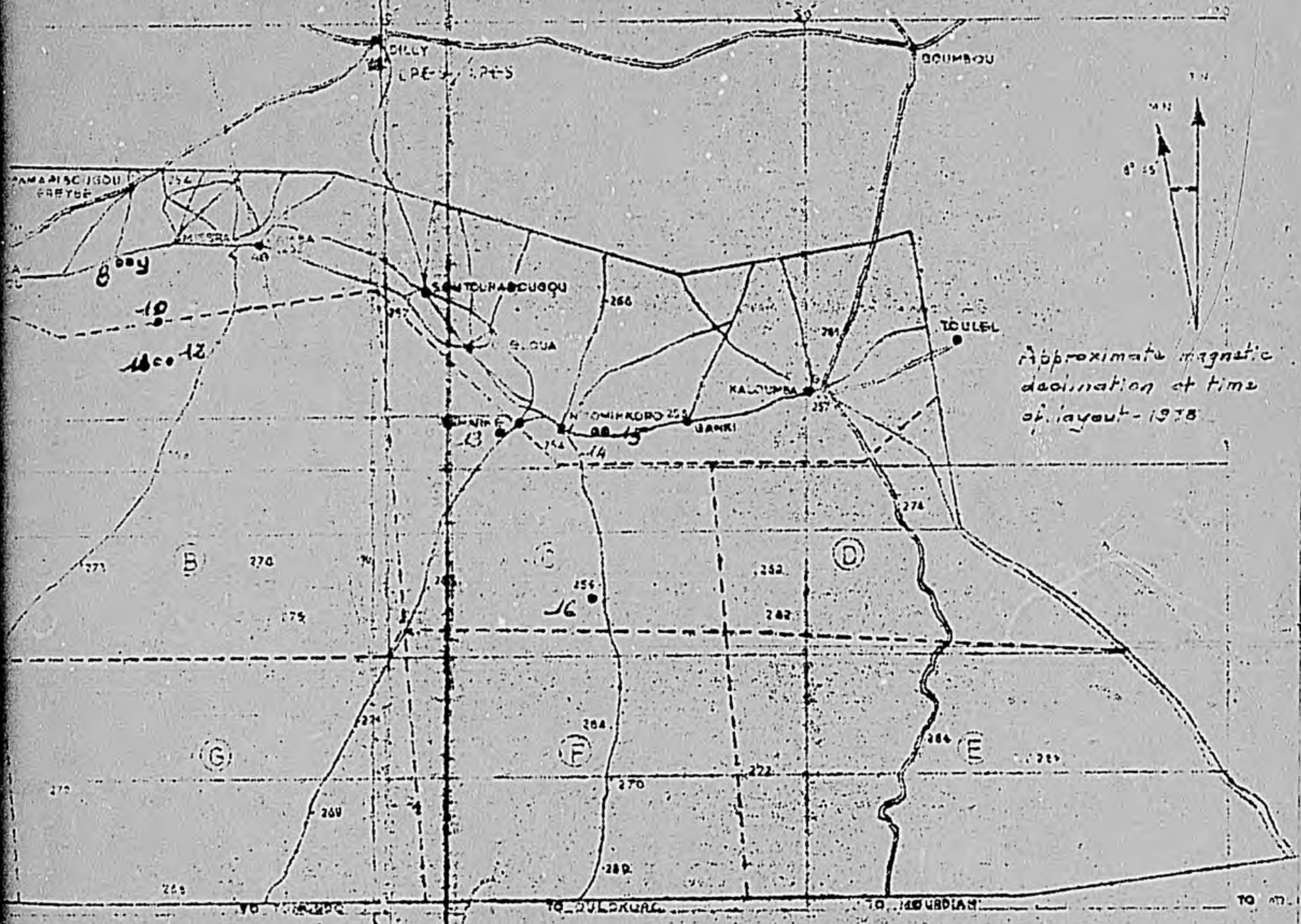
Location of roads, villages, and ground elevations are based upon a published map (1,200.000) by I.G.N. Locations of other features are uncontrolled but approximate.

Several boundary and firebreak lines do not reflect the effect of magnetic declination, which was present during their layout in 1978.

LEGEND OF EXIST

Test perimeter bou
Pasture unit boun
Pasture unit desi
Primary firebreaks
Village
Altitude (elevatio
Drilled wells, br
Drilled wells, nou
Seasonal Water

ENT: TEST PERIMETER -APS-DILLY PASTORAL ZONE



0.000

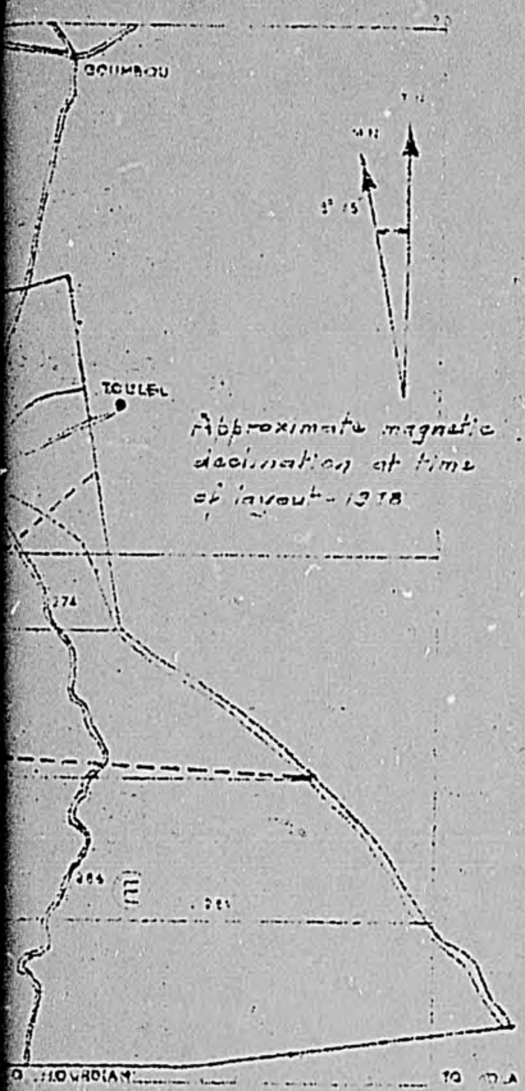
20 Km.

LEGEND OF EXISTING FEATURES

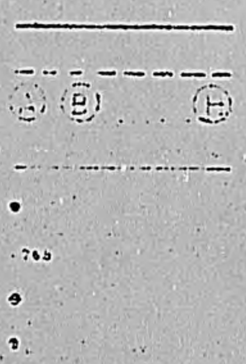
Test perimeter boundaries	
Pasture unit boundaries	
Pasture unit designations	(A) (B) ... (H)
Primary firebreaks, 400-K15	
Village	•
Altitude (elevation)	.265
Drilled wells, previous	•
Drilled wells, new, 1978-79	•
Seasonal water course	

ground elevations
b (1/200.000) by I.G.N.
uncontrolled but approximate
ak lines do not reflect the effect
was present during

RAL ZONE



ES



MAP

PROJECT MALI LIVESTOCK II - OMBEVI

REPUBLIC OF MALI

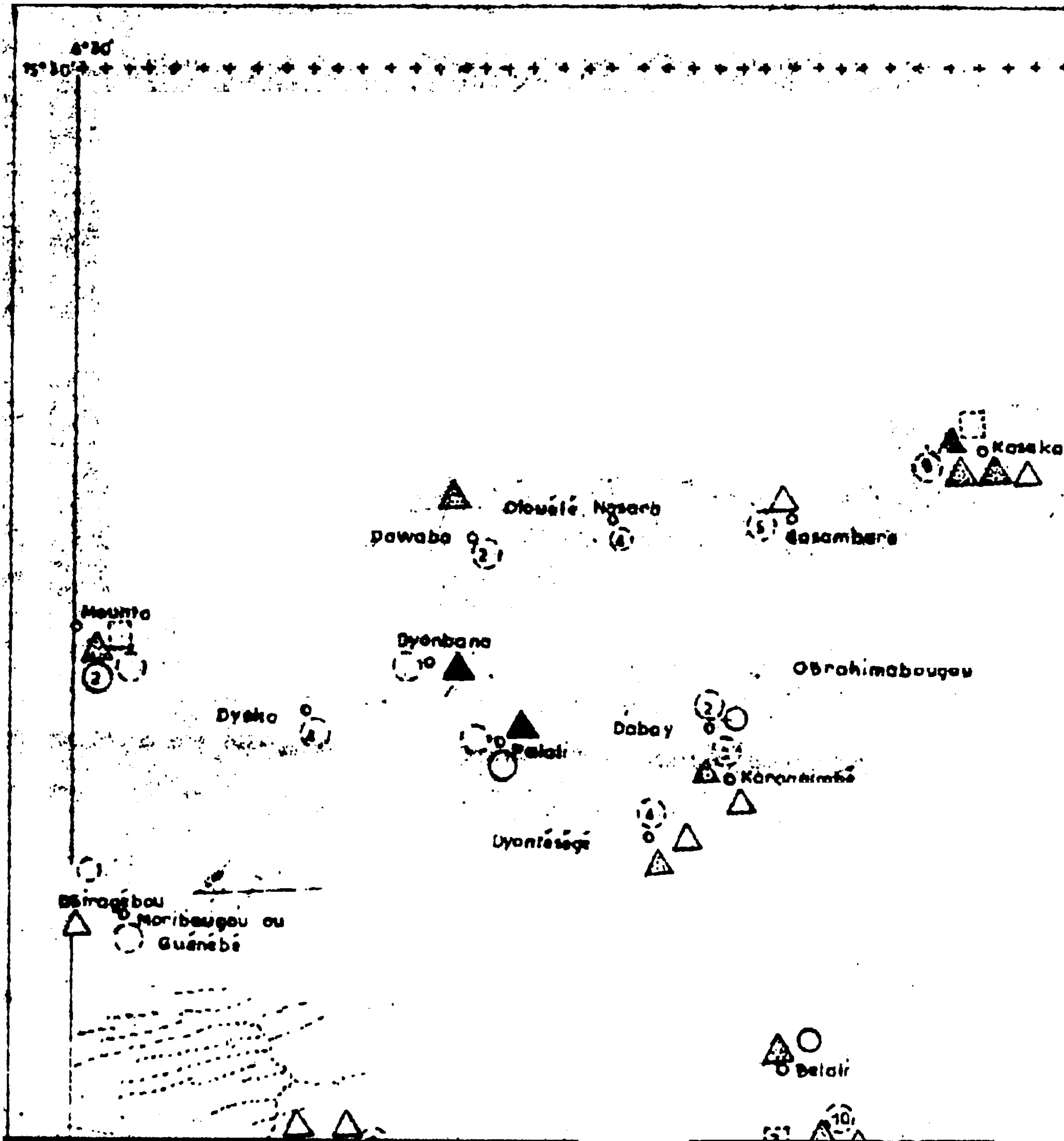
August 1979

POTENTIAL PRODUCTION OF NEW DRILLED WELLS

Well No.	Capacity m³/hr	Quality
1	1.0	Good
2	1.5	"
3		"
4	8.0	"
5	0.8	"
6	4.5	"
7	30.0	"
8	2.5	"
9	20.0	"
10	3.4	"
11	8.0	"
12	6.0	"
13	5.0	"
14	6.0	Usable
15	7.0	"
16	2.8	Good
	106.5	

