BANGLADESH FLOOD ACTION PLAN

Ministry of Water Resources
Flood Plan Coordination Organization (FPCO)

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Prepared by

Environmental Study

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BANGLADESH FLOOD ACTION PLAN

Ministry of Water Resources
Flood Plan Coordination Organization (FPCO)

The Kala-azar Epidemic in Bangladesh and its Relationship to Flood Control Embankments

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EXECUTIVE SUMMARY

Since the late 1980s the number of cases of kala-azar (visceral leishmaniasis) has been growing in Bangladesh. The disease has a high case fatality rate and most untreated patients die one to two years after the first appearance of symptoms. This deadly illness, which causes damage to the spleen, liver, bone marrow, and immune systems of its victims is caused by the protozoan *Leishmania donovani*, which is transmitted to the human population by the sandfly *Phlebotomus argentipes*. This sandfly lives around human settlements and breeds in moist, organically rich soils. The larvae of *P. argentipes* seek out optimum growth conditions, and appear to be particularly responsive to high temperature, humidity, and soil moisture. Seasonal flooding seems to interfere with species propagation, although the mechanism is not well understood.

The objective of this study was to assess the relationship between kala-azar case distribution and flood control, drainage, and irrigation (FCD/I) projects. The principle means of doing this was a review of all available information on kala-azar distribution and relating it to the presence of FCD/I projects, and a case study analysis using data gathered by the Singra Thana Health Center. The distribution of cases, when plotted on maps showing the location of embankments, roads, and rivers, clearly reveals that the cases were heavily clustered within areas protected by Polders C and B in contrast to the origins of Health Center in-patients which were distributed more evenly over the thana. The data also show that risk increased according to exposure level. While there was no increased risk associated with living outside the embankment, living in a mouza that had villages both inside and outside the embankment moderately increased risk, and living in a mouza completely within the embankment substantially increased risk. People living inside the embankment were found to have a risk of developing kala-azar that was 17.69 times higher than among those living outside the embankment. The report presents recommendations for dealing with the spread of kala-azar and for conducting further studies over a wider geographical area and addressing eco-epidemiological, socio-behavioral, and demographic aspects.

Chapter 1

INTRODUCTION

1. Background

Kala-azar, or visceral leishmaniasis, is a parasitic disease that attacks humans and causes damage to the spleen, liver, bone marrow, and immune systems of adults and children. The number of kala-azar cases in Bangladesh has been steadily increasing since the late 1980s. Although the disease affects all age groups, the concentration of cases is highest among those under age 15. Kala-azar has a high case fatality rate and most untreated patients die one to two years after the first appearance of symptoms (Bell 1981).

Kala-azar is deadly if not treated, but because diagnosis is difficult and the therapy is costly, few victims receive adequate treatment. The curative regimen for leishmaniasis, a series of 20 to 30 injections of sodium stilbogluconate, an antimony compound,[1] is both painful and costly. The official cost of the drug for a full course of treatment was between Tk. 432 (children) and Tk. 936 (adults), but it is common knowledge that the market price can be much higher. Additional costs for doctors, administration of the injections, and the performance of blood tests can be considerable.

In Bangladesh, kala-azar is caused by the protozoan *Leishmania donovani,* which is carried by a small sandfly, *Phlebotomus argentipes*. The female *P. argentipes* require human blood for the maturation of their eggs. They become infected with the protozoa when they bite an infected human. During subsequent blood meals, they in turn transmit *L. donovani* to non-infected people. South Asian kala-azar lacks an animal reservoir (Sanyal 1985).

1.1 Diagnosing Kala-azar

Kala-azar is characterized by intermittent fever, anemia, marked swelling of the liver and spleen, and darkening of the skin. A definitive diagnosis of kala-azar can only be made by extracting parasites from the patient. The only way to do this is by a painful bone puncture, lymph node aspiration, or potentially dangerous spleen puncture. These procedures are beyond the capabilities of the average health center in Bangladesh. Another diagnosis method commonly used in place of parasite aspiration is the aldehyde serological test, also known as the Formol-Gel Test.

