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AN ECONOMIC EVALUATION OF THE TRYPANOSOMIASIS PROBLEM IN ZONE ONE

BY

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INTRODUCTION

The terms of reference for this report required the undertaking of a socio-economic analysis in cost-benefit form of the tsetse/trypanosomiasis problem in the area called Zone 1 and the relationship between this analysis and the various possible strategies for dealing with the situation.

To do this, the various types of strategies, essentially vector control compared to prophylaxis and treatment, were elaborated and their costs estimated. The general trends in agriculture and livestock in the Zone were examined and projections made so as to make it possible to estimate the impact of trypanosomiasis over the next twenty years. From this estimate, disease losses were calculated and compared with the costs of the strategies.

Since this is the first economic analysis of the trypanosomiasis problem in Mali and since there has been little work done in the field of animal health economics, a special effort has been made to present a very clear outline and a well-developed methodology so that this approach could be adapted to analyzing the problem in other regions and in different guises. This follows from the fact that one of the objectives of the work of the New Lands Activity has always been to develop approaches and guidelines to deal with all aspects of the tsetse/trypanosomiasis problem and that training has been an important component of its work. For this reason the origin of all the figures is clearly shown and the calculating tables and intermediate stages are included, as well as a section on indirect benefits. Where the necessary data were not available the assumptions made have been clearly stated so that these can be replaced with more accurate information as it becomes available.

This report was prepared under considerable pressure, in the six months dating from the arrival of the present economist in the Socio-Economic Section at New Lands. The problems which

beset this unit are well recognized, but it is worth reiterating that, in addition to the extremely limited time available for a work of this nature, the unit essentially consisted of only two people: the economist and the Malian counterpart, a geographer, who has been with the unit since its formation.

The bulk of the work was done in the first half of 1980, so the most recently available statistics usually refer to 1979, and the prices used are generally applicable to the beginning of 1980.

Another objective of this report is to incorporate in the economic analysis, insofar as possible, the results of the work done by the Entomology and Protozoology Sections of the New Lands Activity, so as to provide a synthesis of the work done by the Activity. Both sections have encountered extreme difficulties in the execution of their studies due to interruptions in the financing of their field work. These studies are especially vulnerable to such interruptions since the basic field work must be undertaken at specific times of the year. Nevertheless, it has been possible to incorporate the results of the protozoology dry-season disease survey and to use it in estimating disease incidence. The report on fly distribution prepared by the Entomology Section has already appeared separately. Summary maps of the tsetse fly situation in Zone 1 were prepared for this report. We are very grateful for the support, help, and advice given to this work by both the Protozoology and Entomology Sections. In addition to providing the results of their studies, the former helped in specifying the prophylactic and treatment strategies presented and the latter provided the outline of the eradication scheme.

The approach used here, which is applicable to most animal health projects, consists of distinguishing, on the costs side, between a continued policy of prophylaxis and treatment as against a once-and-for-all type eradication policy against the vector. Repeated attacks on the vector, in what is usually called a

"control" policy, were not considered particularly feasible by the Entomology Section but are nevertheless discussed. On the benefits side, a distinction is made between direct and indirect benefits. Direct benefits to a strategy dealing with trypanosomiasis are the reduction in projected future costs and losses attributable to the disease. Costs are generally those of anticipated treatment and prophylaxis; losses are the effects of mortality and morbidity due to the disease. These are determined by multiplying the number of animals at risk in a given year by the estimated infection rate and by the value of the production lost due to illness. The indirect benefits are a reflection of the extent to which the disease poses a constraint on certain types of production which people avoid for fear either of contracting the disease themselves, or of their animals falling sick. Indirect benefits occur when people are able to undertake certain types of production in areas which they previously avoided, or to use certain production methods which they previously regarded as not feasible.

Finally, the tsetse/trypanosomiasis situation in Zone 1, and within Mali as a whole, can be briefly characterized as follows: Zone 1 is one of the most densely populated areas of Mali and the most urbanized due to the presence of Bamako and Segou. It is also the area which is the best staffed by the Government Services and has long been under the wings of several "Operations." It is situated on the periphery of the country's tsetse-infested areas. The trypanosomiasis problem is dealt with not by cattle or people avoiding the area, but by the use of extensive treatment and prophylaxis. To this is added the use of Ndama and mixed breed cattle instead of Zebus in the tsetse-infested areas of the Zone.

SECTION A

DESCRIPTION OF ZONE ONE
(Chapters 1-6)

CHAPTER 1
GENERAL FEATURES OF ZONE 1

After its creation, the New Lands Activity was given the responsibility of investigating the tsetse/trypanosomiasis problem and related socio-economic factors in three Zones. For the year July 1979 to June 1980, Zone 1 was selected for intensive studies to be undertaken by all three sections at New Lands: Entomology, Protozoology, and Socio-economics. The Zone follows the Niger River from southwest to Bamako at Bankoumana to Diourou, northeast of Segou. It is about 300 kilometers long and varies in width from 120 to 35 kilometers. The total surface area is calculated to be 19,271 square kilometers (Table 1.1).

The boundaries of the Zone were drawn arbitrarily, with the result that they cut across a number of administrative boundaries (Map 1.1). They follow only one natural boundary, the Niger River, and they bisect the Mandinque Hills. Since it is the administrative boundaries which form the basis for the collection and collation of all official data and information and which are used by the various "Operations" [1/] as their boundaries, a lengthy and cumbersome process had to be undertaken to convert available data to data relevant to the Zone itself.

Although much of the data is presented by cercles, further research and visits to cercle headquarters made it possible to disaggregate it to arrondissement level. There are five arrondissements contained totally within the Zone, while a further twenty are divided by the Zone boundary. Between 0.3% and 99.5% of the area of these twenty is contained in the Zone (Table 1.1). The need to subdivide the Zone was recognized by each section of New Lands. The arrondissement boundaries were only determined after a lengthy process of inquiry just prior to the drafting of this report. The only available and

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1/ The "Operations" are large projects which buy crops and provide inputs, credit and extension services to farmers. They are often geared towards promoting the production of a particular crop. The "Operations" active in Zone 1 are listed in Table 3.8.

consistent set of boundaries for arrondissements were those in the archives of the Census Bureau at Bamako. These were transcribed and used as the basis for Map 1.1 and for all subsequent calculations in this report. The Protozoology and Entomology Sections of the Activity had long since subdivided the Zone as best suited the requirements of their work. These subdivisions are shown in Maps 1.2 and 1.3. The data on infection rates and breeds of cattle in Zone 1 provided by the Protozoology Section was rearranged in this report to fit the administrative boundaries by reclassifying the villages by arrondissement. In this report the Zone has frequently been divided into four areas by grouping together with Koulikoro the small portions of Banamba and Kolokani cercles in the Zone, taking Segou and Baroueli cercles together, and leaving Kati and Dioila to stand alone.

Table 1.1 was produced from a large-scale map by using a planimeter and calculating the areas of each arrondissement inside and outside the Zone. The percentage of each arrondissement contained in the Zone was subsequently applied to all data (cattle numbers, human population, etc.) given for each arrondissement, using the somewhat arbitrary, but unavoidable, assumption that numberswere distributed evenly within each arrondissement. All of this required a great deal of extra work and extra calculations, so it is noted once again that it is regrettable that earlier pleas for a redefinition of the highly arbitrary limits of the Zone were ignored.

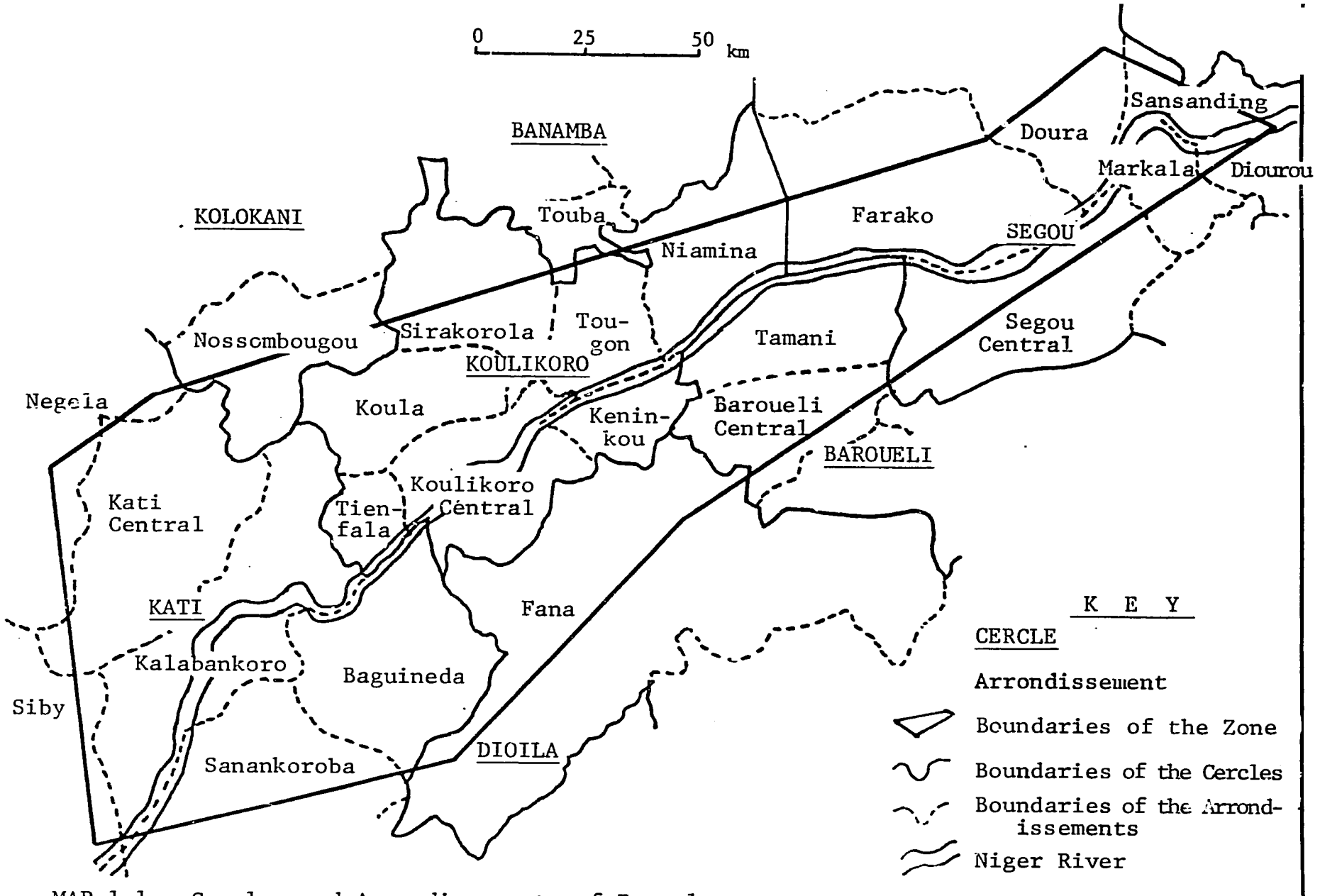
The general features of the Zone are given in Maps 1.4 and 1.5. Map 1.4, showing rainfall, indicates that if the 800 mm line is recognized as the division, the northeastern part of the Zone lies in the Sudan climatic belt, the southwestern part in the northern Guinea Savana Zone. In fact, throughout the report, the gentle transition from the tsetse-free, agriculturally highly-developed, northeastern area, with slightly more dense human and domestic animal populations,

to the tsetse-infested, less agriculturally progressive, less densely populated southwest, is noted. However, it should also be noted that, generally, it is a gradual transition, and that the agricultural differences have been emphasized by the intensive activity of the "Operations" in the northeast.

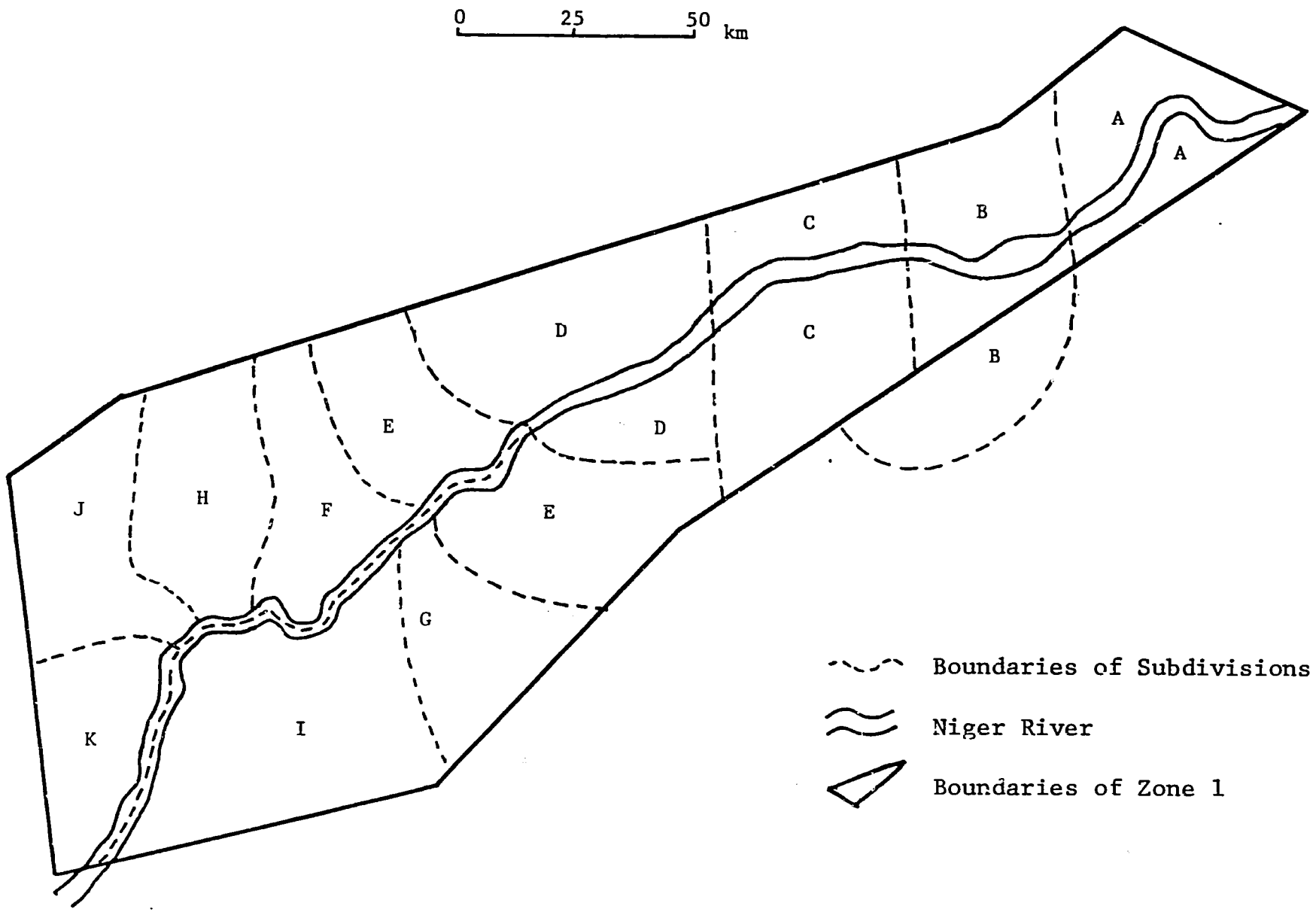
Map 1.5 gives a detailed picture of the main features of the Zone. The southwest is hilly, with the highest point of Mandingues Hills included in the Zone reaching 659 meters. The hills and cliffs along the river continue up to Koulikoro after which they rapidly disappear.

There are nine forest reserves wholly or partially within the Zone, and another three within five kilometers of its borders.

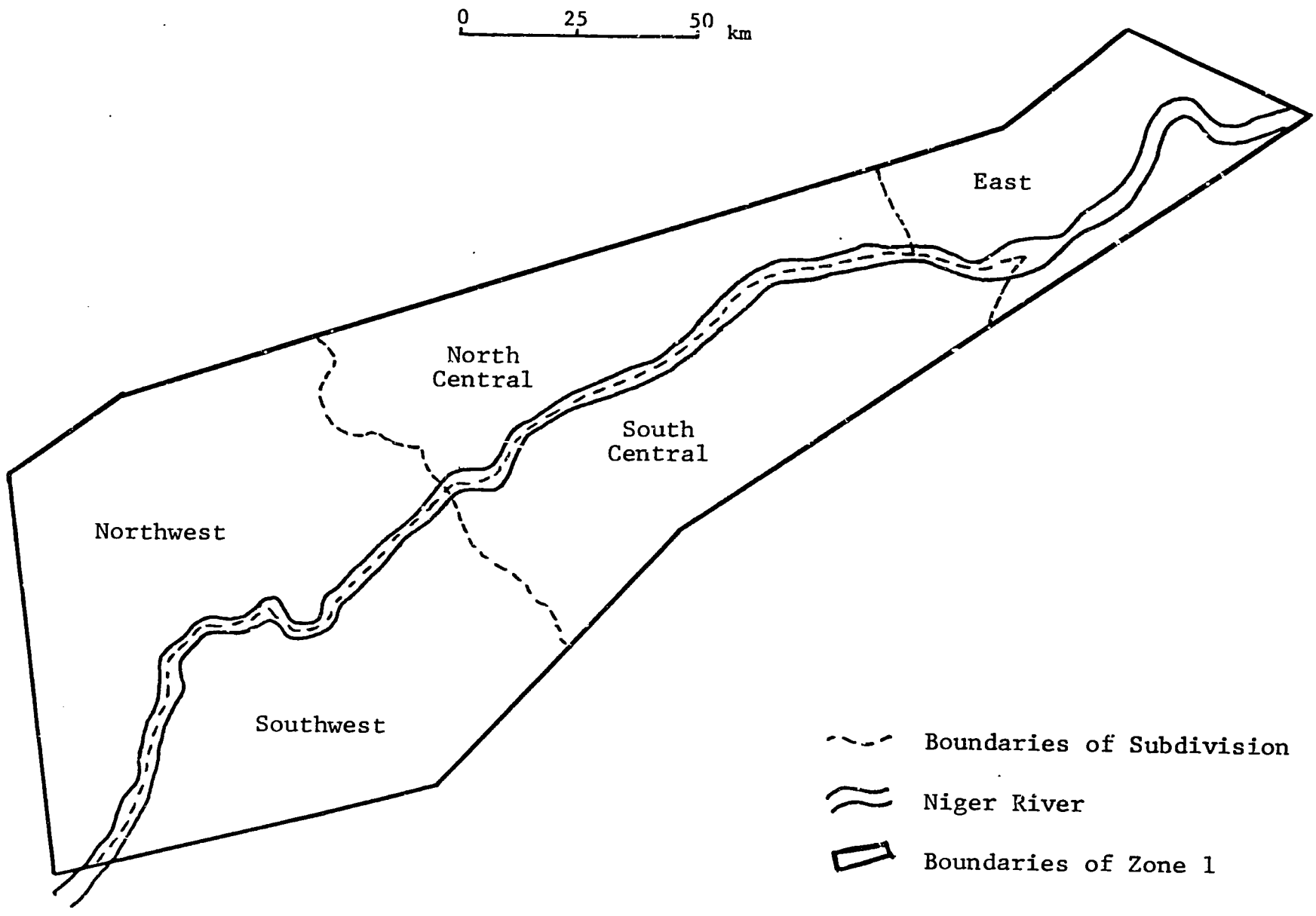
Zone 1 is easily the most favoured area in the country with respect to communications. The Niger River is navigable in the wet season from Koulikoro downstream. There are three hard-surface main roads: from Bamako to Segou, Bamako south towards Bougouni, and Bamako to Koulikoro. Major laterite roads go north from Bamako to Kolokani and Nara and west to Sibi and the Guinea border. The cercle headquarters and most of the arrondissement headquarters are linked to the main roads by reasonably good laterite roads. The railway from Kayes continues through Bamako to Koulikoro.



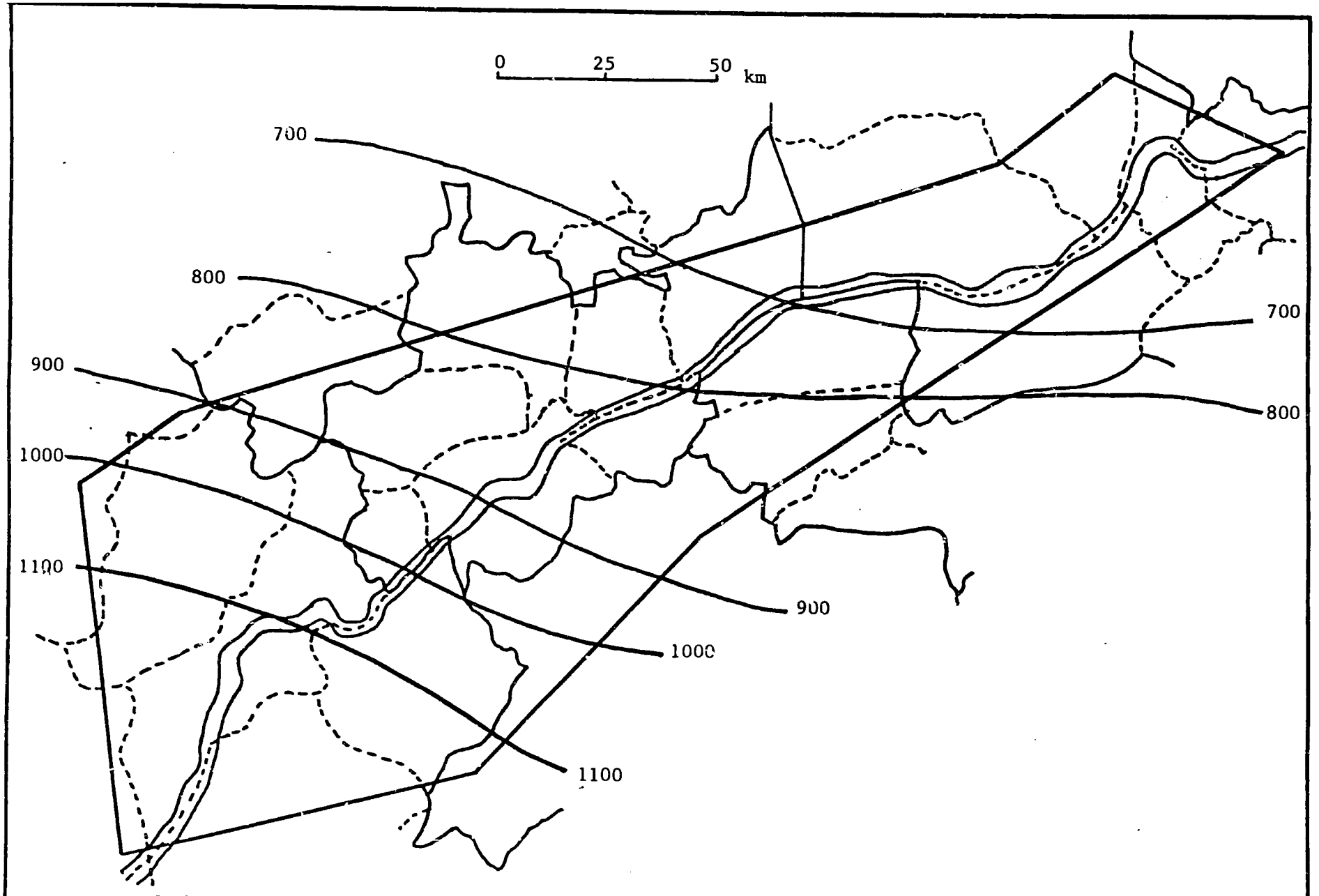
MAP 1.1 - Cercles and Arrondissements of Zone 1



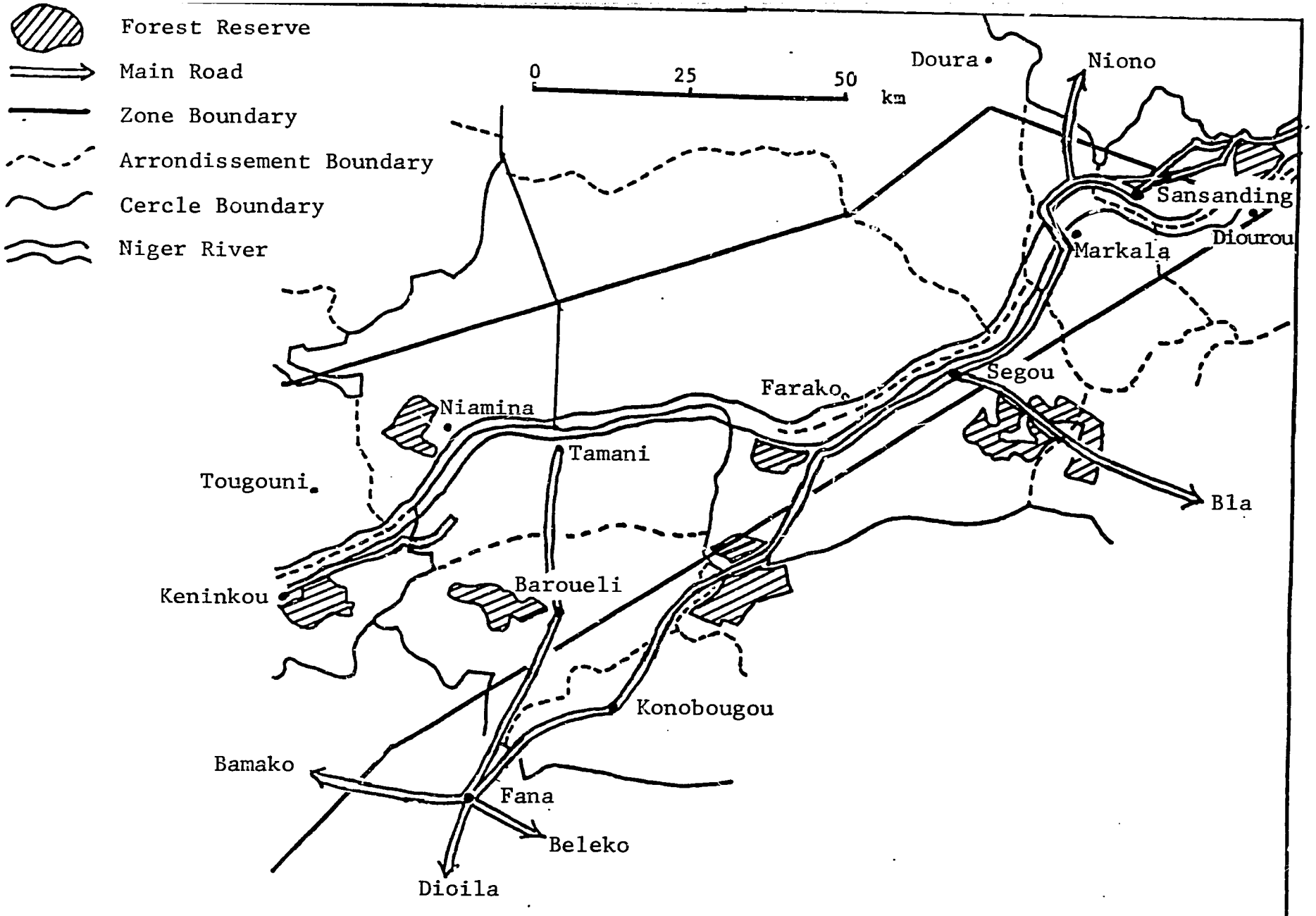
MAP 1.2 - Subdivisions of Zone 1 used by the Entomology Section



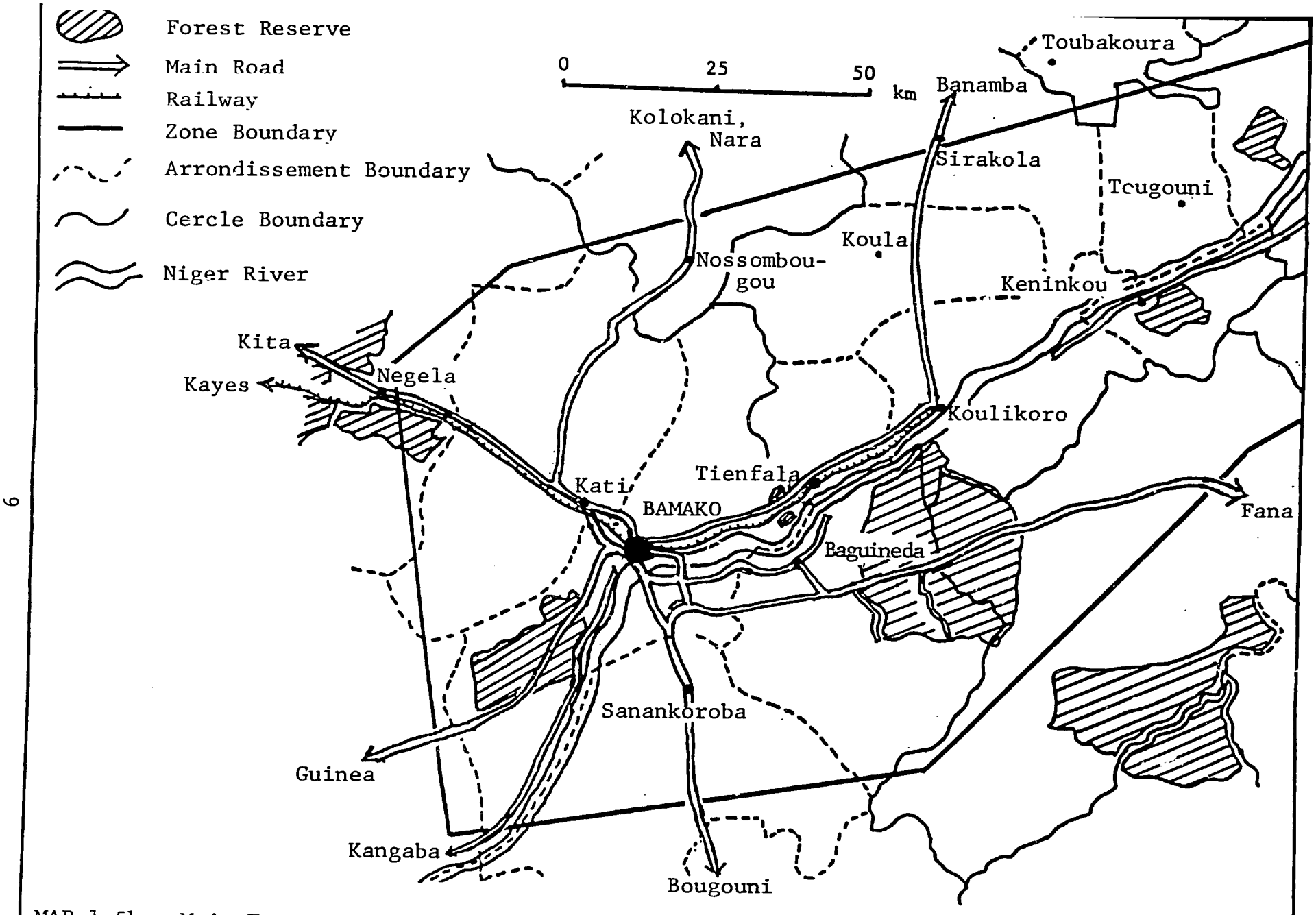
MAP 1.3 - Subdivisions of Zone 1 used by the Protozoology Section



MAP 1.4 - Rainfall in Zone 1 (Millimeters)



MAP 1.5a - Main Towns, Communications and Forest Reserves in the Northeastern Part of Zone 1



MAP 1.5b - Main Towns, Communications and Forest Reserves in the Southwestern Part of Zone 1

TABLE 1.1

TOTAL AREA AND AREA INSIDE ZONE 1 OF THE DIFFERENT ARRONDISSEMENTS OF ZONE 1

Cercle	Arrondissement	Total Area Km^2	Area in Zone 1 Km^2	Percentage in Zone 1
Kati	Central	1,769	1,706	96.4
	Baguineda	1,540	1,532	99.5
	Neguela	3,335	268	8.0
	Sanankoroba	1,590	1,003	63.1
	Sibi	3,489	213	6.1
	Bamako (former) = Kalabankoro	1,866	1,856	99.5
	Total Cercle	15,028 a	6,578	43.8
Kolokani	Nossombougou	1,077	387	35.9
	Total Cercle	11,700 a	387	3.3
Banamba	Toubakoura	319	24	7.6
	Total Cercle	7,700 a	24	0.3
Koulikoro	Central	1,143	1,143	100.0
	Kenenkou	519	519	100.0
	Koula	1,017	1,017	100.0
	Niamina	1,195	781	65.3
	Sirakorola	1,367	588	43.0
	Tienfala	380	380	100.0
	Tougouni	535	519	97.0
	Total Cercle	6,156	4,947	80.4
Dioila	Fana	4,928	1,801	36.5
	Total Cercle	13,000 a	1,801	13.9
Barcueli	Central	1,169	958	81.9
	Tamani	971	971	100.0
	Total Cercle	4,721 a	1,929	40.0
Segou	Central	1,514	740	48.9
	Diourou	1,269	90	7.1
	Doura	6,171	648	10.5
	Farako	2,245	1,501	66.9
	Markala	792	497	62.7
	Sansanding	535	129	24.1
	Total Cercle	15,284 a	3,605	23.6
	Total Zone		19,271	

Note: All figures are calculated following the boundaries used by the Central Census Bureau (BCR) for the 1976 census except those marked "a" which originate from the figures of the "Reforme Administrative."

CHAPTER 2
THE HUMAN POPULATION

A. Sources and Methodology

1. Sources

This study is based on basic information, all collected at the Bureau Central de Recensement (BCR). In essence, this data was extracted from three documents:

- National Population Census for Mali (December 1-16, 1976); provisional results.
- National Population Census for Mali (December 1976). Urban Population (Provisional Results) January 1978.
- Provisional Estimates of Population 1975 - 1985 (October, 1969).

The demographic and statistical data obtained would have been difficult to use for the purposes of this study had it not been for the existence in the archives of the Census Bureau of outline maps drawn at the time of the general population census of Mali in December, 1976. In fact, these outline maps had the advantage of showing each cercle of the country with the boundaries between the different arrondissements drawn in. This made it possible for the first time, and in relation to Zone 1, to manipulate the figures for geographical areas smaller than the cercles and thus to obtain more detailed results than was the case in previous studies.

Initially, the surface areas of administrative divisions (cercles and arrondissements) were obtained from the Direction Nationale de la Reforme Administrative, which published a list of administrative divisions in Mali with details on surface areas and population numbers.

2. Methodology

As explained in Chapter 1, the surface areas obtained for the arrondissements located in Zone 1 were used to determine the rural population for the Zone, on the basis of the equation: percentage of surface area equals percentage of population. This

practice has no disadvantages (or very few) when the arrondissement being considered is almost wholly contained in Zone 1. But it is evident that errors can be considerable for those arrondissements of which a more or less small proportion is located in Zone 1 (e.g. the arrondissements of Toubakoura, Siby and even Nossombougou or Fana). In fact, the approach used implies uniformity in the distribution of populations within the arrondissements although this is not entirely true. For lack of more accurate information, this approximation is tacitly accepted.

With regard to the estimates of urban populations in the Zone, these were much more easily dealt with. The censuses of the large towns within the Zone were taken and the total of their populations was calculated. The "district" of Bamako, the "communes" of Kati and Koulikoro and the town of Markala were retained as urban centers. Although not a "commune," the latter was chosen as an urban center not only because of the size of its population (15,269 inhabitants in 1977) but principally for the reason that Markala participates in activities that increasingly differentiate it from rural towns.

Various other towns in the Zone that have more than 5,000 inhabitants were discarded simply on the grounds that, directly or indirectly, their populations are composed essentially of rural inhabitants. This is the case for Diourou and Sansanding in the cercle of Segou and also for Baroueli, which is a cercle headquarter.

National average growth rates were used to evaluate the population in Zone 1 for the future (up to the year 2000). These rates are 1.81% per annum for rural populations and 6.7% per annum for urban populations.

In order to facilitate calculations, numbers obtained during the national census of December 1976 were simply adopted for January 1977, as was done by the BCR.

B. The Results

These are shown in Tables 2.1 to 2.6. From these, some of the trends emerge which characterize Zone 1 from a demographic point of view.

1. Variations in Population Density in Rural Areas

While the average rural population densities range from 19 to 20 inhabitants per square kilometer in Zone 1, the breakdown shows considerable variation between arrondissements (Table 2.1). While in Doura (cercle of Segou) population density is less than five inhabitants per square kilometer, it reaches 60 inhabitants per square kilometer in the arrondissement of Toubakoura (cercle of Banamba). Similar extremes appear in both these arrondissements with regard to animal population density (Tables 3.2, 4.1, 4.2). Relatively high densities (greater than 30 inhabitants per square kilometer) appear in the eastern portion of the Zone, while in the western portion, the densities are always less than 25 inhabitants/km^2 and in most cases less than 20 inhabitants/km^2 (Map 2.1). However, with the exception of the arrondissement of Doura, it is to be noted that throughout the Zone, the rural population density is higher than the overall national average, which ranges from six to seven inhabitants/km^2, and furthermore, this includes the urban population. The low population density in Doura is in fact rather more representative of the dry northern part of the arrondissement, this dry area being larger in surface area than the riverine part where population density is certainly higher.

From this analysis, it can be concluded that compared to the rest of the country, Zone 1 is an area of high human population.

2. The Importance of the Urban Population

With a surface area of 19,271 km^2, Zone 1 had a rural population of 380,000 inhabitants and an urban population of approximately 600,000 inhabitants in 1979 (Table 2.2). In other

words, the urban population was 160% of the Zone's rural population and 61% of its total population (Table 2.3).

This phenomenon, a priori unexpected, can be explained by the presence of Bamako on one hand and on the other by the existence of a significant movement of people towards the main centers and towards foreign countries.

In fact, the population in the district of Bamako added up to more than 450,000 people in 1979, that is, 47% of the total population of the Zone and 77% of its urban population. Moreover, if Bamako were excluded, the urban population would account for only 27% of the total population in the Zone and somewhat more than one third of the rural population.

In addition, as is the case for Bamako, but to a lesser extent, other cities in the Zone, and in the country as a whole, do experience high annual population growth rates when compared to the rates recorded in rural areas (an average of 6.7% against 1.81%). This disproportion is accounted for not only by the standard explanations given, such as the conditions prevailing in the rural areas, but by the availability in cities of medical facilities that are sufficiently equipped to have a significant effect on death rates (especially on infant mortality) and also by significant and regular siphoning of people from the rural areas surrounding the main urban centers. Although at present in Mali it is difficult to quantify this flow of people, it nevertheless constitutes a reality which, together with the high death rates, leads to a considerable lowering of the demographic growth rates in rural areas.

In Zone 1, most of the arrondissements take part in these population shifts which vary in motivation and type (Map 2.2). However, it seems that the attraction of monetary rewards and in some cases, the desire to evade parental authority, are at the origin of many of the departures of young people from rural areas. But, in some cases, the decision to emigrate takes the form of a joint decision; in such cases, departures are first discussed and then rejected or approved by a family council.

In Zone 1, emigration is either temporary or permanent, but more often the former than the latter. Sometimes the emigration is to important centers (Bamako, Segou) or to foreign countries (mainly the Ivory Coast but also Upper Volta, Senegal, Zaire and Gabon). In the first case, both girls and boys take part. The former seek work as household servants for wages that enable them to obtain the money needed to buy items for their trousseau; the latter seek work as unskilled workers in towns or as agricultural laborers. If unsuccessful, they end up swelling the ranks of the urban unemployed. In the case of long distance migrations, emigrants generally leave rural areas when the agricultural work is completed and come back at the beginning of the rainy season, but in some cases they prefer to remain in the host country for more-or-less extended periods of time. Then, as a general rule, in order to offset the loss to family crop production resulting from their departure, they send gifts (in money or in kind) to their relatives.

It also happens that population transfers occur between one rural area and another. This is especially the case in the cercle of Baroueli, where entire families of farmers, due to the impoverishment of the land they were farming or due to the possibility of monetary rewards, emigrate to better land in the cercle of Dioila which, moreover, benefits from the presence of CMDT and therefore holds out the promise of higher incomes.

From the demographic point of view, the effect of these population shifts is to destabilize the rural area by uprooting manpower which goes to swell the population of the towns, where there is no guarantee of a better existence.

3. The Demographic Future of Zone 1

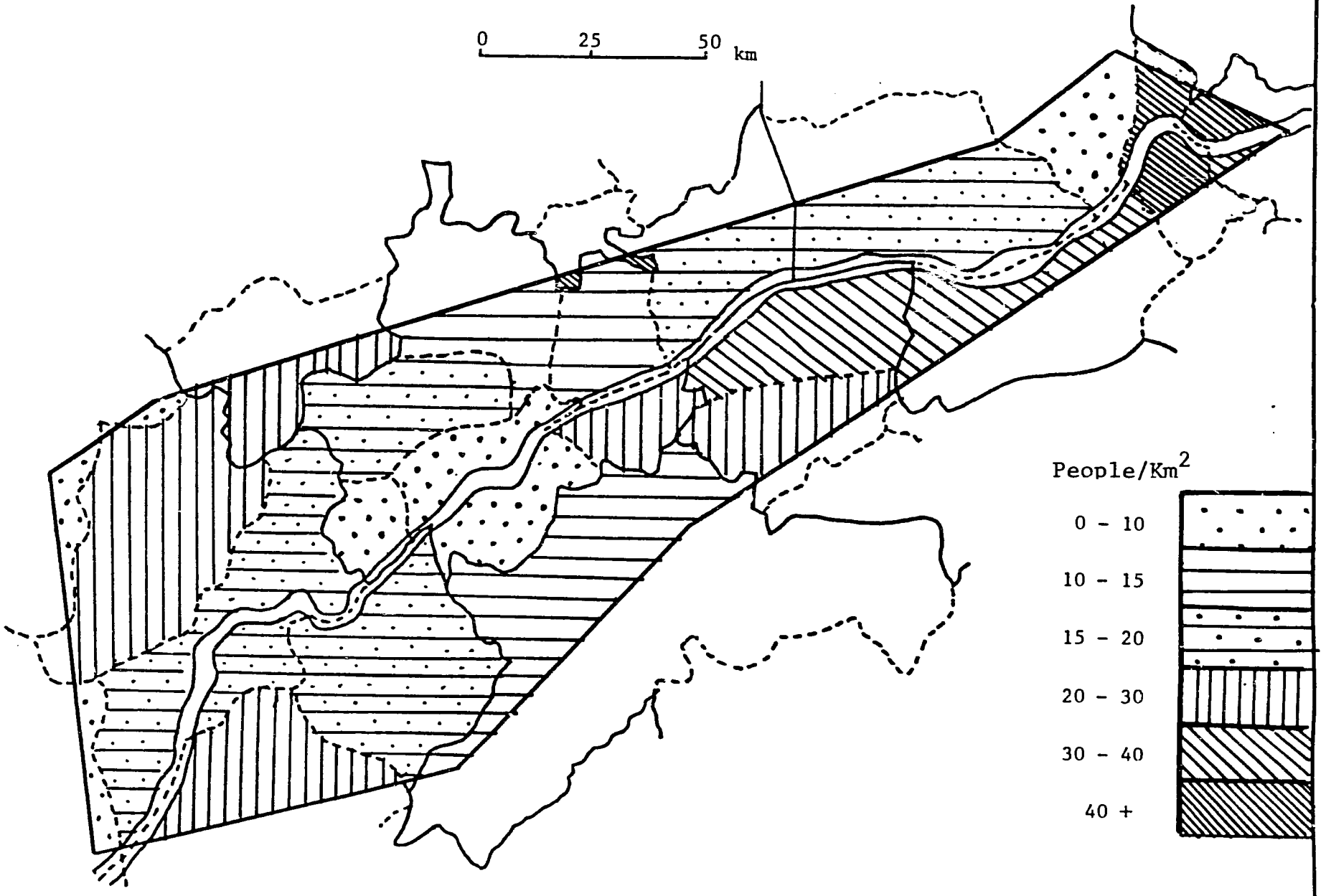
Considering the present growth rate, the population in Zone 1 should double in the next fourteen years and should reach approximately 3,000,000 inhabitants by the year 2000 (see Table 2.4). In fact, if the population in the Zone is

represented by an index of 100 for 1979, then it would increase to approximately 134 in 1985, 172 in 1990, 225 in 1995 and 296 in the year 2000. This will result in the trebling of the population of the Zone in the early years of the twenty-first century (see Table 2.5).

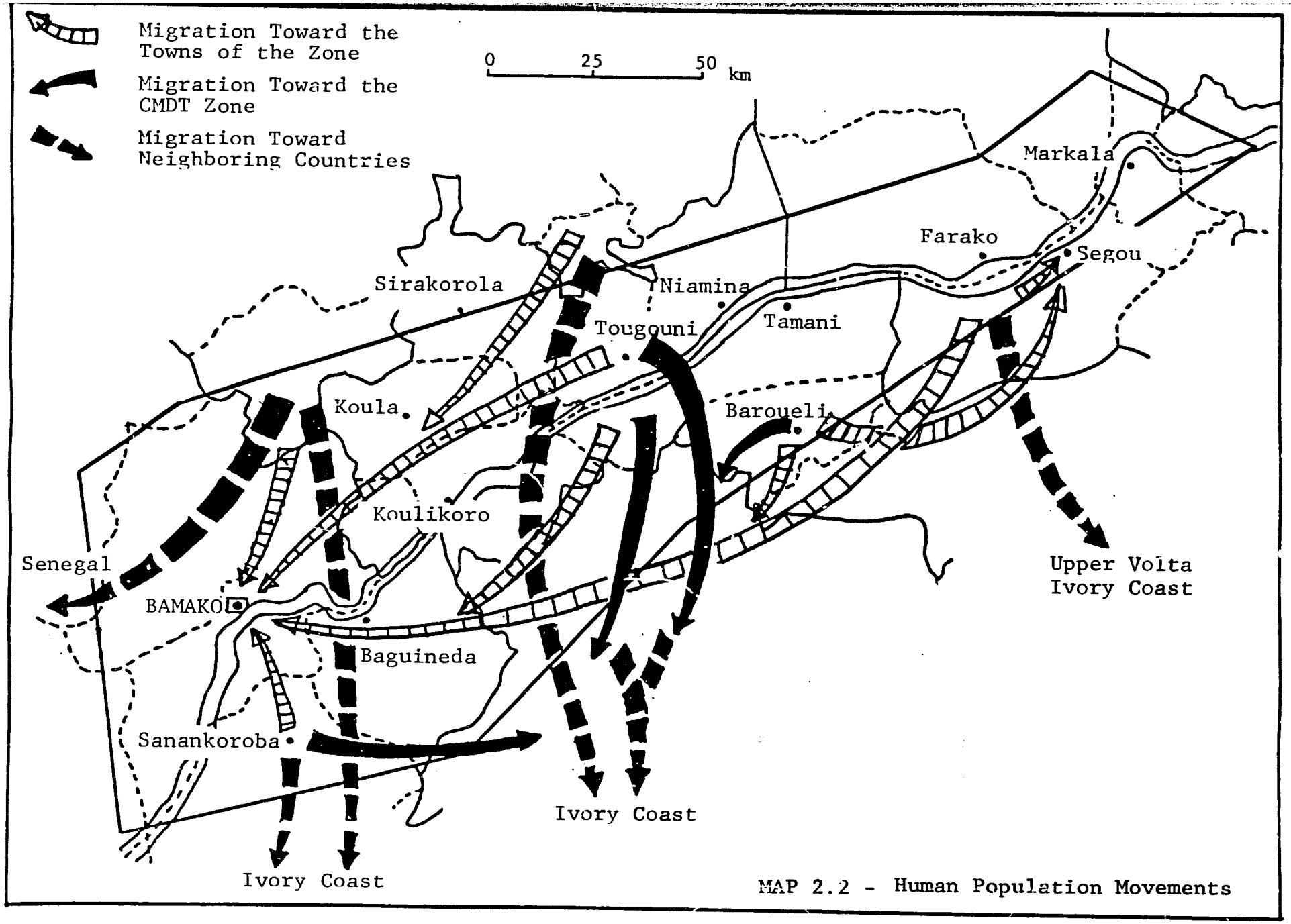
This overall growth, although impressive, does not reflect the full extent of the phenomenon as far as the urban population is concerned. The urban population (598,000 inhabitants in 1979) will reach more than 800,000 inhabitants in 1985; 1,200,000 in 1990; 1,600,000 in 1995 and 2,000,000 in the year 2000. In other words, taking the same years as points of reference, the urban population will constitute respectively, 68%, 73%, 77%, and 81% of the total population in the Zone. It would thus double within a period of eleven years and treble in the next twenty years. In relation to itself, the urban population would increase 38% from 1979 to 1985, 104% from 1979 to 1990, 182% from 1979 to 1995 and 290% from 1979 to the year 2000.

By comparison, the rural areas make a far more modest contribution to population growth, increasing by 11% from 1979 to 1985, 22% the next ten years, 33% within fifteen years and by only about 46% over twenty years. Overall, the rural population's share of the total population of Zone 1 declines from 32% in 1985 to 27% in 1995 and is only 19% in the year 2000. This declining share of the rural population in the total population is reflected in the ratio of urban population to rural population (UP/RP - see Table 2.6), whose gradual increase is a symptom of a fundamental disequilibrium. Thus, while in 1979 each rural inhabitant in the Zone needed to produce an agricultural surplus for 1.6 urban people in order to secure self-sufficiency within the Zone, each rural inhabitant would have to produce surplus for 2.1 people in 1985, 2.7 in 1990 and 3.4 in 1995. In the year 2000, each rural inhabitant of the Zone would have to produce sufficient food for 4.3 urban inhabitants. Whereas agricultural self-sufficiency within the Zone is not an essential goal, this nevertheless illustrates the fact that to feed the

urban population, a considerable surplus must be produced by the agricultural sector. How this can be accomplished is at present very difficult to see.



MAP 2.1 - Number of Rural Inhabitants per Square Kilometer



MAP 2.2 - Human Population Movements

TABLE 2.1

DISTRIBUTION OF THE RURAL POPULATION BY ARRONDISSEMENT IN ZONE 1

Arrondissement	Population - 1977 1/	% in Zone	Population in Zone - 1977	Population in Zone - 1979	Density per Km^2 in 1979
ercle of Kati					
Kati Central	38,041	96.4	36,687	39,027	22.3
Baguineda	28,796	99.5	28,646	29,692	19.4
Neguela	29,671	8.0	2,383	2,470	9.2
Sanankoroba	31,726	63.1	20,013	20,744	20.7
Siby	32,660	6.1	1,992	2,065	9.7
Kalabankoro	34,653	99.5	34,473	35,732	19.2
Cercle Total				128,730	
ercle of Kolokani					
Nossombougou	25,894	35.9	9,304	9,643	24.9
Cercle Total				9,643	
ercle of Banamba					
Toubakoura	17,692	7.6	1,358	1,408	58.7
Cercle Total				1,408	
ercle of Koulikoro					
Koulikoro Central	10,696	100.0	10,696	11,087	9.7
Keninkou	11,321	100.0	11,321	11,735	22.6
Koula	17,509	100.0	17,509	18,149	17.8
Niamina	20,064	65.3	13,106	13,585	17.7
Sirakorola	17,163	43.0	7,387	7,657	13.0
Tienfala	3,270	100.0	3,270	3,389	8.9
Tougouni	7,299	97.0	7,080	7,338	14.1
Cercle Total				72,940	
rcle of Dioila					
Fana	54,935	36.6	20,079	20,812	11.6
Cercle Total				20,812	
rcle of Baroueli					
Baroueli Central	29,995	81.9	24,575	25,473	26.6
Tamani	32,139	100.0	32,139	33,313	34.3
Cercle Total				58,786	
rcle of Segou					
Segou Central	46,380	48.9	22,661	23,489	31.7
Dioro	48,172	7.1	3,430	3,555	39.5
Doura	16,068	10.5	1,687	1,749	2.7
Farako	33,496	66.9	22,402	23,220	15.5
Markala	35,514 2/	62.7	22,278	23,092	46.5
Sansanding	25,814	24.1	6,221	6,449	49.5
Cercle Total				81,554	
TALS			360,697	373,873	19.4

TABLE 2.1 (Continued)

Notes: 1/ In its provisional estimates of the population (1975-1985), BCR considered the figures obtained during the census in December 1976 as figures for the population in January 1977.