POTENTIAL DEVELOPMENT FEATURES

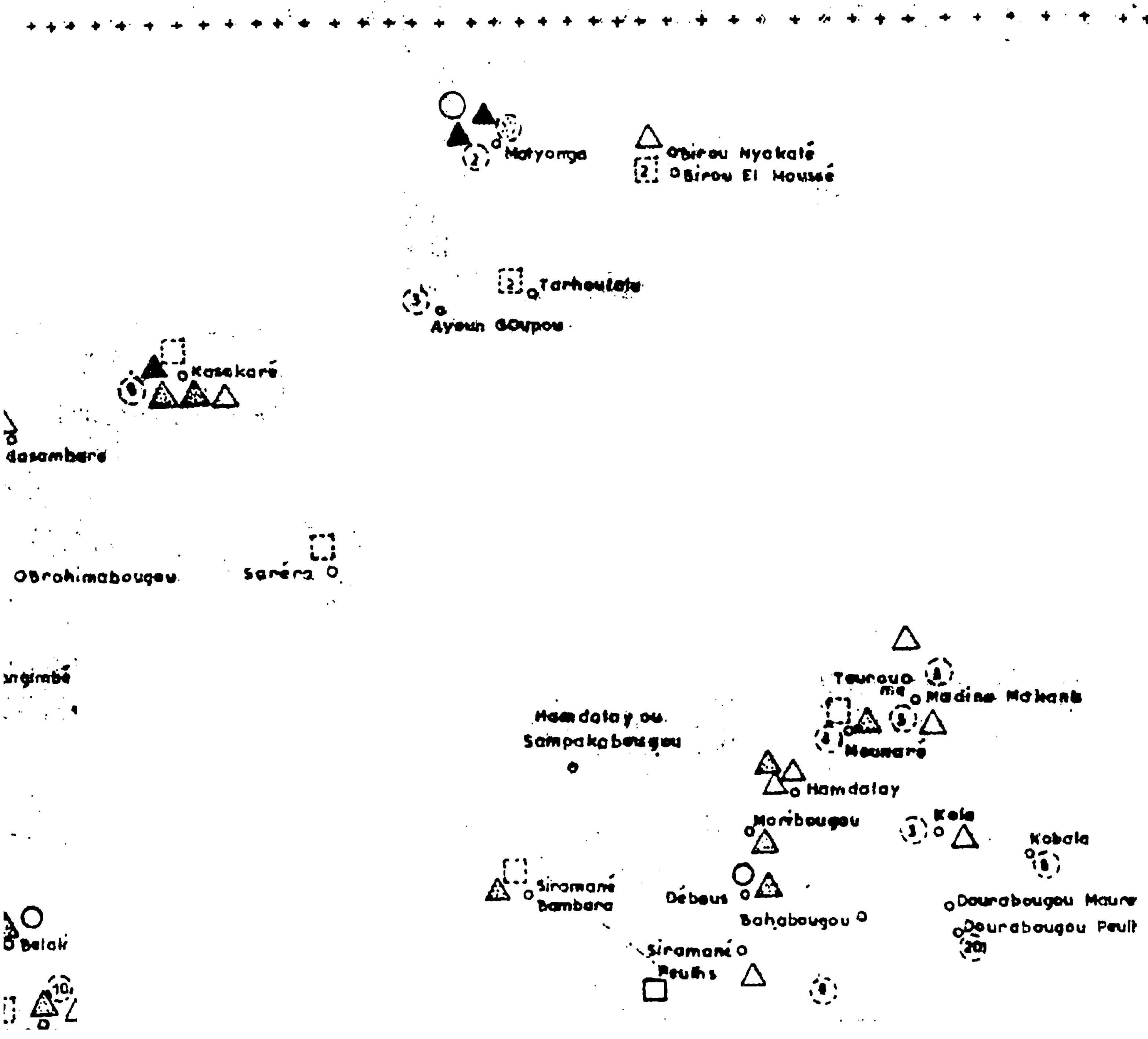
Drilled Wells new; 1978-1979
Pipeline distribution
Water point, usage
Shallow wells
Drilled wells by geophysical location
80% probability of success
50% " " "
10-25% " " "