The cases discussed in this report refer to health center patients who exhibited clinical symptoms of kala-azar and who tested positive on the aldehyde test. This test has been considered non-specific because it can produce false positive results when immunoglobulin are greatly increased, as is the case in multiple myeloma, leprosy, trypanosomiasis, chronic malaria, or chronic liver disease. In most of these conditions, however, the globulin levels do not rise high enough to produce strongly positive aldehyde test results (Chowdhury *et al.* 1992).

A recent study done by Rajshahi Medical College (Chowdhury *et al.* 1992) shows a high correlation between clinically diagnosed cases with aldehyde positive results and definite diagnosis by parasite

[1] The drug is produced in Bangladesh by Glaxo Ltd. under the trade name Stibatin.

aspiration. The Rajshahi study found that the aldehyde test was positive in 94 percent of patients with definitively diagnosed kala-azar. Among the control group of 100 patients with fever or swollen spleens but not kala-azar, six were weakly positive and one was strongly positive. The study concluded that, "although a negative aldehyde test does not exclude kala-azar ... a strongly positive result in a clinically suspected case in an area where kala-azar is endemic is a valuable diagnosis."

1.2 Kala-azar and Embankments

The sandfly responsible for spreading kala-azar lives around human settlements and breeds in moist, organically rich soils. The larvae of *P. argentipes* seek out optimum growth conditions, and appear to be particularly responsive to high temperature, humidity, and soil moisture. Larvae try to avoid flood waters (Mukhopadhyay *et al.* 1990), and it seems reasonable that flooding could interfere with species propagation, although the mechanism is not well understood (LSTM/NIPSOM/ISPAN 1992). In addition, outbreaks of kala-azar have been observed in villages protected by large-scale flood protection projects.

Experts in the field have recognized the need to inform designers and planners of the potential effect of development projects on leishmaniasis. The Expert Committee on Leishmaniasis in the World Health Organization (WHO 1990) has commented on that necessity: "Engineers, planners and developers do not need detailed knowledge of the disease but should be briefed about the actual and potential problems so that they can request advice during the planning phase of development projects. In this respect leishmaniasis should be considered in conjunction with other health and hygiene problems."

A collaborative study by the Bangladesh National Institute of Preventive and Social Medicine (NIPSOM), the Health Impact Programme (HIP) of the Liverpool School of Tropical Medicine (LSTM), and the Irrigation Support Project for Asia and the Near East (ISPAN) has examined the relationship between flood control and vector-borne diseases in Bangladesh. For that study, NIPSOM carried out entomological investigations to determine the absence or presence of vectors in selected study areas, HIP provided technical assistance in both vector biology and health policy, and ISPAN conducted an epidemiological investigation of kala-azar and provided study direction for the overall project. The study results are presented in two reports. LSTM/NIPSOM/ISPAN (1992) contains overviews of vector-borne diseases in Bangladesh, results of site-specific surveys for mosquito and sandfly disease vectors, and an assessment of the implications of the epidemiology of vector-borne diseases for flood control and drainage. The following report presents an analysis of the epidemiology of kala-azar on national, regional, and local levels in Bangladesh and the relationship of the disease to flood control embankments.

2. Objectives and Methodology

The objective of the study was to assess the relationship between kala-azar case distribution and flood control, drainage, and irrigation (FCD/I) projects. This was done at two levels of detail—nationally and for a specific area with FCD/I projects in place.

The first stage of the study consisted of assembling all relevant data on kala-azar in Bangladesh, including the existing literature on the disease. Information about diagnosed cases of the disease was also gathered from thana health centers in Bagatipara, Singra, Natore Sadar, Baraigram, Gurudaspur, and Lalpur of Natore; Tarash, Ullahpara, and Sahjadpur of Serajgonj; and Bhangura, Faridpur, Santhia, Bera, Atghoria, Pabna Sadar and Chatmohar of Pabna. These data, including details of how the disease had been diagnosed and treated, was collected from the Thana Health Inspector or Statistical Assistant through the Thana Health and Family Planning Officer (THFPO). The second stage of the study involved a case control study.