2/ 35,514 is the population of the arrondissement (50,783) less the population of the city of Markala (15,269).

Source: Recensement General de la Population du Mali - Resultats Provisoires.

TABLE 2.2.

URBAN POPULATION OF ZONE 1

Cercle	Urban Centers	Population in 1977	Population in 1979
Kati	Bamako District Commune of Kati	404,022 24,991	459,974 28,452
Kolokani	NIL	NIL	NIL
Banamba	NIL	NIL	NIL
Dioila	NIL	NIL	NIL
Koulikoro	Commune of Koulikoro	16,376	18,644
Baroueli	NIL	NIL	NIL
Segou	Commune of Segou Town of Markala	64,890 15,269	73,877 17,384
Zone 1		525,548	598,331

Source: Bureau Central de Recensement.

TABLE 2.3

RATIOS IN PERCENTAGE OF URBAN POPULATION, RURAL POPULATION AND TOTAL POPULATION IN ZONE 1 IN 1979

Correlation	Bamako Included	Bamako Excluded
UP / TP	61.5%	27.0%
UP / RP	160.0%	37.0%
RP / TP	38.4%	73.0%
RP / UP	62.5%	270.2%

UP = Urban Population
RP = Rural Population
TP = Total Population

Source: Table 2.1. and 2.2.

TABLE 2.4

POPULATION PROJECTIONS FOR ZONE 1, 1979 - 2000 (1000's OF INHABITANTS)

Population \ Years	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Urban	598.3	639.4	681.2	726.5	775.5	827.5	882.9	942.1	1,005.2	1,072.6	1,144.4
Rural	373.9	380.6	387.5	394.5	401.7	409.0	416.3	423.9	431.6	439.3	447.3
Total Zone 1	972.2	1,091.1	1,068.7	1,121.4	1,177.2	1,236.4	1,299.3	1,366.0	1,436.8	1,511.9	1,591.8

Population \ Years	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Urban	1,221.1	1,302.9	1,390.2	1,483.4	1,582.7	1,688.8	1,801.9	1,922.7	2,051.5	2,188.9	2,335.6
Rural	455.4	463.7	472.1	480.6	489.3	498.2	507.1	516.4	525.7	535.2	544.8
Total Zone 1	1.676.5	1,766.6	1,862.3	1,964.0	2,072.0	2,186.9	2,309.1	2,439.0	2,577.2	2,724.1	2,880.5

TABLE 2.5

PERCENTAGE RATES OF GROWTH OF THE POPULATION FROM 1979 to 2000

Population	Percentages				
	1979 - 1980	1979 - 1985	1979 - 1990	1979 - 1995	1979 - 2000
Urban	106.7%	138.3%	204.1%	282.2%	390.3%
Rural	101.8%	111.4%	121.8%	133.2%	145.7%
Total	112.2%	133.6%	172.4%	224.9%	296.3%

TABLE 2.6

RATIOS IN PERCENTAGES OF URBAN, RURAL,
AND TOTAL POPULATION FROM 1985 TO 2000

Ratio	1985	1990	1995	2000
UP / TP	68.0%	72.8%	77.2%	81.1%
UP / RP	212.1%	268.1%	339.0%	428.6%
RP / TP	32.0%	27.2%	22.8%	18.9%
RP / UP	47.2%	37.3%	29.5%	23.3%

UP = Urban Population

RP = Rural Population

TP = Total Population

Source. Bureau Central de Recensement
and Table 2.4.

CHAPTER 3

THE CATTLE POPULATION

The bulk of the research effort in this report has gone into determining the characteristics of the cattle population of Zone 1 and how it is affected by trypanosomiasis. There are two reasons for this focus. Firstly, and most importantly, cattle are currently the main sufferers from trypanosomiasis since the human disease is less prevalent and since the other animals affected, notably donkeys and horses, are less numerous. Secondly, there is a strong bias towards cattle in the work of the institutions with which the New Lands Activity has been associated: Mali Livestock II, the Central Veterinary Laboratory, Mali meat production goals, and in general, veterinary and livestock development efforts also concentrate on cattle. More consideration is gradually being given to small ruminants, but they are relatively less affected by trypanosomiasis than are cattle and therefore are not emphasized in this report.

A. Cattle Numbers

Estimates of livestock numbers in Mali come from two main sources: the administrative census, which is tax-based, and the veterinary estimates, which are made by the heads of each Livestock Sector on the basis of numbers treated and vaccinated. The estimates also take into account past figures. For the cercles of the Zone, Table 3.1b gives the two series of figures. It can be seen that the veterinary estimates are generally between 1.5 and 2.5 times larger than the administrative figures.

The veterinary estimates have been made consistently since the drought, since the "Drought Investigation" report produced "before" and "after" drought figures for Mali's cattle population, showing net losses and redistribution of cattle numbers between regions.

The Livestock Service Headquarters have issued, from year to year, increasingly detailed guidelines for their employees in the field to use as a basis for their estimates. Generally, these estimates rely heavily on the vaccination figures, usually following the numbers for one of the two major campaigns: rinderpest or contagious bovine pleuro-pneumonia. Sometimes the sum of all vaccinations is taken as a basis for population estimates or other adjustments are made to the figures. All the sectors have transport and fuel problems, but the seriousness of these problems varies considerably from sector to sector. Sectors have different capacities for gaining access to and vaccinating the cattle population. However, most cattle owners make their cattle available for the main vaccinations, so the coverage is reasonably good.

Table 3.1a gives the breakdown by arrondissement, which is then converted to the proportion in Zone 1 using the figures derived in Chapter 1. Cattle population density by arrondissement is calculated on the assumption that densities within each arrondissement are uniform and are illustrated in Map 3.1. The number of cattle per rural inhabitant is given in Table 3.2. The table also gives numbers for other livestock. Map 3.2 shows the variation in numbers per rural inhabitant.

It is difficult to judge the accuracy of this data. The number of cattle per rural inhabitant varies surprisingly little throughout the Zone, with most arrondissements falling in the middle range of one-third to two-thirds head of cattle per rural inhabitant (Table 3.2 and Map 3.2). Within this category the great majority falls close to the half-head per inhabitant mark. The low figures for Bamako could be a statistical anomaly, but the high values for the Koulikoro and Fana areas and for Segou are probably real. Although Map 3.1 shows a low density per square kilometer in Fana, the high number of cattle per inhabitant is confirmed when looking at statistics on work oxen (Table 3.8). Nowhere in the Zone do cattle outnumber people.

The density of cattle per square kilometer also shows little variation (Table 3.1a and Map 3.1), though there is a slight progression in numbers towards the northeast to the south of the river. In the case of Diourou, and to a lesser extent Farako, the low average density is probably due to their large northern areas and does not apply to the riverine portions included in Zone 1.

The relative uniformity in density and the great uniformity in numbers per inhabitant is readily explained when, as analyzed in detail in the next section, it becomes evident that the veterinary estimate refers to the wet-season sedentary cattle population.

Little concrete information exists on year-round carrying capacities. This is partly due to the problem of calculating year-round capacities when dealing with a partly transhumant cattle population. Ideally there would be mid-dry and mid-wet season cattle counts and an assessment of forage availability for at least two of the four annual seasons, including the effects of crop residues and supplements, such as cotton seed, both of which are of importance in Zone 1.

A carrying capacity of four hectares per UBT (Unite Bovine Tropicale) was finally chosen, equivalent to one bovine, or eight of the small-sized small ruminants found in the area. This corresponds with estimates given by the Livestock Service and those in Delgado 1980, where 3 Ha/UBT/year are given for the south and 6 Ha/UBT/year for the northwest. This implies that the 208,000 cattle calculated in Table 3.2 plus the 247,600 small ruminants (Table 4.1) of Zone 1, equivalent to a total of 238,900 UBT, already take up 9560 square kilometers, or about half of the Zone, with their pasture requirements. Traveling around the Zone in the dry season, and even more so in the wet season, does not leave an impression of an area that is very heavily grazed nor, despite its high human population by Malian standards, very heavily cultivated. Since this figure does not include the transhumants who arrive in the

dry season, as estimated below, it would seem to indicate that the veterinary estimates may be on the high side. Thus, later on in this chapter, relatively low growth rates have had to be selected so as to keep cattle estimates within the limits of the land available for pasture after agricultural land has been subtracted.

B. Transhumant and Sedentary Cattle: Migratory Patterns

Very little is known, in fact, about the actual numbers of transhumants as against sedentary cattle. When trying to determine numbers of cattle in various breeds, the tendency is to assume that certain areas of the country are occupied by transhumant cattle, others by sedentary, and that transhumants are all Zebus and sedentary cattle are predominantly taurine. Since this information is all deduced from the same well-worn assumptions, none of them can be used to verify the others, and changing trends, local variations and local adaptations to particular circumstances are lost in the generalities. This is particularly true in an area which is situated on the border between the predominantly sedentary and the predominantly transhumant types of cattle-raising and which is characterized by a rapid and advanced integration of livestock and agriculture, as is the case in Zone 1. In addition, in relation to the question of how people adapt to different degrees of tsetse-fly challenge, the existing data begs the question by assuming that virtually no Zebus or transhumants make use of the areas traditionally assumed to be fly-infested. Thus, even changes over time in the fly habitat or fly population tend to be ignored or assumed to be of little importance.

From detailed discussions with the heads of the veterinary sectors and a perusal of their annual reports it was possible, however, to assemble a fairly coherent picture for Zone 1. The eastern sector (cercles of Baroueli and Segou plus the arrondissement of Niamina in Koulikoro cercle) which is drier and almost entirely free of tsetse flies, receives a lot of trans-

humants that come in the dry season when they are estimated to outnumber the sedentary cattle 2.5 to 1. Going south, the number reduces until in the southwest, particularly in the southern part of the cercle of Kati, the cattle are all sedentary throughout the year. During the wet season, it is said that only sedentary cattle remain in the Zone. Using these general guidelines in Table 3.3, it was possible to calculate very approximately the number of transhumant cattle coming into the area during the dry season.

The basis for this calculation is the assumption that the vaccination-based veterinary estimates more or less cover the entire sedentary herd, to which some transhumants are added in the dry season. The vaccinations usually take place between October and February, with the majority being undertaken in the first two months of that period. The Livestock Service tries to vaccinate the cattle in their wet-season grazing grounds, which they usually regard as "home," at the time when they are concentrated there and before they migrate to their dry-season areas.

In Zone 1 some of the cattle owned by sedentary people do go on some transhumances, notably during the wet season, to avoid the heavily cropped areas, especially in the northwestern area where rice-growing renders some of the more convenient watering places inaccessible. These migrations are fairly localized, occurring often within a particular cercle. The home-owned cattle tend to return gradually as the fields are harvested and these cattle are vaccinated in their own area and are thus counted there. During the dry season, once all the crops are harvested, the local cattle more or less wander as they please, since the risk of crop damage and consequent fines is over. Considerable conflict due to crop damage by cattle, especially in the more densely cultivated eastern areas, is noted by all the Livestock Service officers, who deplore the custom of allowing animals to wander freely.

As distinct from the local migrations of sedentary and semi-sedentary groups, it is generally agreed that the transhumants do not arrive until after all the crops have been harvested and they, too, benefit from the crop residues, while farmers, in turn, benefit from the organic manure left behind. All these interactions between livestock and agriculture are already very well established in all parts of Zone 1.

Map 3.3 summarizes the information from the various livestock sectors on the local migrations in their area. It can easily be seen that no very clear-cut north-to-south pattern exists. The migrations depicted are those at the start of the dry season to the dry-season grazing areas. These show two trends. Firstly, there is a tendency for the cattle within a cercle and those coming in from outside to concentrate near the rivers (the Niger in the center of the Zone, in Kolokani the Baoule River area and the south and west of that cercle, and the Bani River for cattle in the Segou area). Secondly, the cattle move in a southerly and westerly direction with cattle from further north moving into areas vacated by the more southerly groups. Thus, cattle from the northeast move in to Farako, cross the bridge at Markala to spread out in the Segou area, while cattle from Segou go south to the Bani towards Baroueli, from where cattle go west into the Dioila area. In Kolokani and Banamba, cattle from Niono, Nara and other northern areas replace the local cattle which have gone towards the rivers and humid areas. Thus, the local sedentary cattle do move, but largely within the confines of their cercle.

Although it would be useful to distinguish between the truly transhumant cattle, the semi-sedentary cattle which migrate locally for part of a season and the truly sedentary cattle which stay within the area surrounding a particular village, this distinction is not really possible. The transhumant cattle are usually regarded as being all Zebus. Using Table 3.3 and assuming that the sedentary herd is that

estimated by the veterinarians, and combining this information with the estimated ratio of transhumants to sedentary animals in the wet season, it was calculated that there is a total influx of 101,000 transhumants in the dry season. An estimate of the truly sedentary animals can be made by assuming that the good milk cows, the calves under one year of age and a proportion of the herd of work oxen stay in the villages all year round. Using the herd composition figures (Table 3.10) the percentage of animals in these classes is 43% for cows, 15% for calves and 14% for work oxen (Tables 3.8 and 3.10) totalling 75%. So in areas where some of the sedentary herd migrate, it would seem that at least half must stay in the village with the total probably reaching 75%.

Finally, given the 101,000 transhumants spending the dry season in Zone 1, 50,500, or half that number, since they only spend half the year there, are added to the 238,900 UBT already in the Zone, bringing the total up to 289,400 UBT. These require four hectares per annum each to sustain themselves and therefore already use 11,600 of the Zone's 19,300 square kilometers. This seems a fairly high proportion.

C. Trade Cattle

Due to the presence of Bamako, Kati and, to a lesser extent, Segou, Zone 1 is the most important collecting point for trade cattle in Mali. The main routes are illustrated in Map 3.4.

D. Different Breeds of Cattle in Zone 1

The cattle in Zone 1 belong to one of three main breeds. The Zebu cattle are humped. Most of the Zebus in Zone 1 are either Zebu Peul or Zebu Maure, with the Peuls predominating. The pure taurine breed, the small Ndama. is found in the southwestern part. Finally there are the crosses between taurine and humped cattle, the Meres. Depending on the type of cross, their characteristics range from mainly taurine to slightly humped. This group of crosses has grown considerably in the

last few years in the Zone, due to the effect of the drought which has brought Zebus into contact with local taurine animals on a greater scale than before. This effect is particularly marked in the center of the Zone, especially in the cercle of Dioila.

Tables 3.4 and 3.5 give estimates from two sources of the percentage of each breed per cercle. These tend to confirm each other once some sources of difference are identified. Firstly, the protozoological survey took place within the Zone, whereas some cercles, especially Banamba and to a lesser extent Kolokani, are almost wholly outside the Zone. This explains why the high proportion of Zebus given by the Livestock Service for Banamba does not really apply to Zone 1.

Secondly, regarding identification of Ndamas as compared to Meres, the Livestock Services of Kati and Dioila are obviously purists in only identifying as Ndama those animals which are purely taurine. In Kolokani, on the other hand, dominantly taurine animals seem to have been identified as Ndamas on a similar criterion to that used in the protozoological survey. The rarity of the pure Ndama breed is generally noted by members of the Livestock Service, but for practical purposes, predominantly Ndama cattle are counted as Ndamas as was done in the survey. The survey, being village-based, tended to encounter more sedentary herds, and in addition, some of the Fulani herders were reluctant to present their animals. In the wet season, there are fewer Zebus in the Zone. Thus, although including slightly fewer transhumants, the dry-season survey is however very representative of the Zone's year-round cattle composition.

The results of the protozoological survey are presented by arrondissement in Table 3.6 and pictorially in Map 3.5. The writers of this report were privileged to be allowed to make use of the data generated by the Protozoological Section's dry-season survey of 1980. The preliminary results of this work

were published in the "Rapport d'Activities July 1979 - April 1980" of New Lands by Dr. Awan and Mr. Bouare. In this report, we were able to use their raw data and, following discussions with Dr. Awan, to analyze the data and thus to anticipate the results of the Protozoology Section's own report, to be produced when the wet-season results are complete.

To group its results, the Protozoology Section divided the Zone into four areas, as shown in Chapter 1 (Map 1.3) in the discussion on boundaries. Since all the livestock data and other information collected by the Socio-economic Section is given by cercles and arrondissements, the villages sampled by the Protozoology Section were re-classified by arrondissements, and the results for proportions of the different breeds are presented in Table 3.6. The number of villages sampled per arrondissement are given. When compared to the map, there is a very high correlation between the proportion of Zone 1 covered by each arrondissement and the number of villages chosen for each. The tiny section of Banamba included in the Zone was not sampled. The samples in Tougouni are more than adequate to represent it.

Map 3.5 shows very clearly the progression from predominantly Ndamas and a large proportion of Meres in the south-western part of the Zone, to mainly Meres with some Zebus in the center, to mainly Zebus in the east, with some Meres south of the River Niger.

Using this map and Tables 3.4 and 3.5 as a basis and after making adjustments for the differences in the Livestock Service and Protozoology Section estimates, Table 3.7 was compiled, giving approximate proportions of the different breeds, following the subdivisions of the Zone used in this report and appropriate for an average year-round figure.

E. The Use of Work Oxen

As explained later in Chapter 5, Zone 1 has the advantage of being an area where the various "Operations" (Map 5.4) have

been established and have had a marked effect. In particular, one of their main aims has been to encourage the use of oxen for plowing by providing credit for plows and trained oxen.

The information available on numbers of work oxen comes from these "Operations." It is given in Table 3.8 and is related to human and cattle populations. It shows that the Fana area is best endowed with work oxen, followed by the Segou area (where Operation Riz animals need to be added to the Operation Arachide et Cultures Vivrieres area, to bring up to around 55% the percentage of cultivating units having a pair of oxen) and by Baroueli. Fana, is in fact, a more humid and more tsetse-infested area than Segou and Baroueli, with relatively few Zebu animals. The high degree of development there illustrates the extent to which the intervention of an "Operation" influences the development of plowing with oxen. It seems that the availability of capital to purchase equipment and oxen is probably a more powerful incentive to their acquisition than animal health conditions. It should be noted, however, that in Dioila the Livestock Service undertakes more trypanosomiasis treatments than in any other cercle by far (Table 7.6), and that this factor, together with treatments performed by the Compagnie Malienne de Developpement Textile (CMDT), facilitates the keeping of oxen in the area.

Although ox-keeping has not reached such a high level in the southwestern part of the Zone, it is expected that, with the intervention of the Operation Haute Vallee (OHV), this area will soon catch up. Overall the Zone, taken with the Niono area where the Office du Niger (O.N.) has long been active, is probably the most developed area of Mali from the viewpoint of integration of agriculture and farming and especially the use of animal traction.

The use of different breeds for animal traction is discussed in Chapter 12.

Using the figures given by the Operations and increasing them slightly, an estimate is made in Table 3.9 for the number of work oxen in the whole Zone.

F. Herd Production Parameters for Zone 1

In this section, an attempt is made to determine appropriate growth, offtake, fertility and mortality rates for Zone 1. At present, data on herd output and production is inadequate for making accurate national projections and is insufficient for extrapolating regional trends. Generally accepted parameters are: a 3% rate of growth for sedentary herds, 4% for transhumants, an offtake rate of 10 to 12%, fertility expressed as the percentage of live births per adult female per annum of 60 to 68%, calf mortality in the first year of 30 to 40% and an adult mortality of 4%. The SEDES study published in May 1979 made projections for the next twenty years with an initial growth rate of 3 to 4% and offtake rates 10 to 12%, final growth rates of zero and offtake of 16 to 18%. These varied with the Sudanian and Sahelien herd and with optimistic and pessimistic hypotheses. These give a fairly reliable indication of what the parameters are.

Another source of information is in the various herd composition studies that have been undertaken. These give a detailed insight into the herds of a particular area. Tables 3.10a to c summarize the results from a number of these studies with applicability to Zone 1. The estimates made by the Livestock Section heads in Zone 1 from their own knowledge or by sampling a few herds, are given in Table 3.10a. As small, personal samples they show considerable variation. Except in the example of Koulikoro, however, where a very high proportion of cows is given, they are broadly similar, showing about 40% males, of which 10 to 13% are castrated adults. The herds actually sampled can be characterized as large to medium-sized sendentary herds or herds with sedentary owners.

Table 3.10b gives figures where a differentiation between age groups and between castrated and entire males was made. Two very striking differences emerge. Firstly, the sedentary herds of "colons"[1] and Bambara show very high proportions of castrated males, which represent the work oxen. As expected, the proportion is higher among the "colons" of the Office du Niger than among the ordinary Bambaras. Secondly, Coulomb's 1972 figures for transhumants show very high proportions of male and female calves.

This high proportion is also found in Table 3.10c, where Coulomb's figures for sedentary herds are compared to the data collected in 1977 by OMBEVI. Since the number of calves added annually to the herd is crucial for determining its gross productivity, this difference is important. Two explanations exist. The first is that whereas the OMBEVI study was undertaken during the dry season, Coulomb's work took place in the months of November and December. He would thus have arrived just after the main season for giving birth in September and October and would have counted proportionately more calves than did OMBEVI later in the dry season when the bulk of calf mortality would have already taken place. Coulomb also has a lower proportion of adult females, with the result that in Table 3.12 the number of calves aged one, or aged between one and two years, is higher than his estimate for the number of live births in a given year for herds considered. Obviously, given a constant number of adult females from year to year, surviving calves for a one-year period cannot exceed live births. However, it does appear that the herds at that time, just before the drought, could have been enjoying a rapid growth rate, evidenced by a high number of calves, within the delta region.

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[1] "Colons" are the farmers allocated land within the area managed and laid out with rice fields by the Office du Niger.

An analysis of the way herd composition figures can be used to verify given production parameters is given in Annex A. Table 3.11 explores the offtake and growth implications of the herd composition figures. The basic relationships used are defined as follows: gross productivity (GP) is the increase per annum in herd numbers after allowing for mortality (M) in adults (A) and calves (C) but before subtracting offtake (O). With fixed biological parameters (fertility and mortalities), gross productivity (GP) is a constant. Calf survivals (CS) are the number of live births less mortality in the first year, thus: GP = O + R = CS - AM, where R represents the annual rate of growth of the herd. This formula is a simplification of actual herd dynamics which enables one to calculate the gross productivity in a particular year from limited data and to derive a possible annual growth rate by subtracting offtake. The relationship between the number of animals at the start of year x and the number at the start of year x + 1, where N stands for the number of animals, and O, R and M are expressed as percentages of N_{x+1}, is given as follows:

$$N_{x+1} = N_x - O_x - R_x - M_x$$

This method is further elaborated in the explanations to Table A.1 in Annex A.

The implications of these relationships are examined as follows. In Table 3.11, calf survivals are taken as given in the herd composition figures. In the OMBEVI example, the adult mortality and offtake are calculated by applying annual rates given in the study for each age group. The calculations and explanations are given in Annex A. The remainder, which is the annual herd growth rate (R), thus ranges from 1.8% to 3.5%. For Coulomb's figures, his offtake and growth-rate estimates were taken from Delgado's report (estimates for sedentary herds). The remainder calculated was adult mortality, using the formula

given. The adult mortality rates appear low but not improbable. However, only the exceptionally high proportion of calves already discussed for Coulomb's figures makes possible the much higher gross productivity of 12 to 15%, as against 9.5 to 11.5% in the OMBEVI example. Since the early figures are regarded as inapplicable today, the OMBEVI estimates giving more commonly used figures, were retained. These imply that estimates of off-take are more likely to be in the 7 to 9% range and estimates of growth rates, in the 2 to 3.5% range.

These figures are lower than those often quoted, but seem reasonable. This lower offtake rate applies not to total out-goings or sales, but is the net offtake, that is, total sales plus gifts given, less total purchases plus gifts received. It covers sales for slaughter and for inclusion in other herds. In the case of a large sample, transhumant herds probably receive few animals, but sedentary herds are net receivers of animals, particularly of young males for traction or plowing.

Table 3.12 examines the range of values possible for calf survivals, using the parameters given in the various studies and those implied by the herd-composition figures. A value of 19.5% of the herd for calf survivals can only be obtained by combining 65% fertility, a low 25% mortality in the first year and a high 40% of adult females in the herd. The OMBEVI herd composition figures (Annex A) imply a far higher calf mortality rate than 25%, averaging 35 to 40%. A calf survival value of 16% is obtained using medium to high values: 60% fertility, 30% first year mortality and 36% adult females. The lower end of the scale is a calf survival of 11%, obtained with 50% fertility, 40% first year mortality and 35% adult females. This range of 11 to 16% calf survival with 3 to 4% adult mortality implies gross productivity of 7 to 13%, rather lower than the 14 to 16% sometimes claimed.

Finally, in Table 3.13, production parameters which are regarded as suitable for Zone 1 are derived using the above analysis. These parameters will be used later in the report.

G. Cattle Prices and Slaughter Figures

Having determined the main biological production parameters applicable to Zone 1, it now remains to select appropriate cattle prices to use in evaluating disease losses and the value of herd output. The main sources of price data are the OMBEVI reports by the market controllers and figures given in annual reports of the Livestock Service. Table 3.14 gives a selection of these prices for slaughtered animals and Table 3.15 prices for animals sold for breeding.

1. Available Information on Cattle Prices: Problems and Limitations

For various reasons, it is difficult for statistics on prices to be accurate. First, the method of going to the market, asking the price of various animals and estimating the weight is subject to error since prices are exaggerated for a buyer, and lowered for government inspection officials. The sampling of animals within the market is also a random process. Many of the published data give very wide ranges of prices and it is difficult to see where the most common price lies in the range. The animals within a category vary greatly between sick animals sold off in a hurry and animals that may have been fattened up for the market.

The weight estimates, however, seem relatively consistant. Although they varied between months, the three-month average turned out very consistent prices per kilogram of estimated carcass weight (Table 3.14b). These averages show prices highest in Bamako, followed by Kati and Segou, declining as one goes to more rural areas as would be expected. Immature males with less meat on a carcass also fetched a lower price.

Comparing these estimated weights with cattle weights put forward in various studies (Table 3.16), shows that weights tend to be over-estimated. The animals in the ILCA sample must be regarded as exceptionally well-cared-for, prime cattle of privileged "colon" households.

Weight can thus be shown to be the major determinant of price for slaughter animals, with buyers able to assess it fairly accurately. Table 3.17 compares wholesale or live animal prices at the market with official butchery or retail prices. The wholesale prices are probably fairly realistic, and although official retail prices are considered low, they are often circumvented by a tendency to charge higher, more realistic prices.

The official prices probably reflect accurately the difference in prices from region to region. The actual price for meat with bone in Bamako is now usually 1000-1200 MF and thus represents about a 25% mark-up on the slaughter price of 900 MF/Kg. The actual prices are higher than official prices by 10 to 20%, which is not a very wide margin.

The second main problem with the price and slaughter data is that it covers only a very small proportion of animals marketed. Table 3.18 presents, for the whole of Mali and for small ruminants as well as cattle, the comparison between animals seen at markets, animals officially slaughtered and total offtake. Thus, only 40% of cattle and 30% of small ruminants are checked at officially supervised markets. The offtake rate of 8% used for cattle is modest. It represents offtake for meat plus net sales out of the herd. The offtake rate for small ruminants is also taken from the OMBEVI study in the Mopti area. It is considerably lower than earlier estimates from different sources which ranged from 25 to 30%. Thus, Table 3.18 is conservative in its estimate of the proportion of animal sales and slaughter which take place unofficially.

2. Influence of Cattle Breed and Purpose of Sale on Prices of Cattle in the Market

The monthly market reports produced by OMBEVI give a breakdown of the breed and destinations of cattle sold at the controlled markets. In Bamako, Kati, and Kayes, 90 to 100% go for slaughter. In Nara, 80 to 90% go to other markets, since it is a collecting point for animals usually going south for export. Niono also sends 70% of its animals to other markets. Only in Segou (30%) and Ansongo (60%) do a significant proportion go to other herds for raising or breeding purposes.

These data illustrate the fact that few sales between herds are recorded in the markets. This is particularly the case with sedentary herds containing mixed breed or Ndama animals where there is a well-known and strong reluctance to buy animals from outside the area. People prefer local animals, because they have developed a resistance to the diseases in the area. Also, knowing the owners, people have some recourse if the animal proves unsatisfactory. Thus, most of these sales occur on an informal basis. In fact, very few Ndamas and mixed breed animals are even recorded at the markets. Data on breeds for Sikasso and Bougouni were not available. The only recorded Ndamas were 1 to 2% at the Bamako market, with a similar figure occurring occasionally at Kati.

Even between Zebu herds, informal sales, gifts and trading of animals occur. Consequently, the sales recorded in the monthly market reports are mainly for slaughter or transport to other markets. This explains why the prices for animals sold for breeding or raising purposes (Table 3.15) do not compare well with the slaughter prices, being generally lower than those for animals in the same category and much more variable. Although the lower prices may be due to the animals being younger, it seems more likely that the good breeding animals are sold in private deals and those brought to market represent a low-grade residual.

3. Calculation of Cattle Values by Sex and Age Group

Despite the problems with the price data, an attempt has been made in Table 3.19 to calculate values for animals at different ages. In the case of a male animal to be sold for meat, the price for a steer at Kati was used. The males are usually sold between age six and eight. The OMBEVI herd-composition data shows the number of males declining rapidly after age seven to eight, so this year was chosen as the year of expected sale. Discounting at 12% per annum and multiplying by the probability of survival gives a price series. The figure of 55,000 MF for a two-year-old coincides well with the prices given in Tables 3.14 (60,000 MF) and 3.15 (50,000 MF) for "taurillons", that is, immature males aged one to three. It was felt that the steer (ox or bullock) price was reasonably representative of what a large male would fetch. It is not clear whether the 3800 steers slaughtered monthly at Bamako abattoir are castrates nor why the bull price is lower than the steer price. Perhaps these are younger animals or culls, or the better bulls are exported.

In the case of a female animal, its own meat is not the only product; in addition it periodically produces milk and calves. For this reason, young female animals are higher-priced than males and receive more care, leading to lower mortality rates. The price of heifers was difficult to extract from Table 3.15. Since they are rarely sold, the sample is unlikely to be representative.

By comparing the ratio of heifer/cow and heifer/immature male prices across the country for 1978, 70,000 MF for a two-year-old female was decided on as a reasonable price. It would be a reasonably modest estimate, since heifer prices frequently exceed cull cow prices and may be as much as one-and-a-half times the price of males of the same age. In these calculations, the rate of 12% was used to discount, with risk in terms of

expected mortality accounted for separately. This discount rate is low for private individuals, but reasonable on a national level. Prices and mortality rates used were taken for Zebu transhumant cattle. By simply discounting final sale price to get present value, it is implied that inputs are relatively costless. In the case of family labor and free rangeland this is so, but veterinary care remains a non-negligible cost.

Despite their limitations, these figures give a good idea of how the animal's value changes over the years.

The value of the milk produced also needs to be considered. In addition to their output of calves of an average value of 25,000 MF roughly every other year, females produce milk. Estimates per lactation vary from 400 to 600 liters in a lactation for the Peul Zebus, 750 to 1000 for the Maure Zebus, 150 to 300 for Ndamas and 300 to 600 for Meres (Cisse 1973). Most transhumants in Zone 1 are Peul cattle, so 500 liters is retained for this group. Most sedentary cattle are Meres with pronounced taurine characteristics, so 350 liters seems a reasonable figure. More than half of this milk goes to the calf (OMBEVI, 1978); most of the rest is consumed within the family, and the remainder is sold when the herd is near towns and villages.

In Zone 1 milk prices in the wet season vary form 100 to 200 MF per liter in the main towns outside Bamako, but are probably half as much in small villages (OMBEVI 1978). In the dry season, prices rise to 150 to 300 MF per liter. A liter of clarified butter sells for 750 to 1000 MF (Annual Reports of Livestock Service Section). Milk is often sold as soured milk (lait caillé), but it is difficult to estimate its price in liter equivalents since it is sold in measures of varying sizes. Imported concentrated milk sold in Bamako shops with controlled prices costs 480 MF for a quantity equivalent to one liter of fresh milk. The price of fresh milk in Bamako is 350 MF per liter.

Thus a transhumant milk cow could add 15,000 MF to the herder's annual revenue, and a sedentary cow 8750 MF (assuming an average price of 100 MF, half of the milk given to the calf, and an annual fertility of 60% for transhumant cows and 50% for sedentary cows).

The value of a pair of work oxen, trained and ready for work, is now estimated at 250,000 MF, that is, 125,000 MF each, using present value calculations at a 12% annual discount and assuming the animal can be sold for meat for 125,000 MF at the end of its working life. This implies an annual income from each animal of 11,000 MF, or 22,000 MF from the pair.

4. Calculation of a Weighted Average Slaughter Price for Zone 1

Finally, appropriate prices need to be determined for Zone 1 using the general prices derived above. From the 258,500 cattle in Zone 1, an annual net offtake of not more than 18,000 to 23,000 animals can be expected. Despite the fact that a large proportion of slaughters are unrecorded, Table 3.21 shows that in Zone 1, about 10,000 head are officially slaughtered outside Bamako, 70,000 in Bamako, having revised the figures upwards slightly to bring them to present-day levels. Not only is 60 to 80% of official slaughtering done in Bamako, but after Bamako, Segou is the fourth most important center for slaughtering cattle, followed by Kayes and Sikasso (Table 3.20). Even excluding Bamako, the inhabitants of Zone 1 eat a lot of meat compared to the rest of the country.

Consequently, it seems reasonable to weight the prices used very heavily in favor of Bamako values, since Bamako is important within the Zone, and since this method counteracts the effect of the government in keeping prices low. Thus, a retail price of 1100 MF per kilogram of carcass weight is used and 900 MF per kilogram of carcass weight at the market.

To calculate the value of the average animal slaughtered, it is necessary to determine the proportion of animals in each class slaughtered. This is done in Table 3.22, and the weighted average values are calculated in Table 3.23.

The offtake of young males and females recorded in the OMBEVI figures would not be for slaughter but for breeding and raising. Cows, however, are hardly ever sold for slaughter except when they are sterile or too old to produce. The official figures are biased by the number of good steers brought to Bamako for slaughter although the best steers which go for export are not included in this estimate of offtake. It seems probable that culled cows form a high proportion of clandestine slaughters. A reasonable overall breakdown would appear to be as given in Table 3.23.

The price of the average animal slaughtered thus comes out, appropriately enough, at 100,000 MF. This wholesale price is retained in the calculations since the variable retail price principally reflects the addition of butchers' fees and marketing costs and is affected by official price control.

Using an offtake rate of 9.0% for transhumant animals yields an annual meat production per herd member of 9000 MF for 10 kgs., at the market price. Applying a retail price of 1100 MF, 1 kg. of meat with bone would give a value per herd member of 11,000 MF.

In the case of sedentary cattle, taking into account the existence of some pure Ndamas as well as Meres with very pronounced taurine characteristics, the average weight of a non-Zebu animal is assumed to be about 70 to 75% of a Zebu's weight. A reputedly better dressing-out percentage for taurines and cross-breeds gives a carcass weight of 80 to 85% of that of a Zebu. Given that about 30% of the sedentary herd of Zone 1 are Zebus, the average sedentary herd member's carcass weight would be 85 to 90% of that of a Zebu, which is valued at

100,000 MF. Therefore, the sedentary animal would be valued at 90,000 MF. Given an offtake rate of 7%, each herd member with an annual meat production of 7.0 kgs. would be valued at 6300 MF.

H. Future Trends and Growth Rates

From the above analysis it is possible to make an estimate of what, given present trends, will be the likely future of cattle-keeping in the Zone. These calculations are based on the current situation and assume that the policy toward tsetse flies, of sporadic treatment and some prophylaxis of work animals, continues unchanged.

1. Sedentary Herds

From the herd composition figures, it was calculated that sedentary herds of a similar composition to transhumant herds (that is, not containing a very large proportion of work oxen) could grow at 3.0 to 3.5% per annum (Table 3.13) with an offtake rate of 7 to 9%. In Zone 1, farmers have tended for some time to invest their profits in cattle, regarding them as a type of bank. Buying cattle from transhumant groups and careful care have meant that sedentary herds have grown very rapidly in recent years, particularly in areas where the "Operations" have affected a significant proportion of farmers. Due to the present high numbers, however, growth rates are projected to decline within the next ten years so as not to exceed carrying capacity of the available land. Given the relatively even distribution throughout the Zone of cattle per inhabitant and per square kilometer according to the veterinary estimates (Maps 2.1 and 3.2), the same growth rates are used throughout.

The decline in growth rates does not imply that actual herd growth is reduced; instead, offtake may increase and a part of the sedentary herd may migrate to an area further south, in which case greater contact with tsetse flies is to be expected outside the Zone. Since this effect is not affected by tsetse

eradication measures within the Zone, which are the subject matter of this report, it is not specifically considered here, but should be noted.

2. Transhumant Herds

The transhumant herds are now well established dry-season visitors in most of Zone 1. After the drought there was a marked shift to the south of most cattle, partly a real shift and partly the result of a proportional redistribution following from heavier losses in the northern areas of the country. The rapid growth of the Mere breed in Zone 1 is often ascribed to this incursion of Zebus. It would seem reasonable to assume that as far as Zone 1 is concerned, the main shift has already occurred and, given the demands made on its land by an already well-developed and rapidly growing agricultural sector plus its large sedentary cattle population, there is not sufficient pasture left to encourage more transhumants to make regular use of the area. However, if generally dry conditions and poor rains persist in the north, Zone 1 may find itself used increasingly as a transit zone, especially during the dry season, by those in search of new pastures.

Thus, although from the herd composition data it appeared that in Zone 1, with offtake rates of 8 to 10%, transhumant herds could achieve growth rates of 2 to 3%, the lower figure of 2% if applied initially, followed by 1% and finally no growth, so as to fit in with grazing land constraints. Off-takes are likely to remain constant, since transhumants will almost certainly look to other areas for extra pasture during the first ten years. During the second decade grazing may be more difficult to find, so some of the herd's growth will probably be absorbed by increased offtake.

3. Work Oxen

The final category to be considered is work oxen. Oxen are treated separately because of their rapid rate of

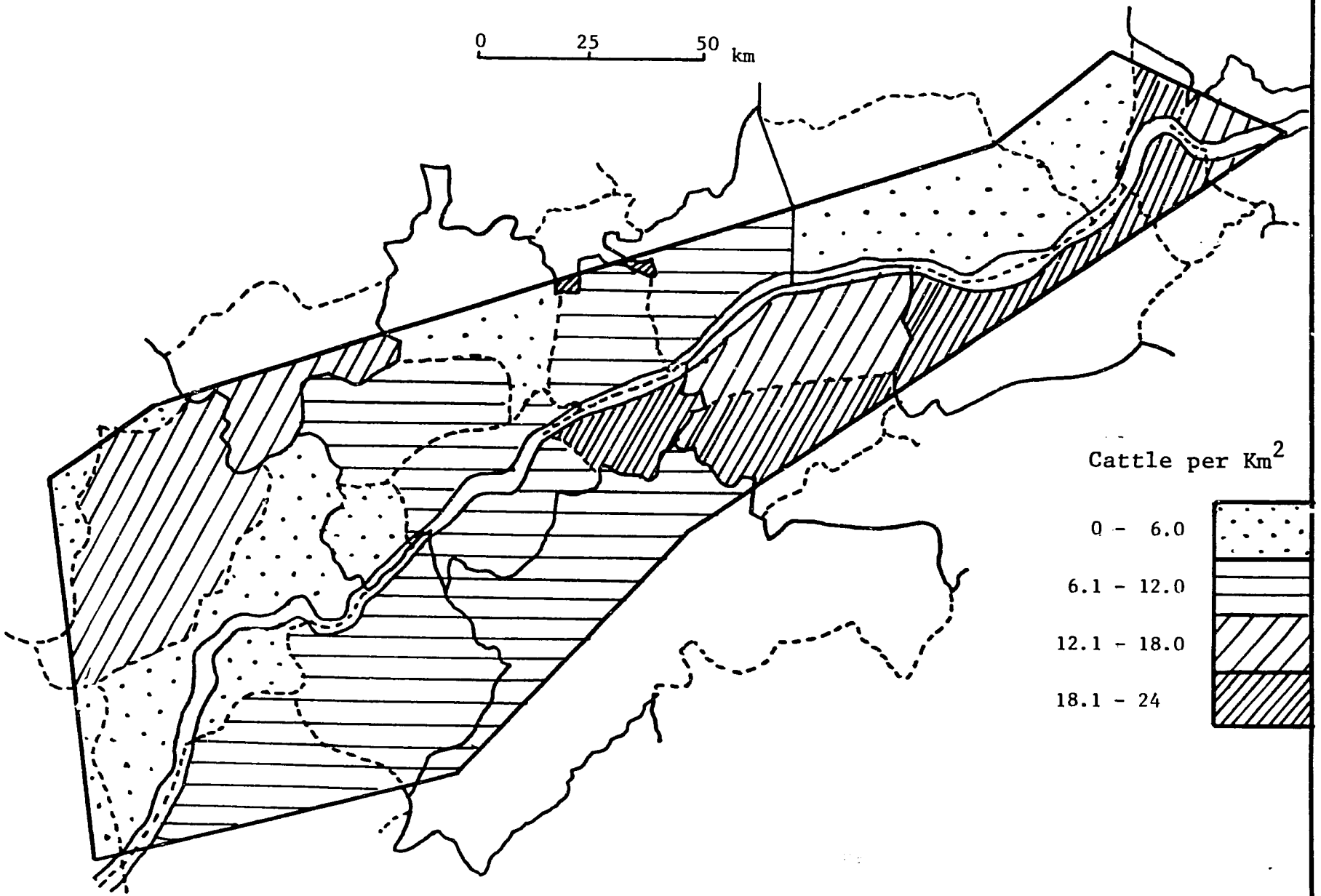
growth and because they require, and receive, as particularly valuable animals, a different attitude regarding medical expenses, including trypanosomiase prophylaxis.

For this purpose, the Zone was divided into two parts. Group I contains Baroueli and Segou cercles, and the arrondissement of Fana, all of which already have a high proportion of work oxen per cultivating unit. This proportion was assumed to increase by about 40% in the first decade, after which oxen would keep pace in numbers with population growth, thus maintaining the number attained per cultivating unit.

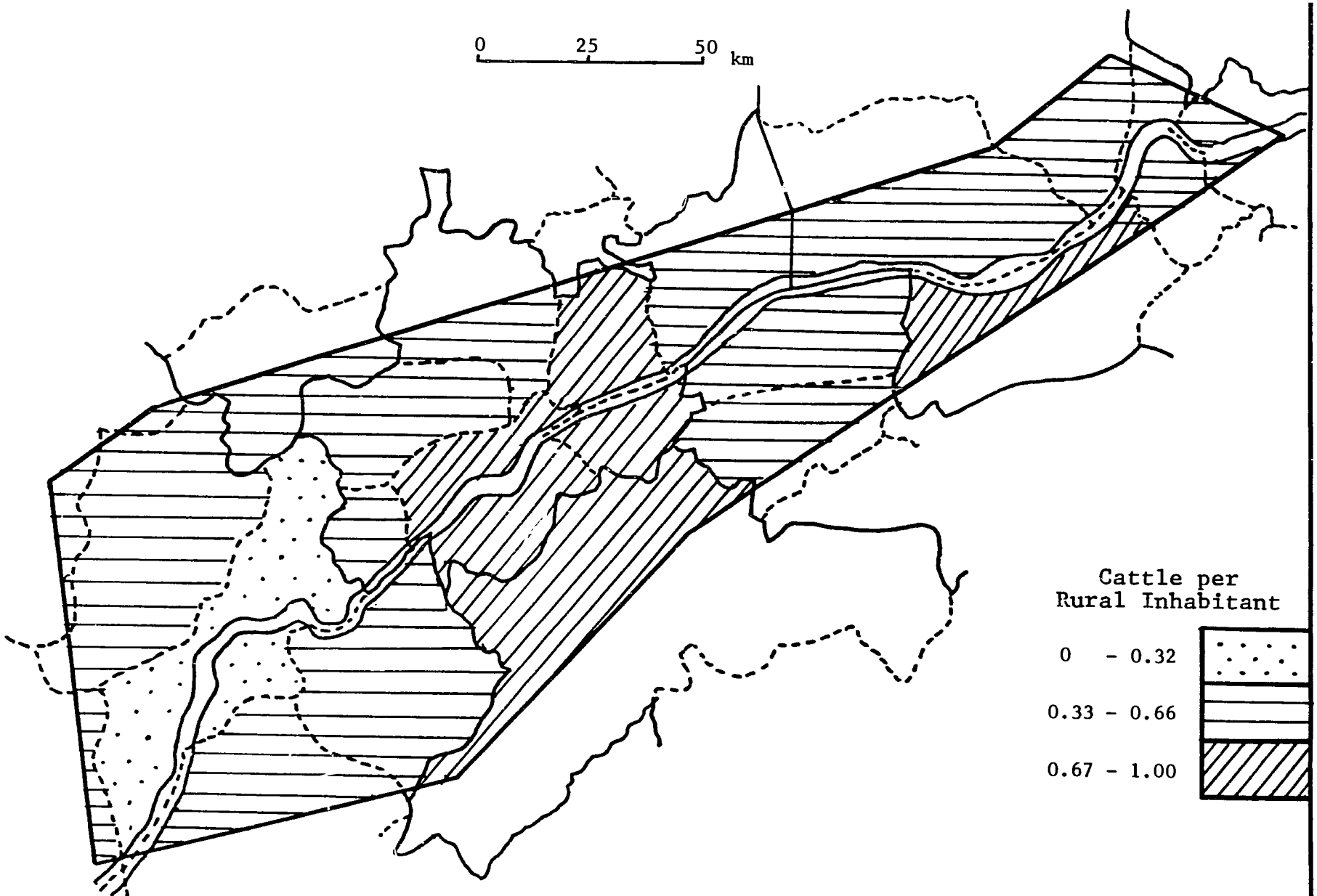
The rest of Zone 1, Group II, (cercles of Koulikoro, Kati, Kolokani and Banamba), has a lower proportion of work oxen, and is assumed to enjoy a more rapid rate of growth, as the use of work animals becomes more popular and agencies like "Operation Haute Vallee" became more entrenched. The proportion of cultivating units with oxen was assumed to nearly double within fifteen years and then remain constant as numbers increased level at the same rate as the human population.

4. Small Ruminants

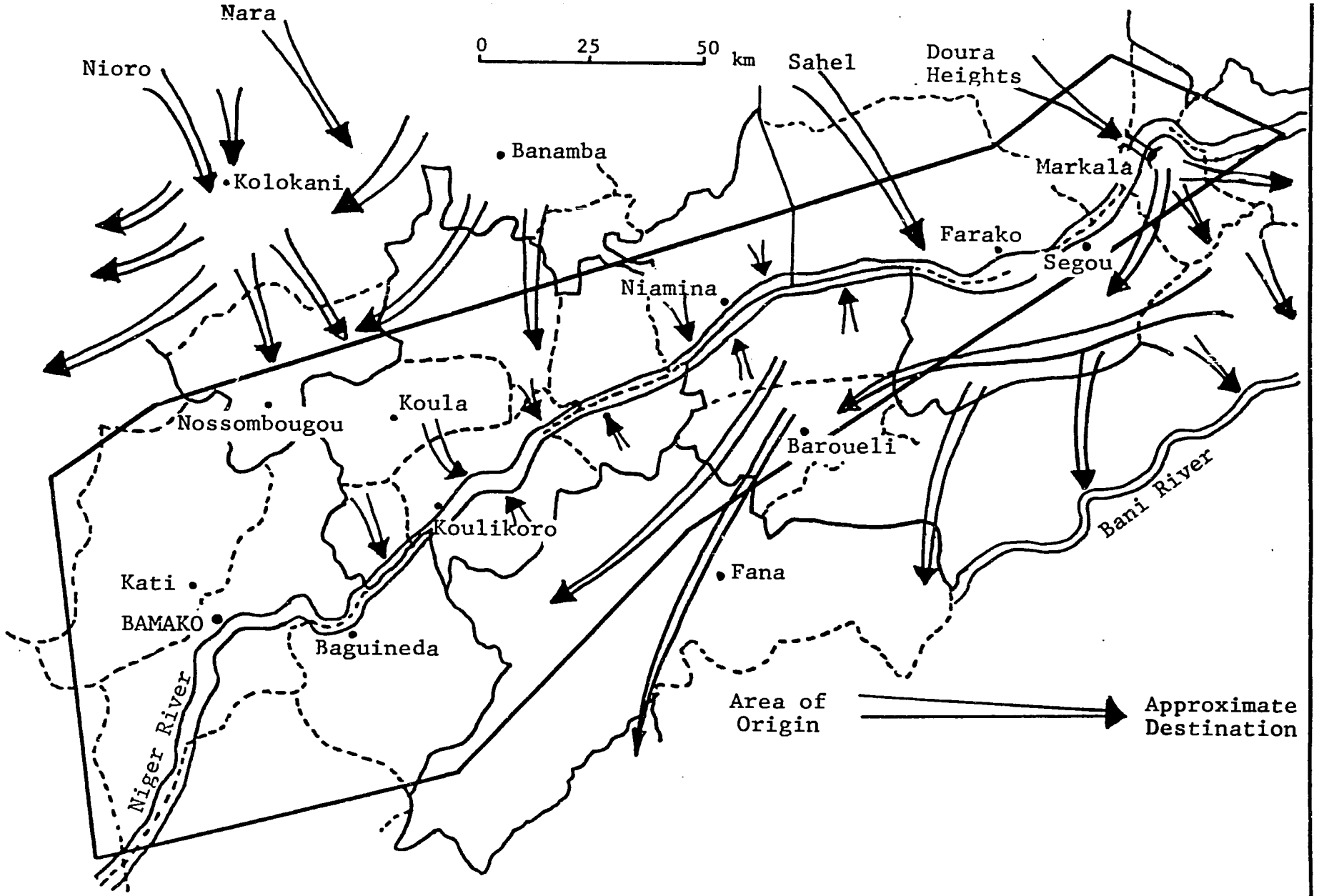
As discussed in Chapter 4, small ruminants are assumed to have an annual growth rate of 2%, which is slightly higher than the growth rate for the human rural population so that numbers per inhabitant stay more or less constant. Figures on small ruminants are included in Table 3.25. The assumptions used for growth are presented in Table 3.24 and the projections in Table 3.25. These projections are used as the basis for calculating the direct benefits, that is, costs and losses which would be avoided if trypanosomiasis were effectively dealt with.