Kaseka
Dawaba
Mounta
Dyonbana
Dyeko
Dabay
Moribougou ou
Guénébé
Belair

ZONE PASTORALE DE

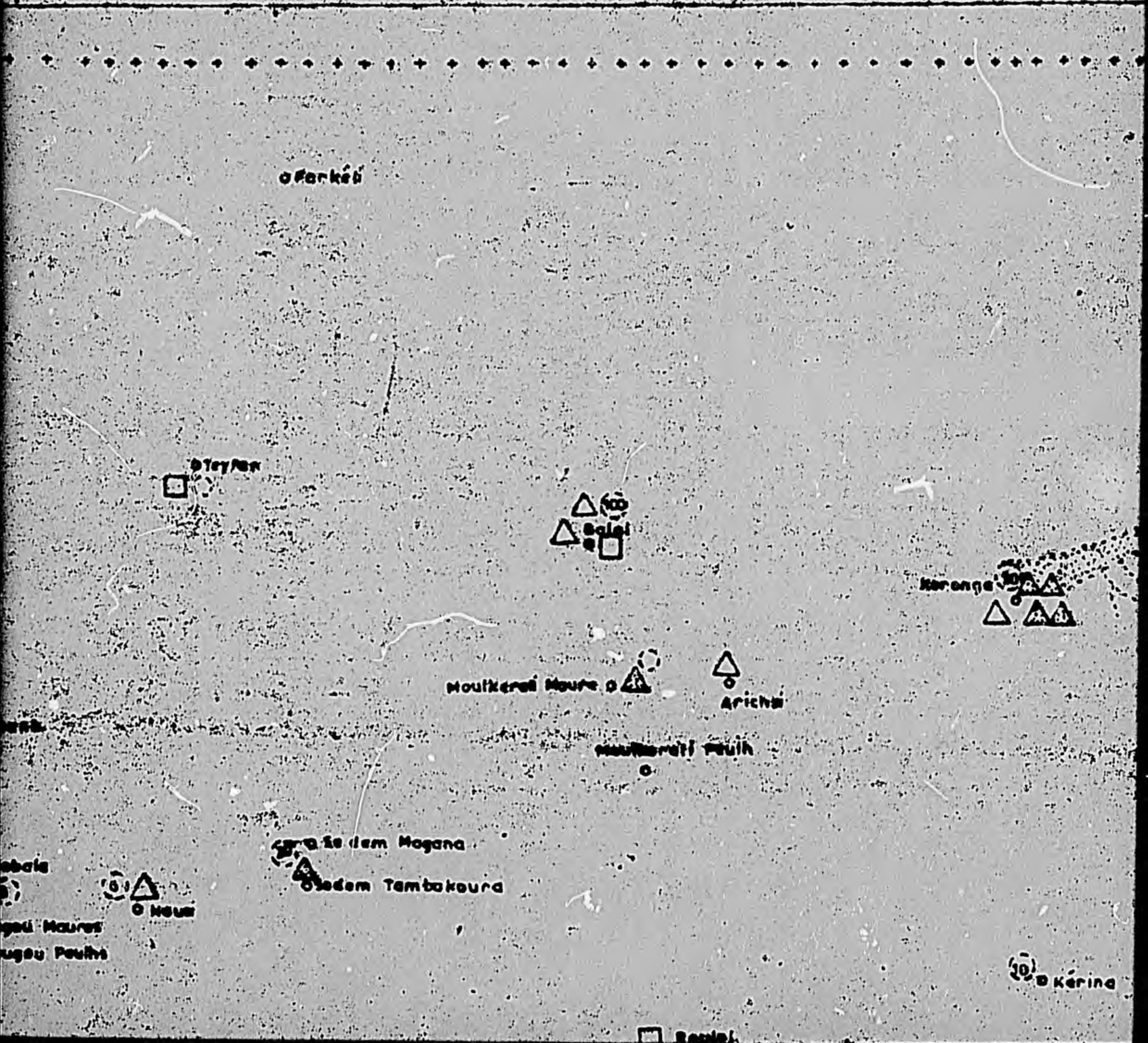
RESSOURCES EN EAU

PASTORAL ZONE OF DILLY
WATER RESOURCES

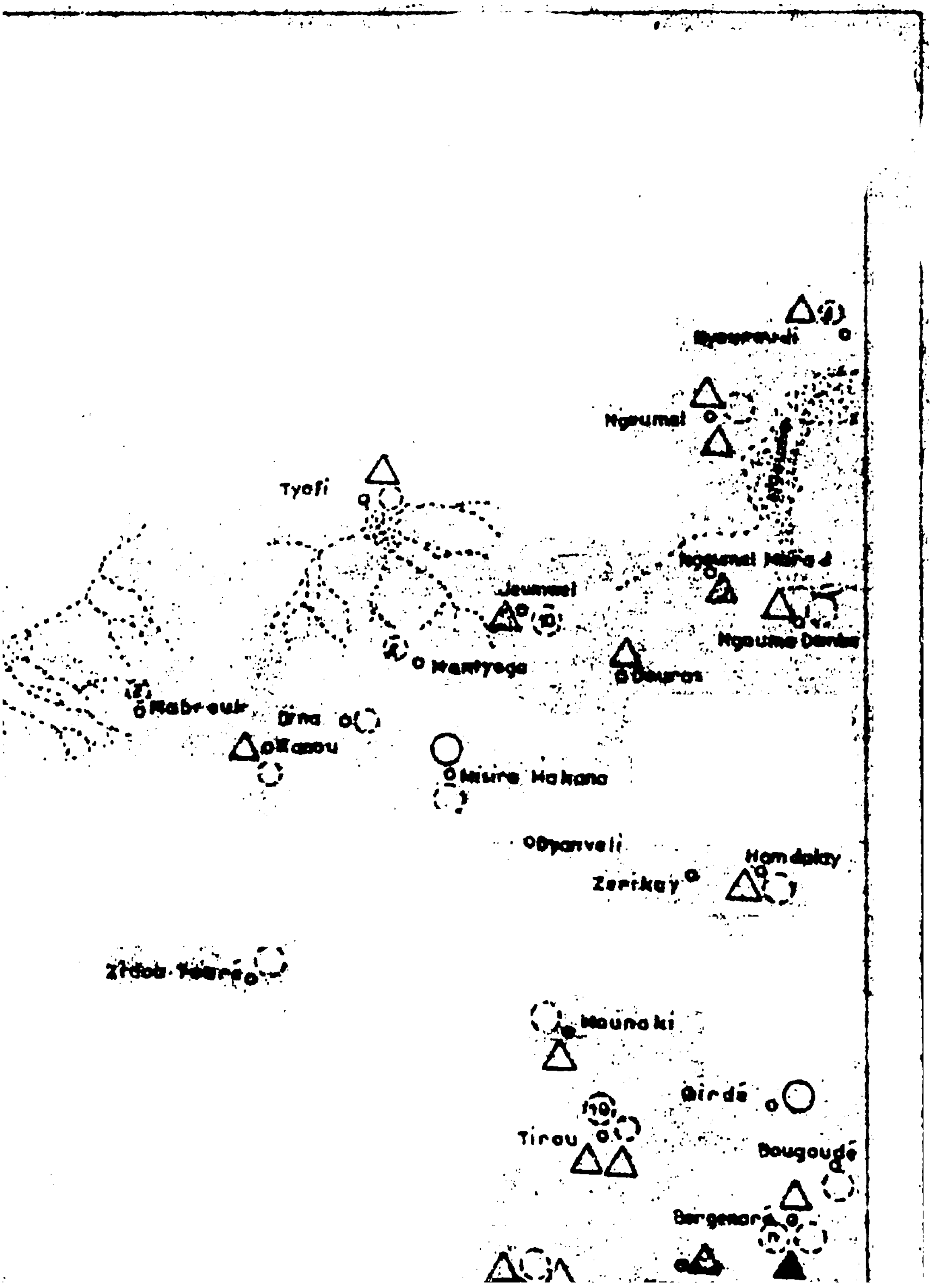


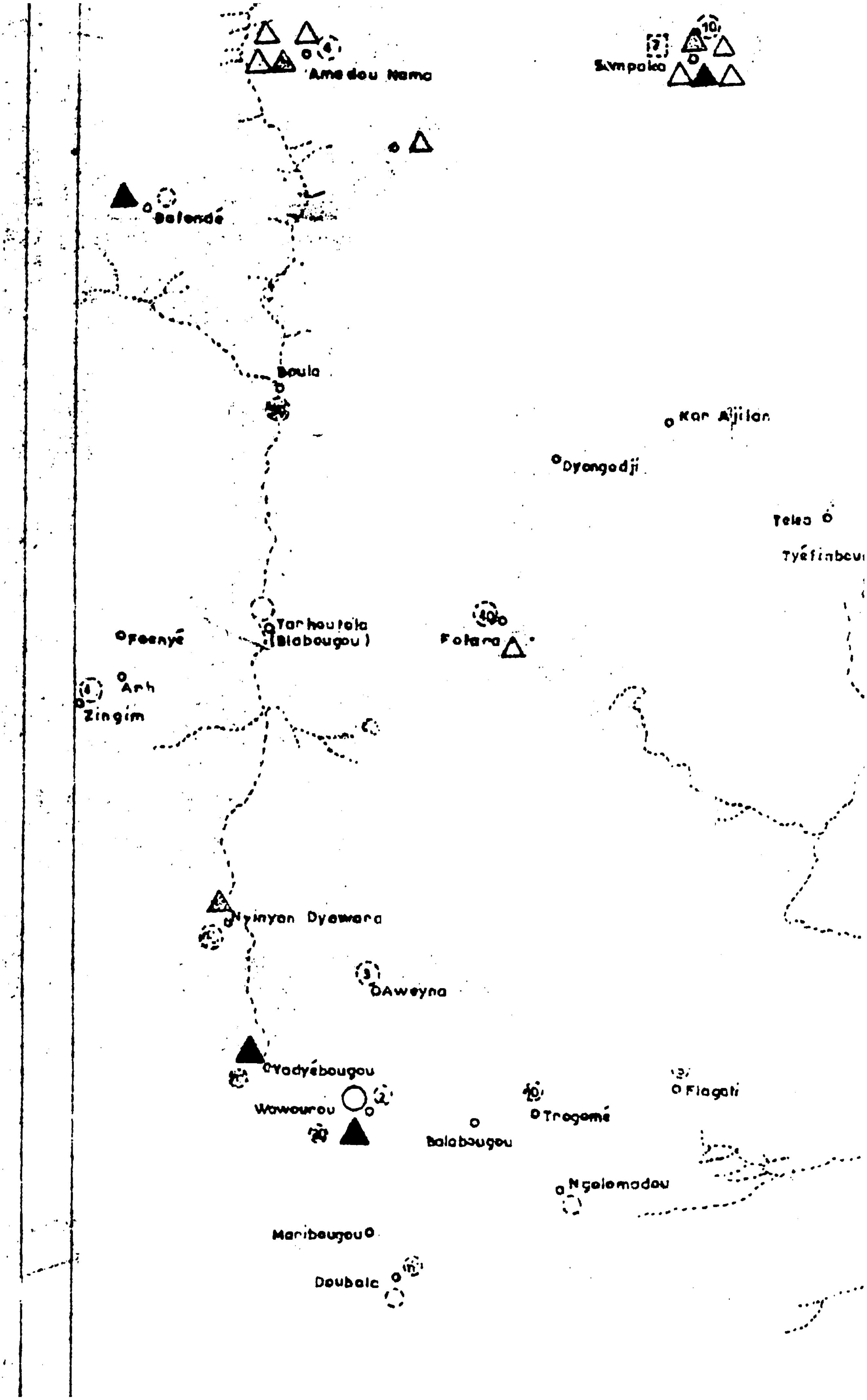
DE DILLY

AU

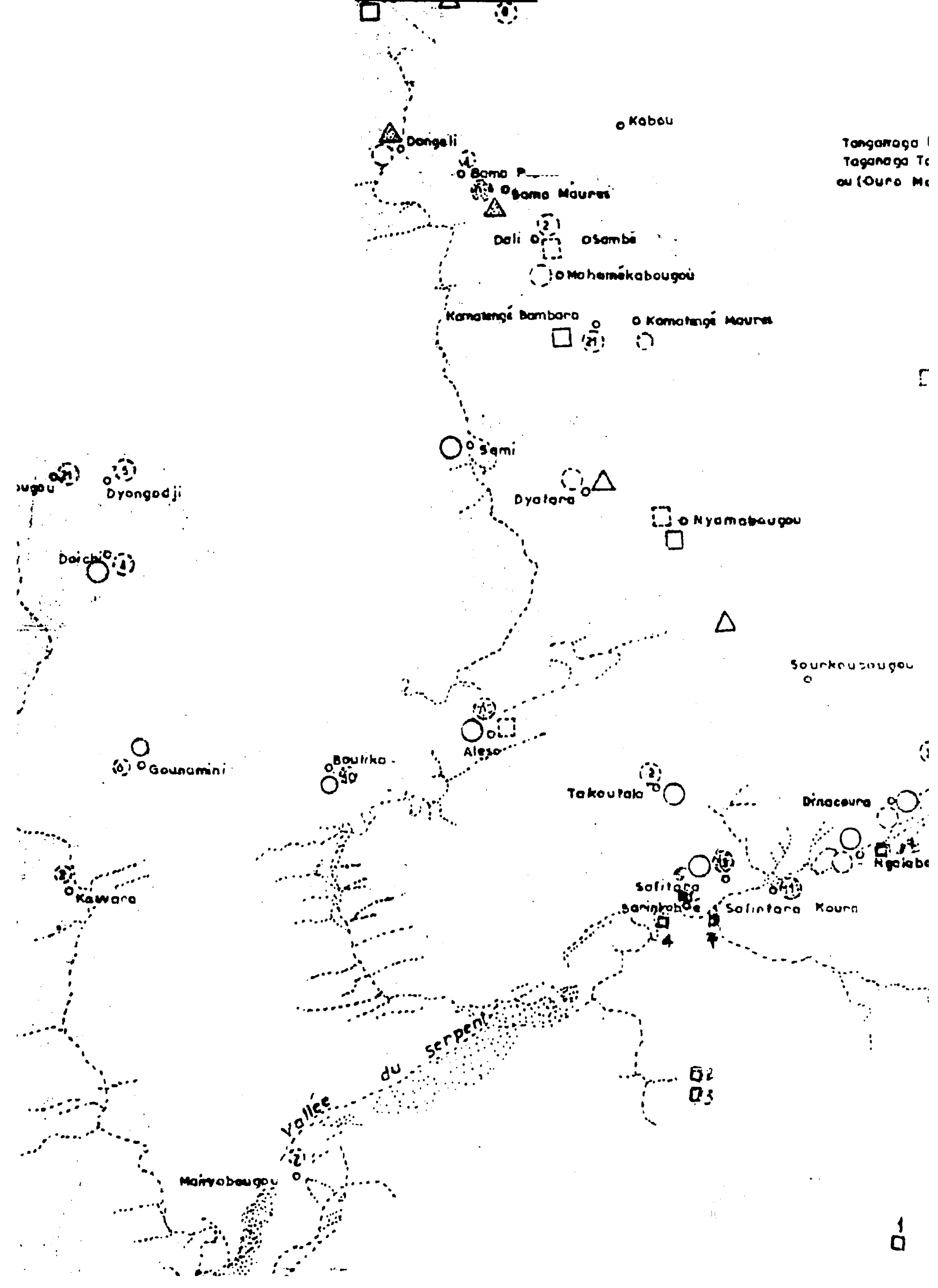


Farkéb
Moulkerei Maure
Arichi
Moulkerei Peulh
Tambakoura
Kérina

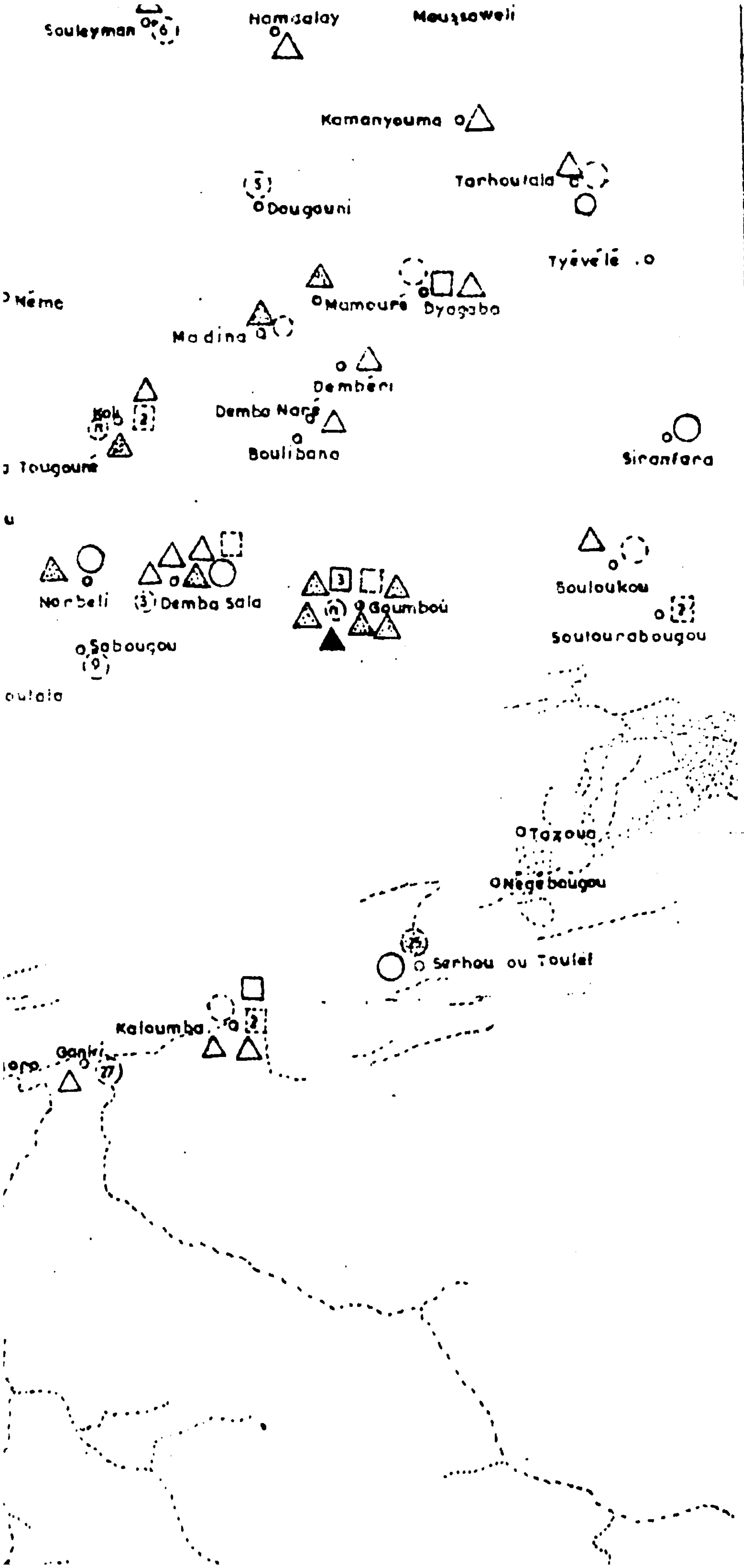

Tyofi
Hamdalay
Zerikay
Maunaki
Girdé
Tirou
Bougoudé



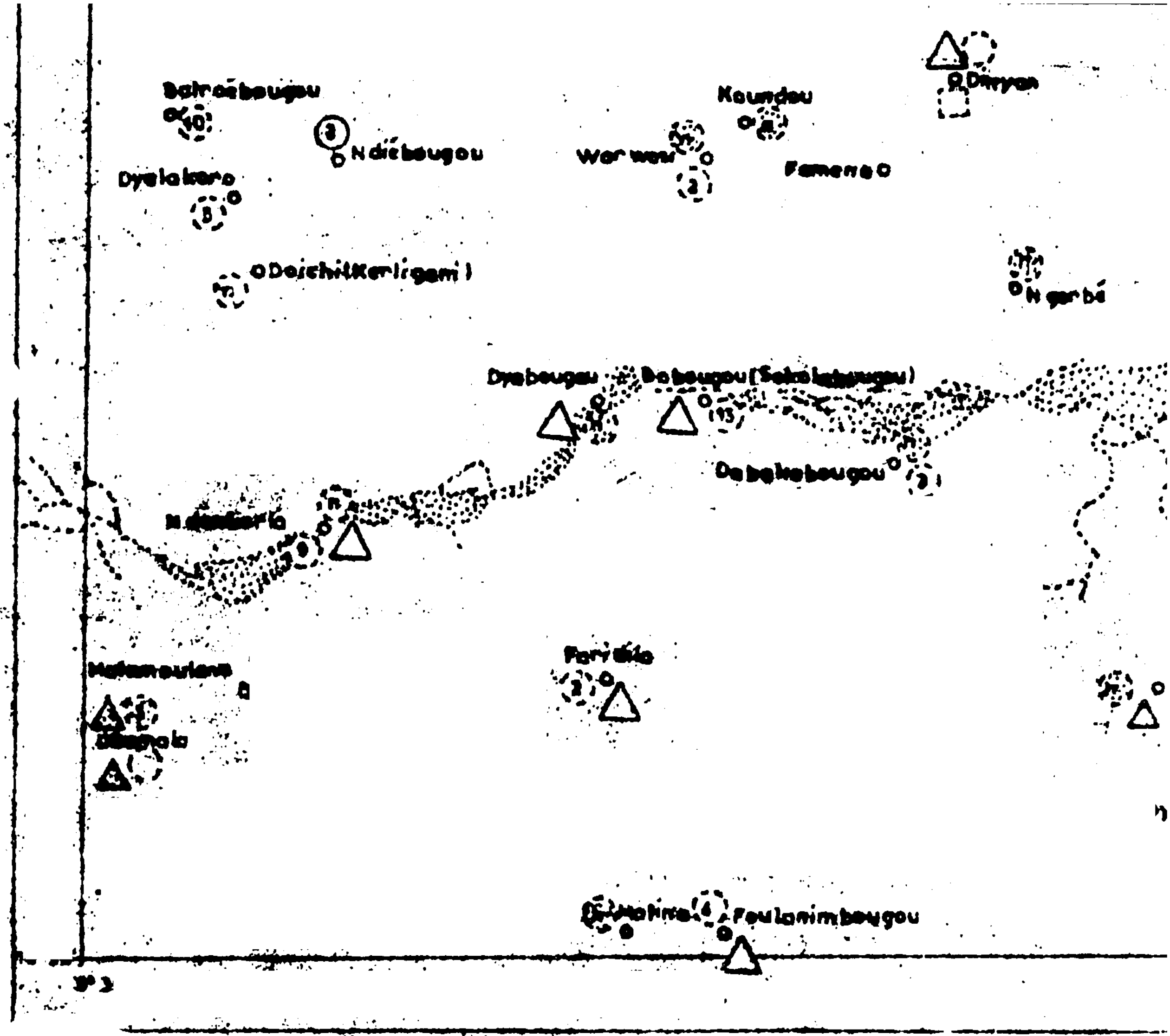
Amedou Nama
Balendé
Boula
Kar Ajilan
Dyongodji
Telea
Tarhoutala
(Blabougou)
Feenyé
Folara
Arh
Zingim
Nyinyan Dyewara
DAweyna
Yadyébougou
Wawourou
Balabougou
Tragomé
Fiagali
Ngolomadou
Maribougou
Doubala


Kabou
Dongeli
Bama Maures
Dali
Sambe
Mahemekabougou
Kamatengé Bambara
Kamatengé Maures
Sami
Dyongodji
Dyatara
Nyamabougou
Darchi
Sourkoubougou
Aleso
Gounamini
Boutrika
Takoutala
Dinacoura
Safitara
Safintara Koura
Kawara
Vallée du serpent
Manyabougou


Tambakoura
Tiapal
Kawach
Tongarraga Debay
Taganaga Tougoumé
ou (Ouro Mody)
Mougou
Bakabaka
Néma Maures
Néma
ollé
Hamdalay
Dino
Dara
Makana
Sorokori
Makana Tougoumé
Taganaga Ba
Dinkoulou
Palali
Dikoni
DILLI
Fagali
Norbeli
Sira
Niyébougou
Takoutala
Mamaribougou Tarebé
Doray
Mamaribougou
Freybe
Foloni
Mamaribougou
Dembakora
Misira
Damba Digila
Damba Diawara
Damba Tchakitala
Damba Tcharkitaré
Tambabougou
Ngolabougou
Koura
Soutourabougou
Deylwo
Nfomikoro
Ganki
9
11
13
14
1

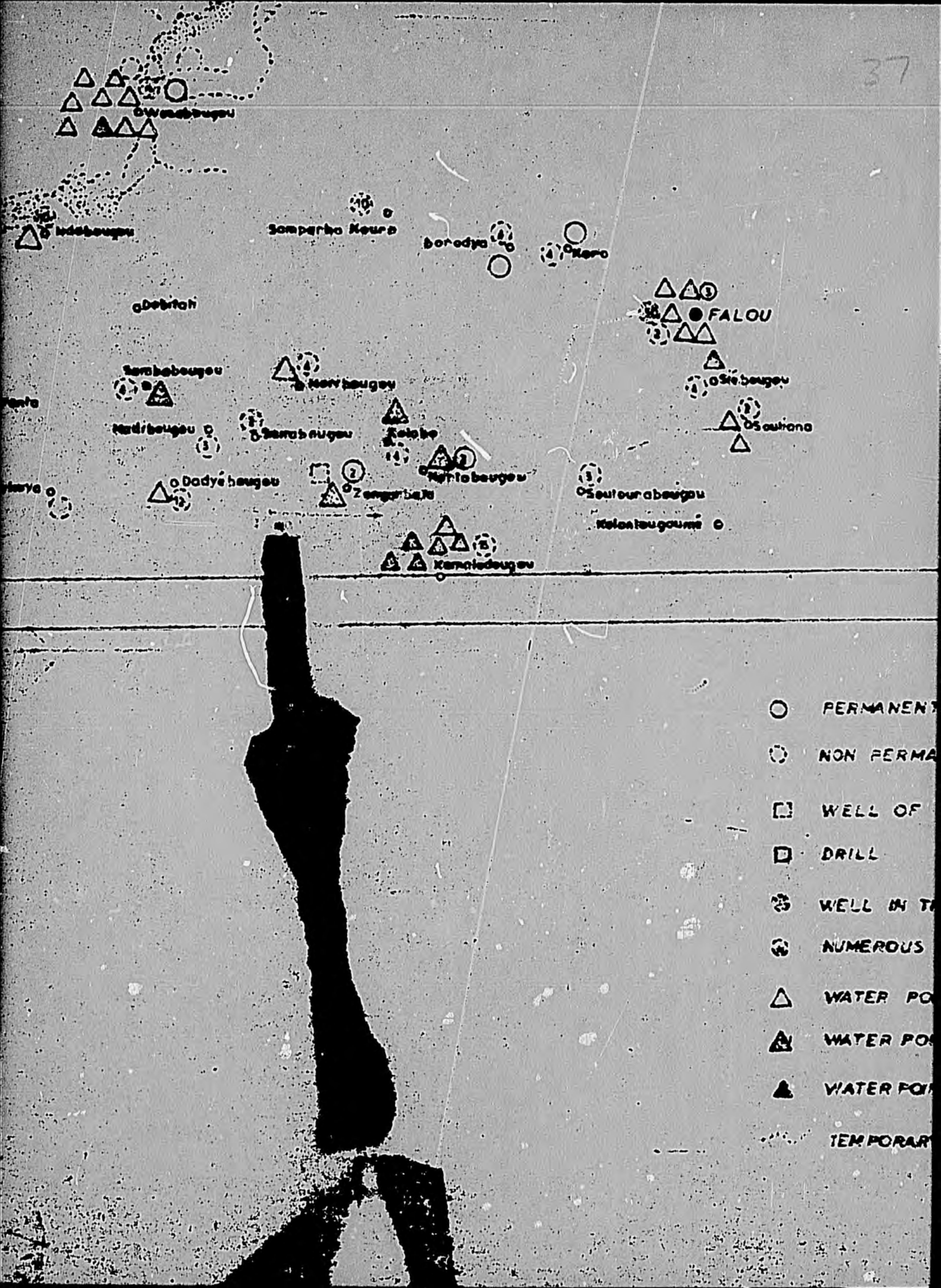


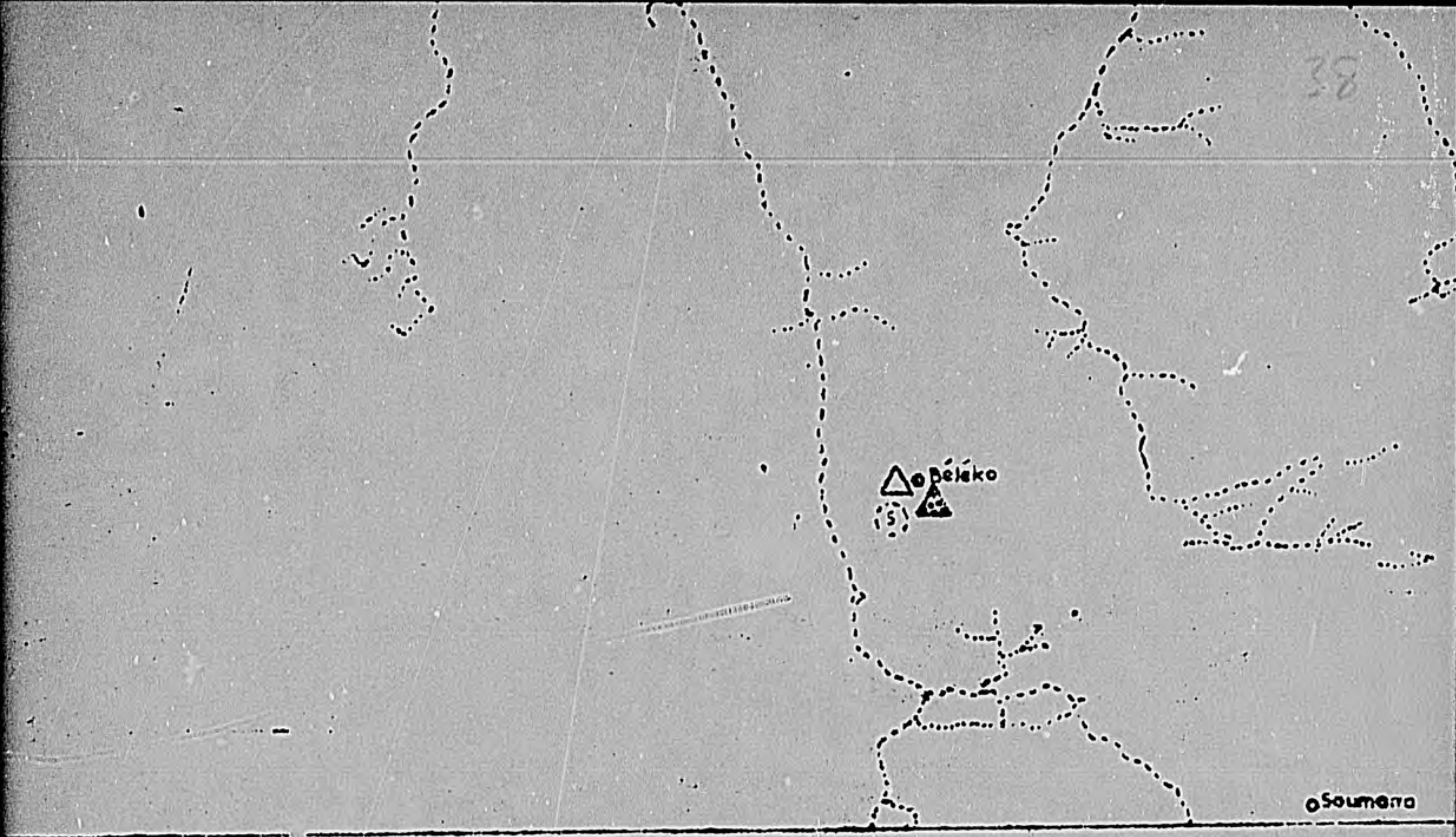
Souleyman
Hamdalay
Mouşsoweli
Kamanyouma
Tarhoutala
Dougouni
Tyévelé
Mémo
Mamouré
Dyogabo
Madina
Dembéri
Dembo Naré
Boulibana
Siranfara
Tougouné
Norbeli
Demba Sala
Goumbou
Souloukou
Soulourabougou
Sabouçou
Tazoua
Negébougou
Serhou ou Toulel
Kaloumba
Ganki



— LEGENDE —

- PUISARD PERMANENT
- PUISARD NON PERMANENT
- PUITS DE PLUS DE 20m DE PROFONDEUR
- FORAGE
- PUISARD DANS LE SABLE -
- NOMBREUX PUISARDS
- MARE DURANT 1 à 2 APRES LA SAISON DES PLUIES
- MARE DURANT 2 à 4 APRES LA SAISON DES PLUIES
- MARE DURANT PLUS DE 4 MOIS APRES LA SAISON DES PLUIES


Borodya
Kero
FALOU
Dadyebougou
Soutourabougou
PERMANENT
NON PERMA
WELL OF
DRILL
WELL IN T
NUMEROUS
WATER PO
WATER PO
WATER POI
TEMPORAR