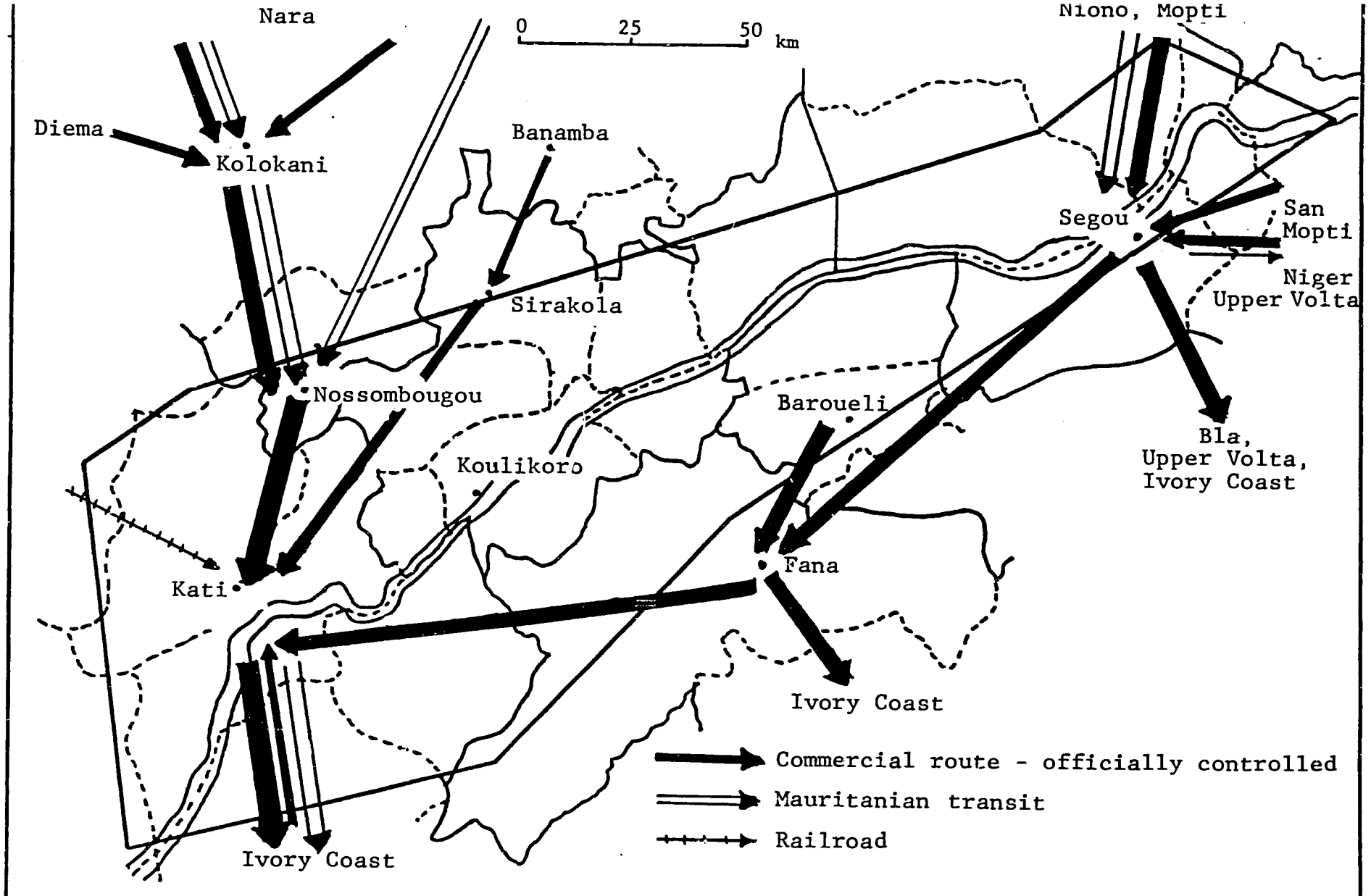
MAP 3.1 - Density of Cattle per Square Kilometer in Zone 1



MAP 3.2 - Number of Cattle per Rural Inhabitant

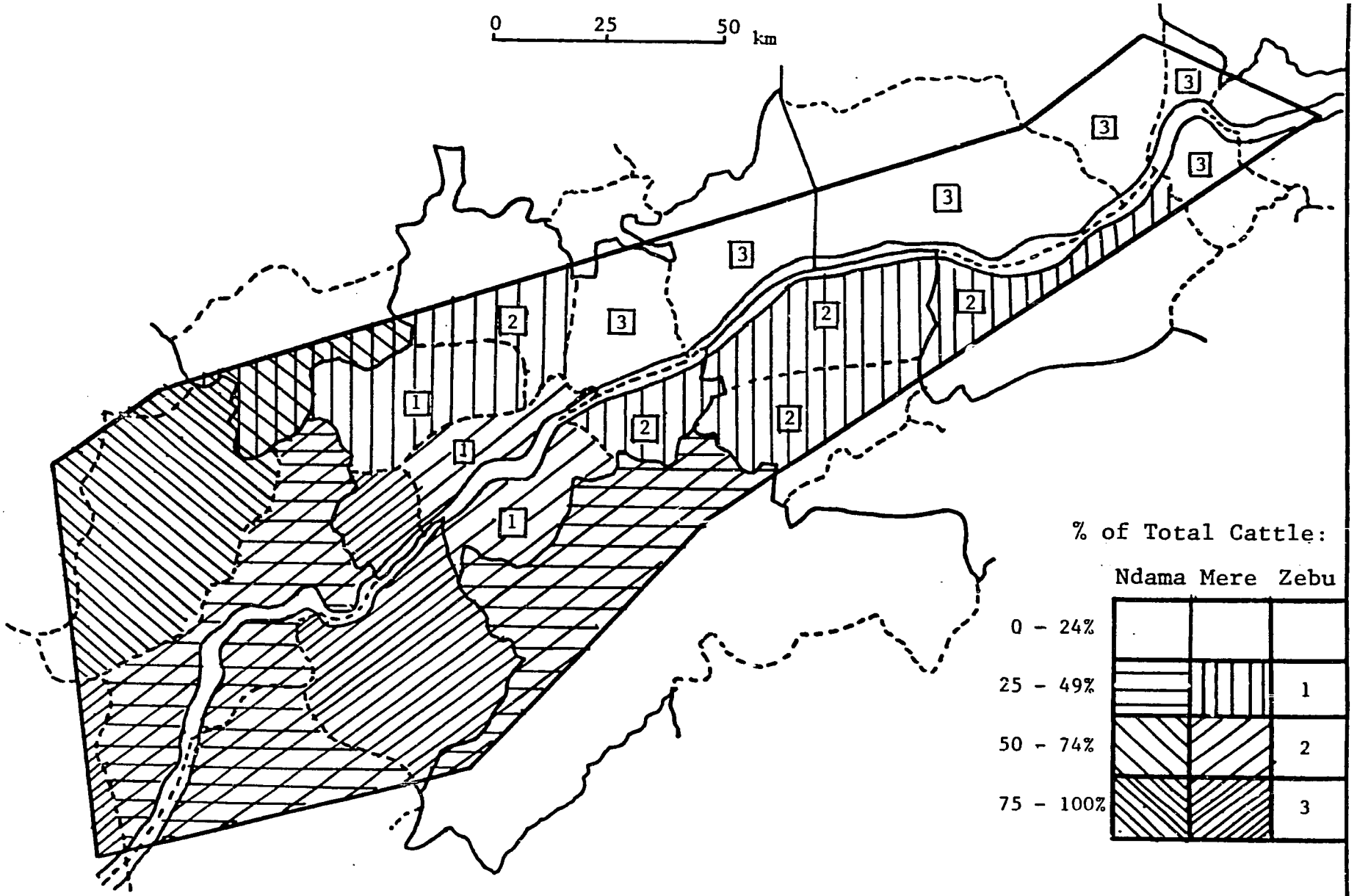


MAP 3.3 - Dry Season Cattle Migrations



MAP 3.4 - Commercial Livestock Routes

Source: Ministere de l'Elevage et des Eaux et Forets, Direction Nationale de l'Elevage.



MAP 3.5 - Proportion of Ndamas, Meres and Zebus in Zone 1

Source: Protozoological Survey.

TABLE 3.1a

CALCULATION OF CATTLE NUMBERS IN ZONE 1 AND OF THEIR POPULATION DENSITY - 1979

Cercle	Arrondissements	Total Number of Cattle	Number of Cattle in Zone 1	Cattle Per Km^2
Kati	Central	22,500	21,700	12.7
	Baguineda	11,777	11,700	7.6
	Negela	12,908	1,000	3.9
	Sanankoroba	16,500	10,400	10.4
	Sibi	15,720	1,000	4.5
	Bamako (former)	8,350	8,300	4.5
	Kalabancoro			
Cercle Total		126,983	54,100	8.2
Kolokani	Nossombougou	13,000	4,700	12.1
Cercle Total		63,000	4,700	12.1
Banamba	Toubakoura	7,350	600	23.1
Cercle Total		76,030	600	23.1
Koulikoro	Commune	1,800	1,800	9.9
	Central	9,560	9,600	
	Keninkou	10,220	10,200	19.7
	Koula	9,710	9,700	9.5
	Nyamina	12,810	8,400	10.7
	Sirakorola	8,730	3,800	6.4
	Tienfala	1,580	1,600	4.2
	Tougouni	5,980	5,800	11.2
Cercle Total		60,390	50,900	10.3
Dioila 1/	Fana	57,000	20,800	11.6
Cercle Total		180,800	20,800	11.6
Baroueli 2/	Central	19,634	16,100	16.8
	Tamani	18,039	18,000	18.6
Cercle Total		68,638	34,100	17.7
Segou	Central	34,640	16,900	22.9
	Diourou	29,580	2,100	23.4
	Doura	10,490	1,100	1.7
	Farako	13,380	8,900	6.0
	Markala	18,720	11,700	23.6
	Sansanding	8,880	2,100	16.6
Cercle Total		138,500	42,800	
Zone 1	Total Zone 1		208,000	10.8

TABLE 3.1a

Source: Livestock Service estimates of numbers.

Notes: 1/ 1978 figures increased by 3%.

2/ 1975 figures, when Baroueli was part of Segou cercle, increased by 7%, which was the average growth in the number of cattle in the other arrondissements of Segou from 1975 to 1979.

All other figures are for the year 1979.

TABLE 3.1b

ADMINISTRATIVE CENSUS AND VETERINARY ESTIMATES
OF CATTLE NUMBERS FOR CERCLES OF ZONE 1 - 1979

Cercle	Veterinary Estimate	Administrative Census
Kati	126,983	77,620
Kolokani	63,000	24,711
Banamba	76,030	26,242 2/
Koulikoro	60,390	34,151
Dioila 1/	180,800 1/	72,291 2/
Baroueli 1/	68,638 1/	45,015
Segou	138,500	69,505 2/

Notes: 1/ These figures were updated from earlier estimates as explained in Table 3.1a.

2/ All figures are those given for 1979. For the administrative census figures, the Banamba estimate was made in 1975, Dioila in 1978, and Segou in 1972.

TABLE 3.2

NUMBER OF LIVESTOCK PER RURAL INHABITANT IN ZONE 1 - 1979

ercle	Arrondissements	Cattle	Sheep and Goats	Horses and Donkeys
ıti	Central	0.57 (0.33)	0.76 (0.44)	0.020 (0.12)
	Baguineda	0.39	0.31	0.009
	Negela	0.42	0.54	0.022
	Sanakoroba	0.50	0.17	0.006
	Sibi	0.46	0.20	0.004
	Bamako (former)	0.23	0.35	0.005
	Kalabancoro			
rcle Total		0.42	0.43	0.011
lokani	Nossombougou	0.49	0.78	0.117
rcle Total		0.51	1.08	0.142
namba	Toubakoura	0.39	0.47	0.036
rcle Total		0.83	0.84	0.088
ulikoro	Commune	0.10	0.08	0.010
	Central	0.87	0.85	0.097
	Keninkou	0.87	0.75	0.195
	Koula	0.53	0.72	0.076
	Niamina	0.62	0.65	0.122
	Sirakorola	0.49	0.68	0.116
	Tienfala	0.47	0.70	0.084
	Tougouni	0.79	1.95	0.226
cle Total		0.67	0.83	0.125
ila	Fana	1.00	0.87	0.058
cle Total		0.96	0.93	0.043
oueli	Central	0.63	0.74	0.071
	Tamani	0.54	0.42	0.057
cle Total		0.61	0.64	0.063
ou	Central	0.72 (0.28)	0.92 (0.36)	0.076 (0.30)
	Diourou	0.59	1.04	0.068
	Doura	0.63	1.60	0.097
	Farako	0.39	0.71	0.076
	Markala	0.51 (0.35)	0.87 (0.59)	0.110 (0.075)
	Sansanding	0.33	0.58	0.102
cle Total		0.52	0.84	0.087

TABLE 3.2

(Continued)

Note: Figures in parenthesis are numbers of animals divided by total inhabitants, i.e., including those in the towns of Kati, Segou and Markala. All other figures refer to animals per rural inhabitant.

TABLE 3.3

CALCULATION OF NUMBER OF TRANSHUMANT CATTLE IN ZONE 1

Region of Zone 1	Cercles or Arrondissements Included (Areas in Zone 1)	Sedentary Cattle As % of Total Cattle: Wet Season	Sedentary Cattle As % of Total Cattle: Dry Season	Transhumant Cattle % Added to Veterinary Estimate	Number of Transhumants in Zone 1
North-East	Cercles:				
	Segou				17,100
	Baroueli	100	40	40	13,600
	Arrondissement:				
	Niamina				3,400
Central	Cercles:				
	Koulikoro (except Niamina)	100	70	20	8,500
	Banamba and Kolokani				1,000
	Dioila				4,200
South-West	Cercle:				
	Kati	100	90	5	2,700
Total	Zone 1				50,500

Source: Veterinary estimates of cattle population made in the wet season, plus estimates of influx of transhumants in the dry season.

Note: The actual number of transhumants entering the area in the dry season is twice the figure given above, that is, 101,000. Since they spend half of the year or less in the Zone, only half of that number are counted. In the case of the sedentary herd, which more-or-less stays in the area all year round, the full figure is taken, giving a total for cattle in Zone 1 of 258,500 head.

TABLE 3.4

DISTRIBUTION OF DIFFERENT CATTLE

BREEDS IN ZONE 1

ESTIMATES FROM THE DRY SEASON

PROTOZOOLOGICAL SURVEY

Cercle	% Ndamas	% Meres	% Zebus
Kati	42	54	4
Kolokani	62	38	-
Koulikoro	6	44	50
Dioila	41	50	9
Baroueli	1	43	56
Segou	0	22	78

TABLE 3.5

DISTRIBUTION OF CATTLE BREEDS IN ZONE 1

LIVESTOCK SERVICE ESTIMATES

Cercle	% Ndamas	% Meres	% Zebus
Kati	3% pure	97%	Transit only
Kolokani	50%	40%	10%
Banamba	-	2%	98%
Koulikoro	few	60%	
Dioila	pure rare	most numerous	few
Baroueli			70%
Segou	none	few	majority

TABLE 3.6

DISTRIBUTION OF DIFFERENT CATTLE BREEDS IN ZONE 1

PROTOZOOLOGY SURVEY

Cercle	Arrondissement	No. of Villages Sampled	% of Total Sample		
			Ndama	Mere	Zebu
Kati	Central	3	90	10	-
	Baguineda	4	20	72	8
	Negela	1	86	14	-
	Sanankoroba	4	37	56	7
	Sibi	1	-	98	2
	Bamako (Former) = Kalabankoro	6	40	60	-
	Total Cercle	19	42	54	4
Kolokani	Nossombougou	1	62	38	-
	Total Cercle	1	62	38	-
Koulikoro	Central	5	3	68	29
	Kenimkou	4	10	40	50
	Koula	3	9	49	42
	Niamina	5	3	22	75
	Sirakorola	3	3	31	66
	Tienfala	1	14	86	-
	Bougouni	2	-	23	77
	Total Cercle	23	6	44	50
Dioila	Fana	12	41	50	9
	Total Cercle	12	41	50	9
Baroueli	Central	9	1	49	50
	Tamani	4	1	31	68
	Total Cercle	13	1	43	56
Segou	Central	5	-	45	55
	Doura	7	-	17	83
	Farako	8	2	3	95
	Markala	4	-	21	79
	Total Cercle	24	0	22	78

Note: 0 signifies a figure of less than ½ a percent.

- signifies no animals in this category were sampled.

TABLE 3.7

DISTRIBUTION OF DIFFERENT CATTLE BREEDS

Regions of Zone 1	Parts of Zone 1	% of Each Breed		
		Ndamas	Meres	Zebus
North East	Cercles: Segou Baroueli Arrondissement: Niamina	0	25	75
Centre	Cercles: Koulikoro (excluding Niamina) Kolokani Banamba	5	55	40
	Dioila	35	45	20
South West	Cercle: Kati	40	55	5

Source: Tables 3.4 to 3.6

TABLE 3.8

SELECTION OF FIGURES FOR NUMBERS OF WORK OXEN UNDER DIFFERENT OPERATIONS

Area	Operation	No. of Work Oxen	% of Cultivating Units owning a Pair of Oxen	Oxen as % of Cattle
Cercle: Kati Arrondissement: Kati Baguineda Kalabankoro	Operation Haute-Vallee (O.H.V.)	2,475	15.0	5.8
Cercle: Banamba Arrondissement: Touba	Operation Arachide et Cultures Vivrieres (O.A.C.V.)	4,520 928	24.5 25.0	6.0 12.6
Cercle: Kolokani	O.A.C.V.	4,680	19.0	7.4
Cercle: Dioila	Compagnie Malienne de Developpement Textile (C.M.D.T.)	24,800	66.0	13.7
Cercle: Baroueli	Operation Riz Segou (O.R.S.) O.A.C.V. C.M.D.T. Total	2,500 1,200 6,413 10,113	45.0	14.7
Arrondissements Segou + Tamani Markala + Sansanding Farako + Doura	O.A.C.V.	5,843 3,092 3,033	30.0	11.1 11.2 12.7 } 11.5

Note: One cultivating unit is assumed to be equivalent to a large family with two to three adult men, consisting of ten people.

TABLE 3.9

ESTIMATE OF WORK OXEN NUMBERS BY CERCLE 1979

Cercle	Work Oxen as % of Sedentary Herd	Number of Work Oxen in Zone 1	Number in Remainder of Sedentary Herd in Zone 1
Kati	6	3,200	50,900
Kolokani	8	400	4,300
Banamba	13	100	500
Koulikoro	11	5,600	45,300
Dioila	14	2,900	17,900
Baroueli	15	5,100	29,000
Segou	19	8,100	34,700
Total	14	25,400	182,600

TABLE 3.10a

COMPARATIVE HERD COMPOSITION FIGURES

(AS A % OF THE TOTAL HERD)

EXTRACTED FROM ANNUAL LIVESTOCK SECTOR REPORTS OF CERCLES OF ZONE 1

Cercle/Year	Koulikoro 1979 General Norms		Baroueli 1979 General Norms	Kolokani 1979 Average 3 Herds	Banamba 1979 General Norms	Dioila 1978 Average of 4 Herds
Age-Designation	Seden-tary	Trans-humant				
Females:						
0 - 1 Calves	12	13.4	19	7.9	9	9.1
1 - 4 Heifers	11	10.3	13	16.6	10	19.6
4+ Cows	50	50.6	23	35.1	40	30.9
Entire Males:						
0 - 1 Calves	11	16	17	11.3	7.5	11.1
1 - 3 Young Males	8	7	11	13.2	12.5	13.4
3+ Bulls	4	2.7	3	4.0	1.0	2.1
Castrated Males:						
3+ Steers	4	-	13	11.9	10	11.3
Total Females	73	74.3	45	59.6	59	59.6 1/
Total Males	27	25.7	54	40.4	41	37.9

- Absent

1/ Add 2.5% for old animals of unspecified sex

TABLE 3.10b

COMPARATIVE HERD COMPOSITION FIGURES

(AS A % OF THE TOTAL HERD)

EXTRACTS FROM "STUDY OF TRADITIONAL LIVESTOCK RAISING SYSTEMS IN THE SAHEL AND IN THE CENTRAL DELTA OF THE NIGER" BY ILCA

Study / Age/Sex	"Colons" of the Office of Niger - ILCA	Bambaras of Niono Region - ILCA	Transhumant Herds of Delta Coulomb - 1972
Females:			
0 - 1	5.7	6.2	10.9
1 - 2	8.1	6.0	9.0
2 - 3	3.0	5.3	6.7
3 - 4	3.6	4.9	6.7
4 - 5	2.1	5.8	8.1
5+	14.5	25.0	20.7
Total Males:			
0 - 1	7.2	5.6	9.8
1 - 2	5.7	4.7	7.7
2 - 3	3.6	3.8	5.2
3 - 4	2.1	2.6	4.0
4 - 5	3.0	3.8	4.0
5+	41.2	26.3	7.1
Entire Males:			
0 - 1	7.2	5.6	9.8
1 - 2	5.7	4.7	7.6
2 - 3	3.0	2.1	3.7
3 - 4	0.6	0.9	1.0
4 - 5	0.9	0.4	0.5
5+	2.1	0.9	0.6
Castrated Males:			
0 - 1	0	0	0.0
1 - 2	0	0	0.1
2 - 3	0.6	1.7	1.5
3 - 4	1.5	1.7	3.0
4 - 5	2.1	3.4	3.5
5+	39.1	25.4	6.6
Total Females	37.0	53.2	62.1
Total Males	63.0	46.8	37.9
Entire Males	19.6	14.5	23.2
Castrated Males	43.4	32.3	14.7
Total number of animals sampled	470	468	13,278

TABLE 3.10c

COMPARATIVE HERD COMPOSITION FIGURES

(AS A % OF THE TOTAL HERD)

EXTRACTS FROM OMBEVI AND FROM COULOMB 1972

Age/Sex	OMBEVI 1977 - ODEM Area				Coulomb 1972
	Transhumants Originating in the Dry Zone		Sedentary Herds Outside Inland Delta		Sedentary Herds Outside Inland Delta
Females					
0 - 1	8.6		8.6		8.8
1 - 2	7.5		6.3		7.9
2 - 3	6.7		5.7		9.4
3 - 4	6.2		5.8		7.6
4 - 5	6.6		4.7		
5 - 6	6.0		6.1		
6 - 7	6.9		6.5		
7 - 8	5.8	38.0	8.4	42.7	24.2
8 - 9	5.3		7.4		
9 - 10	3.3		4.6		
10+	4.1		5.0		
Males					
0 - 1	7.4		6.5		8.5
1 - 2	5.5		5.0		6.7
2 - 3	4.3		3.8		8.0
3 - 4	3.7		3.3		
4 - 5	2.9		3.0		
5 - 6	2.1		2.8		
6 - 7	2.1	15.8	2.2	15.6	19.0
7 - 8	1.7		2.0		
8 - 9	1.6		1.0		
9 - 10	1.0		0.7		
10+	0.7		0.6		
Total Females	67.0		69.1		58
Total Males	33.0		30.9		42

Sources: OMBEVI "Etude du Troupeau" in the ODEM project area.

Coulomb quoted in Delgado "Livestock and Meat Production, Marketing and Exports in Mali."

TABLE 3.11

GROWTH RATE IMPLICATIONS OF VARIOUS STUDIES

FORMULA USED: R = CS - AM - O

FIGURES GIVEN AS A % OF THE TOTAL HERD

Source	Calf Survivals CS	Adult Mortality[3/] AM	Offtake[3/] O	Residual = Growth R
OMBEVI: 1977				
Delta Transhumants	14.6	3.2	8.7	(2.7) [2/]
Transhumants Outside Delta	14.1 14.7 [1/]	4.0	8.3	(1.8) (2.4) [1/]
Sedentary Outside Delta	12.7 13.3 [1/]	3.2	6.7	(2.9) (3.5) [1/]
COULOMB: 1972				
Delta Transhumants	19.3	(3.8) [2/]	11.5	4.0
Transhumants Outside Delta	16.9	(2.7)	10.7	4.0
Sedentary	15.9	(3.5)	9.4	3.0 [4/]

Notes:

1/ Calf survivals if 3% of the difference between one year olds and live births is accounted for by growth of the herd rather than mortality.

2/ Figures in parenthesis are derived by subtracting either O, R, or AM from CS.

3/ AM, O in OMBEVI data are derived from given offtake and mortality figures as described in Annex A and Table A.1.

4/ A generally accepted rate was used here.

TABLE 3.12

DIFFERING ESTIMATES OF TRUE FERTILITY FROM THE VARIOUS SOURCES

	Figures Given in Texts			Figures Based on Herd Composition	
	% of Adult Females giving Birth in Year[1/]	% of Calves born Dying in First Year[2/]	Calves Surviving 1 Year as % of Adult Females - Calculated Fertility	Calves Alive at End of Year 1 as a % of Total Herd	Calves Alive at End of Year 1 as % of Adult Females
Transhumants:					
ILCA: Tenenkou Peulhs	68.7	30 (hypothetical)	48.1		
Coulomb 1972:					
Outside Delta (Seno)	59.66			16.9 13.7 b	59.5 48.2 b
Inside Delta	58.64			19.3 17.8 b	66.6 61.4 b
OMBEVI 1977:					
Outside Delta	59	F:21 M:30 A:25.5	44.0	14.1	
Inside Delta	59	F:10 M:22 A:16	49.6	14.6 a	
Sedentary:					
ILCA: Niono	52 (estimate)	30 (estimate)	36.4	11.2	36.5
Coulomb 1972:					
Outside Delta	58	30 (hypothetical)	40.6	15.9	65.7
				14.6 b	60.3 b
OMBEVI 1977:					
Outside Delta	49	F:15 M:36 A:25.5	36.5	12.7 a	29.7
Sahel Station					
1966	65	35	42.2		
1978	78		50.7		

TABLE 3.12 (Continued)

Notes: 1/ Adult females are taken as those aged four and above.

2/ F = Female, M = Male, A = Average.

3/ All figures in this column are for % of animals aged one, derived as average of 0-1 and 1-2 age groups, except those marked 'a' which were derived by interpolation on a graph, and those marked 'b' which refer to numbers in the 1-2 age group.

Sources: OMBEVI "Etude du Troupeau" for OMBEVI figures.

ILCA "Study of Traditional Livestock Systems" for ILCA, and some of Coulomb's data.

Delgado "Livestock and Meat Production" for the rest of Coulomb's figures.

TABLE 3.13

PRODUCTION PARAMETERS RETAINED

a. ANNUAL RATES OF NATURAL GROWTH

Transhumant herds	2 - 2.5%
Sedentary herds	3 - 3.5%

b. OFFTAKE RATES

Transhumant herds	8 - 10%
Sedentary herds	7 - 9%

c. MORTALITY BY AGE GROUP - AS A PERCENTAGE OF AGE GROUP

	Transhumants		Sedentary	
	Males	Females	Males	Females
0 - 1	40	25	38 - 42	25 - 28
1 - 2	12	10	12	12
2 - 3	10	8	7	5
3 - 4	5	5	2	2
4 +	2 - 3	2	2	2

d. OFFTAKE BY AGE GROUP - AS A PERCENTAGE OF AGE GROUP (VERY APPROXIMATE)

	Transhumants		Sedentary	
	Males	Females	Males	Females
2 - 3	8	1	-	-
3 - 4	15	1	16	-
4+	15	5	16	5

TABLE 3.14

a. PRICE AND AVERAGE CARCASS WEIGHT OF CATTLE SOLD FOR SLAUGHTER (AVERAGE OF JANUARY - MARCH 1980)

(Price: 1000 MF)
(Weight: Kgs.)

Centers Checked	Breed	Steers		Bulls		Cows		Immature Males	
		Price	Weight	Price	Weight	Price	Weight	Price	Weight
Bamako	ZP, ZM	128	142	99	111	84	92	67	79
Kati	ZP, ZM	125	144	105	121	85	99	58	69
Kati	Ndama	154	159	--	--	80	93	43	54
Bougouni	Ndama	90	--	58	--	70	--	51	--
Nioro	ZP	78	--	68	--	45	--	39	--
Nara	ZM	--	--	--	--	45	101	--	--
Niono	ZP	90	--	--	--	53	--	--	--
Segou	ZP	--	--	--	--	80	101	--	--
Kayes	ZP	112	127	103	115	56	85	51	70
Gao	ZP, ZM	--	--	--	--	--	62	--	--
Ansongo	ZT	--	--	--	--	30	--	--	--

b. PRICE PER KILOGRAM OF CARCASS WEIGHT (DERIVED FROM ABOVE AVERAGES IN MF/KG. WHOLESALE)

Centers	Steers	Bulls	Cows	Immature Males
amako	900	890	910	850
ati - Zebus	870	870	860	840
ati - Ndamas	970	--	860	800
ayes	--	--	660	--
ara	--	--	450	--
egou	--	--	790	--

Source: OMBEVI "Evaluation Mensuelle des Controleurs des Marches."
Note: Z - Zebu, P - Peul, M - Maure, T - Touareg.

TABLE 3.15

SOME EXAMPLES OF PRICES OF CATTLE SOLD FOR BREEDING AND RAISING PURPOSES
JANUARY TO MARCH 1980
(IN 1000'S OF MF)

Centers Checked	Breed	Bulls	Cows	Immature Males	Heifers
Bamako	ZM, ZP	88.5	81	48	--
Gao	ZT, ZP	--	--	56	--
Niono	ZP	64	53.5	40	64.5
Kati	Ndama	--	--	--	62
Nioro	ZP	--	--	28	53.5
Segou	ZP	96.5	--	52	--
Nara	ZM, ZP	--	57	55	53
Ansongo	ZT	--	26	54	93

Source: OMBEVI "Evaluation Mensuelle des Controleurs des Marches."

Note: Z - Zebu, P - Peul, M - Maure, T - Touareg.

TABLE 3.16

SELECTED CATTLE WEIGHTS

a. LIVE WEIGHT BY AGE

Age	Male (Kg.)	Female (Kg.)
(Birth) 0	21.0 1/	19.5 1/
0.5	(55) 2/	50
1.5	(145) 2/	140
2.6	170	160
3.5	205	195
4.5	(220) 2/	200
6+	320	235

Source: ILCA 1978 - Study of Traditional Livestock Systems Peul Cattle in Colon Villages.

Notes: 1/ Birth weights at the Station du Sahel, which must be above average.

2/ Figures in parenthesis are interpolations from the graph presented in the report.

b. CARCASS WEIGHTS BY CATEGORY

Category	Carcass weight (Kg.)	Corresponding Live weight (Kg.)
Exceptional Steer	220	460
Export Steer	200	420
Butchery Steer	150	310
Sterile Cow	120	250
Old Cow Culls	100	210
Bullock	75	160

Source: SEDES 1975 - Comptes Economiques de la Production Animale - Mali.

Note: 48% dressing out percentage used.

TABLE 3.16 (Continued)

SELECTED CATTLE WEIGHTS

c. ACTUAL CARCASS WEIGHTS RECORDED AT THE MARKETS FOR ZEBUS

Category	Carcass Weight (Kg)	Corresponding Live Weight (Kg)
Steers	130-145	270-300
Bulls	110-120	230-250
Cows	85-100	175-210
Immature Males	55- 80	115-165

Source: OMBEVI 1980 - "Evaluation Mensuelle des Controleurs."

TABLE 3.17

a. CURRENT WHOLESALE (MARKET) AND RETAIL (BUTCHERY) PRICES FOR MEAT (JANUARY - MARCH 1980 IN MF/KG)

Centers Checked	Wholesale[1/]	Butchery			
		Beef			
	Beef	Without Bones	With Bones	Mutton	Goat
Bamako	890	-	-	-	-
Kati	870	950	850	900	950
Bougouni	-	875	750	650	650
Gao	-	600	615	800	800
Kayes	660	1000	800	1000	1000
Segou	790	800	700	700	700
Nioro	-	1000	750	700	700
Niono	-	770	650	830	830
Sikasso	-	700	600	650	600
Nara	450	600	500	500	500
Ansongo	-	500	500	500	500

Source: OMBEVI "Evaluation Mensuelle des Controleurs"

Note: 1/ Wholesale - derived from Table 3.14.

b. OFFICIAL BUTCHERY PRICES FOR THE CENTERS OF ZONE 1 - 1979 (IN MF/KG)

Town	Beef		Sheep	Goat
	Without Bones	With Bones		
Kati	800	700	700	1400 1/
Banamba	600	450	600	500
Koulikoro	950	650	1200	
Baroueli	500		650	
Konobougou	600		800	

Source: Rapports Annuels des Secteurs d'Elevage

Note: 1/ Varies from 1400 MF/kg. for leg to 700 MF/kg. for shoulder.

TABLE 3.17 (Continued)

c. ACTUAL BAMAKO PRICES

Beef without bone:	1200-1500 MF/kg.
Beef with bone:	1000-1200 MF/kg.

Source: Local experience.

TABLE 3.18

COMPARISON OF EXPECTED OFFTAKE WITH CONTROLLED SLAUGHTERS, EXPORTED ANIMALS AND NUMBERS SEEN AT MARKETS (TOTAL MALI FOR 1977 AND 1978)

Cattle	1977	1978
Offtake:		
Population in Mali	4,058,508	4,334,000
Net Offtake of 8%	325,000	347,000
Officially Controlled:		
Number of Slaughters	98,065	110,770
Number Exported	27,837	43,539
Total	125,902	124,309
DNE Estimate of Clandestine Exports 1/	60,000	70,000
Seen at Markets:		
Presented	215,736	281,055
Sold	120,725	176,410
Those Sold As % of Estimated Offtake	37.1	54.3
% of Estimated Offtake		
Officially Controlled	38.7	38.2
Clandestine Exports	18.5	21.5
Redidual - Clandestine Slaughter	42.8	40.3

Sheep and Goats	1977	1978
Offtake		
Population in Mali	8,532,000	8,553,000
Net Offtake of 15%	1,280,000	1,283,000
Officially Controlled		
Number of Slaughters	232,996	226,363
Number Exported	90,561	168,562
Total	323,557	394,925
Estimate of Clandestine Exports	70,000	200,000
Seen at Markets		
Presented	754,593	791,256
Sold	517,561	545,635
Those Sold As % of Estimated Offtake	40.4	42.5
% of Estimated Offtake		
Officially Controlled	25.3	30.8
Clandestine Exports	5.5	15.6
Residual - Clandestine Slaughter	69.2	53.6

Source: Annual Livestock Service Reports.

Note: 1/ DNE - Director National du Service de l'Elevage (Livestock Service Headquarters).

TABLE 3.19

CALCULATION OF VALUE OF CATTLE AT DIFFERENT AGES

a. MALE ANIMAL EXPECTED TO BE SOLD FOR MEAT AT AGE 7

Expected Mortality		Mid Point of Age Group	(1) Probability of Surviving to Age 7	(2) Present Selling Price	(3) Value of Animals 1/
Year	Mortality %	Year	%	1000 MF	1000 MF
0-1	40	0:birth	41	56.5	23.2
1-2	12	1	69	63.3	43.7
2-3	10	2	78	70.9	55.3
3-4	5	3	87	79.4	69.1
4-5	3	4	91	89.0	81.0
5-6	3	5	94	99.6	93.6
6-7	3	6	97	111.6	108.3
		7	100	125.0	125.0

b. FEMALE ANIMAL SOLD FOR BREEDING AT AGE 2

Expected Mortality		Mid Point of Age Group	(1) Probability of Surviving to Age 7	(2) Present Selling Price	(3) Value of Animals 1/
Year	Mortality %	Year	%	1000 MF	1000 MF
0-1	25	0:birth	68	55.8	37.9
1-2	10	1	90	62.5	56.2
		2	100	70.0 2/	70.0

Notes: 1/ The value of an animal at a given age is calculated in columns (3) by multiplying the discounted present value of the expected future selling price as calculated in column (2) by the probability of realizing that price as given in column (1) by the chance of that animal surviving to the age of sale.

2/ Given the value at present of 70,000 MF for a female aged 2, a value of 85,200 MF can be calculated for age 3. By the time the animal has proven its breeding ability, it would be expected to rise to 90 - 100,000 MF, and to hold this value until it is sold finally for meat, probably after age 10, for 80 - 90,000 MF if in good condition, less if not.

TABLE 3.20

AVERAGE MONTHLY CATTLE NUMBERS SLAUGHTERED BY CLASS OF ANIMAL FOR SELECTED TOWNS

(JANUARY - MARCH 1980)

Market	Total Number Slaughtered	Steers		Bulls		Cows		Immature Males	
		No.	(%)	No.	(%)	No.	(%)	No.	(%)
Bamako	4619	3783	(82)	124	(3)	712	(15)	-	
Nara	67	1	(1)	-		66	(99)	-	
Niono	103	70	(68)	6	(6)	21	(20)	6	(6)
Segou	723	146	(20)	24	(3)	537	(75)	16	(2)
Sikasso	483	66	(14)	98	(20)	319	(66)	-	
Kayes	660	549	(83)	59	(9)	32	(5)	20	(3)
Ansongo	22	-		-		22	(100)	-	
Bougouni	86	18	(21)	28	(33)	33	(38)	7	(8)
Gao	246	69	(28)	8	(3)	134	(55)	35	(14)
Nioro	200	38	(19)	9	(4)	121	(61)	32	(16)
Total	7209	4740	(65.8)	356	(4.9)	1997	(27.7)	116	(1.6)

Source: OMBEVI "Evaluation Mensuelle des Controleurs des Marches."

Note: Percentages per class of animal are calculated over the total for each animal.

TABLE 3.21

OFFICIALLY CONTROLLED SLAUGHTER FIGURES FOR SELECTED SECTORS - 1978

Cercle	Cattle (Number)	Sheep and Goats (Number)	Proportion[1/] of Cercle's Slaughter Taking Place in Zone 1 (%)
Koulikoro	1,102	1,214	100
Kati and District of Bamako	62,130	67,065	100
Kolokani	951	3,626	25
Dioila	2,929	5,346	0
Banamba	416	4,139	0
Segou (including Baroueli)	8,263	41,928	90
Zone 1 Estimate[1/]	71,000	107,000	
Mali Total	110,770	226,363	

Source: 1978 Annual Report of DNE.

Note: [1/] The estimate of the total slaughtered in Zone 1 is made on the basis of the towns included. Thus, cercle by cercle:

Koulikoro: All the main towns are included in the Zone and thus virtually all slaughtering.

Kati: Bamako and Kati are in the Zone so most slaughtering is done in the Zone.

Kolokani: With the inclusion of Nassombogou about a quarter of slaughters are estimated to take place in the Zone.

Dioila: Neither Dioila nor Fana is in the Zone.

Banamba: Only a small rural part of this cercle is in the Zone .

Segou and Baroueli: With the inclusion of Segou, Baroueli, Morkala and Farako, 90% of the cercle's slaughters are estimated to take place in the Zone, especially given the predominance of Segou.

TABLE 3.22

PROPORTION OF ANIMALS SLAUGHTERED IN EACH CLASS

	Official Figures for Main Centers %	OMBEVI 1977 Estimates of Annual Offtake or Class	
		Transhumant Herds %	Sedentary Herds %
Steers	65.8	38.0	37.5
Bulls	4.9		
Cows	27.7	45.7	51.3
Young Males	1.6	12.0	6.7
Young Females		4.3	4.5
TOTAL	100.0	100.0	100.0

Source: Annual Reports of Livestock Service, Table 3.20, OMBEVI, 1977, derived from Table A.1.

TABLE 3.23

WEIGHTED AVERAGE VALUE OF CATTLE SLAUGHTERED

	Weight- % of Total 1/	Value - 1000 MF	Weighted Value MF
Adult Males	45	125	56
Adult Females	50	80	40
Young Males	5	60	3
Total Weighted Mean			99

Source: Tables 3.19, 3.22.

Note: 1/ Representative weights based on Table 3.22 .

TABLE 3.24

GROWTH RATES USED IN PROJECTING CATTLE NUMBERS FOR ZONE 1 OVER THE NEXT TWENTY YEARS

a. SEDENTARY HERDS (% OF RATE OF GROWTH PER ANNUM)

Years	0 - 4	5 - 7	8 - 10	11 - 15	15 - 20
Annual %	3.5	3.0	2.0	0	0

b. OTHERS (% RATE OF GROWTH PER ANNUM)

Years	0 - 5	6 - 10	11 - 15	16 - 20
Transhumant Herds	2	1	0	0
Work Oxen:				
Group I	6	4	2	2
Group II	9	6	4	2

TABLE 3.25

PROJECTION OF CATTLE, SHEEP AND GOAT NUMBERS FOR ZONE 1 (1,000's OF UBT)

Years	Sedentary Cattle	Work Oxen I	Work Oxen II	Transhumant Cattle	Sheep and Goats	Total U.B.T.
0	182.6	16.1	9.3	50.5	30.9	289.4
1	189.0	17.1	10.1	51.5	31.5	299.2
2	195.6	18.1	11.0	52.5	32.1	309.3
3	202.5	19.2	12.0	53.6	32.8	320.1
4	209.5	20.3	13.1	54.7	33.4	331.0
5	215.8	21.5	14.3	55.8	34.1	341.5
6	222.3	22.4	15.2	56.3	34.7	350.9
7	229.0	23.3	16.1	56.9	35.5	360.8
8	233.5	24.2	17.0	57.4	36.2	368.3
9	238.2	25.2	18.1	58.0	36.9	376.4
10	243.0	26.2	19.1	58.6	37.6	384.5
11	243.0	26.7	19.2	58.6	38.4	385.9
12	243.0	27.3	20.7	58.6	39.1	388.7
13	243.0	27.8	21.5	58.6	40.0	390.9
14	243.0	28.4	22.4	58.6	40.7	393.1
15	243.0	28.9	23.3	58.6	41.5	395.3
16	243.0	29.5	23.8	58.6	42.4	397.3
17	243.0	30.1	24.2	58.6	43.2	399.1
18	243.0	30.7	24.7	58.6	44.1	401.1
19	243.0	31.3	25.2	58.6	45.0	403.1
20	243.0	32.0	25.7	58.6	45.9	405.2

Source: Tables 3.1a, 3.3, 3.9, 3.24.

Note: Sheep and goats in the Zone are mainly small animals equivalent to one-eighth of a UBT (Unite Bovine Tropicale), their numbers are given above converted to UBT's.

CHAPTER 4

OTHER DOMESTIC ANIMALS

Sheep, goats, donkeys and horses are the main domestic animals kept in the Zone, if cattle and poultry are excluded. Pigs are very rare in the area since most of the population are Moslem. For estimates of livestock populations, the estimates made by the sector heads of the Livestock Service are again used. Cattle take up by far the greatest share of veterinary time (about 95% of vaccinations and 80% of treatments are for cattle), and the veterinary estimates of numbers are based on numbers seen by the veterinary service and to some extent on the administrative census done for tax purposes. Therefore, in the case of other domestic animals, greater guesswork is needed and a greater reliance is necessarily placed on the usually underestimated tax figures. In examining the figures, this was noticed to be true, particularly so in the case of Kati, where the veterinary estimates are very close to the administrative census figures.

However, despite these difficulties, Table 4.1 and 4.2 have been produced by calculating numbers in the Zone and density per square kilometer. Table 3.2 gives numbers per rural inhabitant by arrondissement. These animals are discussed only very briefly for two reasons. First, the traditional bias of livestock services towards cattle is reflected not only in the difficulty of estimating actual numbers accurately but also in the whole emphasis of research, so that little information is available about herd composition, prices, production, etc., for small ruminants and even less so for donkeys or horses. Secondly, as explained in Chapter 10, Section D, they are relatively more resistant to trypanosomiasis than cattle, so that losses in these animals are not so significant.

A few tentative observations can, however, be made. The density of small ruminants per square kilometer and per rural inhabitant is highest in Segou and Baroueli and lowest in the cercle of Kati. This is no doubt partly due to difficulties in

estimating numbers in Kati cercle, but probably also reflects reality to some extent. High density could also be associated with the greater activity of the "Operations" in the Segou and Baroueli area, and the consequently greater agricultural prosperity, but is less likely to be associated with the fly distribution.

Donkeys and horses, on the other hand, are about equally distributed within the Zone, except for Kati where, again, there are few. Numbers per rural inhabitant are highest in Koulikoro. Since these figures fluctuate a lot and contain a lot of statistical anomalies, it is possible that, although somewhat fewer in number in Kati, donkeys and horses are fairly evenly distributed in the Zone. The growth of animal traction, with donkeys being used with carts, has been encouraged by the "Operations" active in the northeast of the Zone and in the Dioila area and may also explain the distribution of donkeys. However, the donkey has so long been established as a beast of burden that this effect is probably only marginal.

Prices of donkeys in Zone 1 are given by the Livestock Service as about 100 to 120,000 MF in 1979, with much lower prices quoted when, presumably, referring to animals culled and sold for meat. This high price reflects their value as beasts of burden. Sheep prices ranged from 15 to 30,000 MF, goat prices from 10 to 15,000 MF.

Sheep and goats are included in the projections of livestock numbers in Chapter 3, Section H. They are assumed to grow at 2% per annum, slightly more rapidly than the official rate of growth for the rural human population, so that numbers per inhabitant remain more or less constant. It is felt that in the absence of better data, this sufficiently neutral assumption is adequate (see Table 3.25).

TABLE 4.1

CALCULATION OF NUMBERS OF SHEEP AND GOATS IN ZONE 1
AND OF THEIR POPULATION DENSITY - 1979

Cercle	Arrondissement	Number of Sheep and Goats	Number Inside Zone 1	Density of Sheep and Goats Numbers per Km.^{2}
Kati	Central	30,000	28,900	16.9
	Baguineda	9,283	9,200	6.0
	Neguela	16,600 1/	1,300	5.0
	Sanankoroba	5,750	3,600	3.6
	Sibi	6,800 1/	400	1.9
	Bamako (former)	12,600 1/	12,500	6.8
	Kalabankoro			
	Total Cercle	71,524	55,900	
Kolokani	Nossombougou	21,000	7,500	19.5
	Total Cercle	133,000	7,500	
Banamba	Toubakoura	8,700	700	27.3
	Total Cercle	76,940	700	
Koulikoro	Commune	1,500	10,900	9.5
	Central	9,360		
	Kenenkou	8,840	8,800	17.0
	Koula	13,020	13,000	12.8
	Niamina	13,550	8,900	11.3
	Sirakorola	12,010	5,200	8.8
	Tienfala	2,340	2,300	6.2
	Tougouni	14,700	14,300	27.5
	Total Cercle	75,320	63,400	
Dioila	Fana	52,000 2/	19,000	10.6
	Total Cercle	173,988 2/	19,000	
Baroueli	Central	22,929 3/	18,800	19.6
	Tamani	14,104 3/	14,100	14.5
	Total Cercle	72,648 3/	32,900	
Segou	Central	44,310	21,600	29.3
	Diourou	51,720	3,700	40.9
	Doura	26,360	2,800	4.3
	Farako	24,450	16,400	10.9
	Markala	31,940	20,000	40.3
	Sananding	15,540	3,700	29.0
	Total Cercle	273,200	68,200	
Zone 1	Total Zone		247,600	

TABLE 4.1 (Continued)

Source: Veterinary estimates given in the annual reports of each sector.

Notes: 1/ Figures obtained by using the proportions of cattle to sheep and goats obtained through the administrative census and applying this figure to the number of cattle from the veterinary estimate to obtain an estimate of sheep and goat numbers.

2/ 1978 figures increased by 3%.

3/ 1975 figures, from the period when Baroueli was part of the Cercle of Segou, increased by 14%, which was the average rate of growth in the other arrondissements of Segou between 1975 and 1979.

TABLE 4.2

CALCULATION OF THE NUMBER OF HORSES AND DONKEYS IN ZONE 1 AND OF THEIR POPULATION DENSITY - 1979

Cercle	Arrondissement	Number of Horses and Donkeys	Number In Zone 1	Density Animals per Km.^{2}
Kati	Central	782	800	0.44
	Baguineda	255	200	0.17
	Neguela	679	100	0.20
	Sanankoroba	185	100	0.12
	Sibi	138	0	0.04
	Bamako (former) Kalabankoro	176	200	0.09
	Total Cercle	2,944	1,400	
Kolokani	Nossombougou	3,130	1,100	2.91
	Total Cercle	17,460	1,100	
Banamba	Toubakoura	675	100	2.13
	Total Cercle	8,106	100	
Koulikoro	Central	1,080	1,100	0.94
	Kenenkou	2,285	2,300	4.40
	Koula	1,388	1,400	1.36
	Niamina	2,542	1,700	2.13
	Sirakorola	2,067	900	1.51
	Tienfala	284	300	0.75
	Tougouni	1,708	1,700	3.19
	Total Cercle	11,354	9,400	
Dioila	Fana	3,300 1/	1,200	0.67
	Total Cercle	8,100 1/	1,200	
Baroueli	Central	2,200 2/	1,800	1.89
	Tamani	1,900 2/	1,900	1.94
	Total Cercle	7,100 2/	3,700	
Segou	Central	3,650	1,800	2,41
	Diourou	3,400	200	2.69
	Doura	1,590	200	0.26
	Farako	2,650	1,800	1.18
	Markala	4,030	2,500	5.09
	Sansanding	2,730	700	5.10
	Total Cercle	21,360	7,200	
Zone 1	Total Zone		24,100	

Source: Veterinary estimates of numbers.

Notes: 1/ Figures for 1978 increased by 3%.

2/ Figures for 1975 when Baroueli was part of the cercle of Segou increased by 7%.

CHAPTER 5

AGRICULTURE AND LAND USE

A. Forest Reserves and Urban Areas

Forest reserves cover 125,300 hectares of Zone 1, that is, 6.5% of its total area (Table 5.1). Half of these forested areas (50.15%) are concentrated in the far west of the Zone (cercle of Kati). The two cercles of Kati and Dioila have, within those parts included in Zone 1, nearly 80% of the total area in forests (see Map 5.1). It follows that the parts of the other cercles contained in Zone 1, either have no forest reserves (Kolokani, Banamba) or only small areas of forest reserves, about 13% in Koulikoro, 5% in Baroueli and less than 4% in Segou.

As a general rule these forest reserves are closed to farming, but their use for grazing is permitted. In other respects these boundaries are not immutable; the reserves' status can be changed. (For details of the regulations, see "Droits d'usage dans les domaines classes").

As to the large towns (Bamako, Segou, Kati, Koulikoro and Markala) they cover an area of 387 Km.^{2}, i.e. 2% of the Zone. It is worth noting that the urban area of Zone 1 is essentially taken up by Bamako; the District of Bamako alone accounts for 70% of the total area given to towns.

B. Land Available

The "occupied" areas (forest reserves and towns) take up 8.5% of the land of Zone 1. The Zone therefore has a relatively large area of land available for agricultural use (17,631 Km.^{2}). For those parts of each cercle included in the Zone, the areas useable for farming or livestock development activities are more than 80% of the total (see Table 5.2). For the whole of Zone 1, the proportion of land available for agriculture reached 91%.

The ratio of land cultivated to land available reveals a significant potential in land for agriculture in the Zone (see Map 5.2). In fact, the ratio is about 1/18. A breakdown shows that a higher proportion of available land is cultivated in

Segou (9.2%) than elsewhere. This proportion is very low in Kolokani, Kati and Baroueli (Table 5.3).

Thus, if the land in Zone 1 is distributed among the rural population, in 1979, an average of 4 to 5 hectares per rural inhabitant would have been available for farming (Map 5.3). In the cercles of Koulikoro and Dioila (6.5 to 7 ha./rural inhabitant) this level is exceeded. But it seems that in Banamba with only 1.7 ha. per rural inhabitant, the problem of land shortage could arise in the relatively near future compared to the rest of the Zone.

C. Agriculture

1. General Characteristics

As is the case in the country as a whole, agriculture in Zone 1 consists of a traditional sector evolving into a sector with modern features.

The former sector possesses the traditional characteristics of subsistence agriculture where production is essentially geared towards auto-consumption. It is a sector of shifting extensive agriculture, where burning is still undertaken.

In the second sector the tendency is towards the development of mechanized agriculture, the more permanent siting of fields and a more or less significant participation in the market economy. This participation is made possible through the development of cash crops (which is very often impeded these days).

It is worth noting that overall in Zone 1, it is more and more difficult to make a distinction on a geographical basis between a homogenous area of traditional agriculture as compared to an area of modern agriculture. This is due to the fact that in almost the entire Zone, agriculture takes place within the framework and under the wing of the agricultural development agencies (the "Operations") whose role includes training, extension work, marketing and, to some extent, the promotion of social development.

Therefore, the work of these institutions, the "Operations," tends to render more uniform the agricultural picture in Zone 1 especially in the field of agricultural techniques.

In the western part of the Zone, each "Operation" has its own area of intervention which is not shared with the other Operations (see Map 5.4). This is the case for the Operation Haute Vallee in the cercle of Kati, Operation Arachide et Cultures Vivieres in the cercle of Koulikoro and the Compagnie Malienne du Developpement Textile in the cercle of Dioila. In the east the "Operations" overlap and thus intervene in the same area. This is the case in Segou where the Operation Arachide and the Operation Riz implement programs side by side with Office du Niger.

2. Cultivated Areas and Crop Production

In Zone 1, agriculture takes up about 100,000 hectares, that is 5.6% of available land. Cultivation of cereals dominates in terms of tons produced as well as in terms of area cropped. In fact the area under cereal crops (millet/sorghum, corn and rice) totalled about 83,775 hectares in 1979, that is, about 85% of the land tilled. Millet and sorghum together take first place occupying more than 77% of all land under crops (Table 5.4).

The predominance of the millet/sorghum group, although of long standing, seems to be a phenomenon that has increased over recent years. There are two main reasons for this: on the one hand, the reflex of fear which consecutive years of drought have created among the farmers, who thus face a quasi-permanent threat of starvation, and, on the other hand, the decreasing interest in cash crop production, which has arisen simply because producers are affected by the deterioration in the terms of trade. In fact, input prices continue to increase every year while producer prices do not follow suit. This fact leads farmers to hold back and seek a

reduction of areas formerly devoted to cash crops and an extension of the areas under cereals, a practical solution to their problems of survival.