LEGEND

MANENT HAND DUG WELL OF LESS THAN 20m OF DEPTH

PERMANENT HAND DUG WELL OF LESS THAN 20m OF DEPTH

LL OF MORE THAN 20m OF DEPTH

LL

LL IN THE SANDY SITE

IEROUS WELL

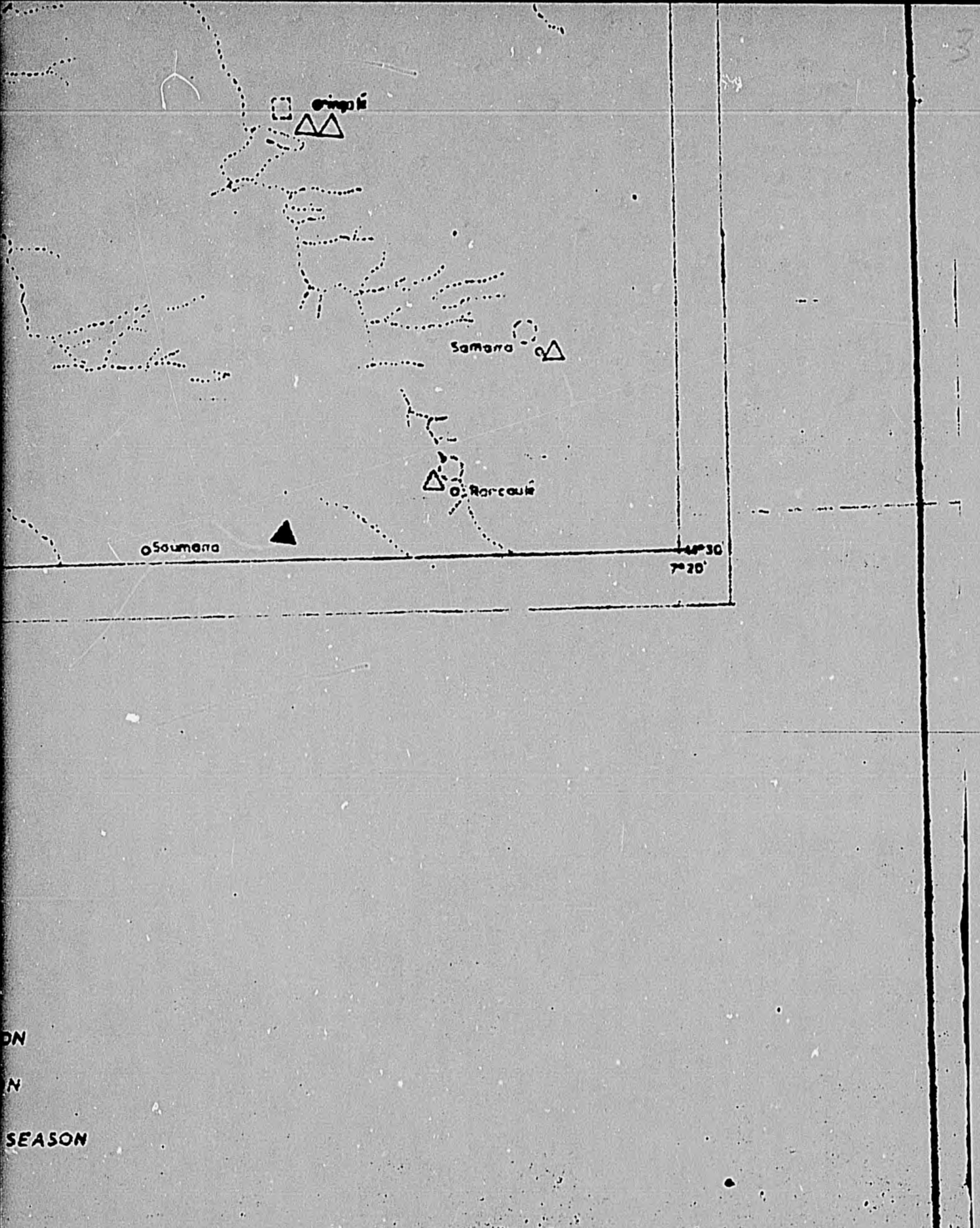
TER POINT WHICH LASTS 1 TO 2 MONTHS AFTER THE RAINY SEASON

TER POINT WHICH LASTS 2 TO 4 MONTHS AFTER THE RAINY SEASON

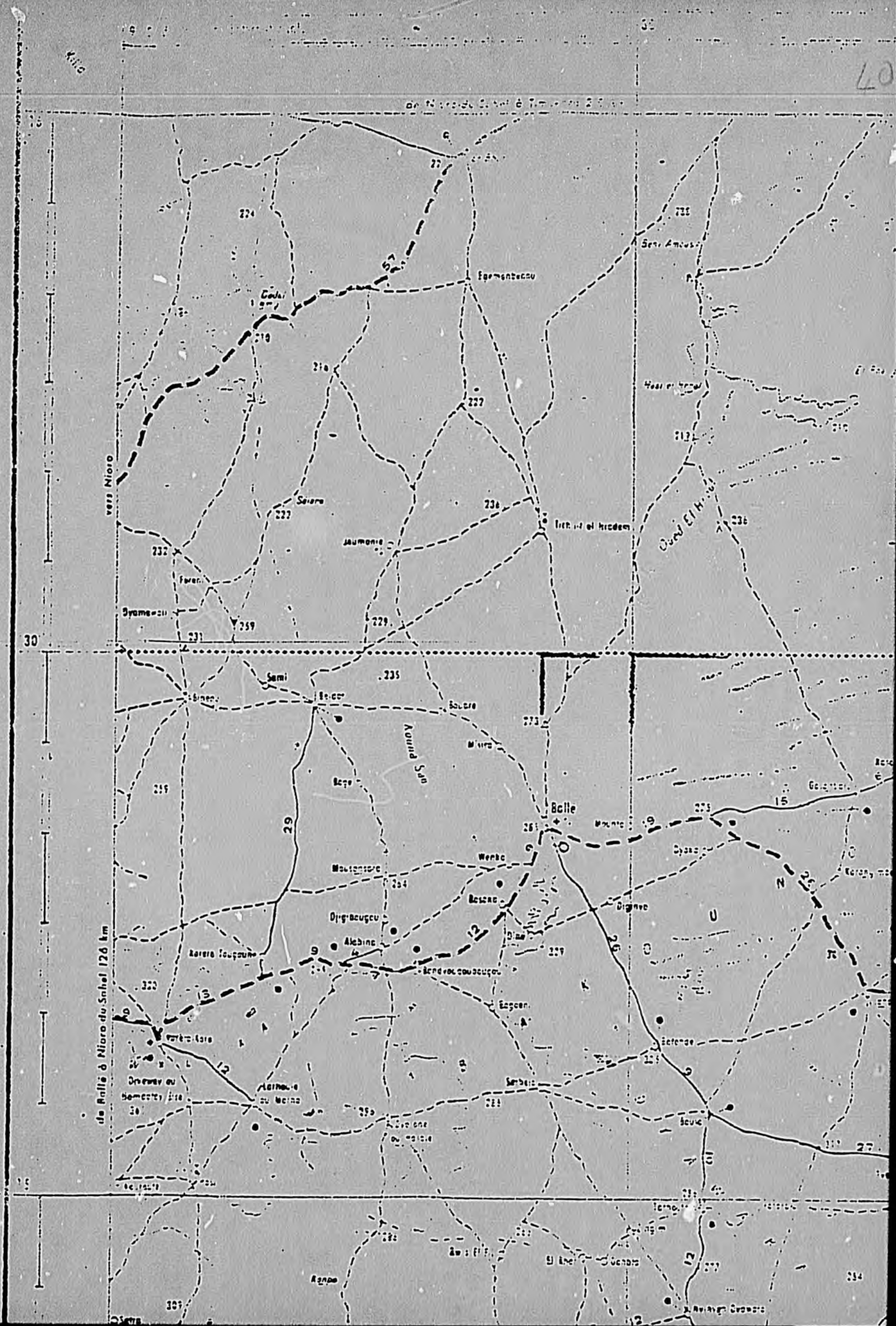
TER POINT WHICH LASTS MORE THAN 4 MONTHS AFTER THE RAINY SEASON

MPORARY DRAINAGE

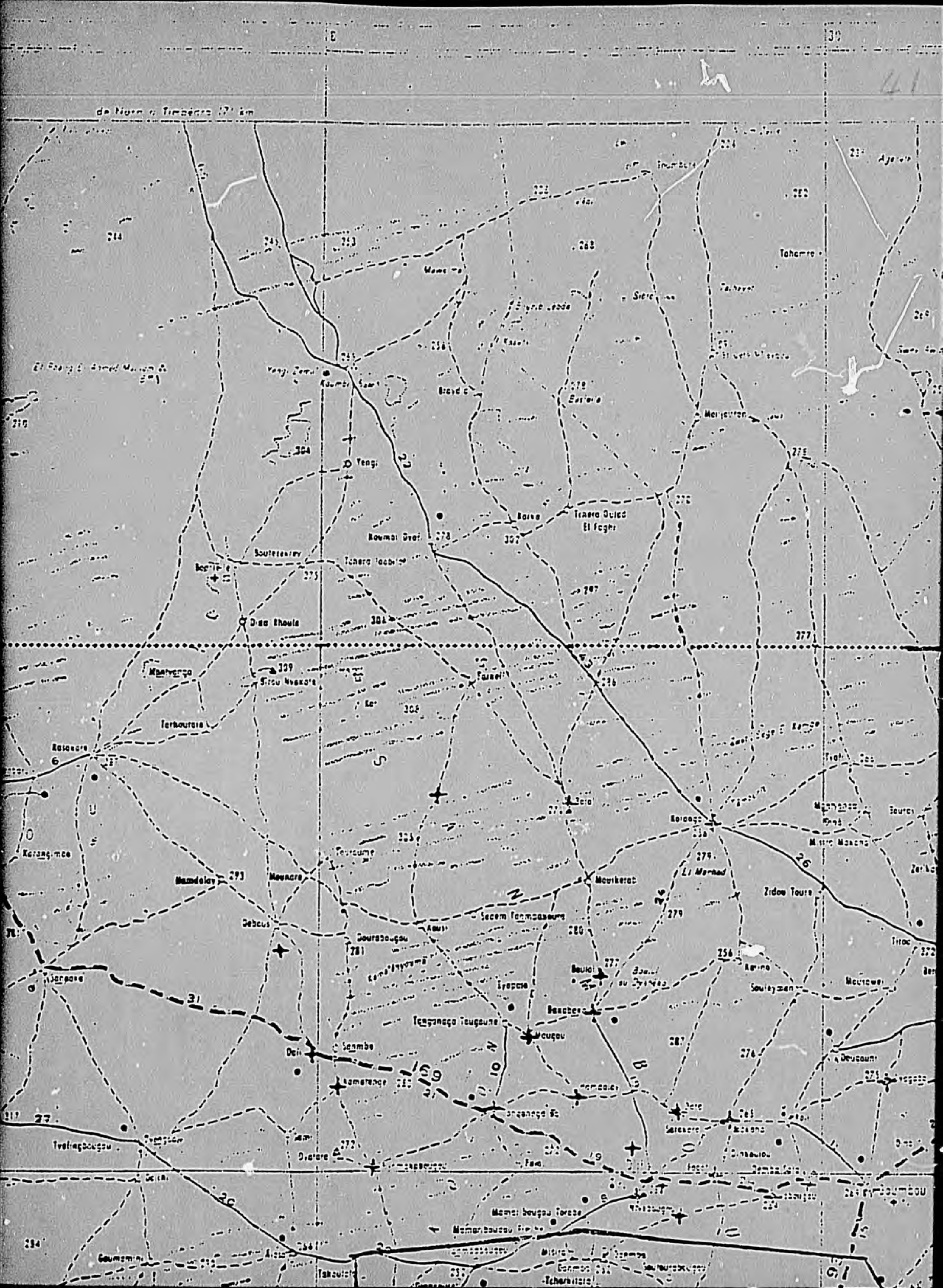
SCALE : 1/200 000



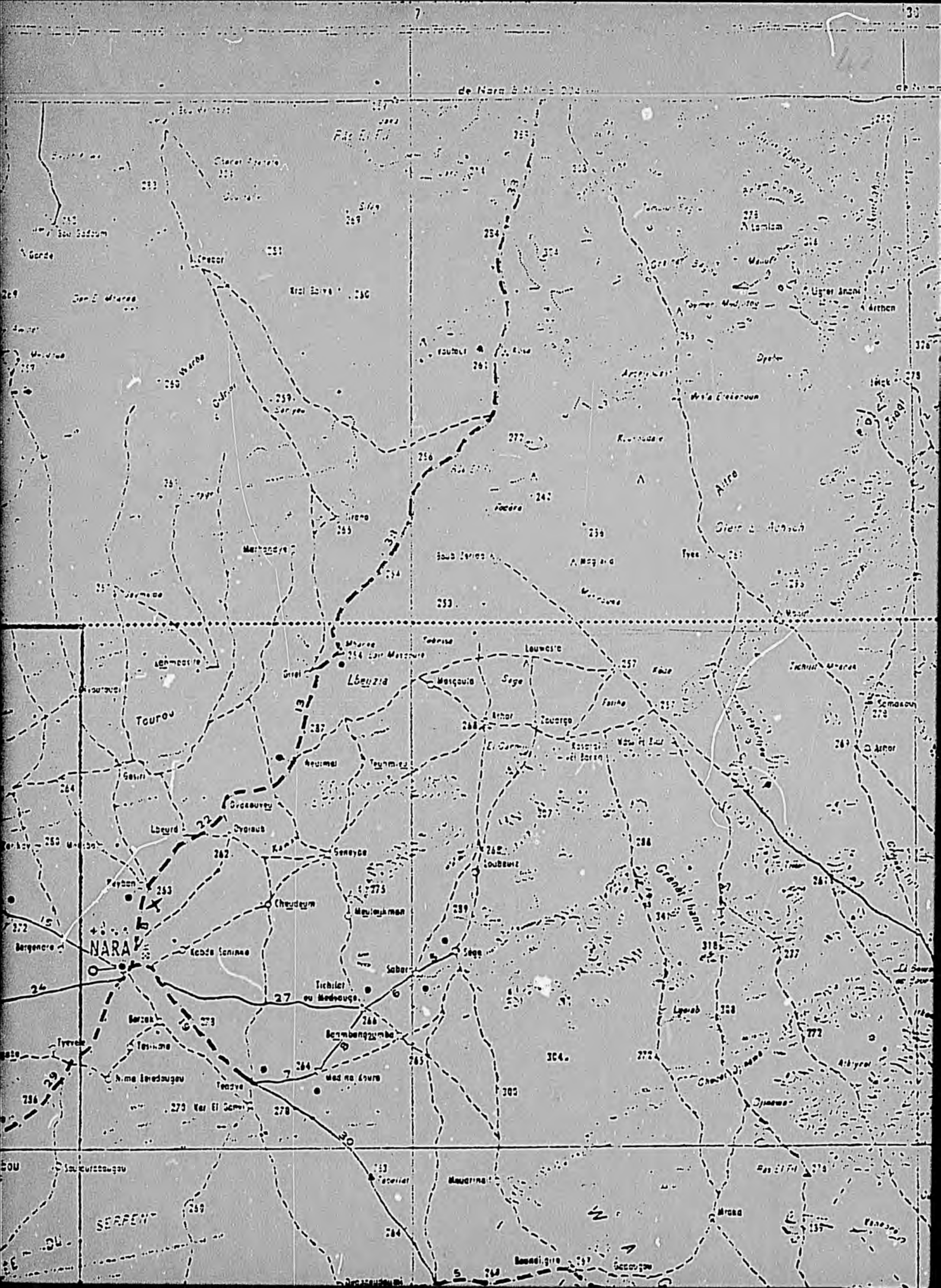
Map 3



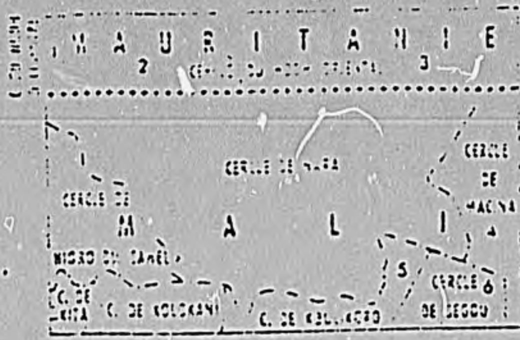
40
vers Nioro
Sami
Balle
de Ballé à Nioro du Sahel 126 km
Kayes



Yengi
Tahamra
Zidou Toure
Boulel
Dei
Diatare



NARA
Tourou
Lbeuzia
Sega
Saber
Tichilet
ou Medouaga
Mrasa



RÉPUBLIQUE DU MALI

RÉPUBLIQUE ISLAMIQUE DE MAURITANIE

SUBDIVISIONS

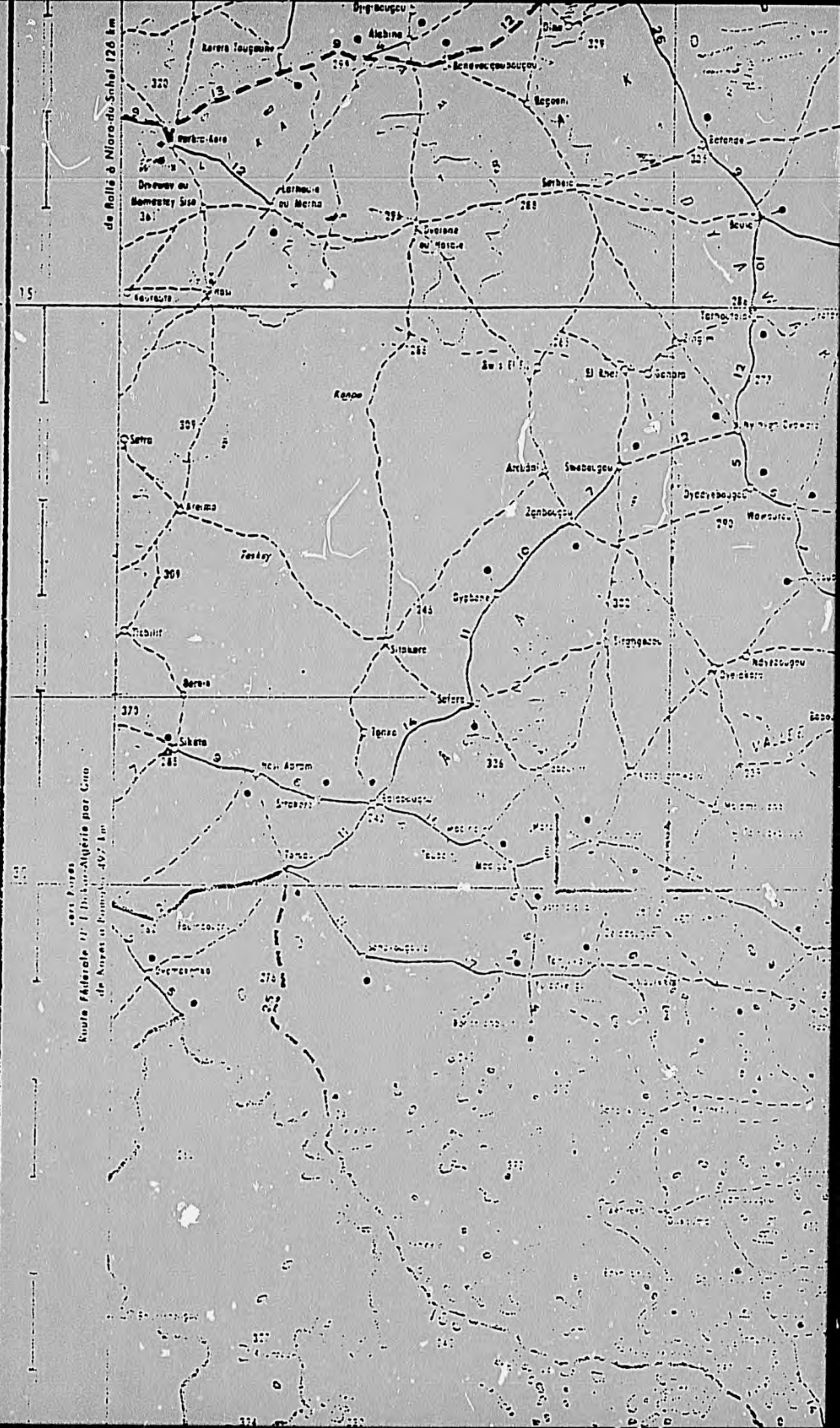
1. d'Aïoun El Atrouss	4. de Niono
2. de Timbedra	5. de Banamba
3. de Néma	6. Centrale de Ségou

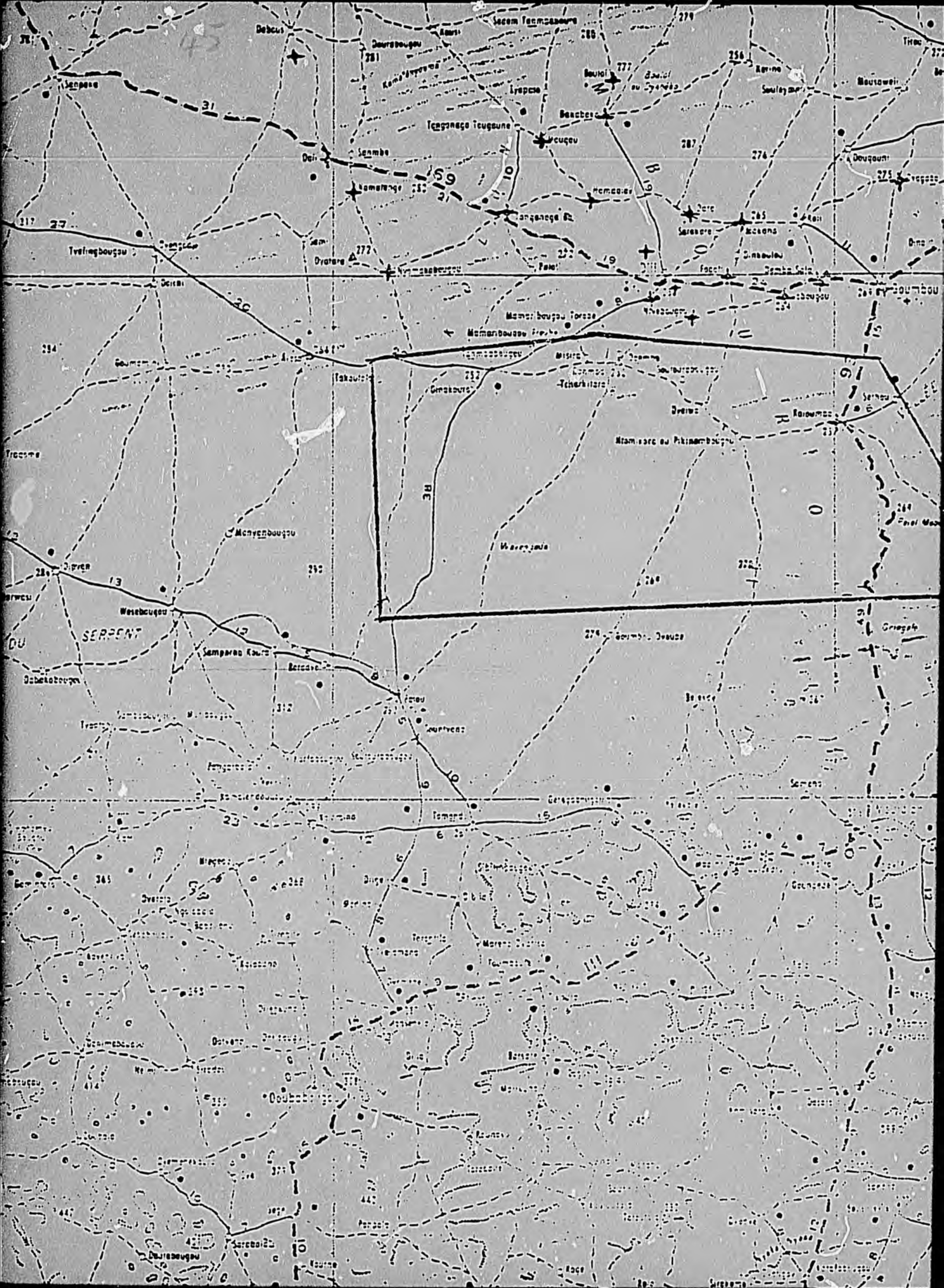
RÉFÉRENCES

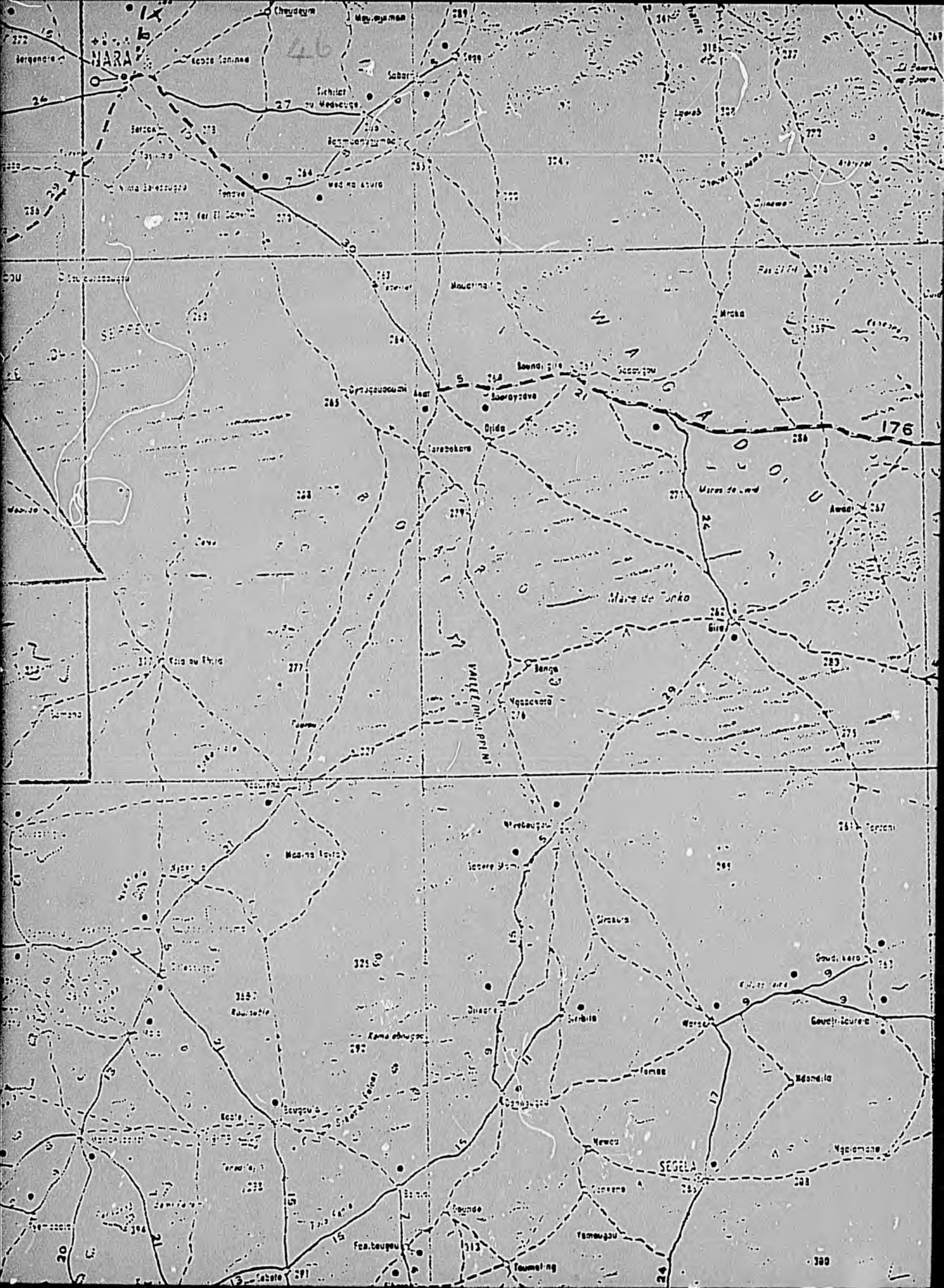
Cartes au 1:200 000 du Service Géographique