In relation to the rural population of the Zone, the area under crops varies considerably in size between one cercle and another: more than 0.50 hectare per rural inhabitant in the cercle of Dioila, 0.46 in Koulikoro, 0.39 in Segou and only 0.13 in Kati, 0.09 in Banamba, 0.08 in Baroueli, and 0.07 hectare per rural inhabitant in the cercle of Kolokani (Table 5.5).

In relation to time, the changes foreseeable in the figure for the cropped area are not that significant. Given an index of 100 in 1979 and evolving at the growth rates of the rural population (Table 2.4), figures for the area under crops may grow from an index of 102 in 1980, to 111 in 1985, 122 in 1990, 133 in 1995 and to an index of 146 in the year 2000 which implies an area of about 144,000 hectares.

In terms of output, with the exception of sugar cane, the greatest tonnages in descending order are as follows: millet/sorghum (165,800 tons for the 7 cercles), cotton (47,000 tons), rice (20,800 tons), corn (15,950 tons) and finally peanuts (14,250 tons) (Table 5.7).

The cercle of Segou produces 84% of the rice, 39% of the peanuts and 33% of the millet/sorghum, while the cercle of Dioila produces about 80% of the cotton and a little over half of the corn (Table 5.7).

Looking at average yields for the Zone, in 1979 millet/sorghum and peanuts yields were the poorest, that is, 615 kg./ha. and 627 kg./ha., respectively. The best yields for millet are estimated to be in Kati and Dioila and the lowest peanut yields in Kolokani and Banamba. Cotton, corn and rice show average yield per hectare of over 1000 kg. almost everywhere in Zone 1. The best yields of cotton are recorded in Dioila (over 1200 kg./ha.) and of rice in Segou (over 1400 kg./ha.).

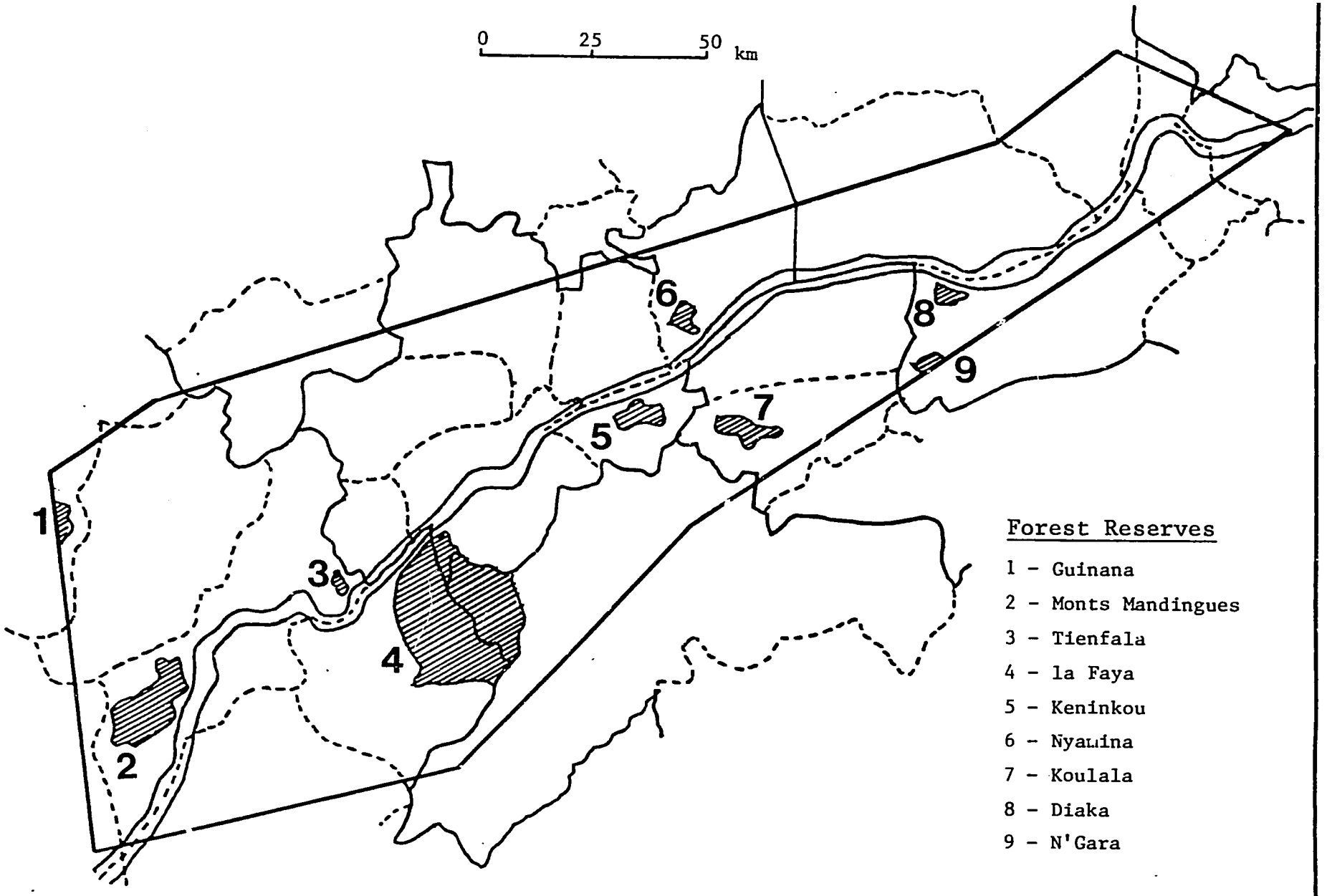
Tobacco (Operation Haute Vallee) and sugar cane (Office du Niger) are fairly localized crops, but they are expected to develop because of the existence of significant local demand which is not yet being fully satisfied.

3. Area Available for Livestock

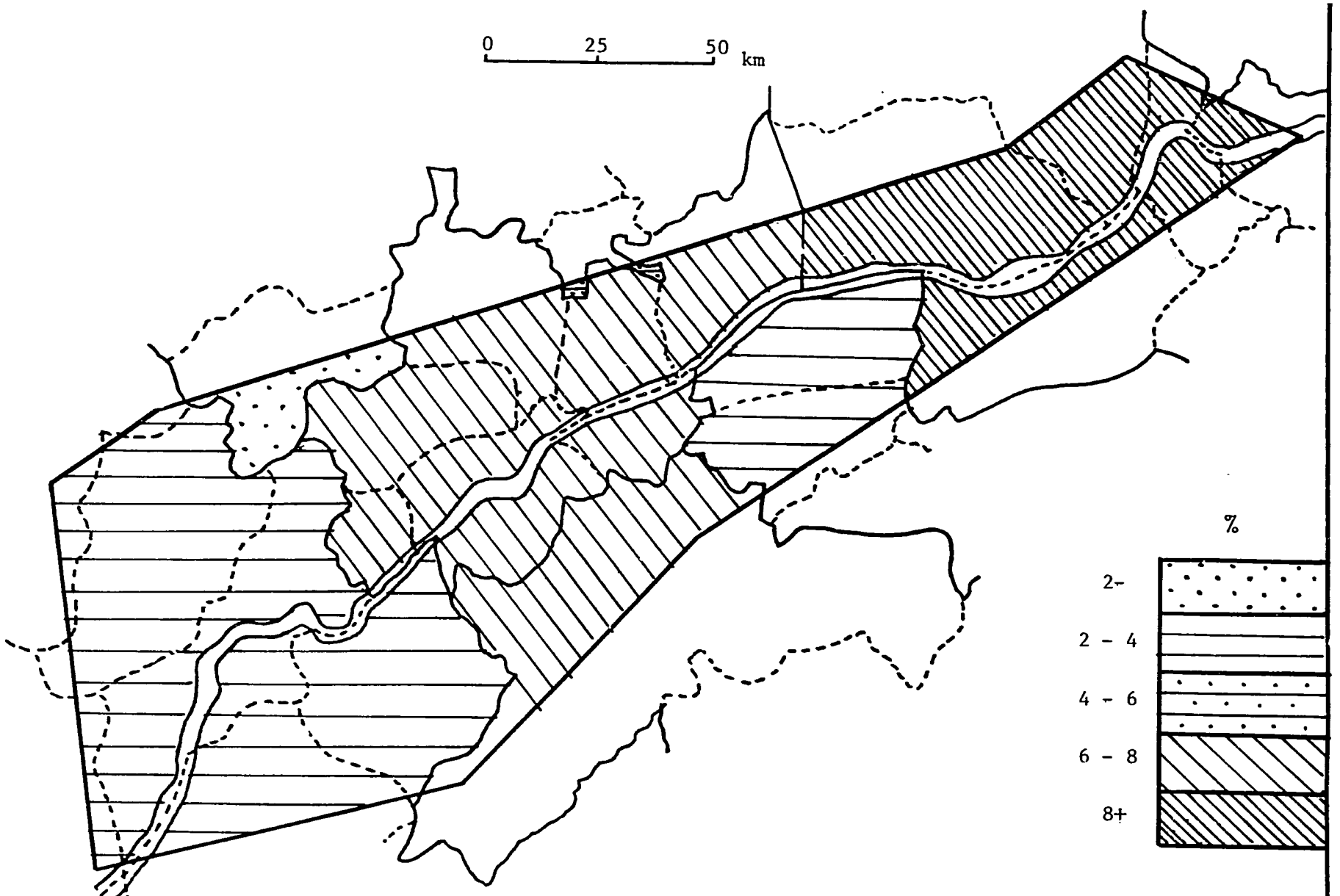
Over the period from 1979 to the year 2000 it follows that the land available for grazing would decrease quite significantly by 33% from 4.9 ha. per rural inhabitant in 1979 to 3.3 ha. per rural inhabitant for the year 2000 (Table 5.6). This does not take into account the spatial expansion of the urban areas which is to be expected .

4. Agricultural Incomes

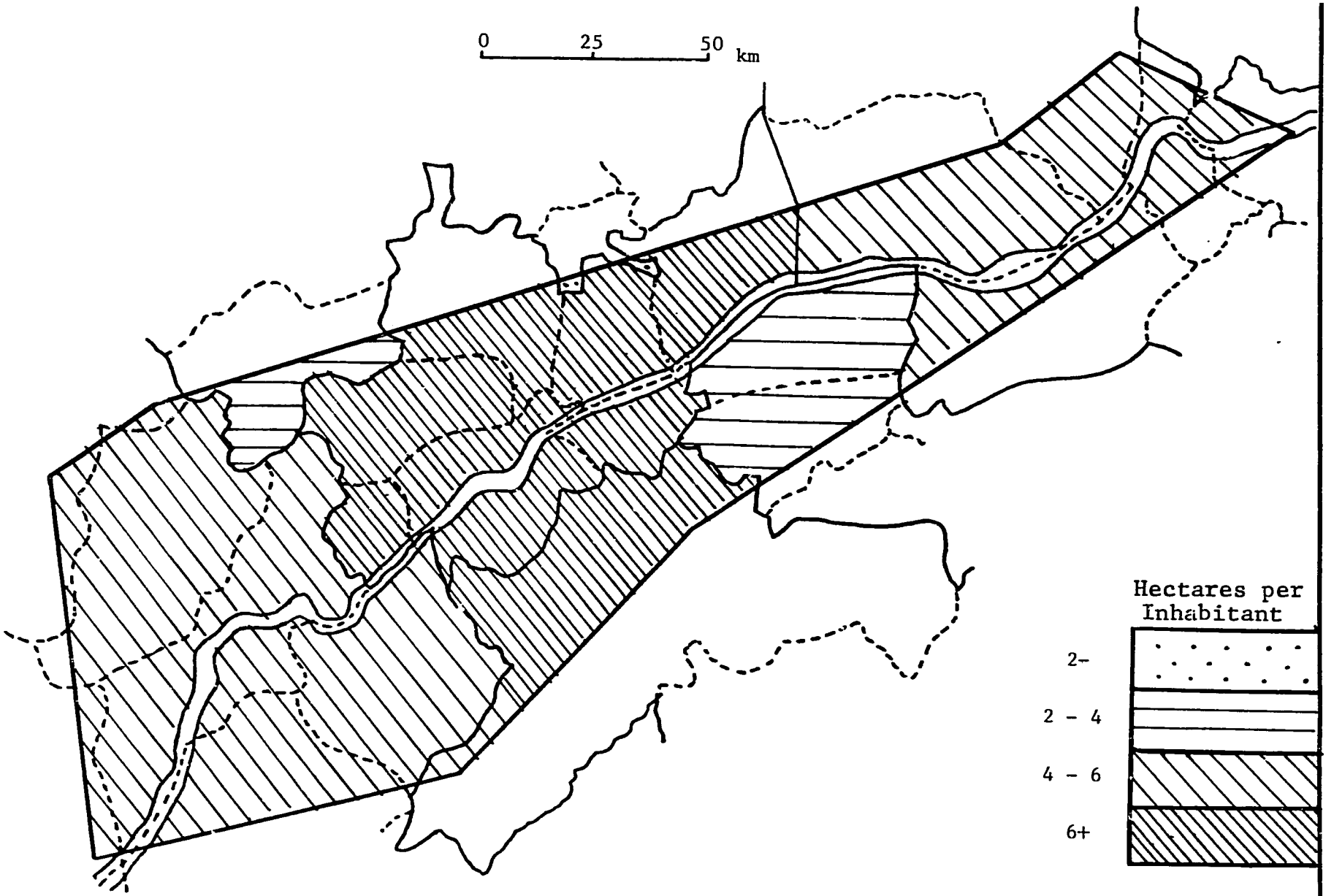
Table 5.8 shows the various levels of agricultural incomes and their origins. Although the study consulted dates from 1971-72, it is possible by applying the present-day prices shown in Table 5.9 to arrive at a rough estimate of today's income per rural inhabitant which comes to about 65,000 MF per annum. It should be noted that overall input prices have increased significantly more than producer crop prices over the period given.



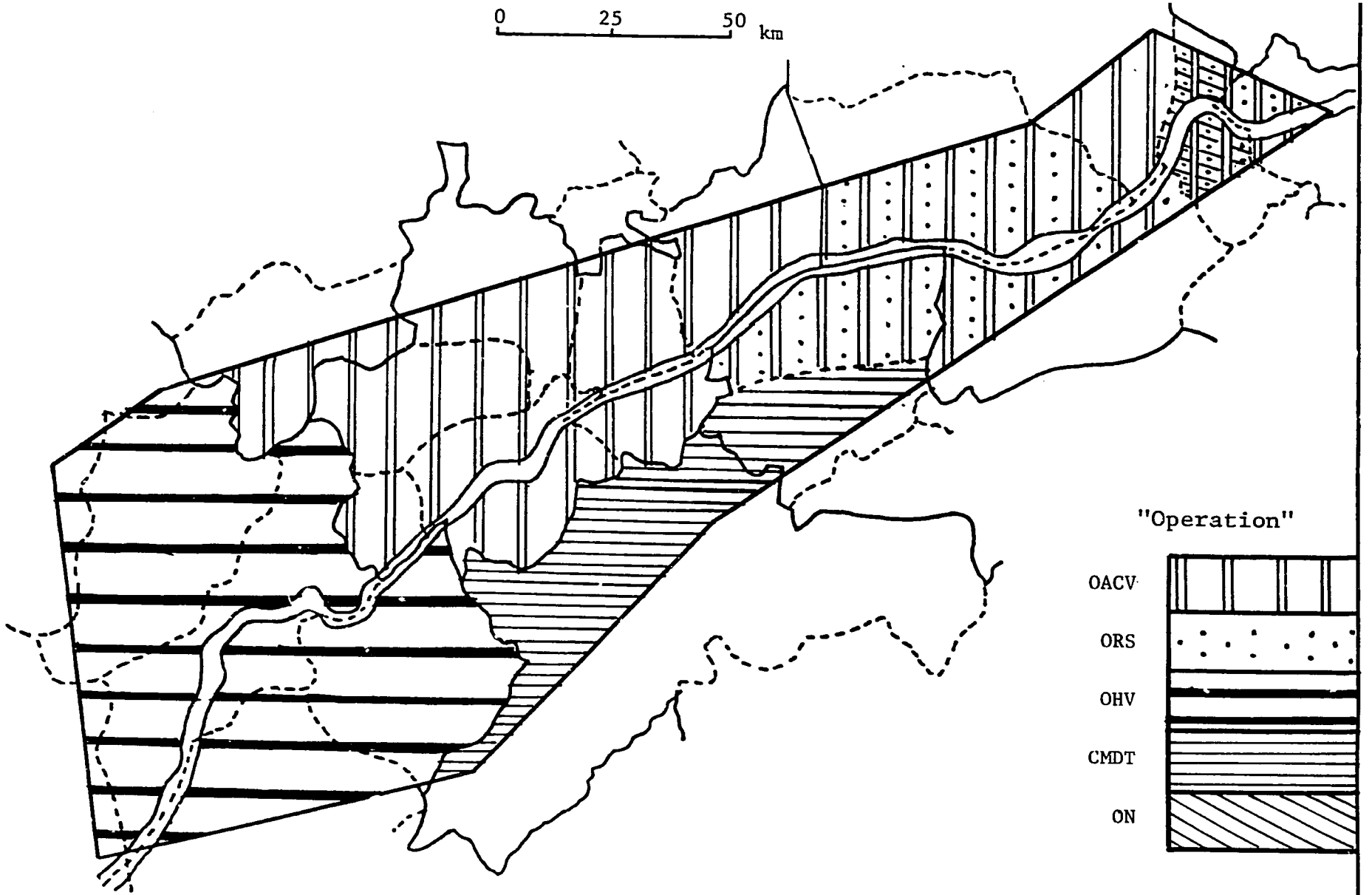
MAP 5.1 - The Forest Reserves of Zone 1



MAP 5.2 - Ratio of Cultivated Area to Available Area



MAP 5.3 - Land Available for Agriculture per Rural Inhabitant



MAP 5.4 - The Various Project Areas under the Different "Operations"

TABLE 5.1

FOREST RESERVES IN ZONE 1

Forest Reserves by Cercle	Total Area in the Cercle (HA.)	Area in Zone 1 (HA.)	Forest Reserves as % of Area in Zone 1
Cercle of Kati			
1. State Forest Reserve of La Faya	42,867	42,867	
2. Monts Mandingues Forest Reserve	14,579	14,579	
3. Guinina Forest Reserve	10,600	3,400	
4. Koulouba Forest Reserve	2,000	2,000	
Total Cercle	70,046	62,846	9.5
Cercle of Koulikoro			
1. Forest Reserve of Tienfala	3,000	3,000	
2. State Forest Reserve of La Faya	1,848	1,848	
3. Forest Reserve of Niamina	5,321	5,321	
4. Forest Reserve of Kenenkou	5,966	5,966	
Total Cercle	16,135	16,135	3.3
Cercle of Dioila			
1. State Forest Reserve of La Faya	35,107	35,107	
Total Cercle	35,107	35,107	19.5
Cercle of Baroueli			
1. Forest Reserve of Kouloula	6,500	6,500	
Total Cercle	6,500	6,500	3.4
Cercle of Segou			
1. Forest Reserve of Diaka	2,440	1,220	
2. Forest Reserve of N'Gara	3,500	3,500	
Total Cercle	5,940	4,720	1.3
Total Zone 1		125,308	6.5

TABLE 5.2

SURFACE AREAS PER CERCLE AVAILABLE FOR AGRICULTURE IN ZONE 1

Cercles	Area of Forest Reserves Km.2	Area of Towns Km.2	Total Area Occupied Km.2	Total Area Available for Agriculture Km.2	Ratio of Available Area/Total Area %
Kati	628	297	925	5,653	85.9
Kolokani	-	-	-	387	100.0
Banamba	-	-	-	24	100.0
Koulikoro	161	20	181	4,766	96.3
Dioila	351	-	351	1,450	80.5
Baroueli	65	-	65	1,864	96.6
Segou	47	70	117	3,488	96.7
Total Zone 1	1,253	387	1,640	17,631	91.5

CULTIVATED AREAS BY CERCLE AND BY CROP IN ZONE 1 - 1979/80

(IN HECTARES)

Cercle	Peanut	Cotton	Millet/ Sorghum	Corn	Rice	Others	Total per Cercle	Total in Zone 1	Ratio of Cultivated Area over Available Area %
Kati	4,763	6,665	19,491	4,692	1,753	100	37,464	16,398	2.9
Kolokani	5,570	-	15,660	-	-	-	21,230	703	1.8
Banamba	780	-	40,000	-	-	-	40,780	126	5.2
Koulikoro	1,600	-	40,000	-	-	-	41,600	33,430	7.0
Dioila	334	28,917	43,612	7,164	-	-	80,027	11,084	7.6
Baroueli	405	4,796	6,001	490	989	-	11,692	4,777	2.6
Segou	8,000	-	113,000	-	12,263	3,006	136,269	32,146	9.2
Total Zone 1								98,664	5.6

TABLE 5.4

AREAS PER CROP IN ZONE 1 - 1979/80
(IN HECTARES)

Cercle	Peanut	Cotton	Millet/ Sorghum	Corn	Rice	Others
Kati	2,085	2,917	8,531	2,053	767	44
Kolokani	184	-	518	-	-	-
Banamba	7	-	124	-	-	-
Koulikoro	1,286	-	32,144	-	-	-
Dioila	46	4,005	6,040	992	-	-
Baroueli	165	1,960	2,452	200	404	-
Segou	1,887	-	26,657	-	2,893	709
Total Zone 1	5,660	8,882	76,466	3,245	4,064	753
Ratio of Area per Crop over Total Area Cropped (%)	5.7 %	9.0 %	77.5 %	3.3 %	4.1 %	0.8 %

TABLE 5.5

SURFACE AREAS RURAL POPULATION PER CERCLE IN ZONE 1
(1979/1980)

Cercles	Rural Population in Zone 1	Area Available for Agriculture (Ha.)	Cultivated Area (Ha.)	Cultivated Area per Rural Inhabitant (Ha.)	Area Remaining per Rural Inhabitant (Ha.)
Kati	128,730	565,254	16,398	13.7	4.4
Kolokani	9,643	38,700	703	7.3	4.0
Banamba	1,408	2,400	126	8.9	1.7
Koulikoro	72,940	476,565	33,430	45.8	6.5
Dioila	20,812	144,993	11,084	53.2	7.0
Baroueli	58,786	186,400	4,777	8.1	3.2
Segou	81,554	348,780	32,146	39.4	4.3
Zone 1	373,873	1,763,100	98,664	26.4	4.7

TABLE 5.6

CHANGES IN THE CULTIVATED AREA AND THE AREA AVAILABLE FOR GRAZING FROM 1979 TO 2000

	Cultivated Area (in Hectares)	Area Available for Grazing	Area Available for Grazing per Rural Inhabitant
1979	98,669	1,834,731	4.9
1980	100,412	1,832,988	4.8
1985	109,835	1,823,565	4.4
1990	120,141	1,813,259	4.0
1995	131,414	1,801,986	3.6
2000	143,746	1,789,654	3.3

PRINCIPAL CROPS BY CERCLE FOR 1979/80

Cercles	Millet/Sorghum		Cotton		Peanuts		Corn		Rice		Other	
	Output[1/] (Tons)	Yield (kg/ha.)	Output (Tons)	Yield (kg/ha.)	Output (Tons)	Yield (kg/ha.)	Output (Tons)	Yield (kg/ha.)	Output (Tons)	Yield (kg/ha.)	Output (Tons)	Yield (kg/ha.)
Kati[2/]	15,593	800	7,032	1,055	3,334	700	6,100	1,300	2,104	1,200	(Tobacco) 170	1,700
Kolokani	7,850	501	-	-	2,700	485	-	-	-	-	-	-
Banamba	19,750	494	-	-	980	408	-	-	-	-	-	-
Koulikoro	29,400	735	-	-	1,120	700	-	-	-	-	-	-
Dioila[3/]	34,890	800	35,445	1,126	234	700	9,313	1,300	-	-	-	-
Baroueli	2,940	490	4,534	945	284	700	539	1,100	1,187	1,200	-	-
Segou	55,370	490	-	-	5,600	700	-	-	17,588	1,434	(Sugar Cane) 228,321	75,950
Zone 1		615		1,075		627		1,233		1,278		

Notes: 1/ Output is given in metric tons.
2/ Output and yield for Kati are estimates given by the OHV.
3/ For Dioila the figures for yield and output are estimates.

TABLE 5.8

AGRICULTURAL INCOMES

a. NET MONETARY INCOME PER INHABITANT GIVEN IN MF FOR 1971/1972 (EXCLUDING FORESTRY, GATHERING AND CRAFTS)

Areas of Activity / Regions	Agriculture	Livestock	Fishing	Total
M.V.N.B. (Middle Valley of the Niger and Bani Rivers)	5,220	1,732	1,061	8,013
Haute - Vallee (Upper Valley of the Niger)	7,854	1,205	461	9,520
Zone 1	6,537	1,468	761	8,766

b. NON-MONETARY INCOMES PER INHABITANT IN MF FOR 1971/1972 (EXCLUDING FORESTRY, GATHERING AND CRAFTS)

Areas of Activity / Regions	Agriculture	Livestock	Fishing	Total
M.V.N.B. (Middle Valley of the Niger and Bani Rivers)	7,156	2,633	78	9,867
Haute - Vallee (Upper Valley of the Niger)	7,151	2,301	461	9,913
Zone 1	7,153	2,467	269	9,889

Source: Rapport de Synthese du Plan Quinquennal 1974 - 1978.

TABLE 5.8 (continued)

AGRICULTURAL INCOMES

c. ADDITIONAL INCOMES PER RURAL INHABITANT IN MF IN 1971/1972

Regions \ Incomes	Monetary	Non-monetary	Total
M.V.N.B. (Middle Valley of the Niger and Bani Rivers)	2,204	2,845	5,049
Haute - Vallee (Upper Valley of the Niger)	2,158	2,840	4,998
Zone 1	2,181	2,842	5,023

d. TOTAL NET REVENUE PER RURAL INHABITANT IN MF IN 1971/1972

Regions \ Area of Activity	Agri-culture	Live-stock	Fish-ing	Additional Sources	Total
M.V.N.B. (Middle Valley of the Niger and Bani Rivers)	12,376	4,365	1,139	5,049	22,929
Haute - Vallee (Upper Valley of the Niger)	15,005	3,506	922	4,998	22,431
Zone 1	13,690	3,935	1,030	5,023	23,678

Note: Depending on whether the average family is regarded as having 10 or 12 people:

- 236,780 FM (family of 10 people)
- 284,136 FM (family of 12 people)

Source: Rapport de Synthese du Plan Quinquennal 1974-1978.

TABLE 5.9

PRODUCER PRICES FOR AGRICULTURAL PRODUCTS AND INPUTS

a. CROP PRICES (MF PER KG.)

Crop	Price in 1971/72	Price in 1979/80	Ratio of 1979/80 price over 1971/72 price
Millet/sorghum/corn	18	50	2.8
Paddy rice	25	60	2.4
Cotton grain	50	110	2.2
Peanuts	30	80	2.7

b. INPUT PRICES (MF)

Input	Price in 1972	Price in 1979	Ratio of 1979 Price over 1972 Price
All purpose plow	30,000	109,455	3.6
Seeder	18,500	58,010	3.1
Cart (1,000 kg)	32,800	71,060	2.2
Pair of oxen	70,000	160,000	2.3
Fertilizer	3,500	4,875	1.4
Donkey	16,500	45,000 (1978)	2.7

Source: Direction Nationale de l'Agriculture (Agriculture Service headquarters)

CHAPTER 6

THE DISTRIBUTION OF TSETSE FLIES IN ZONE 1

A detailed analysis of the distribution and behavior of tsetse flies in Zone 1 has been undertaken by the Entomology Section and presented in Okiwelu, Maiga and Van Wettere 1980. This report therefore reproduces the maps produced in the main entomology report in summary form only and comments briefly on their implications.

Zone 1 is a fairly marginal area for tsetse flies. The northeastern part within the Sudan climate zone is no longer an ideal habitat, particularly given the relatively high human population and the widespread use of oxen for plowing, so that large surfaces are under crops and are relatively treeless. The tsetse flies found in the Zone were G. palpalis, G. morsitans and some pockets of G. tachinoides. Whereas G. palpalis and G. tachinoides can co-exist with high human population densities, making use of occasional riverine vegetation and even fruit groves, G. morsitans is estimated to start to decline in numbers when the human population reaches 15 people per square kilometer, and to disappear when it reaches 40 per square kilometer (Nash, 1948). From Map 2.1, it can be seen that most of the Zone has a rural population density of over 15 people per square kilometer, the exceptions being the extreme western margin of the Zone and the central area. By 1990, the human rural population density in Kati cercle, according to the projections made in Chapter 2, will be 23 per km.^{2} and by 2000 27 per km.^{2}, starting from 19 per km.^{2} in 1980. Thus it would be expected that G. morsitans in that cercle, which is the only one where it is found, would be present still, but in reduced numbers.

From the disease point of view, it is worth noting that it is precisely in peripheral areas such as Zone 1 that one expects to encounter a high level of infection. This is because cattle sensitive to the disease tend to avoid the established tsetse belts, but are likely to come into contact with the disease in the peripheral areas which they enter during the

dry season in search of fodder and water.

Maps 6.1a and b give the late dry-season distribution of tsetse flies in Zone 1. It is put together from Figs. 12 - 22 in Okiwelu et al. 1980. Maps 6.2a and b give the distribution in mid-rainy season as derived from Figs. 3 - 11 in Okiwelu et al. 1980. Due to funding problems, the whole of the area could not be surveyed, so there are some considerable gaps. In addition, the dispersal and consequent low population density of the flies in the wet season makes it more difficult to retrieve the flies and identify focii, so fewer of these are marked on the map. Since spraying against the fly takes place during the dry season when they are concentrated, Map 6.1 gives an idea of the areas to be sprayed, and the resultant fly distribution is reproduced in Map 9.1a and b showing the eradication/control program.

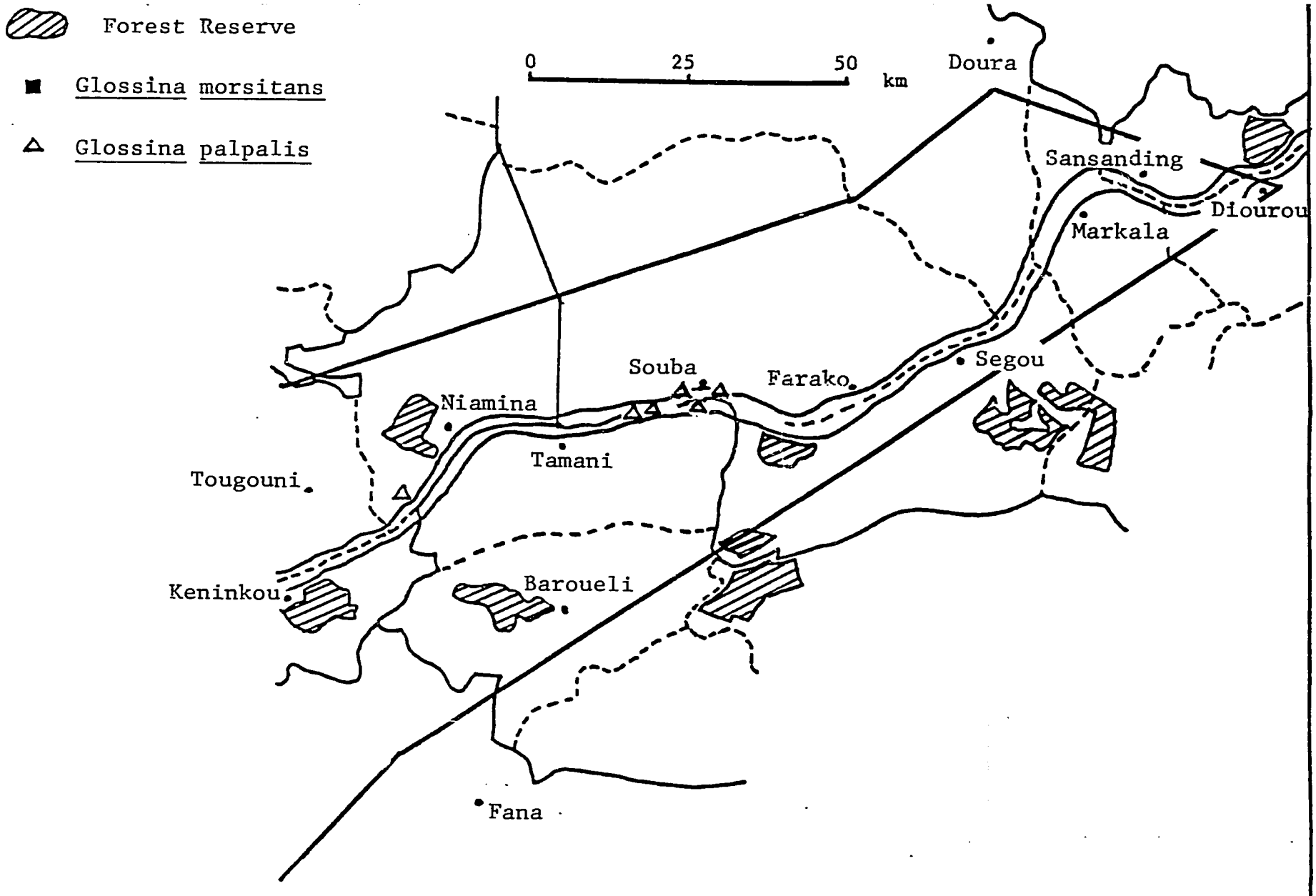
The locations of flies shown on the map indicate approximately where infested areas were found and flies caught. The need to put legible symbols on a small-scale map means that an infested area's size may appear exaggerated. In the dry season, riverine infestations of G. palpalis varied in length from 1 to 19 kilometers, the largest being from Tienfala to Moribabougou on the Niger River. The infestations averaged between 2 and 5 kilometers in length. In the wet season, riverine infestations of G. palpalis were far more extensive, estimated to reach 24 to 36 kilometers along the Niger River along the southern border of Niamina and Kenenkou arrondissements respectively, and 20 kilometers along the Faya River in the Faya forest reserve. In the dry season, G. tachinoides was only found in a few locations in the southwestern part of Kati cercle, on the west bank of the Niger River, in mixed infestations. During the rainy season a small infestation of G. tachinoides was found on the eastern bank of the Niger south of Farabana in addition to the west-bank infestations. G. morsitans was found only in the western part of the cercle of Kati. In the rainy season, all sectors of the Mont

Mandingues forest reserve, and an area of approximately 165 km.^{2} outside it, were infested with G. morsitans. Two small infestations were found in the Kati arrondissement. In the dry season, blocks of G. morsitans of 8 to 14 km.^{2} were found in the Mont Mandingues area (Okiwelu et al. 1980).

Overall, the picture in the Zone is one of widely scattered pockets of tsetse-fly infestation in the dry season, which coalesce to some extent in the wet season when the flies disperse. Except for the G. palpalis along the Niger River near Souba along the Tamani/Niamina/Farako arrondissement borders, the northeast is fly-free. This focus is associated with one of the endemic areas of human sleeping sickness (Chapter 11). As one moves to the southwest in the Zone, the fly infestations become more frequent and dense.

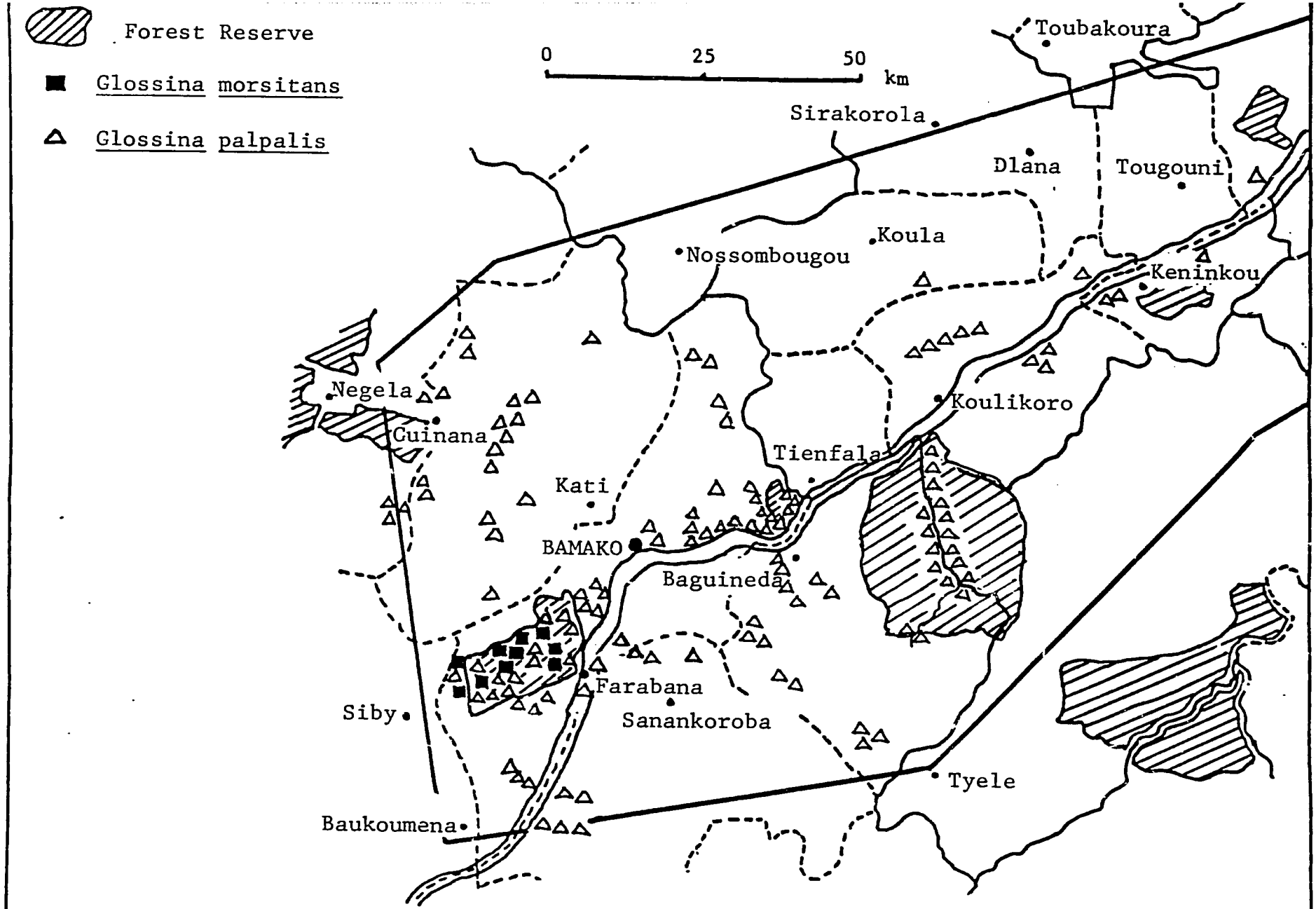
It is not possible to do more than speculate about the future of the fly populations. The G. palpalis populations will probably persist. The Protozoology Section, from its analysis of the disease, speculates that G. morsitans exists at a low density throughout the western part of Kati cercle, particularly the southwest.[1/] Given the human rural population densities discussed above, a severe reduction of low-density fly populations is hypothesized in this report, reducing tsetse challenge in Kati cercle to 75% of its present level in the second decade analyzed, i.e., approximately after 1990.

1/ Personal communication, Dr. Awan.



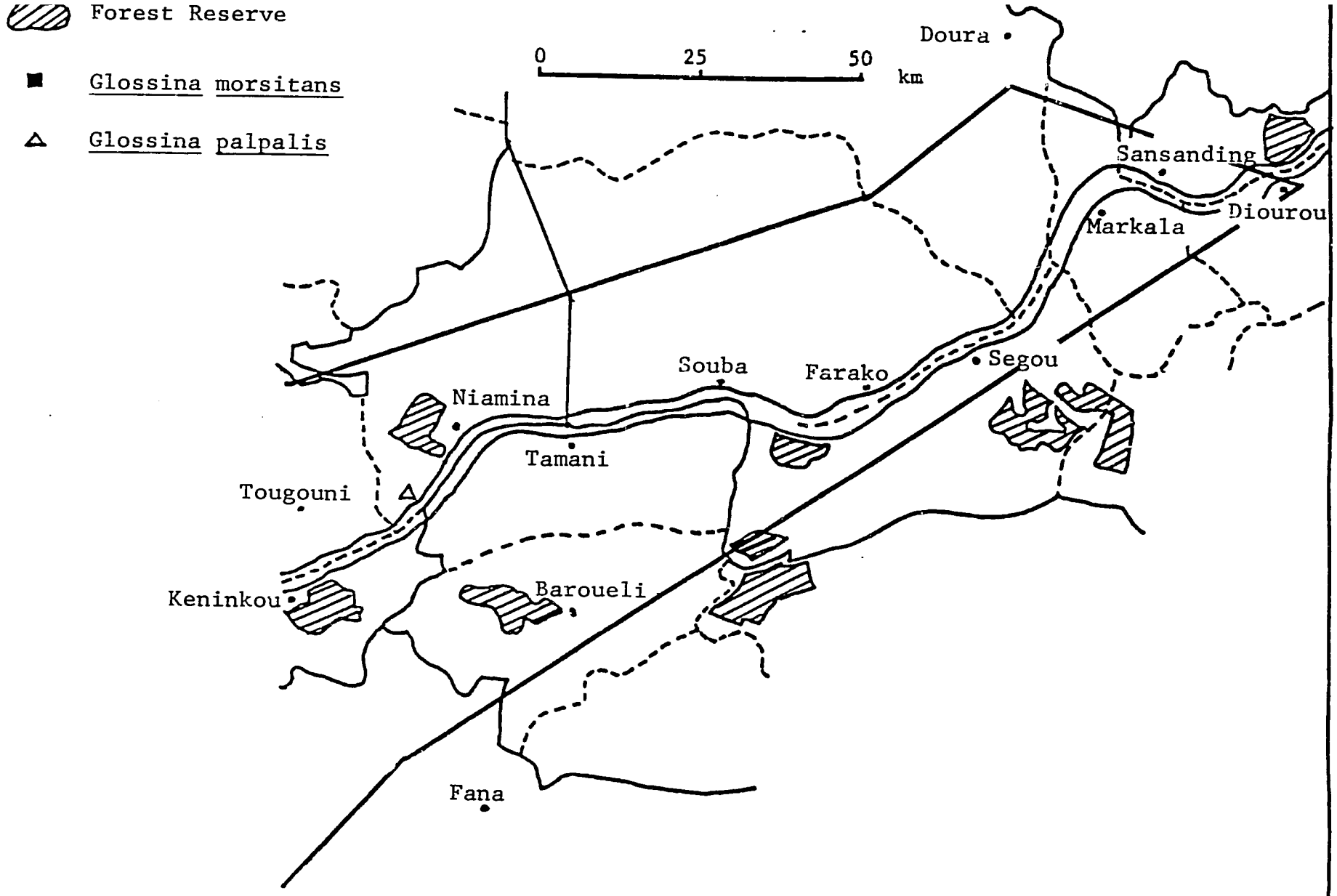
Map 6.1a - Distribution of Tsetse Flies - Late Dry Season - Northeastern part of Zone 1

Source: Figs. 12 - 22, Okiwelu et. al., 1980.



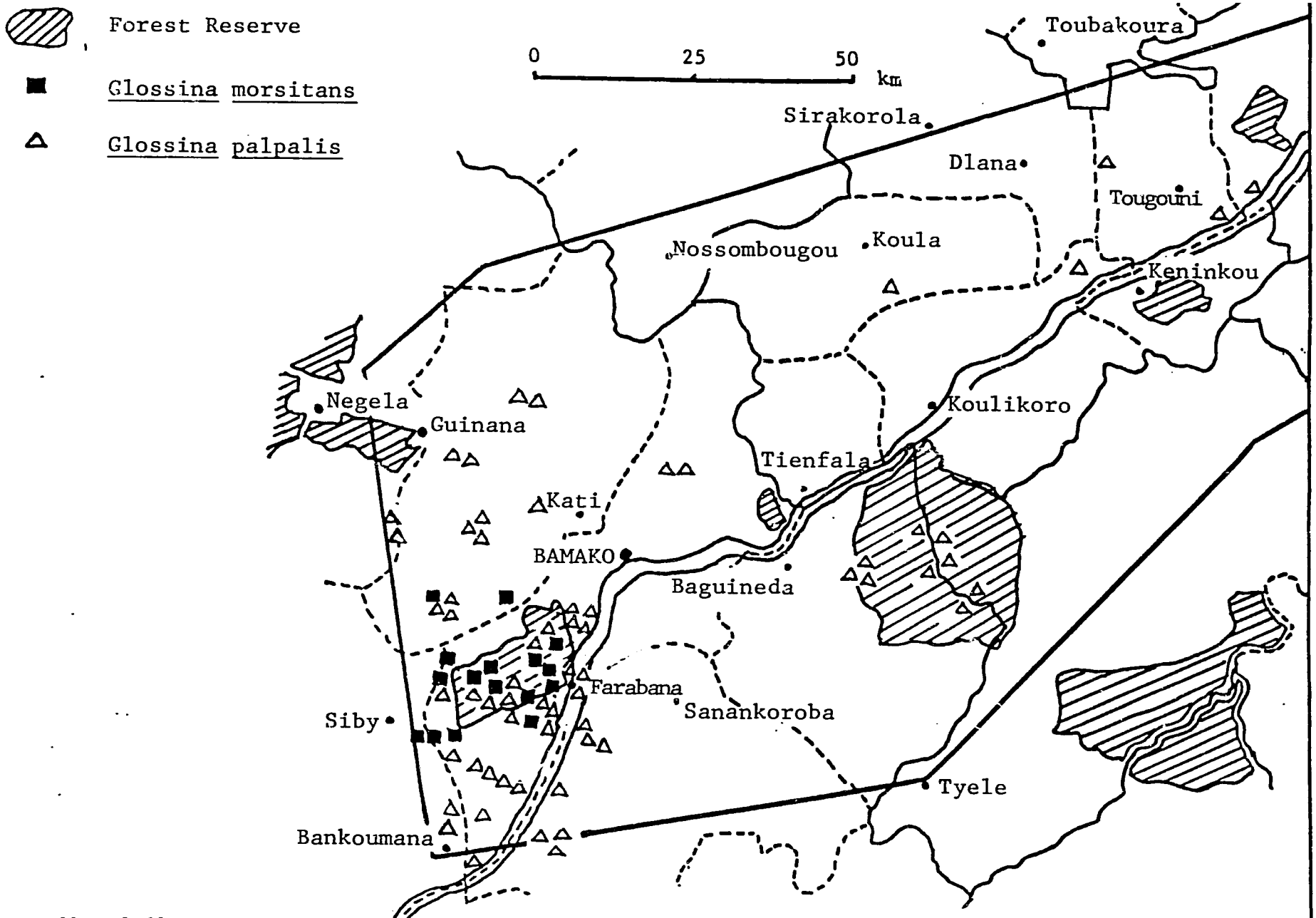
MAP 6.1b - Distribution of Tsetse Flies - Late Dry Season - Southwestern Part of Zone 1

Source: Figs. 12 - 22, Okiwelu et. al., 1980.



MAP 6.2a - Distribution of Tsetse Flies - Rainy Season - Northeastern part of Zone 1

Source: Figs. 3 - 11, Okiwelu et. al., 1980.



Map 6.2b - Distribution of Tsetse Flies - Rainy Season - Southwestern part of Zone 1

Source: Figs. 3-11, Okiwelu et. al., 1980.

SECTION B

THE COSTS OF VARIOUS STRATEGIES AIMED AT REDUCING THE INCIDENCE OF TRYPANOMIASIS IN ZONE 1
(Chapters 7-9)

CHAPTER 7

THE COSTS OF TREATMENT AND PROPHYLAXIS OF TRYPANOSOMIASIS IN ZONE 1

A. The Cost of Administering Trypanocides as Borne by the Livestock Service

1. Livestock in Zone 1: the "Operations" and the Livestock Service

In addition to the presence of the various "Operations" and their effect on agriculture and livestock developments, Zone 1 has the advantage of being one of the best endowed areas in the country with respect to veterinary services. Of the Livestock Service's approximately 700 field staff in 1979, 105 served in the seven cercles wholly or partly included in Zone 1 (Table 7.2). Of the seven sector headquarters, four are in the Zone and of the seven cercles' additional 21 veterinary posts (these are local offices) eight are actually in Zone 1 and three more serve it directly (Map 7.1). The distance between veterinary posts or sector headquarters seldom exceeds 75 kilometers and is frequently as close as 50. The national headquarters are at Bamako, with regional headquarters at Koulikoro and Segou. The chronic supply problems for veterinary medicines have been greatly alleviated by the creation of the national pharmacy at Bamako. Since most of the Zone has good access to Bamako, this means that the drug supply situation, despite the problems mentioned by all the sector heads, is still much better than that in the rest of the country.

In addition, the livestock sections of the different "Operations" (ORS, OACV, CMDT and OHV) employed 81 staff in 1978. Due to expansion, particularly of the OHV project, this number probably reached 100 to 120 in 1979, a large proportion of whom operate in Zone 1. Sometimes the pharmacies of the "Operations" supply the Livestock Service with drugs at the current price.

2. Number of Animals Dealt With in a Year

To gain some idea of the current capacity of the Livestock Service, Table 7.1 gives total numbers of animals

vaccinated, treated and castrated for each cercle in Zone 1, which added together give total numbers visited. This reflects, to some extent, the endowments in terms of staff and vehicles (Tables 7.2 and 7.3), with the high number of treatments in Kati and Segou perhaps reflecting good endowment in terms of staff and veterinary posts, in the case of the former, and vehicles, in the case of the latter.

3. Costs of Personnel

The numbers of employees, their rank and salaries are given in Table 7.2, along with the distribution of veterinary posts per cercle. It should be noted that these costs represent the total wage bill since neither per diem for days on tour nor any allowances or overtime are paid to these officers.

4. Costs of Transport

In every one of the seven cercles, problems such as lack of transport, fuel, oil and funds to maintain vehicles were cited as the single greatest constraints in carrying out veterinary duties. It is estimated that the fuel and oil provided officially covers only 30 to 40% of the total consumed, or a quantity which probably just covers the vaccination campaign alone. From Table 7.3, it can be seen that only four out of the seven cercles even have a Landrover. There are four official mobylettes and, of these, the two from Kolokani date from 1975. About 16 personal mobylettes were listed, but the total number is estimated to reach 40. Some of these are given out on a loan basis by the Livestock Service to its employees, who pay for them over a number of years. This system is not regarded as very effective. Fuel and repair allowances are supposed to be paid to employees using their own vehicles but they often remain unpaid.

Thus the livestock owners increasingly bear the cost of transporting the Livestock Service staff to see their animals, or transport the animals themselves to the veterinary office. In either case they may simply provide a vehicle and fuel or else

the veterinary staff may charge a fee per animal, say 100 or 200 MF to cover the cost of fuel and wear and tear on their personal vehicles.

a. Cost of Transport of Livestock Service Agents

Various estimates exist with respect to the fuel required. In Dioila it was estimated that 3000 liters are required for the vaccination campaign. The Livestock Service headquarters estimate about 20,000 kilometers should ideally be traveled per Landrover in a sector. Having the vaccination campaign use about half this seems reasonable. Of course, some of the fuel required for the campaign would be for mobylettes, say 500 liters in the case of Dioila at about 70 liters per mobylette, with the Landrover thus doing about 10,000 kilometers at 25 liters/100 km. or about 95 kilometers per day of touring (using the number of days toured per employee in Dioila cercle), which seems reasonable.

In Table 7.4, an estimate of the cost of transport for the cercles of the Zone is given. The assumptions about the number of liters used per cercle are made after considering whether or not a Landrover was available or easily borrowed, how many vaccinations were done, the size and remoteness of the cercle and the number of days toured by the employees. The rest of the table is self-explanatory.

Thus, the cost of trips undertaken by the Livestock Service employees to treat or vaccinate animals can be taken to be about 14,000,000 MF. A proportion of the costs of transporting them is borne by the livestock owners when they provide fuel or vehicles, or when they pay a fixed charge to reimburse the Livestock Service personnel. This has been included in the estimate on the basis of the estimate by the Livestock Service that 30 to 40% of fuel is covered by them, and by including a cost for borrowed vehicles.

b. Cost of Transport of Animals to Livestock Service Offices

A large proportion of treatments and vaccinations, however, occur at the veterinary posts or at sector headquarter

offices. In this case, the personnel are not transported. The livestock owner will find transport for his animals if they are sick, or walk them to the veterinary office, if possible. It is difficult to estimate, but probably 1/3 of all animals are seen at the offices. This implies that 2/3 of the total number of animal transport costs have already been covered by the above estimates. If 1/2 of the remainder have to be transported, this adds a further 1/6 or 6,870,000 MF to the transport cost. The total costs attributable to transport are given at the end of Table 7.4 and come to about 48 million MF.

5. The Cost of Buildings and Office Furnishings

The Livestock Service estimates the cost of a sector office at 15,000,000 MF, of a veterinary post at 10,000,000 MF and their life at about 20 years. Office furniture and equipment have a replacement cost of about 600,000 MF and last 10 years. This is calculated in Table 7.5.

6. The Cost of Office Supplies

Office supplies, stationery, etc., are estimated to cost about 5% of salaries, or 2,136,000 MF.

7. Veterinary Equipment and Refrigeration

Trypanosomiasis treatments and prophylaxis, since they consist of injecting powders diluted in water, make no use of any refrigerating equipment. The only equipment needed is syringes and needles. The cost of these and of other specific equipment is calculated in Section B below.

8. Cost of Administration

The administration of the Livestock Service is the responsibility of the national headquarters at Bamako. It is assumed that the share of headquarters' expenses attributable to each area is equivalent to the proportion of the Livestock Service's employees in that area. The 1978 recurrent budget gives a salary bill of 70,716,000 MF and a budget for equipment of 34,700,000 MF for the national headquarters. To this must be added depreciation costs which, given good buildings and a good endowment of vehicles, must be about half the salary

bill, or equivalent to the rest of the recurrent costs. This proportion is similar to that calculated for the cercles. Thus 35,000,000 MF is taken as the value of annual depreciation at headquarters. Adding 10% to reach 1979 levels, and multiplying by 105/700 (the proportion of total field employees found in the cercles of Zone 1), the following cost of administration is calculated:

• Headquarters salaries	77,000,000 MF
• Headquarters recurrent expenses	38,000,000
• Headquarters depreciation	39,000,000
Total	154,000,000 MF

$$154{,}000{,}000 \times \frac{105}{700} = \text{Administration cost for Zone 1 cercles} \quad 23{,}100{,}000 \text{ MF}$$

a. Calculation of the Cost of Administering Drugs or Treatment

Finally, Table 7.5 summarizes all these costs. It should be noted that the charges for borrowed vehicles and the cost of transport of livestock to veterinary offices include a depreciation component although they are listed under recurrent costs. In calculating the proportion of costs due to the vaccination campaign, while the 40% of transport costs attributable to it had already been derived, the proportion of other costs was calculated using the number of touring days, which implies that a maximum of three and a half months, or about 30% of a year was spent on vaccination campaigns. Although some treatments are done during the vaccination campaigns, most are done on smaller numbers of animals during the rest of the year and thus at a greater cost.

So the average cost of administration per animal seen can be calculated at 65 MF. The cost is 30 MF per animal vaccinated and 160 MF per animal treated. This excludes the cost of drugs, syringes and special equipment for diagnosing trypanosomiasis, which are calculated in the next section.

This cost of administration of 160 MF per treatment seems very low. The main reason for this is that the Livestock Service operates with minimum expenditures on equipment and

running costs and that salaries in the civil service are very low and no per diem is paid. Some veterinary agents in fact do charge small extra fees over and above their transport costs to make good this deficiency. Although this practice is disapproved of, it is understandable. Salaries form 35% of total treatment costs, so doubling them and adding a per diem, which would make them more reasonable, would add at least 50% to this cost. However, since the figure calculated represents the actual situation, this figure is retained, although it should be noted that the cost calculated is a modest one.

B. The Cost of Drugs and Other Equipment Used in Administering Trypanocides

1. Drugs Used

The two main trypanocides currently used are Trypamidium and Berenil. The recommended dose of 0.5 mg per kg. of liveweight is usually modified in the field to an average dose of 1 gram per animal which is assumed to weigh 200 kg. At the Livestock Service pharmacy in Bamako, a sachet of 10 doses of Berenil costs 1590 MF and a single dose, 200 MF. Ten doses of Trypamidium cost 1500 MF. Prices quoted by the Livestock Service agents in Zone 1 varied from 160 to 300 MF/dose.

As drugs are frequently in short supply, there is a lucrative black market in trypanocides. Antricide Prosalt can be obtained as well as the two drugs listed above. A lot of drugs are smuggled in across the borders, particularly from the Ivory Coast. On the black market, a single dose of Berenil can cost 100 to 1500 MF and Trypamidium fetches a similar price.

For treatments done by the Livestock Service or the "Operations" a cost of 250 MF/dose is retained. This takes into account supply problems and the need to make use of black market sources for drugs on occasion.

2. Syringes and Needles

This is the only veterinary equipment needed for administering trypanocides. The Livestock Service estimates

that two syringes are needed annually per veterinary agent in the field, plus two boxes of 12 needles. At present there is a shortage of syringes as there is of most equipment. Large numbers of individual livestock owners have procured their own needles and syringes which they use themselves or make available to the veterinary agents.

The cost for the 94 veterinary agents in Zone 1 can be calculated as follows:

94 syringes at 20,000 MF each	1,880,000 MF
2 x 94 boxes of needles, 5000 MF each	940,000
Total	2,820,000 MF

These will serve to do all vaccinations and about one third of treatments (about 1,600,000 injections) at an average cost of 2 MF/dose. This low figure is included henceforth in the cost of administering the drug.

3. Special Diagnostic Equipment

For more systematic treatment or prophylaxis on a larger scale in Zone 1, the Protozoology Section at New Lands has proposed that the following equipment be made available to the Livestock Service for simple diagnostic and surveillance work. This will be supplemented by diagnostic work done by the Protozoology Section. These suggestions are regarded as feasible and welcomed by the Livestock Service.

	Annual Cost - MF
a. For six of the seven sector headquarters:	
• 1 microscope, cost 800,000 MF, with a life of 20 years, annual cost per cercle thus 40,000 MF. Cost for the whole Zone 40,000 x 6	240,000
b. For each of the eleven veterinary posts serving the Zone, plus the six sector headquarters, the following equipment to last six months:	
• 2000 microscope slides at 2200 MF per 100	88,000
• 2000 microscope coverslips at 2000 MF per 100	80,000
• 2 boxes of hypodermic needles, 5000 MF each	20,000

	Annual Cost - MF
• 2 grease pencils for marking slides 500 MF each	2,000
• Alcohol and cotton at 10,000 MF	20,000
Total	210,000
Total for Zone 210,000 x 17	3,570,000

c. In addition, although slide transport can be done by wrapping them up, slide boxes would be needed for storage. These would last two years. Five are required for each sector headquarters and one per post.

• 41 slide boxes at 2500 MF, annual cost for Zone 1	51,000 MF
Total annual cost of diagnostic equipment for Zone 1	3,861,000 MF

Note: Prices are converted to Malian Francs from the US$ price, plus 20% freight charge.

C. Current Practice with Respect to the Use of Trypanocides and the Cost of the Current Policy

Table 7.6 gives the number of trypanocide treatments performed by the Livestock Service in 1979. These amounted to 44,500 for cattle. Since 24%, or roughly a quarter of the seven cercles' cattle, are in Zone 1, this implies that 10,600 treatments were done in the Zone, so that about 5.0% of the Zone's 208,000 cattle (Table 3.3) were treated. To this should be added half as many treatments again to cover the work done by the "Operations." In all cases, the costs of the drug and usually the veterinary agent's transport are paid by the livestock owner, unlike vaccinations, which are nominally free.

On its field trips, the Protozoology Section team did not encounter a single herd which did not have a history of trypanocide treatments. In some cases, a few animals had been treated, in others, the whole herd. Some treatments were done very recently, others as long ago as 18 months or two years. The Livestock Service is well aware of the large number of "clandestine" treatments administered by the livestock owners. It is really impossible to gain an accurate idea of

the number of treatments. A conservative estimate would be half as much again as the treatments done by the Livestock Service. This brings the total percentage of cattle treated annually up to 10% of those in the Zone. This proportion would account for the fact that in the field all herds had some experience of treatment.

The main drugs used are Berenil, Trypamidium and Antrycide Prosalt. In the old days, Prosalt was the most widely used, particularly by transhumants and trade cattle needing several weeks' protection. This drug has largely been superseded, but in some areas, especially around Kati, it is demanded as a first preference by livestock owners since it is well known. Berenil is the most common drug used, but gradually the livestock owners are realizing the value of Trypamidium. Its increased use is demonstrated by the fact that in 1979 in Segou Cercle, 80% of Livestock Service treatments were done with Trypanomidium as against 13% with Berenil and 7% with Prosalt.

Little distinction is made between prophylactic and curative treatments, and there is only a very limited effective diagnosis of trypanosomiasis.

In many areas, whenever a thin or "tired" animal is presented to the veterinary agent, it is treated with Berenil and also for gastro-intestinal parasites. Some herd owners will notice a sick animal and ask that their whole herd be treated. Others will pay special attention to their milk cows. Work oxen everywhere are treated often in an attempt at prophylaxis. Some people will aim at annual or even twice yearly treatments of their whole herd or of its valuable animals. In some areas opinions on the prevalence of trypanosomiasis were exaggerated, even by members of the Livestock Service. In others, it was indicated by the veterinary agents that the livestock owners, once an animal is sickly, tend to assume that trypanosomiasis is the cause and to ask for treatment or to undertake it themselves. However, most of the veterinary agents felt confident of their own ability to diagnose the disease and thought

that many of the livestock owners were also able to diagnose it fairly accurately. It seems certain, though, that a large proportion of "treatments" undertaken were not, in fact, warranted by the presence of trypanosomiasis, nor undertaken in such a way as to constitute effective prophylaxis. This may well apply to half or more of the total treatments.

Not only is little distinction made between treatment and prophylaxis, but there is also little distinction made between which drug is suitable for one or the other. Berenil is essentially curative also curing Babesiosis and a limited range of bacterial infections. Thus some of the Berenil treatments done in the Zone, though not in fact curing trypanosomiasis, may have been effective. Berenil has virtually no prophylactic effect, since it is excreted rapidly from the animal.[1/] Trypamidium, on the other hand, though also curative is more suitable for prophylaxis. It confers about three months' protection from the disease depending on trypanosomal challenge.[1/]

In Zone 1 an attempt at systematic prophylaxis really only occurs for work oxen and is usually administered by the livestock sectors of the "Operations". Often this is done by Berenil treatments given once or twice a year. While this is not true prophylaxis, it is probably effective in catching all new infections.

In some areas Trypamidium is used regularly, but seldom as part of a correctly planned prophylactic regime. In addition to this, the numerous "clandestine" treatments, often for reasons of economy or ignorance, are given with incorrect dosages, usually these being too low. This creates further dangers of drug resistance. Also, the veterinary agents report that they occasionally have to treat cattle with abcesses due to the use of dirty needles, etc. The large number of "clandestine" treatments done at some expense is strong evidence of the importance which livestock owners give to trypanosomiasis and its treatments.

[1/] Personal communications, Dr. Awan.

The current cost of treatments is calculated in Table 7.7. The assumption that only half of the treatments (that is, 5% of cattle treated annually) are really justified as measures against trypanosomiasis may seem harsh, but it is realistic because of the lack of diagnosis and confusion between prophylaxis and treatment. In addition, reducing this cost would tend to make estimates of benefits to eradication err on the conservative side.

In Table 7.8, by using Tables B.1 to B.3 in Annex B and discounting at 12%, the net present value of the current program over 20 years is calculated at 54,302,000 MF on the assumption that it continues to treat effectively 5% of cattle in the Zone at an average cost of 470 MF. This is slightly less than if 5% of the total of cattle were treated over twenty years since it is assumed that over the last ten years *G. morsitans* tsetse flies have been sufficiently reduced in number in Kati cercle, so that challenge is reduced by 25% over what it was in the first ten years (Chapter 6).

This cost of the current program will continue *ad infinitum* if no systematic program of prophylaxis or treatment is initiated or if eradication is not undertaken. When added to the losses in cattle due to the disease, it represents at present the cost to the country of the disease. The saving of these costs is a benefit of any systematic campaign against the disease. The unnecessary treatments would also eventually cease as a result of a systematic approach as people became more aware of the real disease situation.

D. Cost of a Campaign of Systematic Treatment Using Extra Diagnostic Equipment Undertaken Through the Existing Livestock Service

The first strategy to be considered for dealing with trypanosomiasis is systematic treatment with Berenil backed up by diagnostic facilities within the Livestock Service.[1/]

1/ This system of undertaking large scale prophylaxis or treatment using the existing veterinary service was successfully implemented in Zambia. The outline of such a system plus a list of the necessary equipment was provided by Dr. Awan of the Protozoology Section.

The basic annual new infection rate is taken from Table 10.6, as calculated in Chapter 10 based on the protozoological dry season survey. This represents the minimum number of treatments necessary, which vary within the Zone. Fortunately the cercle with the highest infection rate (Kati) has the best developed veterinary infrastructure, in terms of numbers of veterinary posts and staff. With the addition of the special diagnostic equipment for the Zone, this program or a program of wider prophylaxis should be perfectly feasible. Using the unit cost of 160 MF for administering the drugs allows for any necessary expansion in transport and staff numbers, since it includes these costs.

To the number of new infections to be treated needs to be added:

1. a proportion to cover reinfections within the year,
2. a proportion to cover treatments that had to be administered in cases of doubt, where definite diagnosis could not be made,
3. part of the cost of the current policy, which is having some effect in keeping infection rates low.

Thus 1 and 2 taken together are assumed to double the cost of simply treating the estimated new infections. Item 3 is accounted for since the cost of treating the 4% of cattle treated effectively under the current policy has been included in the cost of the treatment strategy. For the first 10 years some black market in trypanocides will continue, after which it is assumed that the campaign will assure a sufficient supply of drugs so that all treatments are done at the price of 410 MF (that is 160 MF for administering the drug and 250 MF for the cost of the drug - Table 7.7). Finally, it is expected that in addition to the 25% reduction in challenge from G. morsitans in the cercle of Kati, after 10 years, there would be an overall reduction of 25% in the infection rate of flies due to systematic killing of the parasite in the host population which, in the absence of significant numbers

of game animals, is essentially composed of cattle and other domestic animals.[1/]

Thus the present value of the cost of systematic treatment in Zone 1, over a period of 20 years is given in Table 7.9. The total cost of treating all infected cattle over a period of twenty years is 104,992,000 MF. This would be associated with a much reduced level of production, losses due to the disease. These are calculated in Chapters 10 and 13. The remaining losses would be due to the effects of the illness on animals while awaiting treatment, plus a small proportion of animals still untreated.

E. Costs of a Campaign of Prophylaxis Covering All or Part of Cattle in Affected Areas

The following prophylactic regime is a preliminary proposal based on the information so far collected by the Protozoology Section.

Since the disease incidence increases in the rainy season the following drug regimen should suffice:

1. Two prophylactic doses of trypamidium to be administered at three-month intervals (each dose of 0.5 mg per kg. liveweight) between July and December. During the period of low challenge, surveillance at regular intervals is to be instituted. This should be accomplished by taking blood smears from 10 to 15% of animals, including suspicious cases. Treatment with Berenil should be provided to animals showing infections.

2. Peri-endemic areas: in peripheral areas and where the disease is not endemic and only occurs sporadically, disease surveillance only backed up by treatment should be sufficient.[2/]

This suggested regimen was used to produce a policy covering, firstly, all cattle in the affected areas, where there

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1/ The possibility of such a reduction in trypanosomal challenge following from systematic treatment or prophylaxis was suggested by Dr. Awan.

2/ Dr. Awan, personal communication.

are significant infection rates and fly infestations were detected and secondly, a cheaper alternative where only the animals in Kati cercle are protected. The third alternative, of only extending prophylaxis to work oxen, is included since it corresponds closely to what is actually happening, since people prefer to pay to treat or protect the animals which they value particularly and the work of the "Operations" currently emphasizes help to work oxen. It would thus be a popular alternative and would seem justified because of the heavy losses associated with the disease in work oxen. (Chapter 10).

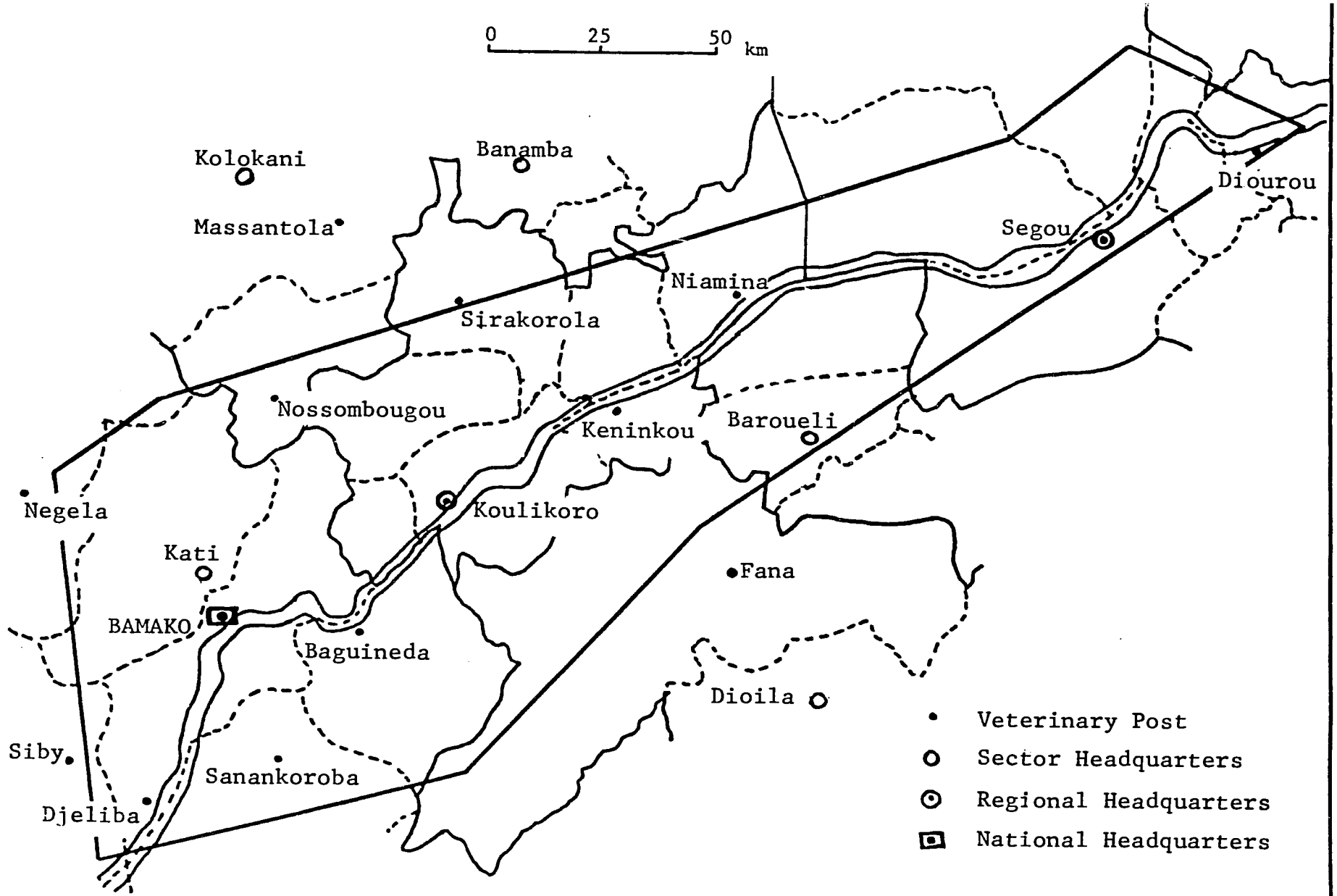
Using Map 6.1 which shows rough areas of tsetse fly infestation and combining this with the different infection rates in each division of the Zone, an estimate of what percentage of cattle will need to be protected was made and is given in Table 7.10. For the Dioila division, due to the extensive prophylaxis which at present leads to a low level infection and thus a low estimate of infection risk, compared to elsewhere, a slightly higher proportion relative to infections seen was chosen. In the second decade the proportion given prophylaxis was reduced by 25% to reflect reduction in the fly population in Kati, a better knowledge of infected areas and a reduction in infection rates in flies. The Berenil treatments needed to cover dry season infections were estimated at 20% of the previously calculated treatment costs (Table 7.9). Since such a large scale program could sell drugs at the lowest price, 160 MF for the drug price was added to the 160 MF cost of administration to give a cost of 320 MF per prophylactic injection, giving an annual cost of 640 MF.

The overall cost of such a program is high: 679,396,000 MF. It would be possible to cut this number down, first, by gaining a better knowledge of infected areas through further protozoological and entomological studies. The probable presence of very low density fly populations in some areas, particularly of G. morsitans in Kati cercle, makes this difficult and expensive. Secondly, the animals to be protected could be

restricted, either by region or by class of animal. Two obvious possibilities are either to restrict prophylaxis to the most heavily infected area, Kati, or to the most valuable classes of animals, work oxen and milk cows, and to combine this with a policy of treatment in other areas, or for other animals. The current policy, although confusing the prophylactic drug Trypamidium with the curative Berenil, is already guided by the "Operations", which are heavily biased towards giving work oxen the benefit of a high degree of protection from losses due to trypanosomiasis. Table 7.11 gives the cost of the two combination policies proposed.

F. Conclusions - Prophylaxis and Treatment for Cattle

Until these policies are compared with the benefits in terms of reduced production losses associated with each, they cannot be definitely evaluated. However, one should note that treatment, despite the higher risk of losses due to the disease, is immensely cheaper. This is due to the fact that prophylaxis is as expensive as treatment but must cover all cattle twice a year. Unlike other diseases, where treatment is costly and recovery slow, and cheap vaccinations are available, in the case of trypanosomiasis treatment is cheap and rapidly effective. Schematically, the effects of prophylaxis and treatment and the relationships are represented in Figure 13.



MAP 7.1 - Offices of the Livestock Service in Zone 1

TABLE 7.1

NUMBERS OF VETERINARY INTERVENTIONS IN THE CERCLES OF ZONE 1 - 1979

Cercle	Vaccinations	Miscellaneous Treatments	Castrations	Total Number Seen
Kati	253,172	223,351	2008	478,531
Kolokani	63,861	1,783	884	66,528
Banamba	171,544	3,255	921	175,720
Koulikoro	189,655	5,127	1280	196,062
Dioila	327,200	21,200	2000	350,400
Baroueli	142,310	46,559	4827	193,696
Segou	338,004	150,000	included with miscellaneous treatments	488,004
TOTAL	1,485,746	451,275	11,920	1,948,941
Correcting Factor	-	90,000	-	2,038,941
%	72.9	26.5	0.6	

Source: Annual reports of the Livestock Service sectors.

Notes:

1/ The report from Dioila sector for 1979 not being available, figures for 1978 were used for vaccinations and castrations and increased by 10%. The ratio of trypanocide treatments to miscellaneous treatments for 1978 was applied to the figures for 1979 trypanocide treatments figures and the figure for miscellaneous treatments was thus derived.

2/ In Segou, the figure 295,502 was given for numbers visited. Since this figure cannot include vaccinations since they exceed it, but is too high for just the treatments, a figure about half this, 150,000, was used. This takes into account the number of veterinary staff; about half of those in Kati and reasonably good availability of transport.

3/ Correcting factor estimated to be 5% of the total number of domestic animals which represents treatments administered after work hours and other interventions which are not noted in the data.

STAFF NUMBERS AND SALARIES FOR THE LIVESTOCK SERVICE IN THE CERCLES OF ZONE 1 - 1979

Grade \ Cercle	Kati	Kolokani	Banamba	Koulikoro	Dioila	Baroueli	Segou	Total	Net Salaries Per Month MF	Total Annual Salaries MF
Veterinary Inspector	-	-	-	-	-	-	1	1	82,000	984,000
Specialist in Applied Sciences	2	-	-	-	-	-	1	3	68,615	2,470,140
Specialist in Animal Husbandry	1	2	1	1	1	1	2	9	51,865	5,601,420
Livestock Assistant	3	3	-	1	2	-	1	10	43,000	5,160,000
Veterinary Nurse	15	2	6	7	6	5	7	48	35,520	20,459,520
Vaccinator	10	2	3	4	2	1	1	23	19,000	5,244,000
Driver	1	1	1	-	1	-	1	5	24,000	1,440,000
Typist	-	-	-	-	-	-	1	1	19,000	228,000
Waterman Laborer	1	1	-	-	1	1	1	5	19,000	1,140,000
Total Number	33	11	11	13	13	8	16	105	-	42,727,080
Number of Veterinary Posts[1/]	8	4	4	4	5	1	2	28	-	-

Source: Annual Reports of the Sectors of the Livestock Service.

Notes: [1/] These are local veterinary offices. In this case the office in the sector headquarters is included.

1979 LIVESTOCK SERVICE VEHICLES FOR THE CERCLES OF ZONE 1

Cercle	Landrovers	Mobylettes		Bicycles		Average Number of Days on Tour Per Employee
		Official	Personal	Official	Personal	
Kati	-	-	NG	-	1	NG
Kolokani	1	2	2	1	NG	85
Banamba	1	-	9	-	NG	NG
Koulikoro	-	-	NG	-	NG	88
Dioila	1	2	5	1	2	107
Baroueli	-	-	NG	-	NG	45
Segou	1 (plus one out of use)	(one out of use)	NG	-	NG	61
Total	4	4	40 1/	2	12 1/	

Source: Visits and Annual Livestock Service Sector Reports.

Notes: 1/ Numbers of personal mobylettes and bicycles were not given for all cercles. The total was obtained by adding to those given a number estimated for the remaining cercles assuming a similar proportion of mobylette and bicycle-owners to that in the cercles where this information was given.

NG: Not given.

TABLE 7.4

CALCULATION OF TRANSPORT COSTS FOR THE CERCLES OF ZONE 1

a. LITERS OF GASOLINE CONSUMED PER ANNUM

i. Vaccination campaign:

- Landrovers and borrowed vehicles:

Dioila	2,500 liters
Segou	2,000
Kati	2,000
Banamba	2,000
Koulikoro	2,000
Kolokani	1,500
Baroueli	1,500
	13,500 liters

- Mobylettes - 40 for seven cercles at 60 liters each 2,500 liters

Total for vaccination campaign: 16,000 liters

ii. Annual Total:

If vaccination campaign, mostly financed by official Livestock Service, uses 40% of the annual total then it follows:

Annual total: 40,000 liters

This can be broken down as follows:

- Mobylettes at 200 liters a year: 8,000 liters
- Fuel for borrowed mobylettes: 4,000 liters
- Remainder for Landrovers and borrowed vehicles is a little over twice that used for the vaccinations: 28,000 liters

b. VALUE OF OFFICIAL AND PERSONAL LIVESTOCK SERVICE VEHICLES

The current cost of using a vehicle for one year is calculated as being the depreciation on the replacement cost.

TABLE 7.4 (Continued)

		1,000's MF
4	Landrovers, cost 9,800,000 MF last three years	13,067
40	Mobylettes cost 302,000 MF last for three years	4,027
12	Bicycles, cost 77,000 MF last for five years	185
	Total Annual Depreciation	17,279

c. COST OF FUEL AND MAINTENANCE

• Gasoline:	
28,000 liters for Landrovers and borrowed vehicles, 350 MF each	9,800
12,000 liters for mobylettes, 405 MF each	4,860
Total Gasoline	14,660
• Oil and Lubricants:	
These costs should be equivalent to 10% of fuel costs, but probably only half of this is used	733
• Maintenance and Spares:	
Spares should be equivalent to 20% of replacement cost plus labor costs assumed equal to about half this since the rural Livestock Service offices do not employ mechanics. Only half of required maintenance done.	2,564
Total Annual Cost of Fuel and Maintenance	17,957

d. ADDITIONAL (NON-FUEL) COSTS CHARGED ON BORROWED VEHICLES

These are assumed to be equivalent to the cost of the fuel used:

TABLE 7.4 (Continued)

	1,000's MF
If the four official Landrovers use 4000 liters each a year then borrowed vehicles use 12,000 each at 350 MF:	4,200
4000 liters were calculated for borrowed mobylettes, at 405 MF:	1,620
Total Extras on Borrowed Vehicles (that is about 6 million MF)	5,820

e. SUMMARY OF TRANSPORT COSTS

• Depreciation of Livestock Service official plus personal vehicles	17,279
• Fuel and maintenance	17,957
• Additional costs on borrowed vehicles	6,000
• Transport of animals to Livestock Service offices (see text)	6,870
Total Transport Cost	48,106

TABLE 7.5

SUMMARY OF COSTS OF ADMINISTERING TREATMENTS
PER ANIMAL IN CERCLES OF ZONE 1 IN 1979

		1,000's MF
a.	TOTAL COSTS	
	i. Recurrent Costs	
	• Salaries	42,727
	• Office supplies	2,136
	• Fuel, maintenance and oil	17,957
	• Borrowed transport	6,000
	• Transport of livestock to veterinary offices	6,870
	Sub Total	75,690
	ii. Depreciation on Capital Assets	
	• Personal and official vehicles	17,279
	• Buildings (21 posts, 7 sector headquarters)	15,750
	• Office furniture and equipment (28 offices)	1,680
	Sub Total	34,709
	iii. Cost of Administration	
	• Cost of national headquarters	23,100
	Total Costs	133,499
b.	UNIT COSTS	
	Proportion of costs attributable to vaccination campaign:	
	• 40% of all transport costs (48,106)	19,242
	• 30% of other costs (85,393)	25,618
	Total	44,860

TABLE 7.5 (Continued)

The total number of vaccinations is 1,486,000, thus:	
The Unit Cost of Administering vaccinations is 30 MF	
Remainder of costs attributable to treatments and castration:	88,615
The number of treatments and castrations is 553,000, thus :	
The Unit Cost of Administering Treatment is 160 MF	
The Average Unit Cost per Animal Seen is 65 MF	

TABLE 7.6

DOSES OF TRYPANOCIDES ADMINISTERED IN THE CERCLES OF ZONE 1

a. BY THE LIVESTOCK SERVICE 1979

Cercle	Number of Animals Treated				
	Cattle	Sheep and Goats	Donkeys and Horses	Camels	Total
Kati	9,221	643	112	0	9,979
Kolokani	1,108	110	39	0	1,257
Banamba	1,884	35	289	313	3,251
Koulikoro	1,723	0	64	0	1,787
Dioila	19,937	0	201	0	20,138
Baroueli	4,180	0	3	0	4,183
Segou	6,421	0	56	0	6,477
Total	44,474	788	764	313	46,339

b. BY SOME OF THE OPERATIONS

Operation	Area/Year	Number Treated
ORS	Segou 1977/8	1932
OACV	Segou - Zone 1977/8	8492
	1978/9	705
OACV	Kolokani - Zone 1979	708
OACV	Banamba 1979/80	1406

TABLE 7.7

COST OF TREATMENTS CURRENTLY UNDERTAKEN FOR TRYPANOSOMIASIS IN ZONE 1

a. UNIT COST OF OFFICIAL TREATMENTS (LIVESTOCK SERVICE AND "OPERATIONS")

• Administration and syringes	160
• Drug	250
Total	410 MF

b. UNIT COST OF UNOFFICIAL TREATMENTS

• Drug 200 - 1500 MF, avarage:	600 MF
• Syringe and needles 25,000 MF, if syringe used 500 times:	50 MF
• Cost administration is nil since the livestock owner does it himself and does not need transport to his herd.	--
Total	650 MF

c. COST OF TREATMENTS DONE IN 1979

Number of Treatments:

10,600	- Livestock Service	
5,300	- Operations	
15,900	- Total Official at 410 MF each	6,519,000 MF
5,300	- Unofficial at 650 MF each	3,450,000
	Total Cost	9,969,000 MF

Because of a lack of diagnosis and a tendency to treat even in areas where there are few tsetse flies (which is the case in the cercles of Segou and Baroueli where 25% of treatments are done) and assuming only 2/3 of the remaining 75% are accurately directed against the disease, then only half of total treatments affects the disease, at a cost of: 4,984,500 MF

From this the average unit cost for each of the 10,600 treatments is : 470 MF

TABLE 7.8

COST OF CURRENT POLICY OVER TWENTY YEARS

	Number of Cattle
Present value numbers for all cattle in Zone 1 discounted at 12% (Table B.2)	2,346,500
Less 25% of cattle in cercle of Kati which due to a reduction in G. morsitans need not be treated during the years 11-20	35,800
Total Cattle at Risk	2,310,700
5% of these are treated at a unit cost of 470 MF thus:	115,500
Total Cost of the Current Policy is:	54,302,000 MF

TABLE 7.9

COST OF SYSTEMATIC TREATMENT OF ALL INFECTED CATTLE IN ZONE 1

a. YEARS 1 - 10		Present Value of Number of Cattle Infected: (Discounted at 12%)
• New infections in subdivisions of the Zone:		
(1) Kati		13,602
(2) Koulikoro, Banamba, Kolokani		6,891
(3) Dioilo		984
(4) Baroueli, Segou		1,053
	Total	22,530
• Unit cost of treatment - 410 MF -- Cost of treating new infections		9,237,300 MF
• Cost of reinfections and where no diagnosis possible		9,237,300
• Cost of current policy: 5% of cattle at 470 MF each		40,060,450
• Cost of treatments over 10 years	Total	58,535,050 MF

b. YEARS 11 - 20		Present Value of Number of Cattle Infected: (Discounted at 12%)
• New infections in subdivisions:		
(1)		3,864
(2)		2,631
(3)		72
(4)		90
		7,257
• Reduced by 25% to reflect reduced challenge		5,443
• Unit cost of treatment - 410 MF -- Cost of treating new infections		2,231,630 MF
• Cost for reinfections and where no diagnosis possible		2,231,630
• Cost of current policy: 5 % of cattle at 410 MF each		13,156,900
• Cost of treatments over 10 years	Total	17,620,160 MF

TABLE 7.9 (continued)

c. YEARS 1 - 20

• Cost of treatments years 1 - 10		58,535,000 MF
• Cost of treatments years 11 - 20		17,620,000
• Cost of special diagnostic equipment 3,861,000 MF for 20 years discounted at 12% (Section B.3)		28,837,000
• Cost of treatment policy	Total	104,992,000 MF

TABLE 7.10

COST OF SYSTEMATIC PROPHYLAXIS OF ALL CATTLE IN THE INFESTED AREAS OF ZONE 1

a. YEARS 1 - 10

Subdivision		Proportion of Cattle Receiving Prophylaxis %	Present Value of Cattle Numbers Receiving Prophylaxis (Discounted at 12%)
Kati	(1)	100	377,800
Koulikoro, Banamba, Kolokani	(2)	60	275,500
Dioila	(3)	30	49,300
Baroueli, Segou	(4)	10	70,300
		Total	772,900

Cost at 320 MF/Dose two times a year over ten years 494,656,000 MF

b. YEARS 11 - 20

Subdivision		Proportion of Cattle Receiving Prophylaxis %	Present Value of Cattle Numbers Receiving Prophylaxis (Discounted at 12%)
	(1)	75	107,300
	(2)	45	78,800
	(3)	23	14,100
	(4)	7.5	19,600
		Total	219,800

Cost at 320 MF/dose, two times a year over ten years 140,672,000 MF

c. YEARS 1 - 20

Cost of prophylaxis years 1 - 10	494,656,000 MF
Cost of prophylaxis years 11 - 20	140,672,000
Cost of special diagnostic equipment (Section B.3 Table 7.9)	28,837,000
Cost of treatments in dry season with Berenil, equal to 20% of total treatment policy cost - excluding diagnostic equipment (Section B.3, Table 7.9)	15,231,000
Cost of Prophylaxis Policy Total	679,396,000 MF

TABLE 7.11

TWO POSSIBLE COMBINATIONS OF PROPHYLAXIS AND TREATMENT FOR CATTLE

a. PROPHYLAXIS IN KATI CERCLE, TREATMENT ELSEWHERE

• Present value of number of infected cattle in Kati:		
	Years 1 - 10	13,602
	Years 11 - 20	3,864
	Total	17,466
• Kati infections as % of total infections		62.4%
• Total treatment cost less diagnostic equipment: 76,155,000 x 62.4% which gives cost of Kati treatments.		47,521,000 MF
i) Cost of treatments and diagnostic equipment excluding those for Kati		57,471,000 MF
ii) Cost of prophylaxis of 485,100 cattle in Kati (Table 7.10) at 640 MF per annum over twenty years		310,464,000 MF
iii) 20% of the total cost of treatments for Kati's dry season treatments		9,504,000 MF
Cost of combined policy a - i + ii + iii: (including cost of diagnostic equipment, for the whole of Zone 1)		377,439,000 MF

b. PROPHYLAXIS OF WORK OXEN, TREATMENT OF OTHER CATTLE

• New infections of work oxen (Table B.4)		
	Years 1 - 10	2,010
	Years 11 - 20	900
• Total number, with 25% reduction in challenge in second decade		2,685
• Cost of treating this number at 410 MF each		1,100,850 MF
• Share of 25% of cost of current policy		13,304,400 MF
• Total cost of treating work oxen		14,405,000 MF
Cost of twenty years of treatment in Zone 1 excluding work oxen		90,587,000 MF

TABLE 7.11 (continued)

Present value of work oxen receiving
Prophylaxis - proportions as Table 7.10

Subdivision	Years 1 - 10	Years 11 - 20	Total
(1)	26,900	10,500	
(2)	30,700	12,100	
(3)	6,400	2,200	
(4)	9,600	3,200	
Total	73,600	28,000	101,600

i)	Cost of prophylaxis of work oxen 640 MF/annum	65,024,000 MF
ii)	Cost of treating other cattle	90,587,000 MF
iii)	20% of the total cost of treatments for dry season	2,881,000 MF
	Total cost of combined policy b (i + ii + iii)	158,492,000 MF

TABLE 7.12

SUMMARY OF PRESENT VALUE CALCULATIONS OF COSTS OF PROPHYLAXIS AND TREATMENTS FOR CATTLE IN ZONE 1 OVER 20 YEARS

	1000's MF
• Current Practice	
Effective treatments and prophylaxis	54,302
Superfluous treatments and prophylaxis	54,302
• A policy of treatment only	104,992
• A policy of prophylaxis in the wet season to cover cattle in infected areas	679,396
• Prophylaxis in Kati cercle, treatment elsewhere	377,439
• Prophylaxis of work oxen, treatment of other cattle	158,492

CHAPTER 8

COSTS OF ADMINISTRATION, PROTOZOOLOGICAL AND SOCIO-ECONOMIC INPUTS INTO TRYPANOSOMIASIS CONTROL

A. Norms and Assumptions

Any systematic approach for dealing with the tsetse problem in Zone 1 requires backup in four fields: administration, protozoology, socio-economic analysis and entomology. Entomology is discussed in the next chapter in conjunction with an eradication program. The other fields are dealt with here.

It should be noted that in this section and in the evaluation of the costs of the Entomological Section and those of an eradication program, the following standards have been used.

1. Staff

Per diem payments cover 200-240 days a year.

2. Technical assistance

An annual cost of U.S.$110,000 per expatriate for transport to and from Mali, expenses in Mali and salary is used.

3. Vehicles

- Vehicles are depreciated on a straight-line basis over 3 years, so that one-third of the current replacement cost per vehicle is borne annually.
- Spares are assumed to cost 20% of total value, spread over 3 years.
- Maintenance is assumed to cost a further 10%, with the labor costs covered by mechanics' salaries.

4. Equipment

Camping equipment is assumed to last three years. For other equipment, the number of years it is expected to last are given.

All prices used are current prices, even for equipment purchased some time ago, so that costs are fully comparable with benefits calculated at current prices. No division of costs according to whether they are paid by the Malian Government, USAID, etc., is made, since in a cost-benefit analysis, total costs are what need to be considered.

Costs for each section are based on past experience and represent streamlined estimates. It is felt that the estimate of cost is fairly conservative but realistic. Since a number of items which have been requested by the project but have not yet been used are omitted, e.g., motorboats, bicycles for captures, etc., it may be necessary to add these at a later stage, but this awaits the formulation of detailed project outlines and proposals by the specialists in entomology and protozoology.

B. Administrative Costs

In this section are included all the expenses incurred at headquarters plus the cost of expatriate staff. Fairly generous estimates of most costs were made. Not included is the cost of miscellaneous cartographic equipment, most of which is on order but which has not yet arrived and been put into use. The costs are given in Tables 8.2 to 8.5. Table 8.6 summarizes the annual costs and gives the allocation of these costs to each section of New Lands. The total annual administrative costs of the current program come to 27,094,000 MF plus technical assistance costs totaling 138,600,000 MF. The additional administrative costs attributable to an expanded program come to 1,482,000 MF.

C. Costs of Protozoological Work

A comprehensive survey of Zone 1 has already been made despite funding problems and interruptions in work. The experience thus gained has made it possible to devise an efficient way of conducting disease surveys and diagnostic work in the area. The costs presented in Tables 8.7 to 8.12 thus represent what cost levels should be in a correctly run operation. Thus, although laboratory equipment is ordered by air freight, sea freight is used for the bulky or heavy items, such as camping equipment, on the assumption that a well-planned program would be able to order well in advance.

The protozoological support needed for a campaign against trypanosomiasis would be either:

- One year of preliminary survey work before undertaking an eradication scheme, using the current level of manpower and equipment as part of the preliminary research program. A follow-up survey on a reduced scale could also be envisaged. OR:

- The support of a treatment or prophylactic campaign in Zone 1 by providing diagnostic aid and undertaking disease surveillance.[1/] This work would make use of the extra team, equipment and field laboratory provided for in the expanded program. The veterinary investigation officer works for this program, which uses about half the other staff of the expanded unit. Meanwhile, the rest of the Protozoology Section could continue survey work elsewhere.

Table 8.12 gives the annual costs of the current program as 75,804,000 MF annually. The additional cost of the expanded program is 27,574,000 MF annually.

Staff costs for the diagnostic support program for the Zone are 1,764,000 MF for the veterinary investigation officer who is brought in especially for this work, plus half of the remaining total staff costs of running the expanded unit, that is, 8,280,000 MF, totalling 10,044,000 MF annually. The protozoological support program will initially take half the veterinary protozoologists time. After two years, as the section expands and the work is well underway, this will be reduced to one quarter. This will be reduced to zero after five years since by then the veterinary investigation officer should be sufficiently well trained to do this work. The additional camping, vehicle and laboratory equipment, plus half the depreciation on one microscope and the field laboratory costs, are added to

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1/ Detailed proposals for this scheme will be included in the Protozoology Section's forthcoming report.

these to give the following total cost for the diagnostic support program.

		1,000's MF
1.	Staff	10,044
	Vehicles	9,550
	Camping Equipment	2,107
	Laboratory Equipment	1,660
	Microscope Depreciation	44
	Field Laboratory	103
	Administrative Cost	5,715
	Sub Total Excluding Technical Assistance	29,223
2.	Technical Assistance:	
	Years 1 - 2	23,100
	Years 3 - 5	11,550
	Years 6 - 20	0
3.	Total Years 1 - 2	52,323
	Years 3 - 5	40,773
	Years 6 - 20	29,223

It should be noted that these figures differ considerably from Table 8.12 where current costs and additional costs for the larger unit are compared. As explained above, in essence, these costs are derived using half the larger units' resources for the surveillance work.

The present value of these expenses discounted at 12% over 20 years, with the costs starting in year one, is 279,435,000 MF. Adding to this the cost of a one-year preliminary survey undertaken in year 0 at 75,804,000 MF (Table 8.12, current program annual cost) gives a total cost to the proposed diagnostic support program of 355,239,000 MF over 20 years, or $846,000.

The diagnostic support program needed is the same for both treatment and prophylactic program. Although fewer drugs are administered in the treatment program, very careful diagnostic work and surveillance is needed.

Excluded from this cost estimate are the following research costs which are partly attributable to the proposed strategies, but also include a large element of training and experimentation.

These are:	1000's MF
1 year Entomological Survey (Table 9.10a)	185,233
1 year Socio-Economic Study (Table 8.14)	60,664
	245,897

These costs are given in today's prices, for the year in which they take place. They amount to 245,897,000 MF or $585,500.

D. Socio-Economic Analyses

In order to perform economic feasability studies of areas where a campaign against trypanosomiasis is being considered, a year's work by a unit such as that presently in existence, but with expanded staff, should be sufficient. If detailed land use studies or attempts at development planning are envisaged a far greater input would of course be required.

The cost of a year's work by the present unit is calculated, but on a fairly hypothetical basis since it was never fully staffed for more than a few months. The total cost is calculated in Table 8.13. It excludes stationery and expatriate staff, which, as in the case of the Protozoology Section, are included in administrative costs (Table 8.6). It should be stressed that this figure is for a unit operating on a modest scale, but this level of expenditure should be sufficient for the initial study. The total annual cost is 60,664,000 MF taken from Table 8.14.

TABLE 8.1

a. CAMPING EQUIPMENT - GENERAL EQUIPMENT REQUIRED PER TEAM

Item	Number Required	Unit Cost in U.S. $	Unit Cost in Mali MF	Total Cost of Item MF
Furniture				
• Tarpaulins	3	15	9,500	29,000
• Folding Tables	8	30	19,000	152,000
• Folding Chairs	16	10	6,300	101,000
Cooking Equipment				
• Cookware Sets	2	25	16,000	32,000
• Kerosene Cookers	3		12,000	36,000
Refrigeration				
• Refrigerator	1		500,000	500,000
• Freezer	1		750,000	750,000
• Cool Boxes	3	30	19,000	57,000
Containers for Water & Fuel				
• Water Filters	3		25,000	75,000
• Plastic Bowls for Washing	5		2,000	10,000
• Plastic Jerry Cans	10		4,500	45,000
• Buckets	15		1,500	22,000
• Fuel Pump for Gasoline	1		80,000	80,000
• 200 Liter Drums	2		8,000	16,000
• Metal Jerry Cans	8		22,000	176,000
Electricity and Light				
• 3000 KVA Honda Generator	1		385,000	385,000
• Coleman Lamps	3	40	25,200	76,000
• Hurricane Lamps	15		5,000	75,000
• Electrical Equipment (bulbs, wire, plugs)	Selection		35,000	35,000
Total				2,652,000

TABLE 8.1 (CONTINUED)

a. CAMPING EQUIPMENT (CONTINUED)

Item	Number Required	Unit Cost in U.S. $	Unit Cost in Mali MF	Total Cost of Item MF
Tools				
• Wheelbarrow	1		29,200	29,000
• Shovels	2		3,300	7,000
• Rakes	2		3,800	8,000
• Picks	4		3,750	15,000
• Matchete	5		2,500	12,000
• Axes	5		4,250	22,000
• Rope (50 m)	1		15,000	15,000
• Compasses	5	30	18,900	95,000
• Binoculars	1	350	220,500	220,000
Maps				
• I G N 1/100,000	5		2,800	14,000
• I G N 1/500,000	5		2,000	10,000
• I G N 1/250,000	10		1,800	18,000
• Topographic Service 1/200,000	40		1,600	64,000
Miscellaneous				
• First Aid Kit (including serums and vaccines) cost for staff	1		250,000	250,000
Total				779,000
Grand Total				3,431,000
Annual Cost - Depreciation over 3 years				1,144,000

Source: Estimated from New Lands Records.

Note: Prices are given for locally available items in Malian Francs. Items purchased in the U.S.A. are given in U.S. dollars, 50% is added to cost for freight by sea, and a conversion rate of $ 1 = 420 MF is used. However, a number of the items listed are being purchased in Mali and all the items for which dollar prices were given were actually imported by air freight. At $2.37 per pound, freight for a sample of Camping and other equipment orders costs between 2 ½ or 3 times the original value of the goods.

TABLE 8.1 (CONTINUED)

b. INDIVIDUAL CAMPING EQUIPMENT REQUIREMENTS

Item	Number per Team Member	Unit Cost per Team Member	
		$	MF 1/
Tents 4-man	1/3 2/	200 - 3 = 67	42,000
Cots	1	28	18,000
Sleeping Bags	1	18	12,000
Mosquito Nets	1	-	2,000
Individual Food Sets	1	3.50	2,000
Working Clothes (average cost varies with category of individual)	1		9,000
"Ranger" Shoes	1	32	20,000
Total			105,000
Depreciation over 3 years, Annual Cost:			35,000

Notes: 1/ Conversion from $ to Malian Francs as in previous table, with assumption that sea freight is used.

2/ 1/3 is used rather than 1/4 to allow for teams not divisible by 4, for visitors and to leave extra space for higher ranking staff.

c FUEL FOR CAMPING EQUIPMENT PER TEAM

Item	Amount	Unit Cost MF	Annual Cost MF
Generator	7 liters gasoline/day for 240 days	350	588,000
Kerosene for Cookers	25 l./month for 8 months	250	50,000
Coleman Lamps	20 l./month	250	40,000
Hurricane Lamps	20 l./month	250	40,000
Total			718,000

Note: The lamps are used when the generator is not working.

TABLE 8.2

HEADQUARTERS STAFF COSTS

a. LOCAL STAFF

i) Salaries

Category	Current Number	Basis Monthly Salary MF	Annual Salaries Total MF
Veterinary Doctors	2	82,000	1,968,000
Accountant	1	35,000	420,000
Secretary	1	26,500	318,000
Mechanic	1	30,500	366,000
Truck Driver	1	30,500	366,000
Drivers (for cars in town)	2	24,000	576,000
Total			4,014,000

Extra required for expanded program:

- 1 Secretary 318,000 MF
- 1 Mechanic 366,000 MF
- Total Additional Annual Salary Cost: 684,000 MF

ii) Monthly Bonuses

Category	Number	Monthly Bonus MF	Annual Cost of Prime MF
Activity Head	1	20,000	240,000
Veterinary Doctor and Deputy	1	15,000	180,000
Secretary and Accountant	2	10,000	240,000
Mechanic and Drivers	4	5,000	240,000
Total			900,000

Additional cost for expanded program: 180,000 MF

TABLE 8.2 (CONTINUED)

iii) Per Diem

Of the headquarters staff, the driver of the truck does 240 days field trips a year at 1500/day and receives 360,000 MF.

The veterinary doctors together do 270 days of field trips at 2,500 MF/day and receive 675,000 MF

Total per diem 1,035,000 MF

TOTAL LOCAL STAFF COSTS:

Current Program	5,949,000 MF
Additional Costs for Expanded Program	864,000 MF

b. EXPATRIATE STAFF - TECHNICAL ASSISTANCE

The annual cost of transporting to and maintaining in Mali an expatriate technical advisor is now estimated at $110,000, or 46,200,000 MF, of which actual salary is only a small proportion.

Current Staff

1 Entomologist
1 Veterinary Protozoologist
1 Agricultural Economist

TOTAL EXPATRIATE STAFF COST: 138,600,000 MF

Additional Staff

1 Toxicologist is required to conduct trials to determine what insecticides should be used and their effects, as a research preliminary to an eradication scheme.
1 Tsetse control specialist, for an eradication scheme.

Their use and costs are discussed in Chapter 9.

TABLE 8.3

HEADQUARTERS VEHICLES COSTS

Type and Number	Unit Cost	Monthly Fuel Consumption	Annual Fuel Cost MF
R12 - Break - 1	4,500,000	300 l. gas	1,260,000
Peugeot 404 - Bachee - 1	3,800,000	400 l. gas	1,680,000
Transport Truck Berliet 64 x 4 - 1	18,500,000	1000 l. diesel	3,000,000
Total	26,800,000		5,940,000

Note: Gasoline at 350 MF/liter.
Diesel at 250 MF/liter.