Ballé 1961	Douentza 1961
Nara 1960	Mourdiah 1961
Ségo 1961	Sokolo 1961

La déclinaison magnétique correspond au centre de la feuille au 1er Janvier 1961


de Rollé à Nioro-du-Sahel 126 km
Kayes
Setra
Sefara
Sikata

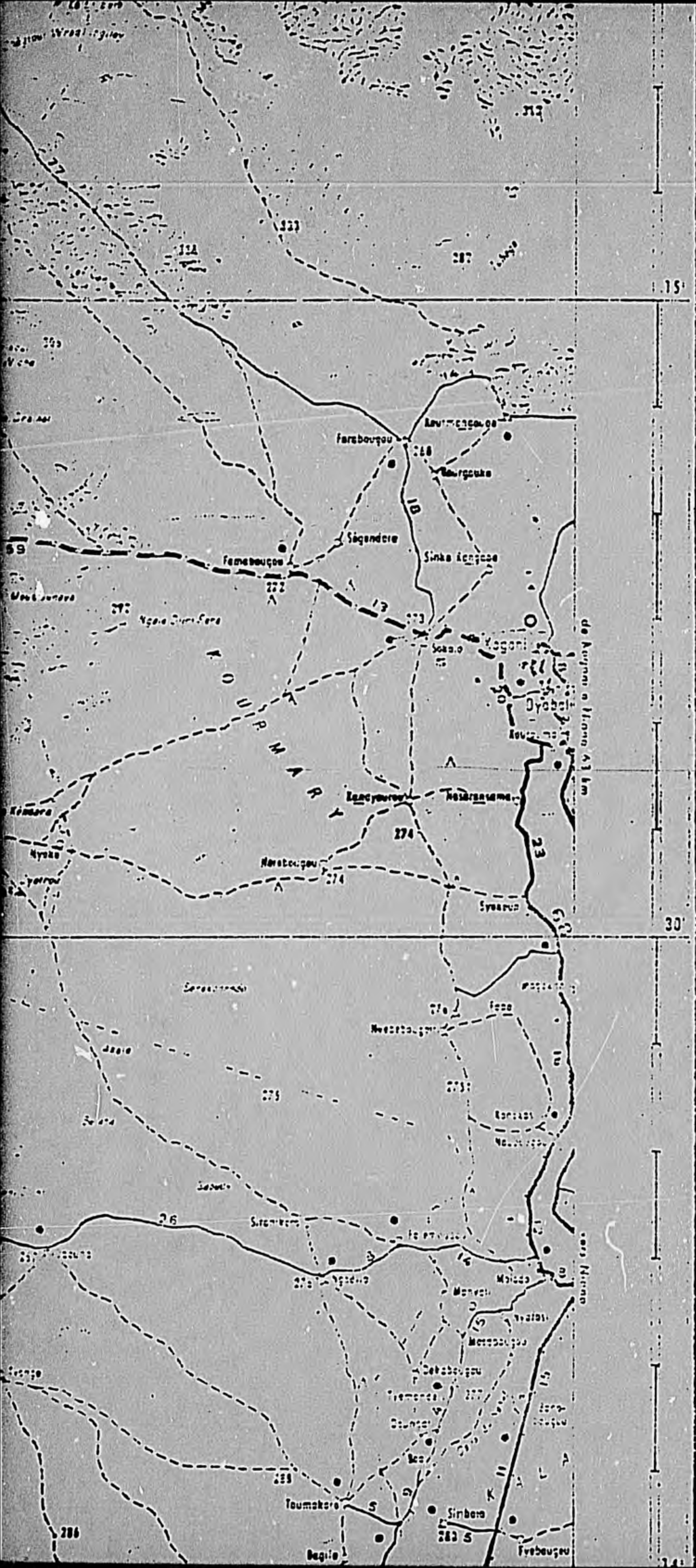

45
Sanpesa
Tvefingbougou
Menyenbougou
DU
SERPENT
Tomoro
Doubabougou
Sarabaiba



46
NARA
Mare de Tonko
SEGELA
176

la feuille au 1er Janvier 1961

47



La déclinaison magnétique diminue chaque année de 6 minutes sexagésimales

CONVENTIONS PHONÉTIQUES

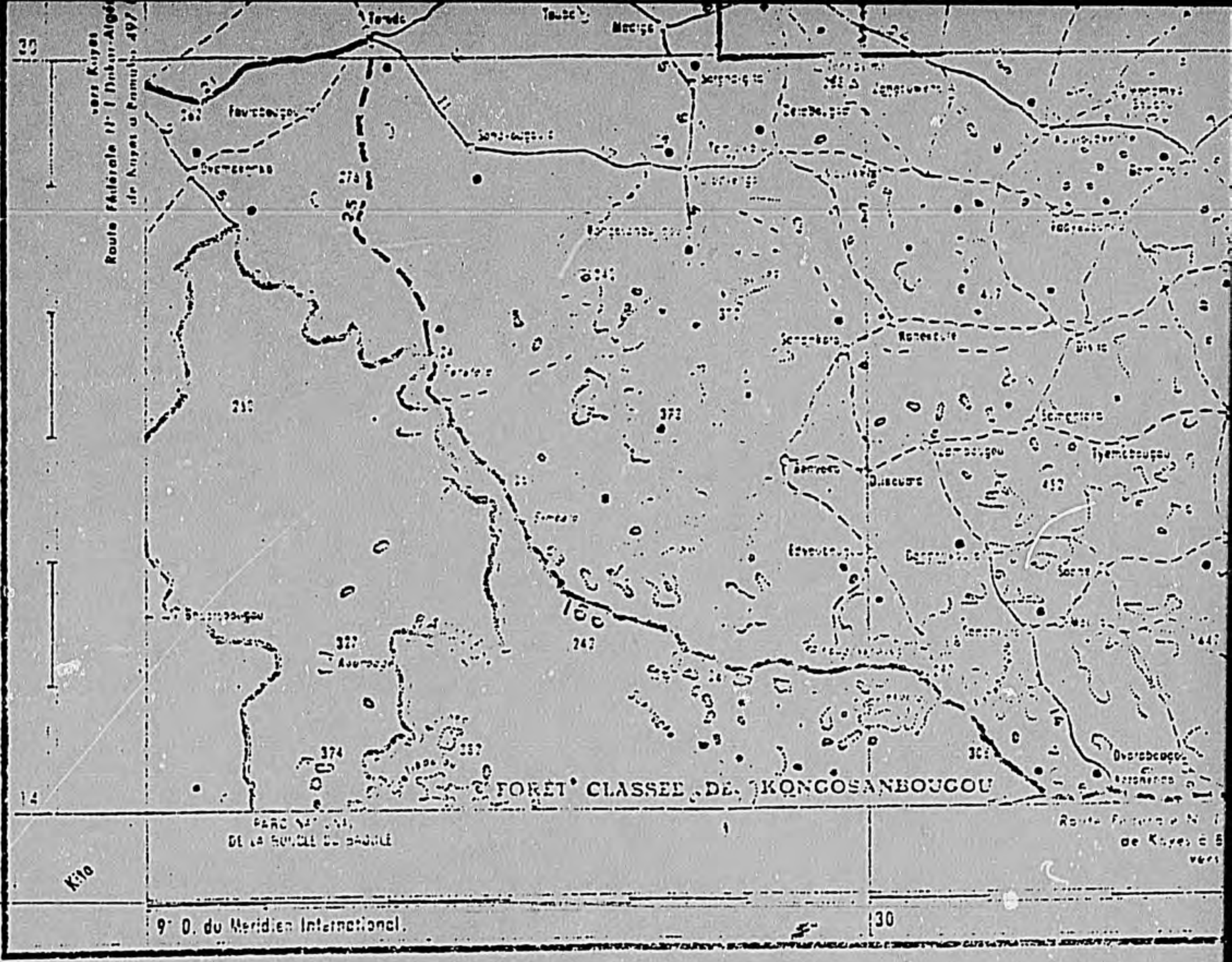
... National

Toutes les lettres se prononcent séparément y compris les E placés en fin de mo

EXCEPTIONS

Les doublets ... AN ON EN UN IN
conservent leur valeur habituelle
le doublet OU ...
à double
IN ...
OUN ...
NG se prononce comme la fin de ...
...
S sera toujours ... comme dans "selle"
G sera toujours ... comme dans "gare"
W a toujours le son anglais, jamais le son V
Y toujours semi consonne ...

48



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(Annexe de DAKAR)
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1re édition Octobre 1961

Toutes les écritures
Toutes les écritures

Autoroute

Routes principales: très bonne viabilité voie moderne; bonne viabilité: praticabilité permanente; praticabilité intermittente

Routes secondaires: praticabilité permanente; praticabilité intermittente

Routes en construction suivant la catégorie

Piste automobile

Piste ordinaire

Distances kilométriques

Aéroport

Terrains d'atterrissage: 1. praticabilité permanente; 2. praticabilité intermittente

Chemins de fer: à 2 ou plus de 2 voies; en construction
Voie normale 1m et au dessus: à 1 voie; en construction

Chemins de fer Voie étroite: de moins de 1 mètre; en construction

Gare Station Halte Arrêt

Chemin de fer sur route

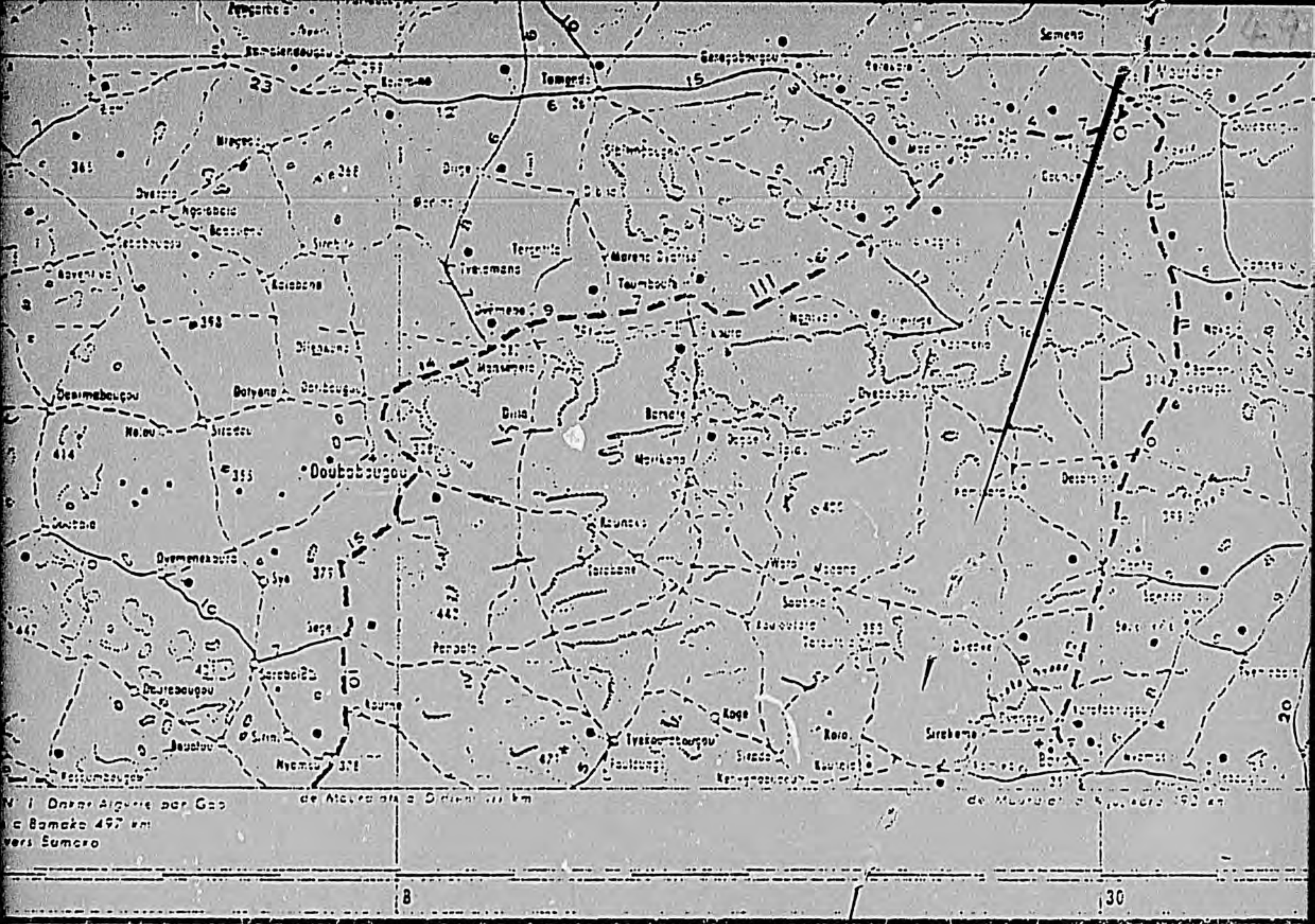
Passages . 1. inférieur - 2. à niveau - 3.