Total Vehicle Costs:	MF
Annual Depreciation (Depreciate over 3 Years)	9,000,000
Fuel	5,940,000
Lubricants (10% of Fuel)	594,000
Spares (20% of Vehicle Cost)	1,800,000
Extra Maintenance Not Done by Mechanic (50% of Above)	900,000
Total	18,234,000

TABLE 8.4

HEADQUARTERS EQUIPMENT COSTS

a. FURNITURE

Item	Number	Unit Cost in U.S. $	Unit Cost in Mali MF	Total Cost MF
Desks	12	164	138,000	1,656,000
Desk Chairs on Wheels	10	62	52,000	520,000
Desk Chairs	6	44	37,000	222,000
Metal Cupboards/ Filing Cabinets	3	168	141,000	423,000
Wooden Cupboards				
- 3 Shelves	2	170	143,000	286,000
- 2 Shelves	2	150	126,000	252,000
Small Metal Cupboards	1	80	67,000	134,000
Benches	4	20	17,000	68,000
Typewriters	2	350	294,000	294,000
Stools	4	10	8,000	32,000
Total				3,887,000

Note: Because of bulk and weight of furniture, sea freight costs are assumed to double the cost. As noted for Table 8.1, a lot of the furniture comes in to Mali by air freight, but a high sea freight cost is used here on the assumption that a properly planned program would place orders a year in advance.

Annual Cost: If furniture lasts ten years, is 389,000 MF, for the expanded program an increase of 25% is needed to cater for additional staff, costing annually 98,000 MF.

TABLE 8.4 (CONTINUED)

b. ELECTRICAL EQUIPMENT

Item	Number	Unit Cost in U.S. $	Unit Cost in Mali MF	Total Cost MF
Refrigerator	1	-	500,000	500,000
Drinking Fountain	1	220	185,000	185,000
Portable Calculator	3	50 (average price)	42,000	126,000
1500 Watt Electric Generator	2	-	275,000	275,000
Total				1,086,000

Note: Freight costs as above Part a).

Annual Cost: Assuming equipment depreciates over three years, 362,000 MF
No extra equipment is needed for the expanded program.

c. CAMPING EQUIPMENT

Four spare sets of individual camping equipment, excluding tents, are kept at headquarters for the use of the headquarters staff and technical assistance staff on their field trips.

Annual depreciation is 21,000 MF per set, that is 84,000 MF for four. All staff in the expanded program have camping equipment, so no increase is forseen.

d. ELECTRICAL AND WATER COSTS

This is included for the sake of completeness and is estimated at 50,000 MF a month, or 600,000 MF annually. An increase of 25% is expected for the expanded program.

e. DEPRECIATION ON OFFICE BUILDINGS

This is not included because the buildings were not built for New Lands and have already been in existence a long time.

TABLE 8.5

OFFICE SUPPLIES

Item	Annual Consumption	Unit Cost MF	Total Annual Cost MF
Typing Paper	35 reams	3,000	105,000
Flimsy Paper	30 reams	2,900	87,000
Stencils	24 boxes	7,800	187,000
Simple File Covers	12 reams	7,000	84,000
Ordianary Ballpoint Pens	12 boxes	3,500	42,000
Felt Tip Pens	60 sets	1,700	102,000
Lead Pencils	250	25	6,000
Erasers	60	50	3,000
Note Pads	350	1,100	385,000
Pencil Sharpeners	40	125	5,000
Paper Clips	24 boxes	3,400	82,000
Typewriter Ribbons	24	1,400	33,600
Small Envelopes	50 packets	250	12,000
Glue	40 pots	400	16,000
Scotch Tape	40 rolls	900	36,000
Bulldog Clips	10 boxes	3,700	37,000
White-out	50 bottles	2,000	100,000
Stencil Corrector	15 bottles	850	13,000
Stapler	1	6,500	6,000
Boxes of Staples	2	1,200	2,000
Ring Files	10	5,600	56,000
Rulers	5	350	2,000
Waste Paper Baskets	2	2,500	5,000
Carbon Paper	15 packets	4,700	70,000
Total			1,476,000

Note: This provision will be increased by 25% or 370,000 MF annually for the expanded program.

Table 8.6

SUMMARY OF ANNUAL COSTS FOR ADMINISTRATION

Item	Current Program 1,000 MF	Current Program % of Total	Additional Costs for Expanded Program - 1,000 MF
1. Staff			
a) Salaries	4,014		684
b) Monthly Bonuses	900		180
c) Per Diem	1,035		-
Total	5,949	22.0	864
2. Vehicles			
a) Depreciation	9,000		Additional vehicles are provided for in the individual sections.
b) Maintenance & Spares	2,700		
c) Fuel & Lubricants	6,534		
Total	18,234	67.3	
3. Camping Equipment			
a) Depreciation on Individual Equipment	84	0.3	-
4. Equipment			
a) Office Furniture Depreciation	389		98
b) Electrical Equipment Depreciation	362		-
c) Electricity and Water Bill	600		150
d) Office Supplies	1,476		370
Total	2,827	10.4	618
Grand Total	27,094		1,482

Note: Technical assistance is excluded.

The administrative costs of the current program are allocated between the sections on a basis of staff numbers and the weight of the sections as follows:

TABLE 8.6 (CONTINUED)

50%	- Entomology -	13,547,000 MF
40%	- Protozoology -	10,837,000 MF
10%	- Socio-economics -	2,710,000 MF

For the expanded program, the total administrative cost of 28,576,000 MF is divided between the sections in the same proportions, with half of the cost going to the new activities. Thus, the Entomology Section accounts for 14,288,000 MF, of which 7,144,000 MF goes for the eradication work. Protozoology accounts for 11,430,000 MF of which 5,715,000 goes for the diagnostic support service.

PROTOZOOLOGY SECTION - STAFF COSTS

a. BASIC SALARY

Category	Current Number	Number Required for Expanded Program	Monthly Salary MF	Present Annual Cost MF	Additional Annual Cost MF
Veterinary Investigation Officer	-	1	82,000	-	984,000
Specialists	1	4	69,000	828,000	2,484,000
Technicians	1	4	52,000	624,000	1,872,000
Assistants	Students being trained	6	43,000	-	3,096,000
Fly Capturers	2	2	20,000	240,000	-
Drivers for Landrover	1	2	24,000	288,000	288,000
Total	5	19		1,980,000	8,724,000

b. MONTHLY BONUSES AND PER DIEM

Category	Primes - for 12 Months of the Year			Per Diem - for 240 Days per Annum		
	Monthly Rate MF	Current Cost MF	Additional Cost MF	Daily Rate MF	Current Cost MF	Additional Cost MF
Veterinarian and Specialists	15,000	180,000	720,000	2,500	600,000	1,200,000
Technicians	12,500	150,000	450,000	2,000	-	960,000
Assistants	10,000	-	720,000	2,000	-	960,000
Fly Capturers	5,000	120,000	-	1,500	720,000	-
Drivers	5,000	60,000	60,000	1,500	360,000	360,000
Total		510,000	1,950,000		1,680,000	3,480,000

TABLE 8.7 (CONTINUED)

Note: Assistants are mainly for laboratory work, but two will also join the field teams. Two of the technicians and two of the specialists will do field work on the average. 'Specialists' has been used to translate the term 'ingenieurs' who in these cases are trained in animal husbandry or applied science. The Veterinary Investigation Officer will also do field work. The Landrover drivers as well as the existing team, excluding the technicians, all work in the field.

VEHICLE COSTS - PROTOZOOLOGY SECTION

a. DEPRECIATION COSTS

Category	Current Number	Required for Expanded Program	Unit Cost MF	Annual Depreciation, over 3 Years	
				Current MF	Expanded MF
Landrover Car	1	2	11,300,000	3,800,000	3,800,000

b. MAINTENANCE COSTS

Category	Current Cost Annually MF	Expanded Cost Annually MF
Spares - 20% of Value of Vehicle	760,000	760,000
Cost of Electric, Body Work and Repairs: Half of Above 1/	380,000	380,000
Total	1,140,000	1,140,000

1/ Other mechanical repairs are done by the project mechanic and is listed under headquarters costs.

c. FUEL AND RUNNING COST

Category	Explanation	Current Cost Annually MF	Expanded Cost Annually MF
Gasoline	25 1/100 km 200 km/day for 240 days at 350 MF/1	4,200,000	4,200,000
Lubricants, etc.	Oil - 50,5 cans/month 3,950 MF each	158,000	
	Oil - 40,2 cans/month, 3,950 MF	63,200	
	Oil - 90,2 x 2 1/month, 4,245 MF	68,000	410,300
For 8 Month Field Work per Year	Hydraulic fluid, 3 cans/month, 4,470 MF each	107,300	
	Grease 1 kg/month, 1,725 MF each	13,800	
	Total	410,300	
Grand Total		4,610,300	4,610,300

Source: Protozoology Section estimates based on their experience.

CAMPING EQUIPMENT COSTS - PROTOZOOLOGY SECTION

Number of Team Members in Field		Unit Annual Cost per Team Member MF	Total Cost Annually MF	
Current	Expanded Program		Current Program	Expanded Program Additional Cost
4	11	35,000	140,000	245,000

Total Camping Costs per Annum

Current Program:	Fuel Costs	718,000 MF
	1 Team's Equipment	1,144,000
	Individual Equipment	140,000
	Total	2,002,000 MF
Additional Cost of Expanded Program:	Fuel Cost	718,000 MF
	1 Team's Equipment	1,144,000
	Individual Equipment	245,000
	Total	2,107,0[illegible] MF

TABLE 8.10

PROTOZOOLOGY SECTION:

LABORATORY AND GENERAL EQUIPMENT

a. ITEMS PURCHASED IN U.S.

Item	Number Required	No. of Years Useable	Unit Cost in U.S. $	Total Cost Per Annum $
1. Binocular Microscope (research) plus accessories	2	20	3,500.00	350
2. Microscope Glass Slides	50,000	1	-	1,610
3. Coverslips for Slides	50,000	1	-	1,670
4. Slide Boxes	50	10	2.00	10
5. Diamond Pencils	2	10	4.50	1
6. Hypodermic Needles				
- 20	20	1	1.65	2.31
- 14	120	1		
7. Glass Syringes	10	1	3.50	35
8. Blood Lancets	20 pkts.	1	5.00	100
9 Xylene	10 litres	1	-	35
10. Methyl Alcohol	20 litres	1	-	38
11. Ethyl Alcohol	20 litres	1	-	30
12. Giemsa Stain 402	70 bottles	1	6.00	420
13. Staining Dishes	20	2	1.95	20
14. Graduated Glass Cylinders 250 cc	5	1	4.60	23
15. Glass Funnels	5	1	2.00	10
16. Filter Papers (Round)	18 pkts.	1	0.75	14
17. Filter Paper Sheets	20	1	-	15
18. Oil Immersion 100 ml/Bottle	20	1	4.50	90
19. Lens Tissue	10 booklets	1	0.30	3
20. Spare Bulbs for Microscope	20	1	1.00	20
21. Laboratory Detergent	10 lrg.pkts	1	5.00	50
22. Laboratory Trays	10	10	6.75	7
23. Incubator	1	510	225.00	22
24. Pair of Scissors	5	2	3.00	8

TABLE 8.10 (CONTINUED)

a. ITEMS PURCHASED IN U.S. (CONTINUED)

Item	Number Required	No. of Years Useable	Unit Cost in U.S. $	Total Cost Per Annum $
25. Pair of Forceps	2	2	1.00	1
26. Buffer (concentrate)	20 bottles	1	8.70	174
Annual Cost:			Total:	4,987
Air Freight Costs 20%				997
Total Cost				5,984
Converted to MF at MF 420 = $ 1			Total Cost:	2,513,000 MF

b. EQUIPMENT USUALLY PURCHASED OR ALREADY ACQUIRED LOCALLY

Item	Number Required	No. of Years Useable	Unit Cost MF	Cost per Annum MF
1. Cotton Wool	5 kg	1	2,800	14,000
2. Refrigerator	1	5	600,000	120,000
3. Veterinary Aid Kit (drugs etc. for treating animals in the field)	1	1	250,000	250,000
4. Duplication Paper	10 reams	1	4,000	40,000
5. Carbon Paper	1 box	1	5,000	5,000
Total				429,000

Total Equipment Cost Annually 2,942,000 MF

c. INCREASE IN EQUIPMENT NEEDED IF SECTION IS TO EXPAND AS DIAGNOSTIC BACK-UP TO SYSTEMATIC PROPHYLAXIS OR TREATMENT PROGRAM

All costs except microscope purchase are estimated to increase 60%

Total extra therefore: 1,660,000 MF

Source: List of necessary equipment supplied by Dr. Awan, Protozoology Section.

TABLE 8.11

EQUIPMENT FOR PROTOZOOLOGY FIELD LABORATORY

Item	Number	Unit Cost in US $	Annual Cost $
Simple Microscope	1	180.00	9
Microscope Slides	2000	-	65
Coverslips for Slides	2000	-	68
Diamond Pencil	1	4.50	4
Slide Boxes	5	2.20	11
Hypodermic Needles	20	1.50	33
Alcohol	5 litres	7.50	8
Total Cost			198
20% Freight			40
Total			238
Converted to MF at $1 = 420 MF			100,000
Plus Cotton	1 kg	2,800.00	2,800
Grand Total			103,000

Notes:
- The headquarters laboratory will provide replacement during the course of the year as samples are taken to headquarters.
- The microscope is expected to last 20 years.
- The expanded program with two teams would need a second field laboratory.

TABLE 8.12

SUMMARY OF ANNUAL COSTS OF THE PROTOZOOLOGY SECTION'S WORK

Item	Current Program 1,000 MF	Current Program % of Total	Additional Costs for Expanded Program 1,000 MF
1. Staff:			
a) Salaries	1,980		8,724
b) Monthly Bonus	510		1,950
c) Per Diem	1,680	5.5	3,480
Total	4,170		14,154
2. Vehicles			
a) Depreciation	3,800		3,800
b) Maintenance and Spares	1,140		1,140
c) Fuel and Lubricant	4,610	12.6	4,610
Total	9,550		9,550
3. Camping			
a) Depreciation per Team	1,144		1,144
b) Depreciation on Individual Equipment	140		245
c) Fuel	718	2.6	718
Total	2,002		2,107
4. Equipment			
a) Depreciation and Laboratory Equipment	2,942	3.9	1,660
5. Field Laboratory	103	0.7	103
6. Administration	10,837	14.3	see text
7. Technical Assistance	46,200	61.0	see text
Total	75,804		27,574

Note: Most of the equipment for the laboratory is replaced annually. The depreciation component is about 11% of the current program annual cost and 6% of the expanded program's annual additional cost.

TABLE 8.13

ANNUAL COSTS OF A SOCIO-ECONOMIC UNIT

a. STAFF

Staff	MF Monthly Salary	MF Annual Salaries Total
2 Specialists	69,000	1,656,000
2 Enumerators	30,000	720,000
1 Driver	24,000	288 000
Total Salaries		2,664,000
	Monthly Bonus	Annual Bonuses Total
2 Specialists	15,000	360,000
2 Enumerators	5,000	120,000
1 Driver	5,000	60,000
Total Bonuses		540,000
	Per Diem	Annual Total for 120 Days
2 Specialists	2,500	600,000
2 Enumerators	1,500	360,000
1 Driver	1,500	180,000
Total Per Diem		1,140,000
Total Staff Costs		4,344,000

b. CAMPING EQUIPMENT

Since the unit does not camp full time in the field but would tend to spend the night at rest houses or with the other teams already in the field, only the individual equipment cost is calculated:

5 team members, 35,000 MF each - 165,000 MF

c. VEHICLES

For One Landrover (from Table 8.3)

- Annual Depreciation 3,800,000
- Maintenance Costs 1,140,000
- Running Costs for 4 Months 2,305,000

Total 7,245,000

d. TOTAL COSTS FOR SOCIO-ECONOMIC UNIT 11,754,000 MF

Note: Excludes administration and technical assistance costs.

TABLE 8.14

SUMMARY OF ANNUAL COSTS OF A SOCIO-ECONOMIC UNIT

Item	Cost of Current Program	
	1,000 MF	%
1. Staff		
• Salary	2,664	
• Monthly Bonuses	540	
• Per Diem	1,140	
Total	4,344	7.2
2. Vehicle		
• Depreciation	3,800	
• Maintenance and Spare	1,140	
• Fuel and Lubricants	2,305	
Total	7,245	11.9
3. Camping Equipment	165	0.3
4. Administrative Costs	2,710	4.5
5. Technical Assistance	46,200	76.1
Total	60,664	100.0%

CHAPTER 9

THE COSTS OF ENTOMOLOGICAL STUDIES AND AN ERADICATION PROGRAM FOR ZONE 1

In this chapter the costs of one year of entomological studies on the scale presently undertaken at New Lands are estimated and then used as an input into a hypothetical tse-tse eradication scheme for Zone 1.

A. The Cost of One Year of Entomological Studies

The annual cost of entomological studies is calculated, as was that for the Protozoology Section and the Socio-Economic Section, in Tables 9.3 to 9.6, and is summarized in Table 9.10a. It is assumed that vehicles and all equipment become economically unrepairable as of the end of three years, except for fly traps which last for five years. The total cost for one year of intensive study is 185,233,000 MF. This cost may be higher than that actually recorded in the past because:

- All equipment is depreciated over a relatively short period of time and at current prices.
- A very full working year of 200 field days per person is assumed.
- Fuel and maintenance costs are estimated generously.
- Technical assistance is expensive.

However, these norms ($110,000 per annum for technical assistance, 3 years for depreciating vehicles, and 20% cost of spares) are generally applied in Mali. Costs have been reduced by streamlining the operation as far as possible and by charging a low freight cost for transport by sea rather than by air. So it is felt that this estimate is fair.

B. The Cost of One Year of Studies by All Three Sections

These costs are presented in Table 9.10b, and include the costs of technical assistance and administration. Totaling

321,701,000 MF, they are very high indeed. Two components stand out as being extremely expensive. Vehicles are one. The norms used are discussed above. Fuel costs and other projections are made on the basis of 200km/day while in the field. These are the norms used at New Lands.

Technical assistance is by far the largest component of cost in each of the three sections. Because of the large staff of the Entomology Section, the proportion of total costs going to technical assistance is lower than in the other two. Overall, it would seem to indicate that the Protozoology and Socio-economic Sections need to be expanded in terms of scope and of numbers of local staff who work in them and who benefit from the training received. This need for expansion has, in fact, already been stressed in the plans for their future work presented by both sections. The Protozoology Section plans to expand into a general diagnostic support structure as well as continuing disease incidence surveys covering trypanosomiasis in cattle in the rest of Mali. The Soci-economic Section envisions an expansion into a general animal health economics unit, which could deal with the economics of the main cattle health and disease problems and eventually the health problems of other domestic animals, and would also train a much expanded staff.

C. A Hypothetical Eradication Scheme for Zone 1

The outlines of a possible eradication scheme were presented in Okiwelu et al, 1980, Annex. The main features of the scheme are summarized in Tables 9.1 and 9.2. The areas affected are roughly illustrated in Map 9.1, showing the main areas of infestation in each sector and location of the insecticide barriers. An approach using discriminative spraying from the ground is suggested. It is believed, as a result of the entomological work, that this approach will be the most effective.[1/]

1/ Personal communication, Dr. S.N. Okiwelu.

In addition, this approach enables use to be made of the existing equipment (Landrovers and camping) and of the staff already trained (the fly capturers), so that the additional cost of the program would be quite small. The number of fly capturers would have to be increased from 33 to 40. The fly capturers would do the actual spraying after having been trained as insecticide pump operators. The main expenditure for vehicles would be for the 3-ton trucks which would accompany each of the five spraying teams. Each team consists of four insecticide pump operators who, together, spray an estimated area of one square kilometer a day. They are accompanied by four path cutters and porters who help with the refilling of the pumps, water pumping and carrying, etc.

1. Specific Equipment Needed for the Eradication Scheme

The sprayers, water-carrying equipment and insecticide costs are presented in Tables 9.7 to 9.9. The American Hudson "6367" model is selected as the sprayer since it is cheaper and requires less water than the others. It should be noted that some experiments have been done in Nigeria with motorized mist blower, ultra-low-volume (ULV) sprayers. These require far less water (about 5 to 10 liters an hour), but do need fuel. However, the more commonly used hand-operated sprayers are used in this estimate.

Total annual costs, for a scheme lasting one year, are therefore:

	US$	MF
• Depreciation on 40 Hudson sprayers plus freight which last years (Table 9.7)	1,400	588,000
• 27 metric tons DDT 75% water dispersible powder (Table 9.9)	56,000	23,520,000
• Depreciation of water-carrying equipment (Table 9.8)	--	510,000
Total Costs		24,618,000 MF

2. The Cost of the Chemical and Cleared Barriers

In addition land-clearing would have to be undertaken for the barriers (See Map 9.16). These are:

- 5 km, between Forest Reserves of La Faya and Soussan-Banifing;
- 75 km, from Guinana to Kankoumana;
- 5 km, along the Dia River.

The chemical barriers are 1 km wide, but must be preceded by a 3 km-wide clearance. Current costs for clearance, excluding removal of roots, in Bamako are 185,000 MF per hectare. Due to the large scale of the operation, costs can be expected to fall to 150,000 MF per hectare. The cost for the 25,500 hectares required thus comes to the enormous sum of 3,825,000,000 MF, or over $9 million. By hand clearing and estimating 8 man days per hectare[1/] at 750 MF/day, the cost would be 153,000,000 MF, or $360,000. However, more detailed fly surveys may make it possible to reduce this figure. Annual re-slashing will be needed as well, but this should only cost about 20% of the original amount, that is, 30,600,000 MF. An annual respray of the barriers will also be necessary. The cost of respraying is estimated from Table 9.11, using the average spraying cost of 1,115,000 MF per square kilometer, and comes to 94,775,000 MF for 85 square kilometers. The annual cost of maintaining the barriers is thus 125,375,000 MF.

The creation of the barrier from Guinana to Bankoumana can only be described as a tremendous undertaking. The need to maintain it from year to year, at an annual cost equal to nearly half that of the whole initial spraying scheme, is extremely costly. Already, 42% of the spraying done for the initial eradication scheme consists of barrier spraying. However, it is to be expected that during the second year of entomological surveys in Zone 1, ways may be found to reduce the length of the barriers. Since it is possible that a chemical barrier would be sufficient,[2/] the reduced cost estimate excludes the land-clearing costs and also assumes that the

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1/ Okiwelu et al., 1980.

2/ Experience in eradication work in Nigeria supports this view.

eradication in Zone 1 is followed up by eradication work elsewhere to the west so that the barrier does not have to be maintained after two years. Otherwise, it is maintained for five years.

3. Cost of an Insecticide Trial and the Training of Pump Operators

Since no scheme has been put forward for this yet, its costs are only very roughly calculated. It could be undertaken within Zone 1, perhaps dealing with only one of the isolated infections in sectors B, C or D or it could take place elsewhere, perhaps in an area where human sleeping sickness is significant and annual control is desirable. An area within the Zone, or representative of it, would be desirable.

In order to give the insecticide pump operators sufficient experience, it would be desirable to spray about five square kilometers, which, at the speed at which training would progress, would take one to two weeks. If insecticide is excluded, the cost per square kilometer sprayed is about 997,-000 MF (Table 9.11), or 4,985,000 MF for the whole work, including costs for per diem, equipment, administration, vehicle costs, etc. To give the pump operators experience, some extra sprayers should be available, say 10, at an annual depreciation cost of 147,000 MF. Finally it would be desirable to try several insecticides. Altogether, 450 kgs. of active ingredient (at 900 g.a.i./hectare) would be required. If 150 kgs. each were purchased of Lindane, Endosulfan and DDT, the cost of this selection would be approximately 1,500,000 MF.

Thus the total cost for the trial would be approximately:

• Cost of spraying 5 km^2	4,985,000 MF
• Depreciation on 10 insecticide sprayers	147,000
• Cost of 450 kg. of selected insecticides	1,500,000
• Six months input by toxicologist	23,100,000
Total	29,732,000 MF

This trial would have to be undertaken at least two years before any large-scale spraying in order to evaluate the results.

4. Toxicologist and Tsetse Control Specialist

The toxicologist would need to spend at least six months in preparing and conducting the trial. He would need six months the following year to assess its effects, and six months of his work are included in the eradication scheme. This input would be increased if a full time toxicologist were appointed. He would then be expected to direct his attention toward other areas of Mali as well. The input would be reduced if a short-term mission were to do the work, visiting Mali perhaps for three years in succession.

A tsetse control specialist is needed to plan and direct the work. Six months of his input is included in the eradication scheme. He would need to be on the spot for six months to a year prior to the initiation of the eradication scheme in order to familiarize himself with the Malian situation and work out his program.

5. Summary of Costs

Table 9.12 summarizes the costs of such a scheme. Year 0 is selected as the year when eradication takes place, and benefits start in year 1. This layout is devised so as to be comparable with the benefits calculated in Chapter 10 and the costs of prophylaxis and treatment as calculated in Chapter 7, both of which start in year 1. All figures are converted to present value in year 0, using a discount rate of 12% as in the rest of the report. Two estimates are produced.

The high-cost estimate includes:

- The cost of the hand-cleared barriers.
- Five years of re-sprays and re-slashing of the barriers on the assumption that there is no further eradication within five years.

- Re-surveys of 10% of the Zone (i.e. 10 times the area sprayed) in years 1 and 2 and a final re-survey in year 5.

Total cost is 1,206,452,000 MF or $2,872,500.

The low-cost estimate:

- Excludes the hand-cleared barriers and re-slashing costs;
- Assumes the spray barriers are created and maintained for two years, by which time there is further eradication work being done along the limits of the Zone;
- Compensates for the lack of a hand-cleared barrier by more intensive re-surveys of 20% of the area which continue annually for five years.1/

Total cost is 853,403,000 MF or $2,032,000.

Excluded from these cost estimates are the following research costs which are partly attributable to the eradication scheme but which also include a large element of training and experimentation. These are:

	1000 MF
One-year protozoological survey	75,804
One-year socio-economic study	60,664
The insecticide trial	29,732
Six months' familiarization by the tsetse control officer	23,100
Total	189,300

These costs are given at current prices for the year in which the work is undertaken. Some of the work has already been accomplished by New Lands, some remains to be completed or to be initiated. These extra costs amount to 189,300,000 MF or $451,000.

1/ This reduction in cleared barrier costs and increase in survey cost is a hypothetical scheme worked out so as to present its economic implications by the writers of the report and was not proposed in Okiwelu et al., 1980. The cleared barrier is considered to be a safer method.

The cost per square kilometer sprayed is 1,115,000 MF or $2,650. This cost is very high for a number of reasons:

- The two most expensive items, technical assistance and vehicles, are used in very large proportions to the less expensive, variable cost items, primarily labor and insecticide.
- This effect is enhanced by the scattered nature of the infestations in Zone 1. Very small spray teams, needing a similar logistic support to that required by the far larger teams conventionally used, travel about to spray extremely small areas. The fuel and traveling time, with associated per diem required for the operation, adds considerably to the overall cost.
- It is not believed possible to divide Zone 1 up into smaller self-contained areas which could be eradicated separately, since there are no suitable natural barriers.1/ This fact is what leads to the very high cost of spray barriers, equivalent to 42% of spraying costs, and to the high costs of re-spraying and clearance and re-slashing of barriers as given in Table 9.12.

These explanations all illustrate the problems of making a concentrated effort at attacking the tsetse fly in an area like Zone 1 which has no natural geographical limits and which has an extremely scattered fly population.

Finally, it should be noted that the cost of intensive studies by all three sections at New Lands is very high relative to the cost of eradication and, as is seen in Chapter 13, relative to the benefits to be expected. This is due to the fact that a region like Zone 1, which does not have a major trypanosomiasis problem, still requires the same level of research as one where the tsetse fly is a major constraint on agriculture and livestock.

D. Alternative Approaches: Helicopter Spraying and Control Work

These approaches are dealt with only briefly, as it is

1/ Personal communication, Dr. S.N. Okiwelu.

the stated opinion of the Entomological Section that they are unsuitable for Zone 1. Helicopter spraying is regarded as less effective and less suited to the area than discriminate spraying from the ground.[1/] Control work would only really be possible where natural barriers exist.

A rough idea of the costs of helicopter spraying can be given using examples from the northern Guinea Zone of Nigeria (Tsetse and Trypanosomiasis Division Annual Report 1976-7). The helicopter program had been underway for some time, and an efficient working system had been developed. Two helicopters, a maintenance crew for each in a landrover, and the insecticide mixer were rented from a German company. The cost of these items was included in a helicopter hire charge which, in 1979, was about $1300 an hour. The cost of support staff, consisting of some laborers and drivers for the food truck plus some camping equipment, was given separately. The main component of cost was helicopter flying time, which averaged 58 hectares/hour of spraying. This implies that Zone 1 would require about 350 hours flying time for the actual spraying, and possibly more since the above timing was for a very experienced team. The flying between infestations would add at least another 400 hours. The cost of helicopter hire is probably around $1800 an hour now, so the total cost of the helicopter spraying element of the scheme would be $1,350,000 or 567,000,000 MF. This is more than twice the cost of the proposed ground-spray program, excluding the cleared barrier, and about one and a half times the cost with the barrier clearing included. The cost of the preliminary studies and post-spray re-surveys would remain the same.

The use of the word "control" as applied to tsetse flies has been subject to many interpretations. A control scheme is sometimes understood to be a cheap alternative to eradication. If it is taken to mean a scheme involving regular, probably

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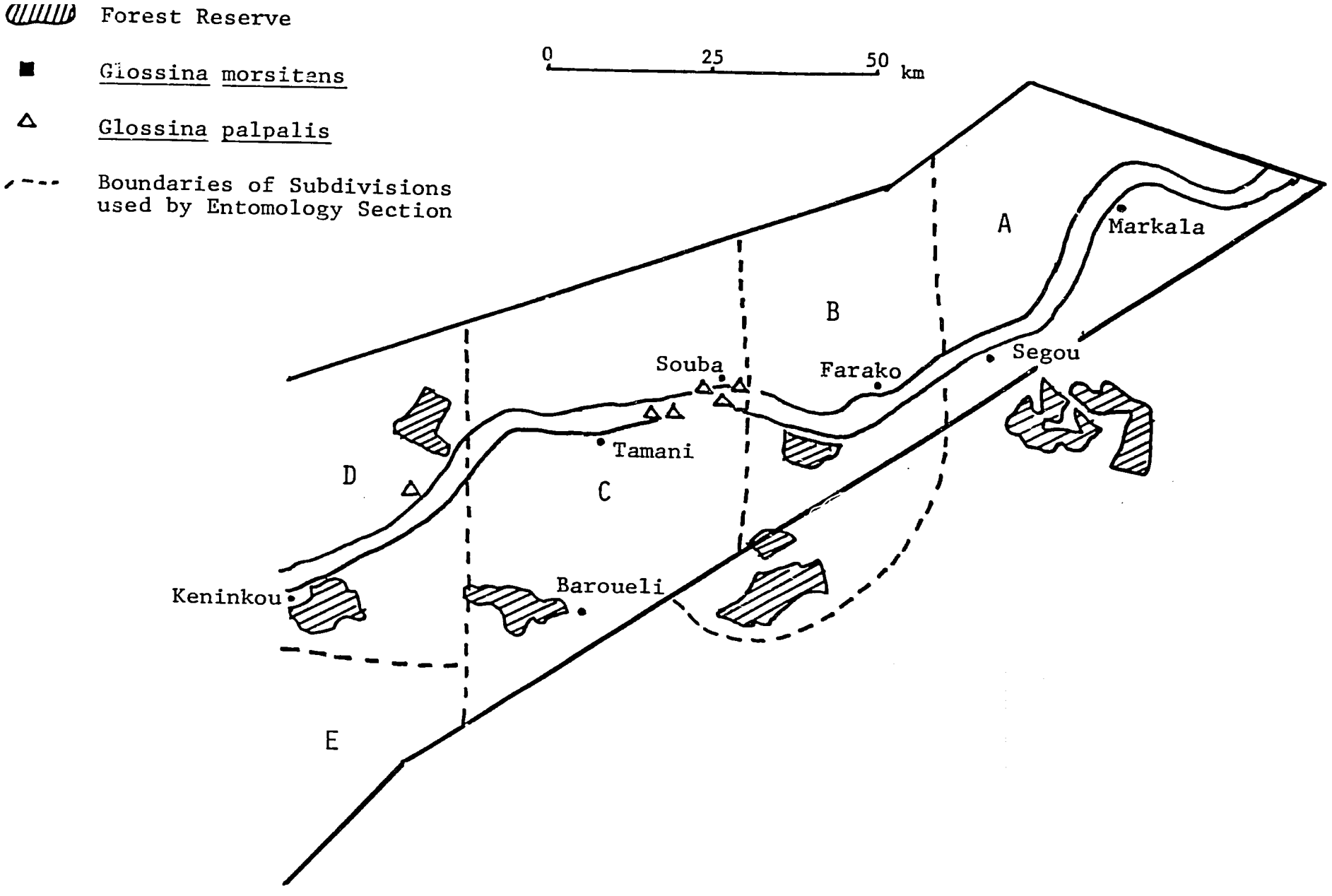
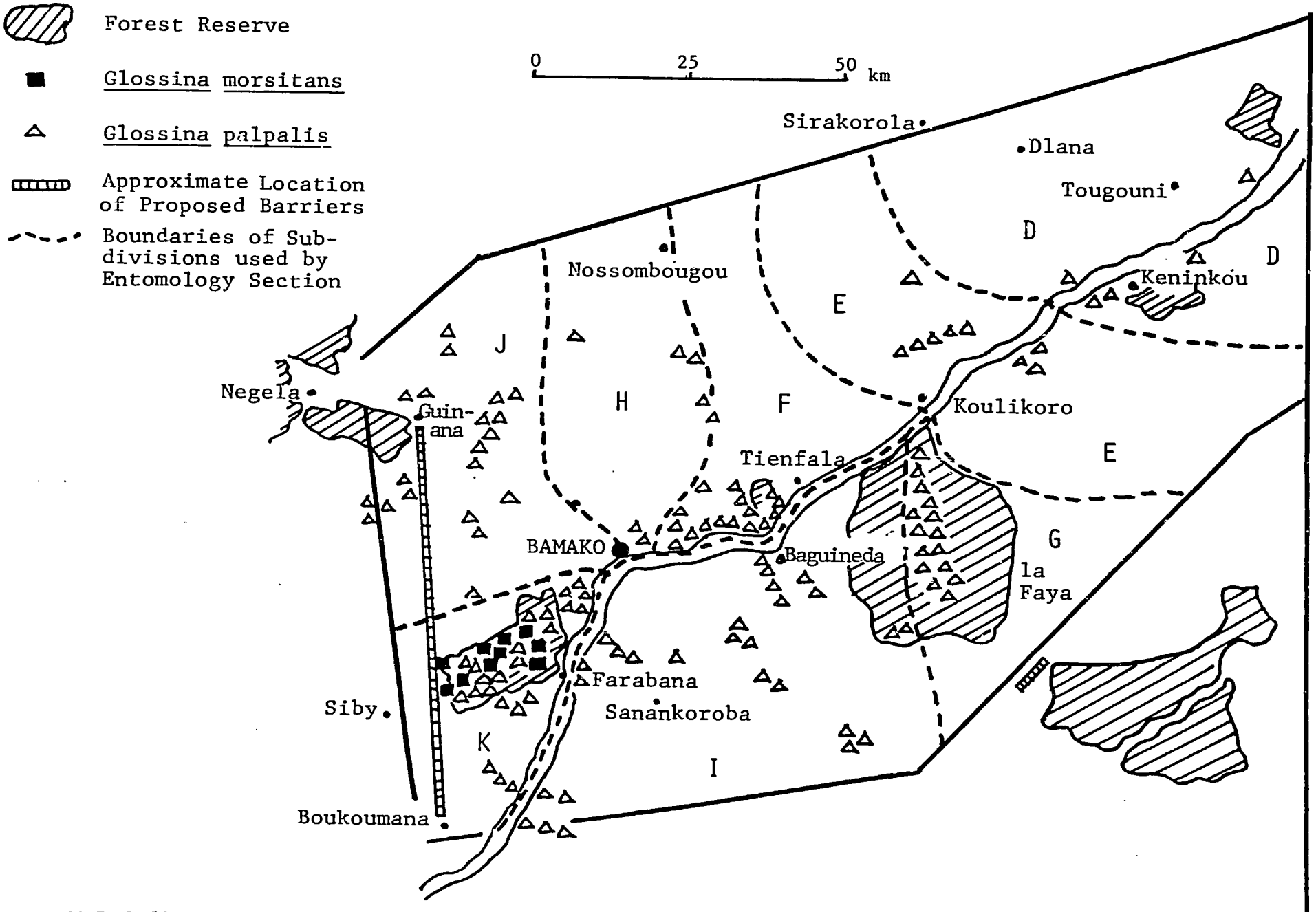
1/ Personal communication, Dr. S.N. Okiwelu.

annual spraying, of an area where the tsetse flies cause particularly serious losses, the following observations can be made. As regards Zone 1, control has not been recommended by the entomologist. From the economic point of view, a control project is always expensive because it consists of annually repeated costs with a high barrier cost component. Control is only justified if extremely heavy disease losses or a serious constraint, for example, to the use of a water resource, are posed in a small, limited area, or if a small but significant and isolated infection can be dealt with cheaply. In the latter case, a small-scale "eradication" of of a fly focus would in fact be taking place. The lack of natural barriers and wide prevalence of the disease in Zone 1 is such that these situations do not arise. The only possible candidate for "control" work would appear to be the scattered focii of G. palpalis along the Niger river near Tamani, since they are in an area where the human disease has been endemic. The human disease incidence is not at present very significant, but these areas should be investigated in any case.



MAP 9.1a - Distribution of Tsetse Flies - Late Dry Season - Northeastern Part of Zone 1

Source: Okiwelu et. al., 1980.



MAP 9.1b - Distribution of Tsetse Flies - Late Dry Season - Southwestern Part of Zone 1

TABLE 9.1

BASIC PARAMETERS FOR HYPOTHETICAL ERADICATION PROGRAM FOR ZONE 1

Team and Sectors	Nature of Work or Infestation	Linear Km	Equivalent Km.^{2}	Days Required		
				Spraying	Travel	Total
1) BCDE	15 scattered pockets of G. palpalis	37	10	18	22	40
	Chemical barrier between forest reserves La Faya and Sousson Banifing	5	5			
2) FHJ	25 pockets of mainly G. palpalis	97	25	24	20	44
3) K	Mountainous Area					
a)	5 pockets of G. morsitans	-	50	50	10	
b)	14 linear infestations of G. palpalis	45	12	12	20	
	Total		62	62	30	92
4) IG	16 pockets of mainly G. palpalis	75	19	20	20	40
5)	Chemical barrier from the Niger at Bankoumana to Guinana	75	80	40	20	60
	Total		201	164	112	176

Source: Okiwelu, Maiga and Van Wettere 1980, Annex. Some subsequent rounding of figures for days needed has been done here.

Note: It is estimated that a four-man spray team can deal with 4 km. of linear infestation (estimated to be 250 M wide) a day. The barriers are 1 km. wide.

STAFF AND VEHICLES NEEDED FOR ERADICATION WORK IN THE FIELD

Team and Sectors	Staff										Vehicles		
	Pump Operators	Path Cutters	Porters	Watch Men	Mechanics	Drivers	Tech. Assist.	Tech. Officer	Sprayers	Total	Land-Rovers	Trucks	Km. Travelled Per Vehicle
1) BCDE	6	4	4	1	1	3	2	1	4	26	2	1	5000
2) FHJ	6	4	4	1	1	3	2	1	4	26	2	1	2500
3) K a) and b)	12	10	10	1	1	4	3	1	8	50	3	1	2500
4) IG	6	4	4	1	1	3	2	1	4	26	2	1	2500
5) Barriers	10	10	10	1	1	4	3	1	8	48	3	1	5000
Total	40	32	32	5	5	17	12	5	28	176	12	5	

Source: Okiwelu *et al.*, 1980, Annex.

Note: 1 spare sprayer is included in the total.

TABLE 9.3

STAFF COSTS FOR ENTOMOLOGICAL STUDIES AND FOR ERADICATION WORK

a. SALARIES - PERMANENT STAFF

Category	Number Currently Employed	Extra Needed for Eradication Work	Monthly Salary MF	Annual Current Cost MF	Additional Annual Cost MF
Technical Officer	4	1	69,000	3,312,000	828,000
Technical Assistant	7	5	52,000	4,368,000	3,120,000
Drivers for Landrovers	10	2	24,000	2,880,000	576,000
Drivers for Trucks	0	5	30,000	-	1,800,000
Mechanics	0	5	30,000	-	1,800,000
Insecticide Pump Operators - Fly Capturers	33	7	20,000	7,920,000	1,680,000
Watchmen	0	5	19,000	-	1,140,000
Total	54	30		18,480,000	10,944,000

STAFF COSTS FOR ENTOMOLOGICAL STUDIES AND FOR ERADICATION WORK

b. MONTHLY BONUSES - PERMANENT STAFF

Category	Number Currently Employed	Extra Needed for Eradication Work	Monthly Bonus MF	Annual Current Cost MF	Additional Annual Cost MF
Technical Officer	4	1	15,000	720,000	180,000
Technical Assistant	7	5	12,500	1,050,000	750,000
Drivers for Landrovers	10	2	5,000		
Drivers for Trucks	0	5	5,000		
Mechanics	0	5	5,000	2,580,000	1,440,000
Insecticide Pump Operators - Fly Capturers	33	7	5,000		
Watchmen	0	5	5,000		
Total	54	30		4,350,000	2,370,000

c. PER DIEM AND DAILY-PAID STAFF FOR SPRAYING PERIOD AND ENTOMOLOGICAL STUDIES

Category	Number Per Diem	Number Currently Used	Cost at 200 Days / Year	Total Days per Category for Eradication	Cost for Eradication
				Number x Average Day	
Ingenieur (Technical Officer)	2500	4	2,000,000	5 x 45 = 225	563,000
Technician (Technical Assistant)	2000	7	2,800,000	12 x 45 = 540	1,080,000
Drivers, Mechanics, Capturers, (Pump Operators) and Watchmen	1500	10	3,000,000	67 x 45 = 3015	4,522,000
Daily-Paid Laborers (daily rate)	750	-		1500	1,125,000
Total					7,920,000

Note: Daily-paid laborers are employed only during the spraying period plus five days help with moving camp, etc., per team. They pump water and act as path cutters and carriers for insecticide and water. Since they are recruited locally, no camping equipment or provision for food is required for them.

TOTALS

Current Cost:

Salaries and Monthly Bonuses:	22,830,000 MF
Per Diem:	7,800,000
Total:	30,630,000 MF

Eradication Cost:

Extra Staff Salaries:	13,314,000 MF
Per Diems:	7,920,000
25% of Other Staff Salaries:	5,708,000
Total:	26,942,000 MF

VEHICLE COSTS FOR ENTOMOLOGICAL RESEARCH AND ERADICATION WORK

Item	Current Number	Extra Required	Unit Cost MF	Total Current Cost MF	Total Extra Cost MF
Landrovers - Pick-up	2	-	9,800,000	19,600,000	
Landrovers - Cars	8	2	11,300,000	90,400,000	22,600,000
3 - Ton Trucks Saviem TP 3 4 x 4	-	5	17,600,000	-	88,000,000
Total				110,000,000	110,600,000

	Current Cost	Extra Cost
Annual depreciation over 3 years	36,700,000 MF	36,900,000 MF
Maintenance and spares. 30%	11,000,000	11,100,000
Fuel		
• Current cost 200 km/day for 200 days at 25 liters per 100 km, 350 MF/1. for ten landrovers	35,000,000	
• Eradication program total of 42,000 Km. for landrovers at above consumption rate		3,675,000
total of 17,500 km. for trucks at 33 1/100 km at 350 MF/1.		2,042,000
Lubricants - 10% of above	3,500,000	572,000
Total Annual Vehicle Costs	86,200,000 MF	54,290,000 MF

COST OF CAMPING EQUIPMENT FOR ENTOMOLOGICAL FIELD WORK

			Total Cost
a. CURRENT ANNUAL COST			
3 teams' depreciation on equipment, each:	1,144,000 MF		3,432,000 MF
3 teams' fuel, each:	718,000 MF		2,154,000 MF
54 staff individual equipment, each:	35,000 MF		1,890,000 MF
		Total	7,476,000 MF
b. EXTRA ANNUAL COST FOR ERADICATION			
A further 2 teams are set up,			
2 teams' depreciation on equipment, each:	1,144,000 MF		2,288,000 MF
2 teams' fuel, each:	718,000 MF		1,436,000 MF
30 extra staff, individual equipment, each:	35,000 MF		1,050,000 MF
		Total	4,774,000 MF
c. TOTAL ANNUAL COST FOR ERADICATION WORK			
Annual depreciation on extra equipment for eradication			4,774,000 MF
25% of annual depreciation on existing equipment, since 50 out of the 200 days in the field are spent on the eradication work			1,869,000 MF
		Total	6,643,000 MF

TABLE 9.6

COSTS OF ENTOMOLOGICAL EQUIPMENT

a. FIELD LABORATORY FOR ENTOMOLOGICAL WORK

Item	Number	Unit Cost in US $	Total Cost $	Annual Cost 1/ $
Simple Microscope (depreciated over 20 years)	1	180.00	180	9
Microscope Slides	2000	-	65	65
Microscope Cover Slips	2000	-	68	68
Diamond Pencil	2	4.50	9	
Plastic Wash Bottles	6	4.20	24	
Insect Stockade	5	12.00	60	
Stockade Box				
Insect Kill Jars	50	3.00	150	
No. 2 Insect Pins	50 packets of 100	1.60	80	
Test Tube Racks	10	7.20	72	
Plastic Test Tubes	500	1.50	750	719
Chloroform	20 litres	7.00	140	
Hand Lenses	25	6.50	163	
Air/Water Recording Thermometers	10	12.00	120	
Pocket Sling	5	18.00	90	
Psychrometer				
Miscellaneous	-	300.00	300	
Glass Ware				
Glass Vials and Stoppers	100	2.00	200	
Total Cost US $			2,471	861
Increased by 20% for freight cost				$1,033
Converted to MF at $ 1 = 420 MF				434,000 MF

Note: 1/ The microscope is assumed to last 20 years. The slides and cover slips last one year. All other equipment lasts for three years.

TABLE 9.6 (CONTINUED)

b. COST OF TSETSE FLY TRAPS

250 Challier traps are needed. They are locally made at a cost of 15,000 MF each. Although they are subject to a lot of wear and tear, they can be repaired and are expected to last five years.

Total cost, therefore, is:	3,750,000 MF
Annual Cost is:	750,000 MF

TABLE 9.7

COSTS OF HAND-OPERATED NON-PRESSURE-RETAINING INSECTICIDE SPRAYERS

Model	Maker	Given Output	Capacity	Unit Cost $	Estimated Sea Freight Cost for 40 Sprayers $	Total Cost for 40 Sprayers $
CP 148	Cooper Pegler Sussex, England	168 liters/ha at 3 km/hour	16 liters	166	800	7,440
Eclipse 'Modern' Knapsack Sprayer	Eclipse Sprayers Warley, England	N/A	15 liters	77	800	3,880
Hudson Sprayer Model 6367	Hudson Sprayers Chicago, USA	95 liters/ hour	17 liters	50	2000	4,000

Maximum Water Requirements:

CP 148: Pump operators on the project are expected to cover a maximum of 3 ha/hour walking at 2.5 km/hour. This would require 420 liters/hour at a maximum, but because discriminative spraying is used rather than full coverage probably only half that amount would be used, i.e., 210 liters/hour. This implies 13 refills, and using 900 gram active ingredient (a.i.) per hectare, a mixture of 1.3% a.i., in water, the total hourly water requirement for the four-man team is 850 liters.

Hudson Sprayer: At 95 liters per hour a maximum of 5 to 6 refills are needed, a maximum per hour. At 32 liters per hectare, the mixture would be just under 3% a.i., of insecticide in water. The total hourly water requirement for the four-man team is a maximum of 380 liters.

TABLE 9.8

WATER CARRYING AND PUMPING EQUIPMENT

Using the Hudson sprayer, about 400 liters of water an hour are needed. The truck will fill two 200-liter drums an hour and exchange them with the empty drums at the spraying site. One water pump is needed at the water point to fill the drums and one at the spraying site to empty the drums. The porters work at this task and at refilling the sprayers.

For the 7 units of 4 active pump operators each (4 each in teams 1, 2, and 4, and 8 in teams 3 and 5) needed are:

Drums

1) 7 x 4 plus 2 spare = 30 200-liter drums
   each costing 8000 MF, at a total cost of 240,000 MF

Pumps

2) 7 x 2 + 2 spare = 16 hand pumps, each costing 80,000 MF, at a total cost of 1,280,000 MF

If the equipment lasts three years, the annual depreciation cost is 510,000 MF.

TABLE 9.9

INSECTICIDE COSTS FOR ERADICATION WORK

For 201 km^2 at 900 g. a.i., a total of 20 tons of active ingredient is needed. The following estimates of costs were obtained.

		CIF/Abidjan/per ton - $
• Lindane (Gamma BHC) (basic active ingredient cost, but formulation required)	Supplied from France (CIF Bamako)	14,500
	Supplied from USA	13,750
• Endosulfan		5,000
• DDT water dispersible powder 75%		2,075
• DDT Calculated cost per ton of active ingredient		2,800

Although Lindane was recommended as being one of the few residual insecticides currently in use in the USA (Okiwelo et al., 1980), DDT is used as a standard in these calculations. After suitable trials the toxicology report will assess what insecticide should be used. Endosulfan is currently used by helicopters in Nigeria but only for ULV spraying. It is felt that, as well as being cheap, DDT, having been successfully used in tsetse control work for many years, provides a suitable standard to determine a cost that is a representative of such schemes elsewhere in the world.

Total Insecticide Cost is: $56,000 or 23,520,000 MF.

TABLE 9.10a

SUMMARY OF ANNUAL COSTS OF STUDIES BY THE ENTOMOLOGY SECTION

Item	Current Program	
	1,000 MF	% of Total
1. Staff		
• Salaries	18,480	
• Monthly Bonuses	4,350	
• Per Diem	7,800	
Total	30,630	16.6
2. Vehicles		
• Depreciation	36,700	
• Maintenance and Spares	11,000	
• Fuel and Lubricants	38,500	
Total	86,200	46.6
3. Camping		
• Depreciation of Team Equipment	3,432	
• Depreciation per individual	1,890	
• Fuel	2,154	
Total	7,476	4.0
4. Equipment		
• Fly Traps	750	0.4
5. Field Laboratory	430	0.2
6. Administration	13,547	7.3
7. Technical Assistance	46,200	24.9
Total	185,233	100.0

TABLE 9.10b

SUMMARY OF THE COSTS OF ONE YEAR OF ENTOMOLOGICAL PROTOZOOLOGICAL AND SOCIO-ECONOMOMIC STUDIES IN ZONE 1

Item	Protozoology Section		Entomology Section		Socio-economic Section	
	1000 MF	%	1000 MF	%	1000 MF	%
1. Staff	4,175	5.5	30,630	16.6	4,344	7.2
2. Vehicles	9,550	12.6	86,200	46.6	7,245	11.9
3. Camping Equipment	2,002	2.6	7,476	4.0	165	0.3
4. Headquarters Laboratory	2,942	3.9	750	0.4	-	-
5. Field Laboratory	103	0.1	434	0.2	-	-
6. Administration	10,837	14.3	13,547	7.3	2,710	4.5
7. Technical Assistance	46,200	61.0	46,200	24.9	46,200	76.1
Total	75,804	100.0	185,233	100.0	60,664	100.0

Total for one year's intensive study in an area the size of Zone 1 by all three sections is 321,701,000 MF or 766,000 US $

TABLE 9.11

COST OF ERADICATION PROJECT IN ZONE 1 FOR 201 KM^2

Item	Cost for Scheme	
	1,000 MF	%
Staff		
1. Staff - for Eradication Work		
• Salaries	10,944	
• Monthly Bonuses	2,370	
• Per Diem	6,795	
• Daily-Paid Laborers	1,125	
2. 25% Share of Current Salaries and Bonuses	5,708	
Total Staff Costs	26,942	12.0
Vehicles		
• Depreciation on Vehicles Bought for Eradication	36,900	
• Maintenance and Spares for Above	11,100	
• 25% of Maintenance, Spares and Depreciation of Currently Owned Vehicles Used on the Project	11,925	
• Fuel for All Vehicles for Eradication Work, Plus Lubricants	6,289	
Total Vehicles	66,214	29.6
Special Equipment		
• Insecticide	23,520	
• Sprayers	588	
• Water Supply	510	
Total Equipment	24,618	10.9
Camping Equipment		
• Depreciation on Extra Equpiment Needed	4,774	
• 25% of Depreciation on Existing Equipment	1,869	
Total Camping	6,643	3.0

TABLE 9.11 (CONTINUED)

COST OF ERADICATION PROJECT IN ZONE 1 FOR 201 KM^2 (CONTINUED)

Item	Cost for Scheme	
	1,000 MF	%
Technical Assistance		
• 6 Months Entomologists Work (½ of his annual input)	92,400	41.3
• 6 Months Toxicological Input		
• 1 Year Tsetse Control Specialist		
Administration Cost		
25% of Cost of the Expanded Section	7,144	3.2
Total	223,961	100
Hand Cleared Barrier	153,000	68 (of above figure)
Total Plus Barrier Clearing	376,961	168

Average Cost per Km^2 Sprayed, Excluding Clearing of Barriers:	1,115,000 MF or $2,650
Annual Respray of Barriers: 85 km^2 at 1,114,000 MF Each:	94,775,000 MF
Annual Reslashing of Barriers, at 20% of the Cost of the Original Clearing:	30,600,000 MF
Total Annual Barrier Maintenance Cost:	125,375,000 MF

TABLE 9.12

THE COSTS OF AN ERADICATION PROJECT

a. HIGH COST ESTIMATE		Cost in Year	1000 MF Present Value in Year 0
Year - 2	Full Entomological Survey of Zone 1	185,233	232,356
Year - 1	Partial Resurvey of 50% of Zone 1	92,617	103,371
Year - 0	Eradication Plus Hand Cleared Barriers	376,961	376,961
Year 1 - 5	Barrier Maintenance Including Reslashing	125,375	451,949
Years 1, 2 and 5	Resurvey of Sprayed Areas 10 of the Zone Surveyed	18,523	41,815
Total Present Value in Year 0			1,206,452

b. REDUCED COST ESTIMATE		Cost in Year	1000 MF Present Value in Year 0
Year - 2	Full Entomological Survey of Zone 1	185,233	232,356
Year - 1	Partial Entomological Survey of 50% of Zone 1	92,617	103,371
Year - 0	Eradication, Excluding Hand Cleared Barriers	223,961	223,961
Years 1 - 2	Respray of Barriers	94,775	160,175
Years 1 - 5	Annual Resurveys - 20% of Zone Surveyed	37,046	133,542
Total Present Value in Year 0			853,405

SECTION C

THE BENEFITS ATTRIBUTABLE TO A REDUCED INCIDENCE OF TRYPANOSOMIASIS IN ZONE 1
(Chapters 10-12)

CHAPTER 10

THE DIRECT BENEFITS OF A REDUCTION IN THE INCIDENCE OF ANIMAL TRYPANOSOMIASIS

The distinction between the direct benefits attributable to a reduction in the incidence of trypanosomiasis and the indirect benefits resulting therefore was made in the main introduction. This chapter, and that on the human disease, is based on projections of the populations from current trends as calculated in Chapters 2 and 3. From these, corresponding projections of current disease losses were made to be compared with the costs of prophylaxis, treatment and eradication.

A. The General Health Situation of Cattle in Zone 1

Very little is known of the current disease situation in Zone 1. The Protozoology Section's survey of trypanosomiasis is the only systematic animal disease survey done in the Zone. Certain contagious diseases have to be reported, so most cases of these are known. Table 10.1 gives the number of outbreaks, sick cattle and deaths for those cases reported in 1978. Pasteurellosis is the most important disease, followed by authrax and blackleg.

The traditionally important contagious diseases, rinderpest and contagious bovine pleuro-pneumonia, are rare now, largely due to the widespread vaccination campaigns (Table 10.2).

Table 10.2 shows where the bulk of veterinary effort is being directed. From Table 7.1 it can be seen that two-thirds of all work consists of vaccinations, which are given free. Trypanosomiasis treatments and treatments for gastro-intestinal parasites take up the bulk of the rest. These are paid for by the livestock owner. The way in which the veterinary effort is distributed, however, probably reflects more the tradition of vaccination campaigns and the importance which herders place on trypanosomiasis treatments than it does the real disease spectrum.

Some idea of the current disease situation was obtained during the team's visits with the Livestock Service sector heads in each of the seven cercles. Trypanosomiasis was thought by all to be of great importance. In Dioila we were told that large numbers of deaths could be attributed to it annually, although this may have referred more to the southern part of the cercle, whose northern extremity is the only part included in Zone 1. In Kati and Koulikoro, trypanosomisasis was considered to be a serious problem. In Banama and Kolokani, it is usually brought back by the transhumants after they have been south in the dry season. In Segou the problem is mainly found near the Bani River and cases in the rest of the cercle are usually imported. In Baroueli, there are thought to be few cases, usually associated with an animal rendered susceptible by malnutrition. This information correlates very well with the infection rates found by the protozoology survey (Table 10.3).

The problem that emerged as most important, or at least equal to that of trypanosomiasis in the veterinary agents' opinions, was gastro-intestinal parasites. These were emphasized again and again in every cercle. In Dioila it was estimated that almost all domestic animals were affected.

Pasteurellosis was cited as a major problem in Kolokani where there were eleven outbreaks in 1979 leading to 84 deaths. It was also mentioned as being of importance in Koulikoro.

Finally, all sectors emphasized the problem of water and fodder shortage in the dry season, leading to malnutrition and increased susceptibility to disease, particularly in the last months of the dry season.

Though it was not mentioned specifically by any of the people met with, it must be noted that calf mortality (of cattle in their first year of life) accounts for nearly three quarters of all cattle deaths. Calf mortality is due to a

variety of causes which are beyond the scope of this report, but trypanosomiasis, while a minor factor, may be included. From the herd composition figures in Annex A it can be calculated that for transhumant herds, out of 11.3 deaths per annum per 100 animals, 4.0 are adults, 5.0, male calves and 3.3, female calves. In sedentary herds of 11.4 deaths per annum per 100 animals, 3.2 are adults, 5.0, male calves and 3.2, female calves. Although it could be argued from the price calculations in Chapter 3, Section G, that calves have a very low value when compared to animals two or three years older, and hence the loss is not so serious, it must be remembered that this low value is a direct result of their low probability of survival.

B. Current Losses in Cattle Due to Trypanosomiasis

Although a lot of research has been done over the years on the behavior and characteristics of tsetse flies, remarkably little is known about the progress and severity of animal trypanosomiasis of which they are the vector. Thus in this section, more than in any other part of this report, it has been necessary to make the most reasonable assumptions possible in order to overcome an almost complete lack of information.

The only concrete data available were the results of the Protozoology Section's dry-season survey. As explained in Chapter 3, Section D, we were allowed to make use of this as yet unpublished data. Data were reclassified by arrondissements and cercles to conform with the administrative boundaries, which has made it possible to see clearly some of the relations between the disease distribution and the fly population and to obtain an estimate of the overall incidence of the disease.

1. Infection Rates

Table 10.3 gives the percentage of positive cases detected for Ndamas , Meres, Zebus and for the total sample

undertaken in Zone 1 during the dry season. The wet-season survey was not complete at the time of writing, but preliminary findings indicate a higher infection rate than in the dry season, as would be expected. Since the area occupied by tsetse flies expands during the wet season as they disperse, this is usually the time when most infections are expected to occur. In the dry season, however, cattle are concentrated at watering points. The flies are also concentrated there, especially the riverine tsetse flies such as G. palpalis, which is the dominant tsetse fly in the Zone. There is consequently a high degree of contact between cattle and the flies.

It is felt that using dry-season figures has some advantages. In calculating costs and benefits of various forms of controlling trypanosomiasis in this study, it is necessary to distinguish between various policies. The current practice of partial prophylaxis and treatment is already having an effect in reducing the level of direct production losses caused by the disease, but what these losses would be in the absence of the treatments is unknown. In the cost-benefit calculations, these losses are simply substituted by the cost of the current policy, as indicated in Figure 13.

The object of this chapter is to calculate the remaining direct losses caused by untreated cases of the disease. For this purpose, the dry-season incidence data is useful since it represents the cases of trypanosomiasis remaining after most treatments have taken place. Similarly, if some cattle are able to shake off the disease relatively rapidly and to recover they would not be included. One possible disadvantage to using the dry-season incidence figure is the existence of imported disease contracted outside the Zone by nomadic cattle who are present only in the dry season. This study, since it is comparing the costs of tsetse-fly control within the Zone to other measures, is only concerned with disease originating from tsetse flies within the Zone.

As noted before, however, the protozoological survey focussed to some extent on sedentary herds. Table 10.4 gives the proportion of sedentary herds as a percentage of total herds sampled by cercle. These figures, in fact, compare well with the rough percentages estimated in Table 3.4 and discussed in Chapter 3, Section B, except in Segou and Baroueli where one would expect more nomadic herds. The only cases of trypanosomiasis found there were in nomadic herds. A full discussion of the disease in nomadic and sedentary herds and whether the nomadic herds have imported disease, or a higher incidence, or higher susceptibility, must await the full report of the Protozoology Section. In this report, it is assumed that all disease cases identified originated in the area, since most nomadic animals come to the area to spend the dry season from non-tsetse fly-infested area (Map 3.3). Transhumants are assumed to suffer greater losses from the disease (Table 10.7) but with the same incidence of trypanosomiasis. The latter assumption can clearly be improved upon when more data is available, but due to the low disease incidence in areas frequented by transhumants this data will not significantly affect the overall results and will also be balanced out by the higher losses attributed to the transhumants.

Similarly, until the full report of the Protozoology Section is available, it is not possible to distinguish positively between infectivity rates applicable to the different breeds. In Kati, a lower percentage of Zebus than Meres were infected. In Segou and Baroueli, only Zebus were infected, but these were also transhument. In Koulikoro, the infection rates among Zebus was higher, but a large proportion of these were probably also transhument. The question of different breeds and trypanosomiasis is further discussed in Chapter 12.

Thus the average dry-season infection rates in Table 10.3 are assumed to apply to all cattle, with the much higher losses

applying to transhumant Zebus, implicitly reflecting the fact that they appear to be the group most at risk.

The second main assumption, in the absence of evidence to the contrary, is that this infection rate would stay more or less constant over the next 20 years. The only decline which is expected is that of 25% in Kati cercle due to a reduction in the numbers of G. morsitans, as explained in Chapter 6. Otherwise it seems that the tendency towards an increase in incidence and the tendancy towards a decrease are balanced.

- The G. palpalis population is not expected to change significantly, since it can co-exist for a long time with very high human population densities, and is able to inhabit groves of fruit trees and even scant riverine vegetation in order to survive.

- The current drug abuse associated with clandestine treatments, often administered at too low a dosage, and the lack of diagnostic facilities, which means that Berenil is often administered when it is not needed, could eventually lead to drug resistance and to a rise in disease incidence. As yet there is no evidence of such resistance.

- On the other hand, most of the Ndama and Mere stock and even some Zebus are well acclimated to the Zone by now, due to the increasing sedentarization of the cattle herd in recent years, as farmers invest such profits as they make in buying cattle, to which is added continuing rapid growth of numbers of work oxen. The result will be that an increasing proportion of the cattle herd will have spent several generations in a particular locality and will thus have acquired a high degree of resistance to its health problems, including trypanosomiasis.

2. Proportion of New and Old Infections in the Average Dry-Season Trypanosomiasis Infection Rate

The ratio of new infections originating in the year of the survey to old infections, if the proportion of infected animals remains constant, can be derived as follows. During the course of one year, of 100 infected animals detected in

the dry season, some would die from causes unrelated to trypanosomiasis. In Table 10.5, the average life expectancy of the average animal is calculated to be only 3.5 years, so that 30% of all animals die or are slaughtered annually. This would leave about 70 of the original 100 infected animals. Trypanosomiasis deaths and recoveries are assumed to remove another 10 to 15 animals (Table 10.7). Taking into account a higher than average death rate among the remainder, some of whom would be weak from trypanosomiasis, a maximum of 55 infected animals would be left. Thus, if 100 animals are again detected the following dry season, at least 45 of these represent new infections. This proportion is taken and multiplied by the dry-season infection rate to give a realistic but conservative estimate of annual new infections.

The difference between the wet- and dry-season infection rates has thus successfully been disposed of, since cattle deaths and ordinary trypanosomiasis deaths and recoveries are accounted for, for the whole year. The remaining difference between the rates is due to rapid recoveries and successfully treated cases of trypanosomiasis. As explained above, the effects of the current treatment policy are not analyzed here. Very rapid recoveries lead to no loss, so all the differences have been resolved.

Table 10.6 thus gives the infection rates used in the Zone, based on the Protozoology Section's dry-season results. From Table 10.3 taken in conjunction with the fly distribution Map 6.1, it becomes clear that there is a high correlation between fly-infested areas and those where the infection is found. Segou and Baroueli are virtually free of the disease. Koulikoro has a higher infection rate than Dioila, probably because the Compagnie Malienne de Developpement Textile (CMDT) has fostered the use of work oxen for plowing and, together with the efforts of the Livestock Service, maintains in Dioila the highest level

of treatment and prophylaxis existing in the Zone. As would be expected, Kati has by far the highest infection rate in the Zone. The disease distribution points to the possibility of the existence or low-density G. morsitans populations in the Zone, which could not easily be detected by the methods of capture used.[1/]

3. Production Losses in Cattle

As a disease, trypanosomiasis is very complex and can take many different courses. In acute cases, the animal will die fairly rapidly. On the other hand, some animals probably recover fairly quickly with minimal ill effects. An animal that has been treated will also recover quickly. The disease may also become chronic in an affected animal. In that case the animal will continue to have the disease until it dies, whether from other causes altogether, or whether, being weakened by trypanosomiasis, it becomes more susceptible to another disease.

In the chronic situation, emaciation, loss of fertility and loss of ability to work, in the case of oxen, may ensue. In addition, cattle with trypanosomiasis are highly susceptible to the skin disease streptothricosis[1/], so that even if slaughtered, a large proportion of their hides are valueless.

Of the infected cattle seen in the field by the Protozoological team, few presented visible signs of the disease. In the case of Farabana village in the arrondissement of Kalabankoro in Kati cercle, situated on the edge of the Mont Mandingues Forest Reserve (Map 6.1), a severe outbreak was monitored. The affected herds showed the characteristic emaciation, were sickly and anaemic, had a rough body coat and the swollen glands which

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1/ Personal communication, Dr. Awan

are associated with the disease. Half the animals examined were positive cases of trypanosomiasis. High mortality was recorded in the past year, especially among calves, affecting sixteen of one herd's 150 animals.[1/] (Some of the calf mortality may have been independant of trypanosomiasis, given the 25 to 40% mortality rates applying to calves in the first year.) In addition there were nine abortions in that herd. The other herd of 130 animals recorded nine mortalities, also mostly calves. This was the most severe outbreak of trypanosomiasis encountered by the team.

Significant outbreaks were encountered in two other villages. At Tyele, at the southern limit of the Zone in the arrondissement of Fana (Map 6.1), two herds of about 70 animals each were examined. Ten percent of cattle sampled were positive cases. So far there had been no abortions or mortality. In one herd, all animals had swollen glands and 15 were very weak and could be described as clinically sick. In the other herd, there were few clinical signs and few enlarged glands. It is likely that mortalities would have occurred if drugs had not been provided.

The third village was Dlana in Sirakorola arrondissement in the northern part of the cercle of Koulikoro. One herd of 48 animals was nomadic. It had experienced one death two weeks previously, possibly from trypanosomiasis, and the herd was in fair condition. The second herd of 50 animals was sedentary and showed no obvious signs of the disease. Berenil had been administered a year ago.

In the other villages sampled during the dry season, there were very few clinical signs of the disease, and no history of mortalities was given, although positive cases of trypanosomiasis were diagnosed in the survey.[2/]

1/ Personal communication, Dr. Awan.

2/ The above description of the disease in the three villages was provided by Dr. Awan of the Protozoology Section.

4. Hypothetical Projection of Production Losses in Cattle in the Zone over 20 Years

From this information, an estimate of the likely results of contracting trypanosomiasis which remains untreated is given in Tables 10.7 and 10.8. Four main results exist: rapid death, high weight and production loss, low weight and production loss and complete recovery. The losses are assumed to be more severe in transhumant herds, as discussed above. In line with the observations made in the field by the Protozoology team, most cattle are assumed to suffer from a low weight and production loss which would not be obvious to the observer. Instead of separately evaluating reduced fertility, loss of hide value, reduced selling price for slaughter, etc., the value of the animal at different ages is taken from Table 3.19. The results already reflect the higher productivity levels of females over males and of work oxen over other cattle. In Table 10.8, in the case of work oxen, an additional provision is made for the production loss of a pair of oxen, when one animal is afflicted with trypanosomiasis, and therefore, neither animal can work.

High and low estimates are given for each group, since in this case, the figures required a lot of assumptions. Thus, the losses are estimated for an average case of untreated trypanosomiasis throughout the animal's remaining life. By multiplying the value of these losses by the number of new infections over 20 years, an estimate of total losses can be made.

For sedentary cattle losses per new infection the range is from 11,300 to 16,600 MF. For transhumant animals, the range is 19,700 to 28,900 MF and for work oxen 22,200 to 32,700 MF.

Using Table B-4, Table 10.9 gives the present value of losses over 20 years, discounted at 12%. For the whole of Zone 1, using present infection rates, the losses come to 577,367,000 MF on the high estimate, and 392,933,000 MF on the low estimate, with an average loss per infected animal of about 19,500 MF in

the former case and 13,200 MF in the latter. These benefits are compared in Chapter 13 to the costs of the policies outlined in Chapter 7 to 9 above.

C. Losses in Trade Cattle

Map 3.4 shows the main trade cattle routes through the Zone. Cattle are at risk from trypanosomiasis on the routes into Kati from Nossombougou, into Kati from Baroueli and Fana, and leaving the Zone, from Kati to Bougouni and from Fana to Dioila and Massigui. For those cattle entering the Zone for the purpose of slaughter, which includes the 62,000 slaughtered annually in Bamako alone, the effects of trypanosomiasis are insignificant since they seldom spend more than a week alive in the Zone. For those leaving the Zone again for export, infections picked up in the Zone may lead to significant losses, especially for transhumant Zebus coming into prolonged contact with the fly for perhaps the first time. However, since Zone 1 is only on the periphery of the tsetse areas which these animals must pass through on their routes towards the Ivory Coast, it is likely that only a small proportion of trypanosomiasis infections will be contracted there.

A large proportion of exports are undertaken clandestinally, in numbers which the Livestock Service estimates to be at least as great as official exports (Table 3.18). Systematic prophylaxis of these animals would be very difficult, although the exporters ask for trypanocides or administer them themselves.

Animals traded clandestinely would benefit from any fly control or eradication program. However, since their numbers are unknown, with an error factor of 100%, and since the proportion of infections they would pick up in Zone 1 is small, and there is no information on infection rates available, it has been decided not to try and quantify this item for the cost-benefit calculations.

D. Losses in Other Domestic Animals

Overall, it can be said that other domestic animals are far less susceptible to trypanosomiasis. Sheep and goats are considered to be relatively resistant to the disease, whereas donkeys and horses do succumb to the disease when it is caused by trypanosomes belonging to the brucei group.[1/] Local livestock owners do regard the disease as having some effect on these animals as evidenced by the 788 treatments requested for small ruminants and 764 for donkeys and horses in 1979 (Table 7.6). However, although the Protozoology Section did do some sampling of sheep, goats and donkeys in the villages visited, it discovered that even in donkeys, the incidence was far lower than in cattle and infection rates were negligible. Occasional treatments as necessary would suffice for small ruminants, horses and donkeys, with some surveillance being undertaken. Prophylaxis is not considered necessary.[1/]

Given their lesser importance in the disease picture and the lack of information, not only on infection rates, but also on prices and production parameters for other domestic animals, disease losses are not quantified for them in this report. It should be noted, however, that because of their value as traction animals, losses in donkeys due to trypanosomiasis are of some importance in the Zone.

[1/] Personal communication, Dr. Awan

TABLE 10.1

CONTAGIOUS DISEASES OF CATTLE IN THE CERCLES OF ZONE 1 - 1978

(OUTBREAKS NUMBER, SICK NUMBER DIED)

Disease / Cercle	Rinderpest	Contagious Bovine Pleuro - Pneumonia (CBPP)	Blackleg	Anthrax	Pasteurellosis
Kati	-	3/3/2	3/16/14	5/113/37	10/277/85
Kolokani	1/2/2	1/2/1	1/5/5	6/610/610	7/231/181
Banamba	-	-	-	-	-
Koulikoro	-	-	-	-	1/12/5
Dioila	-	1/1/0	7/22/18	-	6/25/17
Segou and Baroueli	-	1/8/5	6/28/20	-	2/9/5

Source: Annual Report of the Livestock Service 1978

TABLE 10.2

PRINCIPAL DISEASES OF CATTLE DEALT WITH BY THE LIVESTOCK SERVICE IN THE CERCLES OF ZONE 1 - 1979

Disease / Cercle	Vaccinations					Treatments	
	Rinder-Pest	CBPP	Blackleg	Anthrax	Pasteu-rellosis	Trypano-somiasis	Gastro Intestinal Parasites
Kati	97,580	100,716	19,472	7,750	25,259	9,221	1,835
Kolokani	17,106	19,322	4,554	4,708	15,529	1,108	328
Banamba	64,745	58,107	14,892	4,329	15,232	1,884	412
Koulikoro	70,030	69,470	15,850	-	34,020	1,723	676
Dioila 1978	101,773	93,726	31,577	-	16,891	19,937	12,490
Baroueli	45,671	45,046	13,625	-	27,466	4,180	3
Segou	144,798	128,445	25,893	-	28,084	6,421	61
Totals	541,703	514,832	125,863	16,787	162,481	44,474	15,805

Source: Annual sector reports of the Livestock Service for 1979, for 1978 in the case of Doila.

TABLE 10.3

TRYPANOSOMIASIS INFECTION RATES IN CATTLE BY BREEDS AND ARRONDISSEMENT OR CERCLE IN ZONE 1

Cercle	Arrondissement	Number of Villages Sampled	% Positive Cases of Cattle in Sample			
			Ndama	Mere	Zebu	Total
Kati	Central	3	9.5	23.1	-	10.8
	Baguineda	4	0	7.6	6.2	6.0
	Negiela	1	4.6	28.6	-	8.0
	Sanankoroba	4	0	5.4	0	3.0
	Sibi	1	-	40.8	100.0	6.0
	Bamako (former) - Kalabankoro	6	7.6	15.0	0	12.0
	Total Cercle	19	5.6	10.1	6.2	8.1
Kolokani	Nossombougou	1	0	5.3	-	2.0
	Total Cercle	1	0	5.3	-	2.0
Koulikoro	Central	5	0	5.1	6.9	5.5
	Kenenkou	4	0	0	1.8	0.9
	Koula	3	0	0	3.8	1.6
	Niamina	5	0	3.0	4.6	4.1
	Sirakorola	3	0	2.2	5.2	4.1
	Tienfala	1	0	3.1	3.2	2.0
	Bougouni	2	0	0	-	2.5
	Total Cercle	23	0	2.6	4.4	3.4
Dioila	Fana	12	1.4	0.7	4.1	1.3
	Total Cercle	12	1.4	0.7	4.1	1.3
Baroueli	Central	9	0	0	1.6	0.8
	Tamani	4	0	0	0	0
	Total Cercle	13	0	0	0.7	0.5
Segou	Central	5	-	0	0.8	0.5
	Doura	7	-	0	0	0
	Farako	8	0	0	0	0
	Markala	4	-	0	0	0
	Total Cercle	24	0	0	0.2	0.1

Source: Dry season survey by the Protozoology Section in Zone 1

Note: 0 = No positive cases

- = No animals of that breed were sampled

TABLE 10.4

PROPORTION OF SEDENTARY HERDS IN DRY SEASON

Cercle	% of Herds Sedentary
Kati	96
Kolokani	100
Koulikoro	72
Dioila	100
Baroueli	61
Segou	82

Source: Protozoological survey in Zone 1

TABLE 10.5

CALCULATION OF LIFE EXPECTANCY OF AVERAGE MEMBER OF CATTLE HERD

a. SEDENTARY HERDS

O = Offtake Rate
M = Mortality Rate

Age	Males - % of Age Group				Females - % of Age Group			
	O	M	O+M	Cumulative Probability of Surviving to Age 8 %	O	M	O+M	Cumulative Probability of Surviving to Age 10 %
3-4				37				60
4-5				45				65
5-6				55				70
6-7	16	2	18	67				75
7-8				82	5	2	7	80
8-9				100				86
9-10								93
10-11								100

The average male is aged 3-4 will live 5 years to preferred offtake age with probability of 37%, therefore is expected to live 1.85 years. 30% of the herd is male.

Similarly, a female aged 3-4 has 60% probability of living a further 7 years, therefore is expected to live 4.2 years. 70% of the herd is female.

Weighted average life expectancy is therefore 3.5 years.

b. TRANSHUMANT HERDS

Age	Males - % of Age Group				Females - % of Age Group			
	O	M	O+M	Cumulative Probability of Surviving to Age 8 %	O	M	O+M	Cumulative Probability of Surviving to Age 10 %
2-3	8	10	18	33	1			
3-4		5	20	39				
4-5				47				65
5-6				57				70
6-7	15			69				75
7-8		2	17	83	5	2	7	80
8-9				100				86
9-10								93
10-11								100

TABLE 10.5 (CONTINUED)

The average male is aged 2-3, and will live 6 years to the age when sold with 33% probability, therefore is expected to live 1.98 years. 33% of the herd is male. The average female is aged 4-5 and is expected to live 6 years with 65% probability, therefore is expected to live 3.9 years. 67% of the herd is female.

Weighted average life expectancy is therefore 3.26 years.

Since over 80% of the cattle in Zone 1 are sedentary this brings the average life expectancy to about 3.45, say 3½ years.

Source: Chapter 3, Section F, and Annex A on Herd Composition.

Note: The age of the average animal is defined as that age group which has an equal proportion of the herd above and below it. This definition is also used in Table 10.7.

TABLE 10.6

NEW AND OVERALL TRYPANOSOMIASIS INFECTION RATES IN ZONE 1

Division (Cercles)	Overall Dry Season Infection Rate % of Cattle	Annual New Infection Rate % of Cattle 1/
1. Kati	8.1	3.6 years 1-10 2.7 years 11-20 2/
2. Koulikoro Kolokani Banamba	3.4	1.5
3. Dioila	1.3	0.6
4. Baroueli Segou	0.3	0.15

Note: 1/ New infection rates equal 45% of the dry season infection rate.

2/ This reduced figure reflects the reduction in G. morsitans in this cercle.

TABLE 10.7

HYPOTHETICAL LOSSES ASSOCIATED WITH UNTREATED CASES OF BOVINE TRYPANOSOMIASIS: SEDENTARY AND TRANSHUMANT CATTLE

a. CALCULATION OF CATTLE VALUES

	Sedentary Herds		Transhumant Herds	
	Male	Female	Male	Female
Average Age	3-4	3-4	2-3	4-5
Value at Age	60,000 MF	75,000 MF	55,000 MF	100,000 MF
Ratio Males/Females	30%	70%	33%	67%
Weighted Average Value	70,000		85,000	

b. POSSIBLE OUTCOMES OF INFECTIONS - HIGH AND LOW LOSS POSSIBILITIES

H - High Loss
L - Low Loss

Effect	Sedentary Herds			Transhumant Herds		
	% Affected	High Loss MF	Low Loss MF	% Affected	High Loss MF	Low Loss MF
i) Rapid Death within a Year H: Complete Loss L: 1/3 of Value Salvaged	4	2,800	1,900	10	8,500	5,700
ii) High Weight Loss and Production Loss H: 50% Loss of Value L: 35% Loss of Value	20	7,000	4,900	30	12,800	8,900
iii) Low Weight Loss and Production Loss H: 15% of Value L: 10% of Value	65	6,800	4,500	60	7,600	5,100
iv) Recovery within a Year No Loss	11	0	0	0	0	
Totals	100	16,600	11,300	100	28,900	19,700

TABLE 10.8

LOSSES FOLLOWING FROM UNTREATED TRYPANOSOMIASIS INFECTIONS IN WORK OXEN

Value of Work Oxen: 125,000 MF, throughout 5 to 6 years of work.

Value of Annual Production: Estimated at 11,000 MF, (Chapter 3, Section G).

Losses: As for sedentary cattle plus an equivalent loss of production in the other animal in the pair since it cannot work alone. The average work oxen is assumed to have 3 years of work ahead of it, yielding a present value of 30,000 MF. It is assumed that in half of cases the other animal of the pair is also infected so that the losses of its work are already calculated as due to its own infection. Thus, losses are calculated on half the production of the other member of oxen pairs. A weak animal will reduce the work done by the pair or need to be replaced with a borrowed animal at some cost whereas a dead animal will be totally replaced.

H - High Loss
L - Low Loss

Effect	% Affected	High Loss MF	Low Loss MF
i) Rapid Death H - Complete Loss L - 1/3 Salvage	4	5,000	3,300
ii) High Loss H - 50% Loss of Value L - 35% Loss of Value	20	12,500	8,800
iii) Effect of High Loss on Partner H - 50% Production Loss L - 35% Production Loss	10	1,500	1,000
iv) Low Loss H - 15% L - 10%	65	12,200	8,100
v) Effect of Low Loss on Partner H - 15% L - 10%	32	1,500	1,000
vi) Complete Recovery - No Loss	0	0	0
Total	100	32,700	22,200

TABLE 10.9

PRESENT VALUES OF LOSSES DUE TO TRYPANOSOMIASIS IN CATTLE
(DISCOUNT RATE 12%)

a. YEARS 1 - 10

Group Affected	Present Value of No. Infected	MF Value of Loss Per Animal MF		1,000 MF Present Value of Losses	
		High	Low	High	Low
All Sendentary Cattle	18,303	16,600	11,300	303,830	206,824
All Transhumant Cattle	2,217	28,900	19,700	64,071	43,675
All Work Oxen	2,010	32,700	22,200	65,727	44,622
All Cattle in Zone 1	22,530	Average: 19,200	Average: 13,100	433,628	295,121
All Cattle in Kati Cercle	13,602	Average: 18,300	12,400	248,663	169,230

b. YEARS 10 - 20

Group Affected	Present Value of No. Infected	MF Value of Loss Per Animal MF		1,000 MF Present Value of Losses	
		High	Low	High	Low
All Sedentary Cattle	5,643	16,600	11,300	93,674	63,766
All Transhumant Cattle	714	28,900	19,700	20,635	14,066
All Work Oxen	900	32,700	22,200	29,430	19,980
All Cattle in Zone 1	7,257	Average: 19,800	Average: 13,500	143,739	97,812
All Cattle in Kati Cercle	3,864	Average: 18,700	Average: 12,700	72,111	49,068

TABLE 10.9 (CONTINUED)

c. YEARS 1-20 - TOTALS

Group Affected	1000 MF	
	High	Low
All Sedentary Cattle	397,504	270,590
All Transhumant Cattle	84,706	57,741
All Work Oxen	95,157	64,602
All Cattle in Zone 1	577,367	392,933
All Cattle in Kati Cercle	320,774	218,298

CHAPTER 11

THE MAGNITUDE OF THE HUMAN TRYPANOSOMIASIS PROBLEM AND THE DIRECT BENEFITS OF A REDUCTION IN THE INCIDENCE OF SLEEPING SICKNESS

Although programs of treatment and prophylaxis for human sleeping sickness are not considered in this report, since the project for which it is written is primarily livestock-oriented, the human disease picture cannot be ignored. The effects of an eradication program eliminating the tsetse fly would be to eliminate the focii of G. palpalis, which is the vector of human sleeping sickness.

A. The General Human Health Situation

1. The Main Insect-borne Diseases: Onchocerciasis and Malaria

In every cercle, either the office of the Grandes Endemies or the local human health authorities was visited. Malaria is present on a very large scale everywhere. Table 11.4, which shows reported cases, gives an impression of the problem, although these cases represent only a fraction of the total. Malaria seems to be farily evenly distributed throughout the country.

Onchocercosis was considered to be a very serious problem. Table 11.4b gives reported cases for the whole country, showing Kayes, Koulikoro and Sikasso to be the most affected regions. Map 11.1 shows the distribution of cases in 1973. Although somewhat out of date, it does show clearly that the southwestern half of the Zone, particularly along the Niger, upriver from Tienfala, is most affected. It is possible that the disease has influenced human population density, particularly in the densities of less than 10 people per square kilometer found in Koulikoro and Tienfala arrondissements (Map 2.1).

In Koulikoro cercle the health authorities estimated that 90% of people in Tienfala were infected with onchocercosis, and villages with 100% infection rates exist. The central arrondissement of Koulikoro is also affected, but to a lesser extent, as are Sirakorola and Koula. Niamina arrondissement has only sporadic cases. Kati cercle is also very badly affected. Most villages in Negela arrondissement are infected. In Dioila cercle, 20 to 30 cases are reported per month. In Kolokani, 50 of the cercle's 273 villages are affected.

In Banamba, Baroueli and Segou most cases of onchocerciasis are imported, usually by seasonal migrants who return to the area after farming outside it.

2. Other Health Problems

The other common disease problems are measles, particularly in children, trachoma, which was particularly common in Banamba and Kolokani, bilharzia, intestinal parasites and hernias.

B. Human Sleeping Sickness

Zone 1 contains two of the traditional endemic focii of human sleeping sickness in Mali: the Bamako area and the Farako-Tamani-Cinzana-Sanando area near Segou. The 1973 flare-up of the disease occurred in Ouelessebougou on the southern borders of the Zone. The socio-economic team was told that as recently as the early 1960s a village about six kilometers from Kati was abandoned by its inhabitants due to sleeping sickness.

Overall numbers of cases of trypanosomiasis are very low, both in the country (Tables 11.1 and 11.2) and in Zone 1 (Table 11.3). Certainly the disease is far less widespread than either malaria or onchocerciasis. However, several factors must be considered in estimating its importance. Firstly, the systems of surveillance, diagnosis and prophylaxis

have largely broken down, so that the only cases discovered are those where people themselves come forward for treatment. Some surveillance is still undertaken in the Segou area, and the ORSTOM mission from Bobo-Dioulasso undertook systematic surveillance in the Ouelessebougou area at five intervals since the outbreak of 1973. However, it is still true that by far the majority of cases are discovered "passively"[1/] when people present themselves for treatment, rather than "actively"[1/] as a result of a systematic survey.

Secondly, the treatment for the disease using drugs is fairly radical, so that usually one tries to get the patient's strength up before administering the treatment, which carries in itself a death rate of 2 to 3%. A case treated in the first stage of the disease requires 20 days hospitalization, in the second or advanced stage of the disease, 45 days. People are thus afraid of the treatment and are reluctant to face hospitalization far from their homes and to bear the costs of transport to and from the hospital, and certain other costs. The result is that the majority, say 80 to 90%, of cases are only discovered in the second stage of the disease. This implies that an equal or probably greater number of people in the first stage of the disease exist and are as yet undiscovered. The first stage is also the most infectious period.

Finally, sleeping sickness, after the period of very severe outbreaks leading to the disappearance of whole villages all over West Africa in the 1930s and 1940s, was subjected to intensive surveillance and prophylaxis and thus became a very minor problem. However, surveillance, diagnostic and prophylactic systems have broken down in most countries and

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1/ The Service Grandes Endemies makes this distinction between "active detection" and "passive detection" of the disease.

this, together with the possibility of a cyclic increase in the virulence of the trypanosome, is held responsible for the recent upsurges of the disease in the Congo, Chad, the Republic of Central Africa, Cameroon and the Ivory Coast.

Thus it seems likely that the reported cases represent only a fraction of the total due to people's reluctance to come forward and since only extreme cases in the second stage are seen. These are conservatively estimated to represent only 1/10 of existing cases. It seems highly probable that Mali will experience its share of the recent upsurge of the disease, in the near future.

C. Losses Attributable to Trypanosomiasis in Humans

1. Treatment costs

The cost of drugs for treating someone in the first stage of trypanosomiasis is conservatively estimated at 10,000 MF. Twenty days of hospitalization are required. In the second stage, drugs cost 30,000 MF and 45 days of hospitalization are required. Bamako hospitalization costs, depending on the status of the patient, vary from 8000 to 33,000 MF a fortnight. To cover the costs of medical supervision, the figure of 10,000 MF at the upper end of the scale is selected. To this must be added the patient's transport costs to and from the hospital, estimated at 5000 MF. Thus, the cost of treatment for a person in the first stage of the disease is 58,000 MF, in the second stage, 130,000 MF.

It must be added that before a successful diagnosis is made, sleeping sickness patients have often tried a number of treatments which may add considerably to actual costs.

2. Social Cost

No monetary value can be put on human suffering and death, but some attempt can be made to enumerate the effects of the

disease. A person diagnosed in the first stage of the disease has usually lost half his ability to work for the previous 3 to 12 months. In the second stage he will have been totally unable to work for between 12 and 30 months and at least 20% of treated cases never work again. In addition, abortion and premature births are frequent in women in the first stage of the disease and in the second stage, both sexes become sterile.[1/]

A price can be put on the lost production capacity of an individual. Since every member of the household contributes to its income, the average income per rural inhabitant is used. It is calculated to be 65,000 MF from Tables 5.8 to 5.9, using the price of millet and sorghum as an index for converting from 1971/72 prices to current prices. Thus, a case treated in the second stage would have lost on average 30 months work, including his treatment period, and a notional recovery period of six to eight months. (Of course a high percentage do not recover fully.) This brings the total cost of a treated case up to 292,500 MF.

Since for each diagnosed and treated case, usually in the second stage of the disease, there are nine other cases which will go untreated, the economic loss due to incapacity for these can also be calculated. Assuming, conservatively, that an average of 10 years' active production is lost per untreated case, due to death or incapacity once the disease has entered the second stage with the classic symptoms of lethargy, the present value of 10 years' production, discounted at 12%, is 367,100 MF. This is not much higher than the costs and losses ascribed to a treated case, since it only reflects the economic loss. Treatment is expensive but brings more non-monetary

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1/ The information above in Sections B and C relating to the general aspects of the disease and its situation in Mali, as well as the figures in Tables 11.1 to 11.4, was very kindly supplied by Dr. Coulm of the Grandes Endemies in Bamako.

benefits.

From Table 11.3, it can be conservatively assumed that an average of 20 cases are reported and treated annually. For these the cost of treatment and lost production will be 5,850,000 MF. A further 180 cases exist that are untreated. Assuming an average of 5 to 10 years life ahead of each infected person, between 18 and 36 of these people will die annually and will be replaced by new infections, if the infection rate remains constant. Taking 25 new infections a year, the annual loss from new untreated infections in terms of the present value of income lost is 9,118,000 MF.

Thus the total annual loss due to human trypanosomiasis, if the disease level remains constant, is:

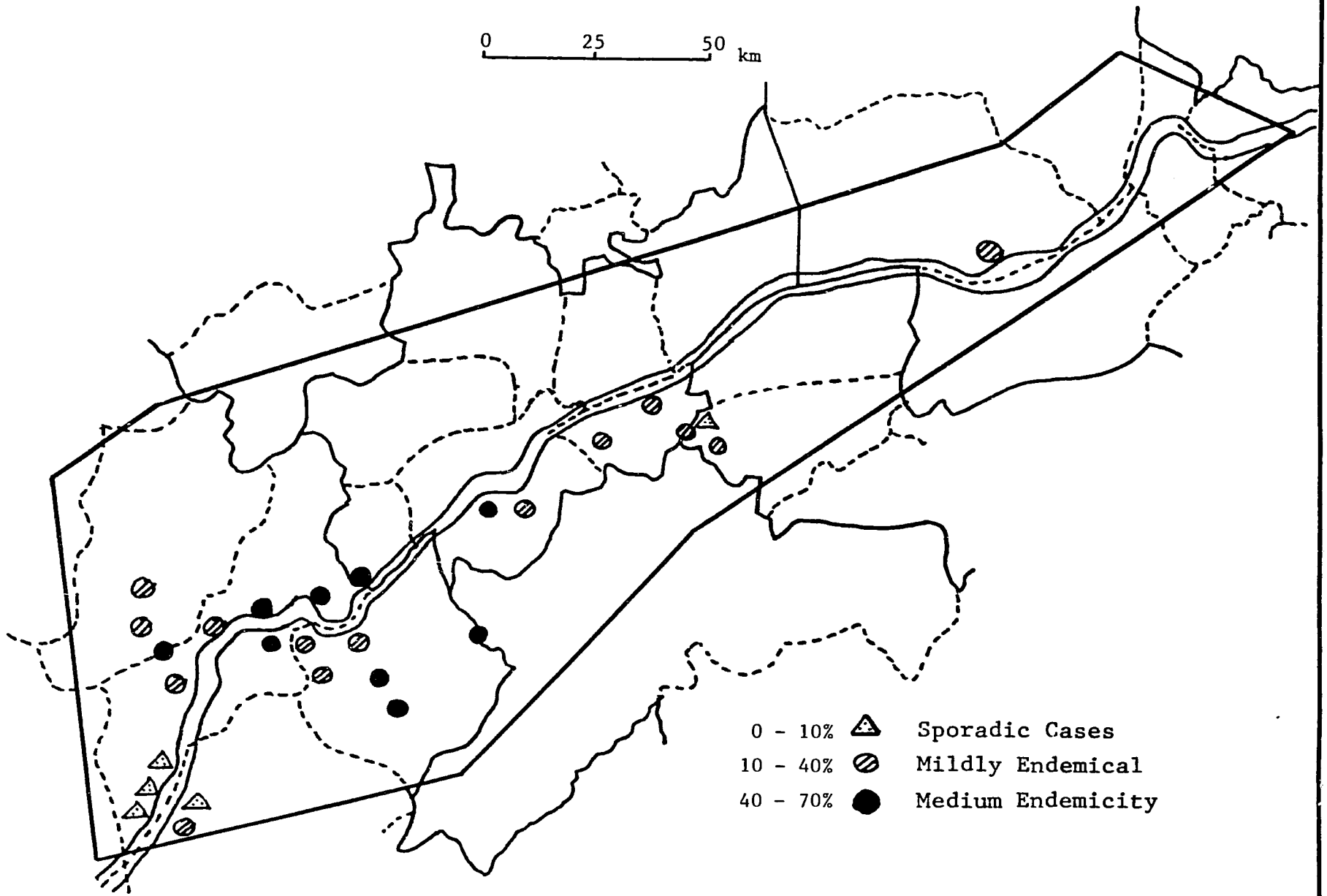
Treated cases:	5,850,000 MF
Untreated cases:	9,118,000
Total:	14,968,000 MF

Occurring annually over 20 years, the present value of this amount is 111,802,000 MF. This forms the low-level economic loss due to the disease.

However, a resurgence in the disease could well be expected. Assuming that infection rates, and hence losses, increase at 5% per annum, the present value discounted at 12% per annum of the economic loss due to the human disease would then be 155,016,000 MF. This forms the high-level estimate. In fact, rather than a steady increase in the disease level, a sudden upsurge could be expected, but since its timing is totally unknown, a hypothetical low steady increase has been substituted.

Thus, although in the absence of any systematic diagnostic work, knowledge of human sleeping sickness incidence is minimal, an attempt has been made here to derive a rough order of magnitude for the purely economic losses to be

associated with the disease. Although the disease at present is of very minor importance in the human health picture in the Zone and in Mali, the lack of knowledge about the disease, the tendency to have only those cases of people in its last stages actually diagnosed, plus the resurgence currently occurring in other areas of Africa, should give some cause for concern.



MAP 11.1 - Prevalence of Onchocerciasis in Zone 1 - 1973

Source: "The Control of Onchocerciasis in the Volta Basin Region," Geneva, 1973.

TABLE 11.1

CASES OF TRYPANOSOMIASIS IN HUMANS IN MALI 1970-1979

Year	Cases
1970	231
1971	190
1972	210
1973	388
1974	215
1975	175
1976	105
1977	105
1978	83
1979	87

TABLE 11.2

NUMBER OF NEW CASES AND DEATHS FROM HUMAN TRYPANOSOMIASIS IN MALI 1975-1979 BY REGION

Region	1975		1976		1977		1978		1979	
	C	D	C	D	C	D	C	D	C	D
Bamako District	61	2	25	-	25	-	18	-	22	-
Kayes	-	-	6	-	1	-	5	10	3	3
Koulikoro	-	-	-	-	-	-	-	-	21	-
Sikasso	79	14	62	7	63	2	53	4	31	7
Segou	22	5	12	2	16	3	7	-	10	3
Mopti	3	2	-	-	-	-	-	-	-	-
Total	175 1/	23	105	9	105	5	83	14	87	13

Source: Grandes Endemies, Bamako.

Note: C - Cases
D - Deaths

1/ There were no cases in Gao or Tombouctou except in January 1975, when 10 were found in Gao, presumably imported by migrants. These are included in the total for 1975.

2/ This table gives new cases discovered during the year.

TABLE 11.3

RECENT CASES OR TRYPANOSOMIASIS IN ZONE 1

a. SEGOU/BAROUELI AREA

Year	Total	Arrondissement			
		Segou Central	Tamani	Markala	Sansanding
1977	3	-	3	-	-
1978	3	1	1	-	1
1979	2	-	-	1	1

Source: Grandes Endemies, Segou.

Note: One or two cases also occur regularly in the arrondissement of Sanando, which is immediately south of Segou Central arrondissement.

b. DISTRICT OF BAMAKO

Year	1975	1976	1977	1978	1979
Number	61	25	25	18	22

Source: Grandes Endemies, Bamako.

Note: Since many people come to, or are sent to, Bamako for treatment, it may be that not all of these cases originate in the Zone.

c. OTHERS

Dioila: One case in the second stage of the disease found in 1977.

Kati: One case discovered in 1979.

Source: Grandes Endemies at Dioila and Kati.

TABLE 11.4

CASES OF MALARIA AND ONCHOCERCIASIS IN MALI 1975-1979

a. CASES OF MALARIA

Region	1975		1976		1977		1978		1979	
	C	D	C	D	C	D	C	D	C	D
Bamako District and Koulikoro	117,985	198	105,820	495	80,666	471	42,691	167	17,788	29
Kayes	45,575	96	62,223	82	46,081	55	24,885	40	17,314	37
Sikasso	60,386	117	58,921	83	31,307	73	34,879	40	31,103	63
Segou	87,581	136	80,021	153	29,454	380	79,210	369	53,699	186
Mopti	56,791	73	49,170	90	43,727	118	43,543	129	28,184	71
Gao and Tomboctou	40,616	179	27,631	76	33,382	133	25,015	13[illegible]	32,148	96
Total	408,934	799	383,786	976	324,617	1230	250,223	881	180,176	482

Source: Grandes Endemies, Bamako.

Note: C - Cases
D - Deaths

TABLE 11.4 (Continued)

b. CASES OF ONCHOCERCIASIS

Region	1975	1976	1977	1978	1979
	C	C	C	C	C
Bamako District and Koulikoro	1428	1587	1404	3573	1093
Kayes	1221	1536	1688	2160	1072
Sikasso	2399	2071	1557	1908	1243
Segou	92	565	192	133	263
Mopti	85	105	192	156	57
Gao	6	4	-	9	-
Total	5230	5868	5048	7939	3734

Source: Grandes Endemies, Bamako.

Notes: C - Cases

No cases of onchocerciasis occurred in Tombouktou .

CHAPTER 12

INDIRECT BENEFITS OF TSETSE OR TRYPANOSOMIASIS CONTROL IN ZONE 1

Indirect benefits have already been defined as those arising when a project, by controlling tsetse flies or dramatically reducing the incidence of trypanosomiasis, succeeds in removing a recognized constraint to livestock or agriculture production, with the result that people are able to make greater and more productive use of certain areas or to change to more profitable methods of production. These benefits are distinct from the direct losses due to illness as calculated in Chapters 10 and 11.

Examples of tsetse clearance exist in many parts of Africa. In the Ningi area of Nigeria, within three years of tsetse clearance, cattle figures had risen from 100 to 18,500. In some of the areas where sleeping sickness was endemic, people were well aware of the disease, since it had led to the decimation of entire villages and the health service had publicized the problem. Consequently, the riverine forests were avoided. Tsetse clearance, plus the availability of good roads to transport perishable vegetables to the big markets, has fostered the development of very widespread and extremely profitable riverside market gardening.[1/] Other examples can also be found. They have several elements in common:

- A widespread awareness of the disease in humans and in animals;
- The existence of an unsatisfied demand for land due to pressure on grazing land elsewhere or on agricultural land due to high human population densities on the margins of the tsetse infested areas;
- The ineffectiveness of prophylaxis or treatment in reducing the disease level to acceptable levels, so that avoidance of infested areas was the solution favored by people and cattle.

It is immediately obvious that Zone 1 differs from this picture in several respects. Most importantly, far from being

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1/ "A Socio-Economic Analysis of the Trypanosomiasis Problem in Northern Nigeria," Putt, Matthewman and Shaw, 1980.

an area of low population density and underdeveloped resources, it is one of the most developed areas of Mali in terms of agriculture and has the highest human population density. There is widespread awareness of trypanosomiasis in cattle but almost no awareness of human sleeping sickness. Treatment and limited prophylaxis of animals are practiced universally. These elements are considered below, and the various potential sources of indirect benefits are dealt with separately.

A. The Effects of the Human Disease

Occurring on a large scale, human sleeping sickness leads to extensive depopulation, since whole villages can be decimated. As noted above, fear of the disease can stop people from using certain areas for many years after the last epidemic, particularly if the causes of the disease are well publicized.

In Zone 1 in Mali, however, despite the existence of several of the old focii, awareness of the disease is found to be virtually non-existent. There are very few cases reported annually (Chapter 11). Although the Office du Niger realizes that health problems are an increasing danger in rice cultivation, trypanosomiasis was not listed among these risks. As another example, market gardening is developing in most areas. The main constraints on its development are, probably, finance and, definitely, the difficulty of transporting perishable vegetables to markets because of the limited road network.

The main insect-borne health problem in Zone 1 was seen in Chapter 11 to be onchocerciasis. Its presence coincides with some of the areas of low human population density, particularly around Tienfala and Koulikoro.

Thus, no changes in production patterns, such as a shift towards market gardening, are expected as a result of tsetse control. Onchocerciasis control, since the disease is well

recognized and constitutes a visible constraint, might provoke such changes.

B. The Effects of the Disease in Animals

1. Sedentary Cattle and Other Domestic Animals

In Chapter 3 it was noted that the number of sedentary cattle per inhabitant showed a remarkable uniformity throughout the Zone. Thus, in terms of cattle numbers it cannot be said that a serious constraint on sedentary numbers is posed by the disease, since the fly-free northeastern part of the Zone had only marginally more cattle per rural inhabitant in some of its arrondissements than was the case in the extreme southwest.

In Chapter 11, the same was shown to be the case for other domestic animals. Although the number of donkeys was lower in the southwest of the Zone, this was partly due to statistical peculiarities. Since these animals are much less affected by the disease than cattle, the differences are not considered to be significant.

The distribution of sedentary cattle was generally described as being a function of the wealth and success with breeding stock of the individual farmer. In Zone 1 cattle are generally regarded as a convenient form of relatively safe investment by farmers, and ownership has been increasing significantly in recent years.

Thus, it is not regarded as likely that control of trypanosomiasis or of tsetse flies would lead to a significant increase in village domestic animals or of cattle numbers in the tsetse-infested southwest of the Zone.

2. Transhumant Cattle: Wet and Dry-season Pasture Demands

Since no real figures exist for the number of transhu-

mant cattle which visit the Zone in the dry season, the figures used in Chapter 3 were based on local estimates. These indicate that the transhumants definitely avoid the tsetse-infested areas in the wet season and even prefer the relatively tsetse-free areas in the dry season.