Ligne de transport d'énergie électrique

Ligne télégraphique et téléphonique

1. Courbes de niveau - Courbes 2. intercalaires

1. Escarpement - 2. Falaise - 3. Dune



…res droites se rapportent à des lieux habités.
…res penchées se rapportent à l'hydrographie
…

Echelle 1 : 500 000

Km 5 0 5 10 15 20 25 30 35

Fleuve et rivière: 1. Origine de la navigation · 2. Barrage; 3. Chute · 4. Rapides

Cours d'eau à sec une partie de l'année

Ponts (avec charge limite): 1. Maçonnerie ou métal 2. Bois et terre; 3. Passerelle, pont de lianes

Bacs (avec charge limite), 1. à moteur · 2. ordinaire

3. Chaussée submersible · 4. Gué ou pirogue

Gare · Halte · St^{on}

Canal d'irrigation ou d'assèchement

…supérieur

Zone inondable et sa limite

Puits · Citerne · Source · Oasis · Réservoir

1. Lac et Mare · 2. Mare temporaire

…calcaire · 3. de cuvette

1. Sables humides · 2. Limite de zone humide

Zone marécageuse

1. Poste · 2. Télégraphe

1. Poste et télégraphe

1. Campement · 2. …

1. Mission catholique

1. Cimetière chrétien

1. Cimetière musulman

1. Monument · 2. …

1. Tour · 2. Phare · 3 …

1. Station de T.S.F. · 2 …

1. Quai · 2. Wharf · 3 …

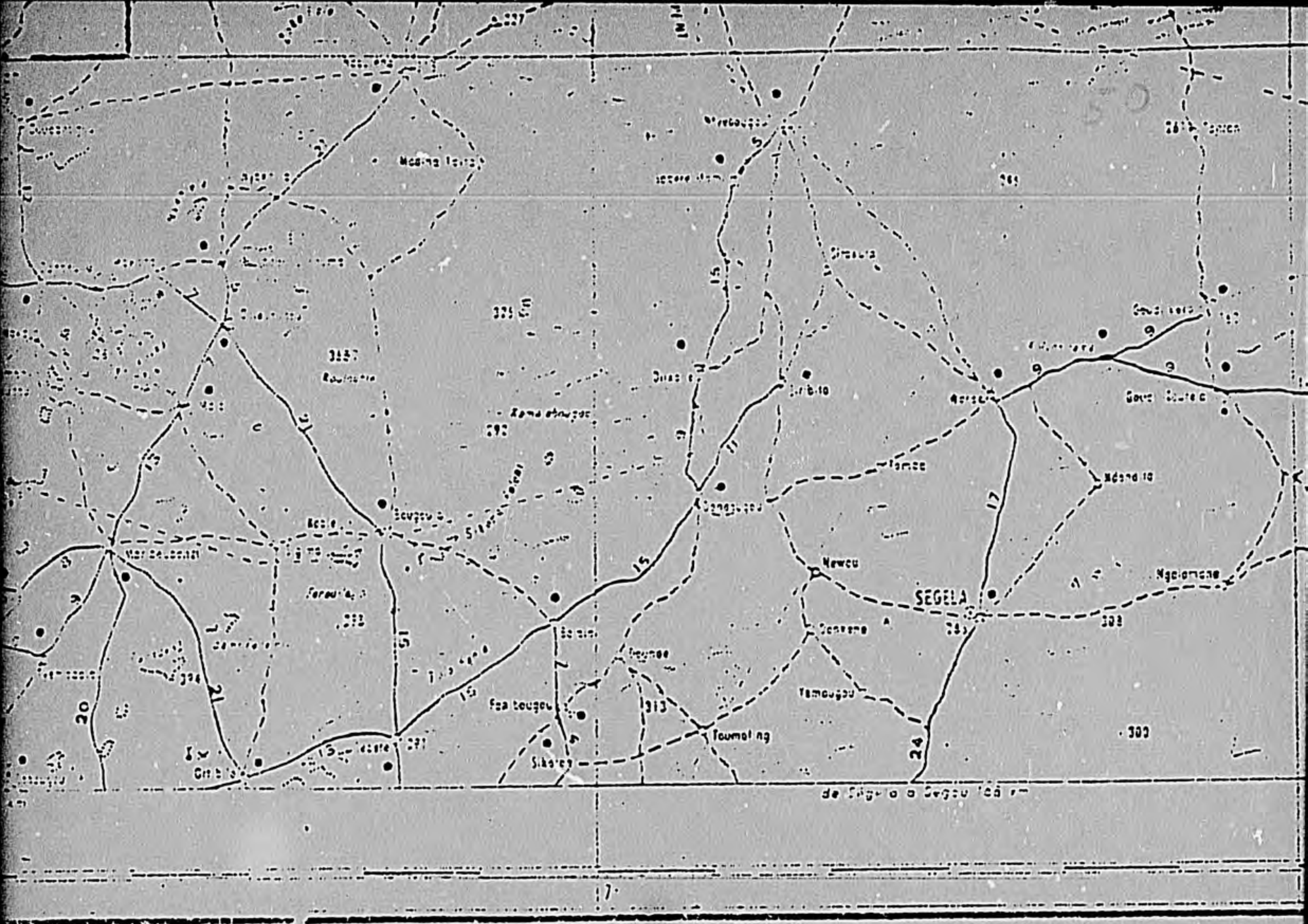
1. Localité pittoresque

1. Curiosité naturelle

Parcours pittoresque

INSTITUT GÉOGRAPHIQUE NATIONAL — PA…

ANNEXE DE DAKAR



Les courbes de niveau sont à l'équidistance de 100 mètres.

35 40 45 50 Km

2. Télégraphe · 3. Téléphone · 4. Poste et téléphone. 1 2 3 4

télégraphe · 2. Poste, télégraphe, téléphone 1 2

ment · 2. Dispensaire · 3. École 1 2 3

catholique · 2. Mission protestante · 3. Mosquée 1 2 3

re chrétien · 2. Tombe isolée 1 2

re musulman · 2. Tombe isolée 1 2

ent · 2. Monument ancien · 3. Poste de Douane 1 2 3

. Phare · 3. Ruines 1 2 3

de T.S.F. · 2. Usine · 3. Carrière · 4. Mine 1 2 3 4

2. Wharf · 3. Digue 1 2 3

pittoresque · 2. Point de vue ..... 1 Korkadio 2

té naturelle · 2. Curiosité touristique 1 2 3

pittoresque .....

1. Forêt 1

2. Forêt claire et fourré 2

3. Savane 3

4. Prairie 4

5. Brousse tigrée 5

6. Mangrove 6

Limites { de forêt classée, de réserve de faune ..... / de parc national .....

1. Rizière 1

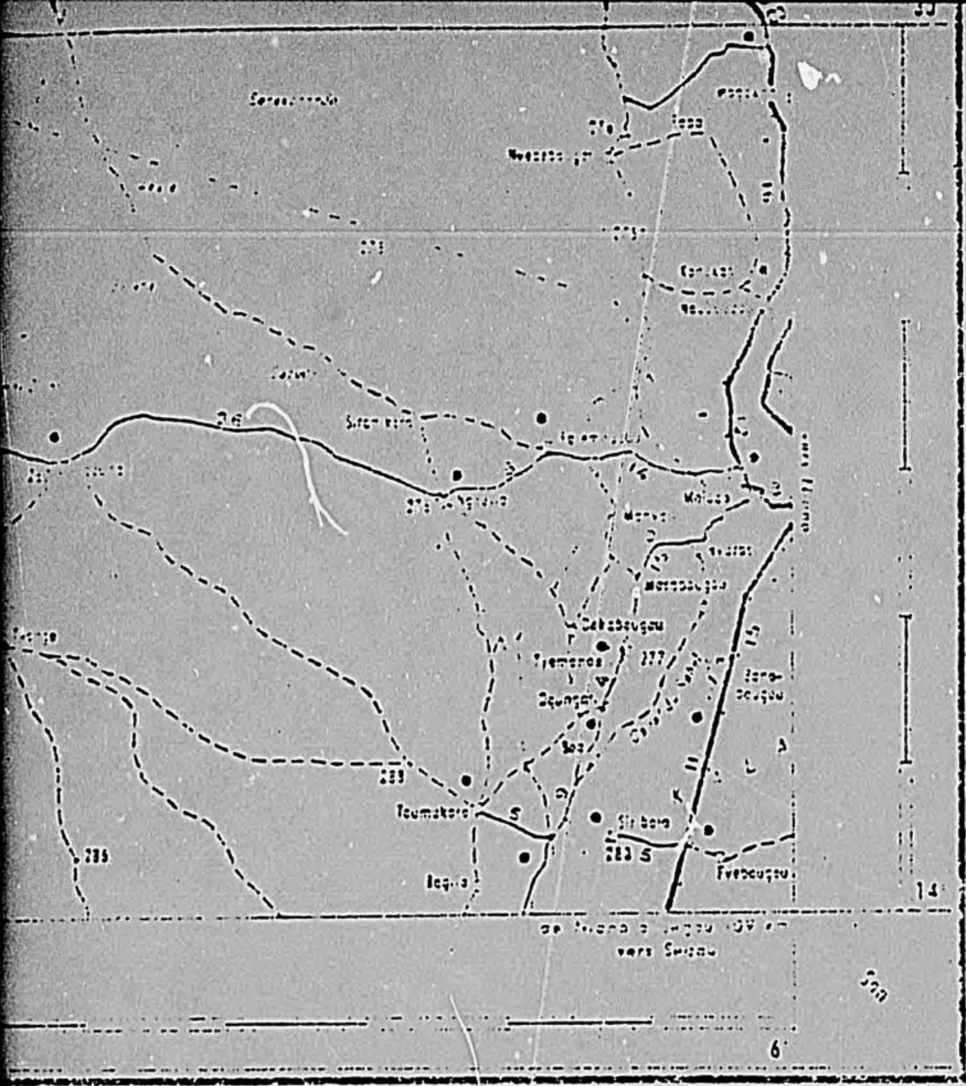
2. Plantation avec signe d'essence 2

Arbres isolés ou plantes arbustives { 1. Baobab 2. Cotonnier 3. Caféier 4. Hevea ..... 1 2 3 4 / 5. Palmier 6. Sisal 7. Bananier 8. Palétuvier 5 6 7 8

1. Point astronomique · 2. Point coté ..... 1 2 ·140

NAL — PARIS

51



Projection conique conforme de Lambert.
Ellipsoïde de Clarke 1880
Parallèles de longueurs conservées 7° et 20°

[illegible]

Toutes les lettres se prononcent séparément y compris les E placés en fin de mot

EXCEPTIONS

Les accents [illegible] conservent leur valeur habituelle
Le doublet OU [illegible]
IN représente le "in" nasalisé
OUN représente "oun" nasalisé
NG se prononce comme le "ng" de [illegible]
[illegible] grasseyé
[illegible]
S sera toujours [illegible] comme dans "salle"
G sera toujours [illegible] comme dans "gare"
W a toujours le son anglais [illegible]
Y toujours semi-consonne [illegible]

Capitale d'Etat .... BAMAKO
Chef-lieu de Cercle .... NARA
Chef-lieu de Subdivision .... GOROM GOROM
Chef-lieu de Canton .... TONGOMAYEL
Village important .... Niangassagou
1. Village 2. Campement nomade .... 1 Tessemakat 2 Gule

Les limites imprécises ou mal déterminées sur le terrain sont figurées en signes discontinus

Frontière _ Borne frontière et son numéro .... Lb. 2
Limite entre Etats de la Communauté ....
Limite de Cercle ....
Limite de Subdivision ....
Limite de camp ou de terrain militaire ....