However, a large part of the tsetse-infested regions are more or less accessible in the dry season to cattle, since the fly recedes to the damper areas. Thus, in the dry season, while rivers and swamps tend to remain infested, a lot of pasture inaccessible in the wet season is available. Depending on the level of challenge posed by flies at water points, it can still be stated more or less generally that large-scale tsetse clearance makes a greater addition to wet season pasture availability than to dry season pasture. Since the main shortage of pasture is still in the dry season, the urgency of clearing land from tsetse flies, particularly with respect to facilitating the regional stratification envisaged for Mali (breeding in the north, fattening and finishing in the south) is diminished. It becomes clear that as long as dry-season pasture is the main constraint, studies comparing dry-season to wet-season fly challenge are necessary to an accurate evaluation of the need for tsetse clearance.

It is, of course, easily possible to imagine a situation where wet season pasture becomes in very short supply. This has already occurred in areas of high rural human population density, notably in Nigeria. Since nearly 100% of land may be under crops and due to heavy fines imposed for causing crop damage, rivers and marginal land are difficult for cattle to reach, the cattle owners have to shift to new areas to find wet-season grazing. After the harvest, they return to graze the crop residues. However, even in Zone 1, which is densely populated by Malian standards, there is no overall shortage of wet-season grazing, although people do send their cattle away from the main village area while the crops are in the

fields.

Thus, in Zone 1, it is felt that there is a constraint on grazing land only in the limited area of Kati and, to a lesser extent, in Koulikoro and Dioila arrondissements, since in the dry season they receive fewer transhumants than the Segou area. Whether those grazing patterns would change as a result of tsetse clearance or whether they are too well established by tradition is open to question.

3. The Distribution of Mere and Ndama Cattle

From Map 3.5, it can be seen that the main strategy used by the inhabitants of Zone 1 to avoid losses due to trypanosomiasis, aside from treatment and prophylaxis, is the use of so-called trypano-tolerant cattle and crosses between these and Zebus. High proportions of Ndamas are found in the southern and western parts of the Zone. Zebus are in the majority in the northern and eastern part, which is virtually fly-free. Meres or crossbreds dominate in the central part.

The keeping of Ndama and Mere cattle is, however, a very well-established feature of the areas where they are found. Their resistance to trypanosomiasis is generally said to be confined to the area around their village of origin. Once outside this area, their susceptibility increases. These animals are, partly for this reason, seldom sold away from their area of origin. Most change hands via local, informal transactions.

In the course of interviews with Livestock Service staff and officials from the "Operations," it was repeatedly stressed that Mere and Ndama animals were valued because they were "robust" and resisted well the whole gamut of health problems associated with a more humid climate. This emphasis on their general ability to remain healthy in humid areas rather than on their specific resistance to trypanosomiasis is particularly

noteworthy because of the tendency everywhere to overemphasize the problem of trypanosomiasis.

In addition, although less valuable as milk animals than the Zebus, the Meres and Ndamas have a slightly higher dressing-out percentage and as discussed below, are valued as work animals.

It thus remains open to question whether tsetse clearance would lead to a large-scale shift from Ndamas and Meres to Zebus and whether this shift would be beneficial. Zebus might succumb to other health problems in the area to which Ndamas and Meres are resistant, or their performance as milk and meat animals might be affected. It seems likely that the local populations would continue to keep the animals with which they are familiar.

4. Cattle and Agriculture: The Use of Work Oxen

Work oxen are used throughout the Zone, and the other main input from cattle, organic manure, is also in use everywhere. The number of work oxen, however, is far higher in the northeast than in the southwest, and the combined effect of a slightly higher human population and widespread cultivation using work oxen means that the northeast has a far higher proportion of its area under cultivation than the rest of the Zone (Map 5.2).

In the analysis of the numbers of work oxen (Table 3.8), it was noted that one of the main determinants of their distribution was whether their use had been encouraged by the presence of one of the "Operations" in the area. Thus, the cercle of Dioila, although in a more humid and more tsetse-infested area, had a very high proportion of work oxen per cultivating unit. This is associated with the presence of the CMDT and exists despite the proximity of the highly tsetse-infested Faya river.

Regarding the choice of breed, it was stated that whereas the Zebu is preferred for the heavy work, such as in the rice-growing areas, many farmers prefer the more robust Mere, which is perfectly adequate for working the lighter soils.

Owners of work oxen are very aware of the problem of trypanosomiasis. Work oxen are the only group to receive any systematic prophylaxis, and losses due to the disease in work oxen are costly because of their high value (Chapter 10). Thus, the use of widespread prophylaxis indicates that people who want to keep work oxen do so regardless of the tsetse fly but do incur the added expense of protecting their animals.

It would thus appear that expansion in the use of work oxen in Zone 1 will occur more as a result of the availability of credit and the promotion of their use by the "Operations" such as "Operations Haute Vallee," which is starting up in the area, than as a result of tsetse clearance.

C. Conclusions

It is clear that in Zone 1 a number of differences exist between the tsetse-free northeast and tsetse-infested southwest. The northeast has:

- most of the Zone's Zebus;
- slightly higher human population densities;
- slightly more sedentary cattle, sheep, goats, and donkeys per inhabitant;
- most of the Zone's transhumants who come in the dry season;
- more work oxen, along with the CMDT area in the central southern part or Zone 1; and
- a higher proportion of cultivated land.

However, several other factors make it questionable whether tsetse clearance will affect these differences:

- The generally low density of tsetse flies even in Kati cercle (excluding the Monts Mandingues, Faya river and Tienfala areas) is not such as to pose a major constraint.
- It is not clear whether the geographical distribution of the factors noted above is due to the tsetse flies or whether the tsetse flies are simply a reflection of climatic difference which poses a number of other constraints, both on animal health and on the development of agriculture.
- It is not obvious whether tsetse clearance would result in a change in these factors. Onchocerciasis may limit human populations in some areas by making them unattractive to human settlement. Work oxen numbers may respond more rapidly to investment and encouragement by the "Operations." People may prefer to keep ~~their~~ Ndama and Mere cattle.

Overall it is felt that since even the Kati area has a high population density and is developed by comparison to other parts of the country, it is not possible to predict large scale indirect economic benefits arising from tsetse clearance or trypanosomiasis control in the Zone. However, the uneven development within the Zone, which follows the northern Guinea Zone/Sudan Zone climatic division, and the contrasts between tsetse-infested and tsetse-free areas should be noted as well as the potential for making more dry-season grazing available in Kati as a result of tsetse clearance. The question of the viability and economic importance of Zebu versus Ndama and Mere cattle requires more research, especially into the ability of Ndamas and Meres to withstand health challenges other than trypanosomiasis.

SECTION D

CONCLUSIONS

CHAPTER 13

COST AND BENEFITS COMPARED - SUMMARY AND CONCLUSIONS

A. Summary of Preceding Chapters

1. Introduction

This report undertakes a socio-economic analysis in cost-benefit form of the tsetse/trypanosomiasis problem in Zone 1. The bulk of the work was done in 1980, so that most available statistics refer to 1979 and prices generally date from the beginning of 1980.

2. Description of Zone 1

a. Zone 1 is on the periphery of the main tsetse-infested areas in Mali which are to the south and west of it. It can be divided roughly in two, with the northeast being in the Sudan climatic zone and the southwest in the Guinea zone. It is very well served in terms of communications, particularly by roads and also by the river and the railway. Its boundaries were drawn up in an artificial manner, and do not correspond with natural or administrative boundaries.

b. The current rural human population of Zone 1 is 374,000 people, with an average density of 19.4 people per square kilometer, a very high density by Malian standards. By the year 2000, the rural population is expected to rise to 545,000 people, with an average density of 28.3 people per square kilometer. The current urban population, dominated by Bamako, is 598,000; it is expected to rise to 2,336,000 by the year 2000. Most migration of people in the area consists of dry-season migrations to the towns and other countries, such as the Ivory Coast, in search of work as laborers, or into the project areas of the "Operations" for farming purposes.

c. A detailed examination of cattle numbers, divided into sedentary, nomadic and work oxen was undertaken, along with a study of herd composition and production parameters in

order to determine growth rates and prices. Currently it is estimated that 182,600 sedentary cattle and 25,400 work oxen are in the Zone all year round, and some 101,000 transhumants spend the dry season in the Zone. Populations were projected for 20 years at annual growth rates of 2 to 3% up to the carrying capacity of the Zone once agricultural land needs had been subtracted. Work oxen numbers increase more rapidly at rates of 3 to 9% per annum. By the year 2000 there are expected to be 243,000 sedentary cattle and 57,700 work oxen in the Zone, and 117,200 transhumants visiting it. Zebus predominate in the northeast, Meres in the center, and Ndamas in the southwest of the Zone.

The price of the average Zebu slaughtered is estimated at 100,000 MF at the market, and of the average Mere just under 90,000 MF. Current offtake rates for transhumants are estimated at 8 to 9%, and for sedentary herds at about 7%. Sedentary cattle are evenly distributed throughout the Zone; transhumants primarily visit the northern and eastern parts in the dry season.

d. Sheep, goat, horse, and donkey numbers are briefly examined. According to the estimates, there are about 248,000 sheep and goats in the Zone and 24,000 donkeys and horses.

e. Agriculture and land use are studied in the Zone. In the northeast, about 8% of land is under cultivation annually; this figure reduces to 2% in the southwest. Approximately 5.6% of the Zone is under crops annually, rising to 8.1% in the year 2000, on the assumption that the area cultivated increases at the same rate as population growth. Forest reserves take up 6.5% of the Zone's surface, and urban areas, which consist principally of Bamako, a further 2%. Agriculture has developed significantly in the Zone, due, in part, to the activities of the "Operations," so that work oxen are used exten-

sively. In recent years there has been an increase in subsistence crop production at the expense of cash crops, due to unfavorable prices for the latter. The average annual income per rural inhabitant is calculated to be about 65,000 MF.

f. The tsetse fly population is illustrated in Maps 6.1 and 6.2. It consists mainly of G. palpalis with G. morsitans in the southwestern part of the Zone ; occasional G. tachinoides was found. The G. morsitans is assumed to decline in number as human population increases. The northeast part of the Zone is relatively fly-free.

3. The Costs of Various Strategies Aimed at Reducing the Incidence of Trypanosomiasis in Zone 1

a. The cost of treatment and prophylaxis as undertaken by the Livestock Service is calculated. The cost of the drugs per dose varies from 160 to 250 MF. The cost of administering a dose within the Service is calculated at 160 MF each. The costs of two main strategies (treatment only, as compared to prophylaxis in the wet season plus occasional treatments as necessary in the dry season) are calculated. Combination strategies of prophylaxis of all cattle in Kati or of all work oxen in the Zone combined with treatment only elsewhere are calculated. The results are presented in Table 7.12, giving the present value of costs over the next 20 years, discounted at 12%.

b. The costs of the work done by the Protozoology and Socio-economic Sections and of headquarters administration at New Lands are calculated, based on existing staff and equipment lists plus estimated per diem, fuel and lubricant, office supplies and laboratory materials consumption. All depreciation is calculated on a relatively short life of three years for vehicles and equipment, five years for fly traps, 10 years for furniture and 20 years for microscopes, and on a straight-line basis using current replacement cost.

The annual depreciation cost is included in the cost estimates. Technical assistance costs are included using current norms. The total cost of diagnostic support by the Protozoology Section for the treatment and prophylaxis programs is calculated.

c. Using the same norms as above, the cost of entomological studies is calculated. Table 9.10 summarizes the costs of studies undertaken by each section. Using the outline of an eradication scheme given in the Annex to Okiwelu, Maiga and Van Wettere, 1980, the costs of a hypothetical eradication scheme are calculated for Zone 1. Two factors are responsible for costs being very high: the scattered nature of the tsetse infestations, necessitating a lot of traveling by the eradication teams, and the high cost of the 75 kilometer long barrier needed to protect the Zone in the west. The costs of eradication are summarized in Table 9.11, and Table 9.12 gives the cost for a full eradication program.

4. <u>The Benefits Attributable to a Reduced Incidence of Trypanosomiasis in Zone 1</u>

a. The general cattle disease picture is discussed. The direct losses due to trypanosomiasis in cattle are calculated using an annual new infection rate derived from the Protozoology Section's disease-incidence survey. Hypothetical losses per new infection are calculated using the likely outcomes of infections. High and low estimates of these losses are given. These are 28,900 and 19,700 MF respectively for transhumant cattle, 16,600 and 11,300 MF for sedentary cattle, and 32,700 and 22,200 MF for work oxen. The present value of these losses, discounted over 20 years at 12%, is given in Table 10.9.

b. The general human health picture is presented and the importance of onchocerciasis is emphasized. Losses due to trypanosomiasis in humans are even more difficult to

estimate than those for cattle. This is due to the fact that the disease incidence is virtually unknown and to the technical and moral difficulty of assigning a monetary value to human suffering and loss of life. A purely economic loss representing the cost of treatment and lost production is therefore calculated. The cost of disease losses and treatment, where treatment takes place, is conservatively estimated at 292,500 MF per individual affected. If treatment does not occur, production losses alone account for at least 367,100 MF per individual case. Since a resurgence of the disease is to be feared, high-level losses are calculated on the assumption of a 5% annual increase in infection; low-level losses assume the incidence remains constant. The results over 20 years are presented at the end of the chapter.

c. The potential for changes in production methods or land use due to control of trypanosomiasis are discussed. Since Zone 1 is already a highly populated and agriculturally progressive area, it is felt that these potential changes are limited and these effects are not quantifiable. The use of Ndama and Mere breeds in the southwest appears to be firmly established, and they are valued for their general sturdiness in the climate as much as for their trypano-tolerance. The southwest of the Zone is hardly used by transhumants in the dry season. It is felt that the tsetse fly plays a minor role in the differences in population density and agricultural development, including that in the use of work oxen noted between the northeastern part of Zone 1, in the Sudan climatic zone, and the southwest, which is in the Guinea climatic zone.

B. Comparison of Costs and Benefits

This analysis covers Zone 1 considered as a separate entity. In the case of the treatment and prophylaxis strategies, this approach is fully comprehensive since the cost of the strategies excludes imported infections and applies to the cattle and to infection rates within the Zone. It can thus

be compared to the effect of eradication of flies from Zone 1. However, in the case of attempts at eradicating or controlling the vector, it might be possible to consider Zone 1 as part of a larger area in a future study, as discussed in the recommendations below. In that case it would be necessary to undertake disease incidence surveys in the areas to the south and west so as to gain an idea of what the benefits of eradication there might be. Some of the barrier costs could then perhaps be avoided.

Figure 13 outlines the relationships between the various strategies and the costs and benefits to be associated with each. Although it is estimated that as many as 50% of treatments currently done are given either to animals which are not infected or have no prophylactic effect, the current practice nevertheless has the effect of reducing the disease incidence by an unknown amount to the present incidence level as detected in the protozoological survey. The high level of clandestine treatments at incorrect dosages tends to increase the risks of drug resistance and means that some animals have to be treated for abcesses, etc., due to badly administered injections. The benefits of this reduction in the disease incidence are not known, so they are substituted for by the costs of the current practice. This same reduction also results from the systematic treatment and prophylaxis strategies proposed. The treatment program costs include the effective part of the current practice but the prophylaxis program supersedes it. The costs of the current practice would also be saved as a result of an eradication project, since it would no longer be necessary to undertake treatments.

A program of systematic treatment is estimated to reduce current disease losses by 90% of their present level. It is accompanied by diagnostic work and surveillance undertaken both by the Livestock Service and the Protozoology Section.

Systematic prophylaxis accompanied by the diagnostic and surveillance program should virtually eliminate all disease losses, so a 100% reduction is assumed in the calculations. In time, systematic prophylaxis and treatment will lead to an overall reduction in the infectivity rate of flies. The level of treatment and prophylaxis needed can be reduced accordingly. This is reflected in lowered costs for both strategies during the second half of the 20 years considered.

Tables 13.1 to 13.3 summarize the cost and benefit situation for the six strategies analyzed. Overall, it is clear that the costs of dealing with trypanosomiasis in Zone 1 are high relative to the benefits to be expected (Table 13.3). Only one strategy had a positive net present value at both high and low-benefit levels, that of systematic treatment plus diagnostic support. Prophylaxis of work oxen with treatment of other cattle was profitable using the high-benefit assumptions. This result implies that if the present policy in the field (which approximates partial prophylaxis of work oxen plus treatment of other cattle) were fully implemented, it could be a very feasible strategy in economic terms.

All other strategies were not profitable according to these results. Eradication at reduced cost and the strategy of prophylaxis in Kati, with treatment elsewhere, performed comparatively well at the high-benefit level, with costs not greatly exceeding benefits.

The two most costly strategies, universal wet-season prophylaxis and eradication as proposed in the Entomology Section report, both realized benefit-cost ratios of only about 0.5 using the low benefit assumptions.

The assumptions made in calculating costs and benefits have been clearly stated in the relevant chapters. Costs were streamlined and most research and training components eliminated. A large proportion of the vehicles, equipment and

staff needed for the execution of each strategy already exists at New Lands. The initial protozoological and entomological surveys needed for the prophylaxis/treatment strategies and the eradication work respectively have already been partially completed, so that a significant proportion of the costs have already been incurred. It remains to decide how to use the research performed and the resources already acquired to best effect (Table 13.2). The benefits were calculated on relatively modest assumptions. They cover disease losses in cattle and the economic cost of the disease in humans. To the benefits of eradication could be added some increase in dry-season grazing land in Kati. The full cost of human suffering and illness has also not been included in these benefits. However, there are other constraints on grazing and more serious human health problems than those stemming from trypanosomiasis, so these remaining potential sources of benefit are not regarded as being very important. Benefits for cattle are based on the infection rate found in the dry-season survey and on cattle numbers as estimated by the Livestock Service, which are projected to increase until the pasture resources of Zone 1 are fully utilized.

Thus, costs and benefits are both felt to have been estimated at reasonable levels. When comparing the strategies, it should be noted that the use of a discount rate makes benefits in perpetuity, such as those accruing to eradication, seem relatively small when compared to high initial investment costs. Since it is a once-and-for-all cost, one usually expects the cost of eradication to compare favorably with the cost of continued annual expenditures, whether on control, prophylaxis or treatment, unless there is a reason for assuming that these continued annual expenditures are reduced over time. But even excluding the barrier costs, the eradication cost for Zone 1 is high for work of that nature. There is some reduction in annual expenditures on trypanosomiasis control in Zone 1,

since some reduction in fly challenge from G. morsitans has been assumed to occur in Kati cercle, and the prophylactic and treatment campaigns, as well as reducing the risks of resistance, are assumed to lead to a lower infectivity rate in flies.

Results are presented in net present value form and in terms of cost-benefit ratios (see note to Table 13.3). Internal rates of return were not calculated, but since the discount rate used was 12% and several of the net present values are nearly zero, the internal rate of return on these approximates to 12%.

From this discussion it is evident that two strategies (eradication with cleared barriers and wet season prophylaxis covering all cattle in the fly-infected areas) can be definitely rejected. The possibility of eradication at a reduced cost needs to be examined. At present the most favorable strategy, on purely economic terms, would be either a program of treatment only, or of partial prophylaxis combined with treatment. If the severely infected areas of Kati were selected for wet-season prophylaxis, and treatments were carried out in the rest of the Zone, the cost of strategy three (prophylaxis in Kati, treatment elsewhere) could easily be reduced sufficiently to make the project profitable. As it stands, strategy four remains attractive because it is close to present practice in the field.

C. Recommendations for the Continuation of Work at New Lands

Recommendations are based purely on the results of the economic analysis contained in this report.

A clear decision for or against eradication work as against prophylaxis and treatment cannot yet be made until a better idea of the cost of barriers to protect Zone 1 is obtained and until the details concerning the level of support that the Protozoology Section would need to give to a prophy-

lactic and treatment campaign are finally worked out. Meanwhile, the following are recommended:

1. Although no natural barriers could be found inside or on the periphery of Zone 1, it is nevertheless recommended that some work be undertaken to determine the feasibility of reducing the cost of barriers:

- either by dealing with some of the more isolated infected areas separately, or
- by examining the possibility of using purely chemical barriers, and determining whether their size and location would need to be modified from those presently proposed.

This endorses the recommendation in Okiwelu et al., 1980, that at present, insufficient data exists for the undertaking of any large-scale tsetse control or eradication program. As stated in that document, it is also recommended that insecticide trials be carried out for research and training purposes.

2. In the interim, the Protozoology Section survey results should be used as follows: the distribution of the disease should immediately be communicated to the Livestock Service and steps should be taken to inform their local staff and the staff of the livestock divisions of the "Operations" of the real prevalence of the disease in their areas. Thus, in areas like Segou, where a lot of unnecessary treatment and prophylaxis is undertaken, the Service would be informed of the distribution of the tsetse flies and would be able to avoid treatment or prophylaxis of sedentary cattle residing in areas of no risk. An awareness of diagnostic facilities at New Lands would enable them to send in samples for examination. The Livestock Service sector head office at Kati and at one other location in the southern part of the cercle of Kati could be equipped with a microscope and some of the special equipment needed for diagnostic work as suggested in Chapter 7. The cost of this would be 420,000 MF (approximately) for slides and other equipment plus about 800,000 MF for each

microscope. These relatively small investments, plus advice and support from the Protozoology Section at New Lands, would make a significant start towards rational prophylaxis and treatment and would lead to some savings by reducing the number of unnecessary treatments.

If, however, research reveals ways of reducing the costs of barriers for an eradication scheme, since its basic cost is lower than any other strategy excepting that of treatment only, eradication could still be undertaken, since the cost of the above diagnostic work is low and might even be covered by the expected savings in treatments.

3. It is recommended that New Lands subsequently direct its attention to an area of Mali which forms a contrast to Zone 1, in that tsetse flies constitute a real constraint on production rather than primarily imposing disease losses. The recommendation is made so that the situation can also be examined from the economic point of view relative to trypanosomiasis control strategies. As has been seen, research costs are very high, so they should be directed as far as possible towards areas where trypanosomiasis poses a serious threat.

A knowledge of costs and benefits in an area which contrasts with Zone 1 is particularly important in the context of tsetse and trypanosomiasis control in Mali taken as a whole, if Zone 1 is regarded not as an area standing alone, as has been done so far, but as the periphery of a larger tsetse fly eradication project of which it could be a part. The following questions will need to be answered. With respect to direct benefits, it will be important to know whether, despite the use of Ndama cattle, infection rates are significant, and whether there are sufficient people and cattle to benefit from tsetse control. With respect to indirect benefits, the following questions are of paramount importance: when and where grazing land is in short supply; whether the fly-infested areas could fill pasture needs in the dry or the wet season; and the viability of the Ndama and Mere cattle. These are discussed below.

D. General Recommendations for Areas where Research is Needed Most Urgently

1. The respective merits of Ndama, Mere, and Zebu cattle need to be examined more thoroughly. As well as the studies currently being undertaken to test the Ndamas' alleged trypanotolerance in various situations, studies need to be undertaken testing Ndamas' and Meres' performance for a wider range of health indices and in the local environment from which the animals originate and in which they are kept under characteristic local conditions. The performance of Zebus in the same climate and conditions should be evaluated and compared as far as possible.

Also, a clearer idea of local people's appreciation of the value of Ndamas and Meres needs to be obtained, to determine whether they have a real preference for these animals or whether they regard them as second best compared to the Zebus.

2. Research is urgently needed into the course of the disease of trypanosomiasis in cattle in the field, or under experimental conditions approximating those in the field. The almost total lack of knowledge of mortality rates ascribable to the disease and of the extent of production losses in animals suffering from chronic forms of the disease makes any assessment of losses very hypothetical.

3. A knowledge of separate wet and dry-season grazing patterns is crucial to many aspects of livestock development work in Mali. Such knowledge would enable one to establish where the dry-season grazing shortages are most acute and how cattle herders cope with the problem. It would enable one to begin to quantify the demands for grazing land in a more relevant way than year-round carrying capacity analyses permit. In this way, the actual location, urgency and magnitude of needs for more grazing land could be clarified.

4. In conjunction with this, the extent to which the presence of the tsetse fly prohibits dry-season grazing in the infested areas should be investigated to determine if tsetse clearance contributes mainly to wet-season grazing land availability or also to dry-season grazing land availability.

FIGURE 13

SCHEMATIC REPRESENTATION OF THE COSTS AND BENEFITS OF THE VARIOUS STRATEGIES FOR DEALING WITH TRYPANOSOMIASIS

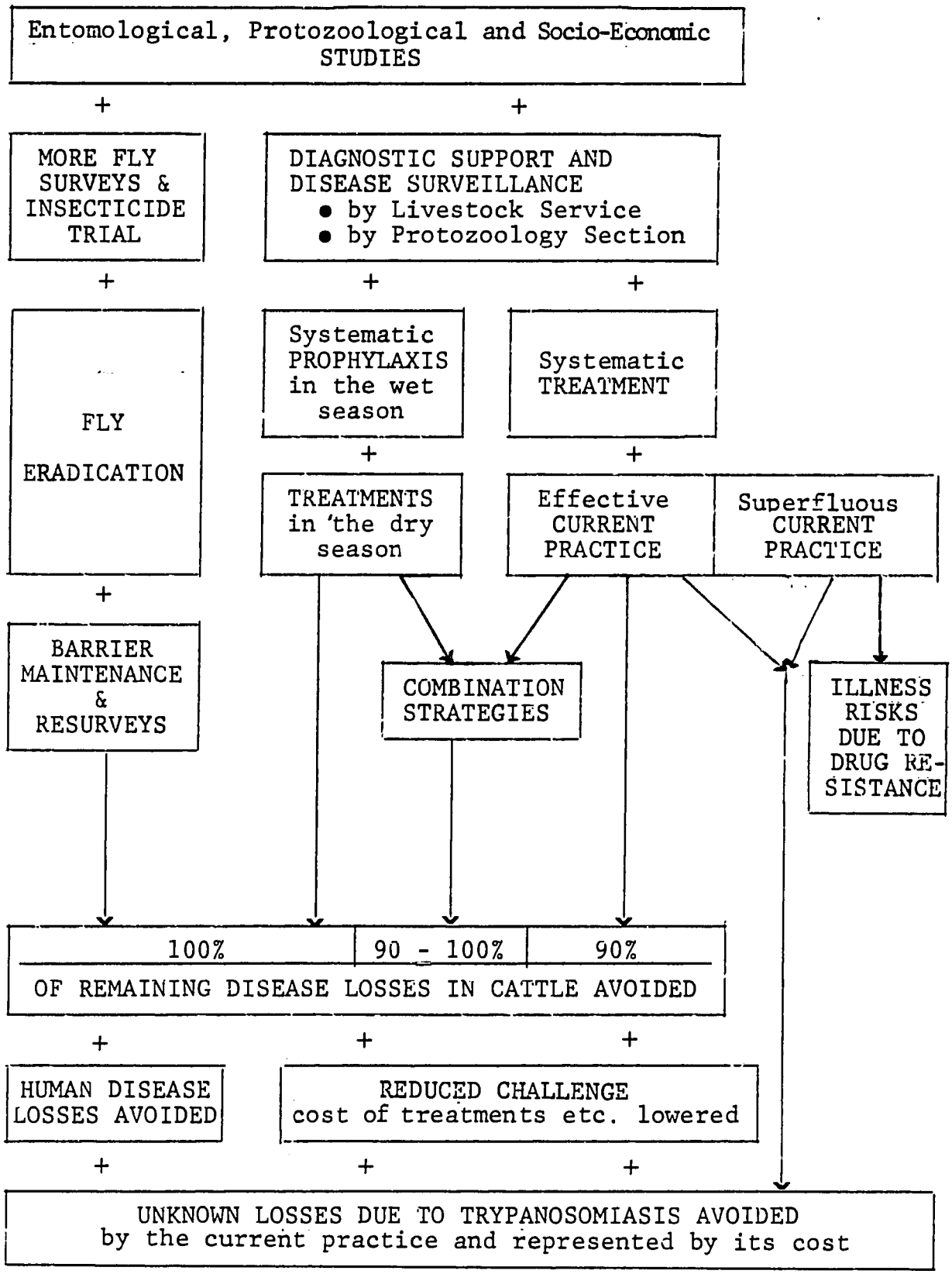

TABLE 13.1

PRESENT VALUE OF THE BENEFITS
ASSOCIATED WITH EACH STRATEGY

(1000 MF)

Strategy	Benefits of current practice	Losses due to disease in cattle	Losses due to disease in humans		Total
1) Treatment	108,604	E x 90% = 519,630	-	E	628,234
		L x 90% = 353,640	-	R	462,244
2) Prophylaxis	108,604	E x 100% = 577,367	-	E	685,971
		L x 100% = 392,933	-	R	501,537
3) Prophylaxis in Kati and Treatment Elsewhere	108,604	Kati E x 100% = 320,774 Others E x 90% = 230,934 Total 551,708	-	E	660,312
		Kati R x 100% = 218,298 Others R x 90% = 157,172 Total 375,470	-	R	484,074
4) Prophylaxis of Oxen and Treatment of Other Cattle	108,604	Oxen E x 100% = 95,157 Others E x 90% = 433,989 Total 529,146	-	E	637,750
		Oxen R x 100% = 64,602 Others R x 90% = 295,498 Total 360,100	-	R	468,704
5) Eradication in Zone 1	108,604	E x 100% = 577,367	155,016	E	840,987
		R x 100% = 392,933	111,802	R	613,339

Source: Chapters 10 (Table 10.9) and 11.

Note: Calculated for 20 years and discounted at 12%. Benefits begin in year 1, and present value is given for year 0, the year in which eradication would take place.

E - high-benefit level
R - low-benefit level

TABLE 13.2

PRESENT VALUE OF THE COSTS ASSOCIATED WITH EACH STRATEGY FOR DEALING WITH TRYPANOSOMIASIS

a. Strategy of Prophylaxis and Treatment

Strategy	Present value of costs 1000 MF		
	Diagnostic Assistance Provided by the Protozoology Section and Initial Protozoological Survey	Cost of Medication, Intervention and Diagnostic Assistance Provided by the Livestock Service	Total Cost 1000 FM
1) Treatment of all of Zone 1	355,239	104,992	460,231
2) Prophylaxis During the Rainy Season, Treatment During the Dry Season in all of Zone 1		679,396	1,034,635
3) Prophylaxis in Kati, Treatment Elsewhere in Zone 1		377,439	732,678
4) Prophylaxis of Work Oxen, Treatment of Other Cattle in Zone 1		158,492	513,731

Source: Table 7.12

Note: The cost of research, at current prices, for the year in which it is carried out, is adjusted to 245,897,000 MF.

Costs are calculated for 20 years at current prices discounted at 12% to year 0, the year in which eradication would take place.

TABLE 13.2

b. ESTIMATION OF COSTS OF ERADICATION

Strategy	Present Value of Costs 1000 MF
i) Inflated cost: Barriers cleared of brush and insecticide maintained for 5 years1/	1,20 52
ii) Reduced cost: Only insecticide barriers are maintained and for two additional years, supplemental entomological reexaminations	853,405

Source: Table 9.12.

Note: Research costs at current prices for the year in which they occur amount to 189,300,000 MF.

Costs are calculated over 20 years at current prices, depreciation included, and are discounted at 12% per year to year 0, the year in which eradication would take place.

1/ Scheme as presented in Okiwelu et al. 1980, Annex.

2/ The above scheme with some hypothetical changes introduced in this report.

TABLE 13.3

COMPARISON OF PRESENT VALUE OF COSTS AND BENEFITS OF VARIOUS STRATEGIES FOR DEALING WITH TRYPANOSOMIASIS

a. INFLATED BENEFITS

Strategy	Present Value Benefits 1000 FM ($1000)	Present Value Costs 1000 FM ($1000)	Net Present Value 1000 FM ($1000)	Ratio of Benefits/ Costs
1) Treatment of all of Zone 1	628,234 (1,496)	460,231 (1,096)	168,003 (400)	1.36
2) Prophylaxis in the Rainy Season for all of Zone 1	685,971 (1,633)	1,034,635 (2,463)	-348,664 (-830)	0.66
3) Prophylaxis in Kati, Treatment Elsewhere	660,312 (1,572)	732,678 (1,744)	-72,366 (-172)	0.90
4) Prophylaxis of Oxen, Treatment of other Cattle	637,750 (1,518)	513,731 (1,223)	124,019 (295)	1.24
5) Eradication at High Cost	840,987 (2,002)	1,206,452 (2,872)	-365,465 (-870)	0.70
6) Eradication at Low Cost	840,987 (2,002)	853,405 (2,032)	-12,418 (-30)	0.99

TABLE 13.3 (cont'd)

b. LOW-BENEFIT LEVEL

Strategy	Present Value Benefits 1000 FM ($1000)	Present Value Costs 1000 FM ($1000)	Net Present Value 1000 FM ($1000)	Ratio of Benefits/ Costs
1) Treatment for all of Zone 1	462,244 (1,101)	460,231 (1,096)	2,013 (5)	1.00
2) Prophylaxis in the Rainy Season for all of Zone 1	501,537 (1,194)	1,034,635 (2,463)	-533,098 (-1269)	0.48
3) Prophylaxis in Kati, Treatment Elsewhere	484,074 (1,153)	732,678 (1,744)	-248,604 (-591)	0.66
4) Prophylaxis of Oxen Treatment of other Cattle	468,704 (1,116)	513,731 (1,223)	-45,027 (107)	0.91
5) Eradication at High Cost	613,339 (1,460)	1,206,452 (2,872)	-593,113 (-1412)	0.51
6) Eradication at Low Cost	613,339 (1,460)	853,405 (2,032)	-240,066 (-572)	0.72

Notes: $1 U.S. = 420 MF.

Net present value is the discounted value of benefits after the subtraction of that of costs. The ratio of benefit to cost is the discounted value of benefits divided by that of costs. A positive net present value or a ratio of benefits/costs greater than one (1.00) indicates that the project is profitable, since after 20 years the rate of return on invested capital is greater than 12%. 12% is the discount rate used.

ANNEX A

A. THE IMPLICATIONS OF THE HERD COMPOSITION DATA

B. METHODOLOGY AND EXPLANATIONS TO TABLE A.1

A N N E X A

THE USE OF HERD COMPOSITION FIGURES TO VERIFY GENERAL PRODUCTION PARAMETERS

A. The Implications of the Herd Composition Data

Selected herd composition studies for Mali are included in the main section of the report (Table 3.10). From these, the most recent comprehensive study, done by OMBEVI in 1977 on a sample of 30,000 animals in the inland delta area of the Niger, has been selected for in-depth analysis. Although we realize that conditions in the delta do not necessarily apply in Zone 1, it is felt that considerable insight into herd dynamics in Mali, which has some general applicability, is thus gained. The implications for herd growth, mortality and offtake are calculated in Tables A.1a and b, and the assumptions and methodology are outlined in detail in the explanations to that table which are given in the following Section B. The results of the analysis are used in the main report to derive production parameters appropriate for Zone 1 (Chapter 3, Section F).

Taking into account the various problems involved in obtaining reliable information on herd histories and performance, Table A.1 shows that the estimated mortality and offtakes are, to a great extent, confirmed by the herd composition figures. Variations would be expected between currently applicable parameters and those applicable in the past when conditions were different. Thus, the drought years will have affected one generation more than another, which might be seen in the composition figures. Finally, it is not always clear whether respondents describing offtake in fact refer to net offtake, that is, sales and gifts made less purchases and gifts received. However, in the case of the transhumants, a sufficiently large sample tends to describe a fairly closed system, with most of the net offtake being animals for slaughter and animals sold to sedentary herds for traction or milk and breeding. Few animals are bought

into the transhumant herd. Instead, transhumants keep their own animals for breeding. The sedentary herd is much more open; it buys in a lot of animals from other herds or from the transhumants.

The results of the comparison undertaken in Table A.1, between parameters given for cattle herds and those implicit in the herd composition data, are given below.

1. From Table A.1 it can be seen that given the fertility rate calculated by OMBEVI, first-year mortalities for both males and females are considerably higher than those given. They are closer to the 30 to 40% range usually cited than to the 25% average given in the study. Male rates are higher than female and easily pass 40% for both transhumant and sedentary herds. Since the fertility rates of 59% for transhumants and 49% for sedentary herds are modest compared to previous estimates, these are considered fairly accurate.

2. Mortality rates in the second year of life, however, seemed generally lower than those given, partially offsetting the underestimated mortality in the first year. This fact emphasizes even more the high proportion of all mortalities which occur in the first year, which is about 75% for transhumant as well as sedentary animals.

3. In the sedentary herd, the tendency for more females to exist in one generation than in the subsequent one perhaps reflects the open nature of the herd, i.e. a tendency to buy in heifers in certain years. If it were a question of changes in climate or the animal health situation, one would expect this tendency to be reflected in the figures for males as well, which is not the case.

4. Offtake rates for adult animals appear to be slightly lower than those given.

5. In the sedentary herd, there exist some residuals in column 8 which could indicate that there is a steady rate of growth, around 2% per annum, which inflates the size of one year's group relative to the previous year's and which is not accounted for by offtake or mortality.

   In the transhumant herd this phenomenon is not evident. The higher rates of offtake in transhumant rather than sedentary herds would appear to be accurate, but this could reduce and thus mask growth from generation to generation in transhumant herds.

6. The growth rate and offtake implications are discussed in the main report.

To verify data from the herd composition against the parameters given from the interviews, column 6, summarizing the given data, is compared with the calculated annual decline in numbers from one age group to the next as given in column 7. Column 8 shows the difference. A detailed explanation of the methodology used follows.

B. Methodology and Explanations to Table A.1

This table examines the implications of the herd composition data collected by OMBEVI. The percentages in each age group 0-1 to 10+ are taken from their study, as are given mortalities (column 2) and offtake (column 4) as percentages of each age group. Since offtake and mortality figures were estimated separately from herd composition, the latter can be used to check the extent to which the offtake and mortality figures are consistent with the observed age distribution. The following procedure was used:

1. Live Births

LB stands for live births which are calculated by applying the annual fertility rates calculated by OMBEVI from individual cow profiles to the number of cows, i.e. females over four years old. Fertility rates given were 59% for transhumants and 49% for sedentary herds, which are relatively modest and probably realistic figures. Live births are given as a percentage of the total herd counted, but since at the time of counting some calf mortality had already occurred, the actual number in the 0-1 age group is lower than the number of births. It is assumed that males and females are born in equal numbers.

2. Estimate of Calves Surviving to the Age of One Year

A further problem in calculating reductions in numbers for each age group was posed by the fact that the count represents roughly mid-year estimates, whereas mortality and offtake are calculated from year end to year end. An approximate estimate of year-end figures was made by calculating the figures

in the last column using the arithmetic mean of subsequent pairs of years to represent the end-year figure. Because of the rapid decline in the mortality rate in year 0-1, the figures denoted by 2/ were obtained by interpolation on a graph.

3. Offtake and Mortality Percentage Points (Columns 3 and 5)

The herd composition distribution could be seen as the number of animals in each age group for a herd of 100 animals. To obtain the percentage of those dying or leaving the herd as offtake as a percentage of the whole herd, the percentage of each age group leaving (columns 2 and 4) was multiplied by the number in that age group (column 1) to give columns 3 and 5 respectively. Calf mortality was not included, since columns 7 to 9 imply that the given rates should be revised upwards.

4. Mortality Plus Offtake as Given (Column 6)

This column is the sum of columns 2 and 4.

5. Actual Mortality, Offtake and Herd Growth, as implied by Herd Composition (Column 7)

In order to calculate the reduction in number in each time period of one year from a sample showing a cross-section of generations or annual age groups at a given moment, the following reasoning was adopted.

In a closed herd, which this large sample is assumed to approximate, the number of animals in a given age group x at the start of year t is represented by xt and equals the number of animals in the previous age group (x-1) in the previous year (t-1) (that is, those same animals when they were a year younger), less those that have died ($M_{x-1,\ t-1}$) or been sold ($O_{x-1,\ t-1}$) during the previous year of that age group. Thus

$$N_{xt} = N_{x-1,t-1} - (M_{x-1,t-1} + O_{x-1,t-1}).$$

However, if one is looking at a cross-section of age groups in one year t, the difference in numbers between the generation

aged x and the generation aged x-1 is not accounted for simply by mortality and offtake but also by the growth in the herd. Thus each new generation will also be larger than the previous one by the amount of annual growth, so that

$$N_{xt} = N_{x-1,t-1} - (M_{x-1,t-1} + O_{x-1,t-1} + R_{x-1}) .$$

Here R_{x-1} is the rate of growth in live births in the year of generation x-1's birth, i.e. it represents how much they exceeded the previous year's live births. This growth rate will determine their relation to the previous generation throughout their lives and will thus remain constant. Mortality and offtake will vary from year to year for all generations according to sanitary, climatic and market conditions, but adult mortality will always be lower and adult offtake higher than for young animals.

Broadly speaking, it has been assumed here that mortality and offtake rates are more or less fixed and have not changed significantly over the ten-year age range. This is true insofar as major disturbances caused by the drought of the early 1970s tended to wipe out whole herds rather than parts of currently existing herds, and variations in the forms of good or bad years for particular herds would tend to cancel each other out for a large sample. The rate of growth, however, probably varies from year to year, since it is unlikely that a constant annual rate applies. The rate for a given year t can, however, be calculated as follows:

$$R_t = LB_t - (M_t + O_t) .$$

Total mortality and offtake in year t can be divided into adult and calf mortality, as can offtake. Calf offtake (calves being less than one year old) is zero, so that offtake (O) can be taken to refer to adults only. If CS_t is calf survivals at the end of year t and A stands for adult, C for calf,

$$R_t = CS_t - (AM_t + O_t) \quad \text{where} \quad CS_t = LB_t - CM_t .$$

The concept of calf survivals is useful since it enables one to use actual numbers estimated to reach age one (see 2 above) divided by total numbers of cows as an index of fertility, rather than trying to distinguish between first-year mortality and actual fertility in terms of live births per adult female per annum. Effective or real fertility is in fact the product of both (see Table 3.12).

IMPLICATIONS OF OMBEVI HERD COMPOSITION DATA
a. DRY ZONE TRANSHUMANTS

Column Number	1	2	3	4	5	6	7	8	9
		Mortality		Offtake		2 + 4 =		7 - 6 =	
Age/Sex	Given % in Herd	Given % of Age Group	Adult Deaths: % Points	Given % of Age Group	Offtake in % Points	Mortality plus Offtake % of Age Group	Mortality plus Offtake + Growth : Implied %	Difference Between Given and Implied %	Comments on Origins of Difference
Females									
LB	11.2 1/								
0-1	8.6	21	-	0	0	21	29.5	8	Underestimated mortality
1-2	7.5 7.9 2/	12	0.9	3	0.23	15	10.1	-5	Overestimated mortality and offtake
2-3	6.7	8	0.54	1	0.07	9	9.2	0	
3-4	6.2	4	0.25	1	0.06	5	0.8	-4	Herd variations
4-5	6.6)	)	)	)	)	)	1.6)	)	
5-6	6.0)	)	)	)	)	)	-2.4) Aver-	)	
6-7	6.9)	)	)	)	)	)	1.6) age	) -5	Overestimated
7-8	5.8) 38.0	) 2	) 0.76	) 10	) 3.80	) 12	12.6) 7.2	)	offtake
8-9	5.3)	)	)	)	)	)	22.5)	)	
9-10	3.3)	)	)	)	)	)			
10+	4.1)	)	)	)	)	)			
Total	67.0		2.45		4.16				
Males									
LB	11.2 1/								
0-1	7.4 2/	30	-	0	0	20	44.6	15	Underestimated mortality
1-2	5.5 6.2	15	0.82	12	0.66	27	21.0	-6	Overestimated mortality
2-3	4.3	10	0.43	8	0.34	18	18.4	0	and offtake
3-4	3.7)	)	)	)	)	)	17.5)	)	
4-5	2.9)	)	)	)	)	)	24.2)	)	
5-6	2.1)	)	)	)	)	)	16.0) Aver-	)	
6-7	2.1)	)	)	)	)	)	9.5) age	) -5	Overestimated
7-8	1.7) 15.8	) 2	) 0.32	) 20	) 3.16	) 22	13.2) 16.9	)	offtake
8-9	1.6)	)	)	)	)	)	21.2)	)	
9-10	1.0)	)	)	)	)	)	21.2)	)	
10+	0.7)	)	)	)	)	)			
Total	33.0		1.57		4.16				
Males + Females	100.0		4.02		8.32				Little evidence of herd growth

Notes: 1/ Live Births (See Annex A, Section B.1).
2/ Figures obtained by interpolation on a graph (See Annex A, Section B.2).

Column Number	1	2	3	4	5	6	7	8	9
		Mortality		Offtake		2 + 4 =		7 - 6 =	
Age/Sex	Given % in Herd	Given % of Age Group	Adult Deaths: % Points	Given % of Age Group	Offtake in % Points	Mortality plus Offtake % of Age Group	Mortality plus Offtake + Growth : Implied %	Difference Between Given and Implied %	Comments on Origins of Difference
Females									
LB	10.5 1/								
0-1	8.6) 2/	15	-	0	0	15	31.4	16	Underestimated mortality
1-2	6.3) 7.2	12	0.76	3	0.19	15	16.7	2	annual growth?
2-3	5.7	5	0.28	1	0.06	6	4.2	-2)	
3-4	5.8)	)	)	1	0.06	3	8.7	-5)	
4-5	4.7)	)	)	)	)	)	-2.9) Aver-	)	
5-6	6.1)	)	)	)	)	)	-16.7) age	)	Herd variation
6-7	6.5)	)	)	)	)	)	-18.2) 4.9	) -15)	plus
7-8	8.4) 42.7	) 2	) 0.97	) 8	) 3.41	) 10	-19.5)	)	overestimated
8-9	7.4)	)	)	)	)	)	32.6)	)	offtake
9-10	4.6)	)	)	)	)	)			
10+	5.0)	)	)	)	)	)			
Total	69.1		2.01		3.72				
Males									
LB	10.5 1/								
0-1	6.5) 2/	36	-	0		36	47.6	12	Underestimated mortality
1-2	5.0) 5.5	12	0.60	6	0.30	18	20.0	2	annual growth?
2-3	3.8	7	0.27	4	0.15	11	19.3	8	Growth + underestimated
3-4	3.3)	)	)	)	)	)	11.3)	)	offtake
4-5	3.0)	)	)	)	)	)	7.9) Aver-	)	
5-6	2.8)	)	)	)	)	)	13.8) age	)	
6-7	2.2)	)	)	)	)	)	16.0) 20.1	) 2)	Annual
7-8	2.0) 15.6	) 2	) 0.31	) 0.16	) 2.50	) 18	28.6)	)	growth?
8-9	1.0)	)	)	)	)	)	43.3)	)	
9-10	0.7)	)	)	)	)	)			
10+	0.6)	)	)	)	)	)			
Total	30.9		1.18		2.95				
Males + Females	100.0		3.19		6.67				

Notes: 1/ Live Births (See Annex A, Section B.1).
2/ Figures obtained by interpolation on a graph (See Annex A, Section B.2).

ANNEX B

CALCULATION OF PRESENT VALUE FOR THE COST BENEFIT ANALYSIS

A N N E X B

PRESENT VALUE CALCULATIONS FOR THE COST-BENEFIT ANALYSIS

In order to simplify the calculation of the benefits to various schemes and combinations of schemes, the actual numbers of cattle, as projected in Table 3.25, were discounted at 12% per annum over 20 years. The total numbers could then be multiplied by infection rates, number needing treatment,etc., in their present value form in Chapters 7 and 10. Thus, it should be borne in mind that all the figures for costs and benefits produced in those chapters are already in present value form and apply to the projections of cattle numbers made in Table 3.25.

TABLE B.1

PRESENT VALUE CALCULATIONS OF CATTLE NUMBERS
FOR THE WHOLE OF ZONE 1
(1000 CATTLE)

Year	Sedentary Cattle	Transhumant Cattle	Work Oxen I	Work Oxen II
0	(182.60)	(50.50)	(16.10)	(9.30)
1	168.75	45.98	15.27	9.02
2	155.93	41.85	14.43	8.77
3	144.14	38.15	13.67	8.54
4	133.14	34.76	12.90	8.33
5	122.45	31.66	12.20	8.11
6	112.62	28.52	11.35	7.70
7	103.59	25.74	10.54	7.28
8	94.31	23.18	9.77	6.87
9	85.90	20.92	9.09	6.53
10	78.24	18.87	8.44	6.15
11	69.86	16.85	7.68	5.52
12	62.37	15.04	7.01	5.31
13	55.69	13.43	6.37	4.93
14	49.72	11.99	5.81	4.58
15	44.40	10.71	5.28	4.26
16	39.64	9.56	4.81	3.88
17	35.39	8.53	4.38	3.52
18	31.60	7.62	3.99	3.21
19	28.21	6.80	3.63	2.93
20	25.19	6.07	3.32	2.66

Source: Table 3.25

Notes:
- Figures in brackets are not included in Table B.2 totals. as they are for year 0.
- The discount rate is 12%.

TABLE B.2

PRESENT VALUE OF FUTURE CATTLE NUMBERS
(1000 CATTLE)

Present Value in Year 0	Sedentary Cattle	Transhumant Cattle	Work Oxen I	Work Oxen II	Total
Years 1-10	1199.1	309.6	117.7	78.3	1704.7
Years 11-20	442.1	106.6	52.3	40.8	641.8
Total	1641.2	416.2	170.0	119.1	2346.5

Source: Table B.1.

TABLE B.3

DISTRIBUTION OF CATTLE BY CATEGORIES AND CERCLE WITHIN ZONE 1 IN 1979

a. ACTUAL NUMBERS BY CERCLE

Cercle	Sedentary	Transhumant	Work Oxen
Kati	50,900	2,700	3,200
Kolokani	4,300	1,000	400
Banamba	500		100
Koulikoro	45,300	11,900	5,600
Dioila	17,900	4,200	2,900
Baroueli	29,000	17,100	5,100
Segou	34,700	13,600	8,100
Total	182,600	50,500	25,400

b. PERCENTAGES BY DIVISION

Division	Sedentary	Transhumant	Work Oxen I	Work Oxen II
1. Kati	27.9	5.3	-	34.4
2. Koulikoro Kolokani Banamba	27.4	25.6	-	65.6
3. Dioila	9.8	8.3	18.0	-
4. Segou Baroueli	34.9	60.8	82.0	-

Source: Tables 3.2, 3.4 and 3.9.

TABLE B.4

PRESENT VALUE OF CATTLE NUMBERS BY DIVISION AND YEARS

(1000 CATTLE)

Division	Years	Sedentary Cattle	Transhumant Cattle	Work Oxen	Total
1. Kati	1-10	334.5	16.4	26.9	377.8
	11-20	123.4	5.7	14.0	143.1
	1-20	457.9	22.1	40.9	520.9
2. Koulikoro Kolokani Banamba	1-10	328.6	79.3	51.3	459.2
	11-20	121.1	27.3	26.8	175.2
	1-20	449.7	106.6	78.1	634.4
3. Dioila	1-10	117.5	25.7	21.2	164.4
	11-20	43.3	8.8	9.4	61.5
	1-20	160.8	34.5	30.6	225.9
4. Baroueli Segou	1-10	418.5	188.2	96.5	703.2
	11-20	154.3	64.8	42.9	262.0
	1-20	572.8	253.0	139.4	965.2

Source: Tables B.1, B.2. and B.3.

Note: Since from Table 3.24 the same growth rates apply to all cattle within each category in the Zone, except for work oxen which are divided into two groups, the proportions calculated in Tables B.3 for 1979 can be applied to the present value of the numbers to calculate numbers per division.

TABLE B.5

PRESENT VALUE NUMBERS OF UNTREATED CATTLE WITH NEW INFECTIONS OF TRYPANOSOMIASIS BY DIVISION

a. YEARS 1-10

Division	Sedentary	Transhumants	Work Oxen	Total
1. Kati	12.042	591	969	13.602
2. Koulikoro Kolokani Banamba	4.929	1.191	771	6.891
3. Dioila	705	153	126	984
4. Segou Baroueli	627	282	144	1.053
Total	18.303	2.217	2.010	22.530

b. YEARS 11-20

Division	Sedentary	Transhumants	Work Oxen	Total
1. Kati	3.333	153	378	3.864
2. Koulikoro Kolokani Banamba	1.818	411	402	2.631
3. Dioila	261	54	57	372
4. Segou Baroueli	231	96	63	390
Total	5.643	714	900	7.257

Source: Tables 10.6 and B.4.

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