The sophisticated use of case control studies has been described as the "most outstanding methodological development in modern epidemiology" (Rothman 1986). A case control study is one in which people with and without the disease being studied are selected and the number of those exposed and unexposed to the disease vector is ascertained. Both cases and controls are selected independent of their risk of exposure.

A necessary tool in the case control methodology is the two-by-two table shown below. The table is used in epidemiology to explore associations

	Disease: Cases	Disease: Controls
Exposed	a	b
Not Exposed	c	d

between exposure and disease. Odds ratios are calculated from cells in the tables representing cases and controls according to exposure to potential risk factors. An association is suggested when the odds ratio is more than 1.0. This methodology is useful when evaluating risk if the disease is rare in the general population, where the odds ratio is an accurate estimate of the relative risk. In the present study, the odds ratios presented can be simply interpreted as in the following examples. If the exposed group has an odds ratio of 2, individuals with the exposure are twice as likely to acquire the disease being studied when compared to those not exposed. Similarly, an odds ratio of 0.3 indicates that those exposed are 0.3 times (30 percent) as likely to acquire the disease, etc.

The table and the use of its cells (a, b, c, d) to interpret the risk of disease have been described by Mausner and Kramer (1985).

> *If there is a positive association between the factor and the disease, those exposed will tend to develop the disease (group a) and those not exposed will tend not to develop it (group d). Thus there will be a disproportionate aggregation of study subjects in groups a and d as compared to b and c.*

The Singra Thana Health Center was selected for the kala-azar case distribution study on the basis of a preliminary study (ISPAN 1992) and field visits. As part of this process, data on the distribution of cases in the contiguous thanas extending from Sahjadpur to Singra[2] were collected. Kala-azar cases were found to be routinely treated on an out-patient basis because of the lack of resources for hospitalization at the Singra Health Center. The Center keeps a separate register of kala-azar cases, with relatively accurate information about the names and addresses of its out-patients. The location of the mouza where the infected person lived could thus be accurately established. Using the case control study method, therefore, the data from the Singra Health Center could be analyzed to determine if there was an association between embankments and the risk of developing kala-azar.

If a positive association exists between kala-azar and living within an embankment, then a higher rate of infection would occur among people protected by Chalan Beel flood control projects, which encloses part of the catchment of the Singra Health Center area, than among those living outside of the protected area.

To see if the distribution of the disease could be explained by the catchment area of the health center, the addresses of the kala-azar cases were compared with those of two control groups attending the health complex during the same period (August 1989 through November 1992). One control group comprised a 10 percent sample of in-patients at Singra Health Center. The results of this comparison are presented in Chapter 3. The sample was selected by taking all patients on every tenth page of the in-patient register. The second control group consisted of the entire population of

[2]In addition to the list in the previous section, this included Sujanagar and Ishurdi.

the heath center's tuberculosis patients. TB patients, like most of those with kala-azar, are treated as out-patients with fever. The number of TB patents diagnosed at the health center was substantially lower than the number of kala-azar patients. Further, they tended to be concentrated in non-embanked areas, although they were less dispersed than the inpatient controls. Exposure was defined as living inside Polder B and C. Cases of kala-azar and inpatient controls were excluded if the home address could not be determined, if the address was outside Singra thana, or if it was a duplicate address.

The main criteria for the selection of a control group is "to select subjects who represent those who might have become cases in the study; if cases are selected from one hospital out of many in a city, then controls should represent those people who, had they developed the disease under study, would have gone to the same hospital" (Rothman 1986). Controls for this study were selected independent of the risk of exposure or the relationship of their residence to an embankment.

The recorded information for all patients was cross-checked at random through household visits and interviews with patients. During those interviews, some additional data on household status and medical history was gathered. From the detailed information gathered from the Singra Thana Health Center, a series of two-by-two tables was constructed and analyzed. Finally, a logistic-regression analysis was performed which examined the strength of the relationships between the incidence of kala-azar in the sampled populations and the distributed characteristics of those populations, i.e., position with regard to embankments, age, and sex.

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Chapter 2

EPIDEMIOLOGY OF KALA-AZAR IN BANGLADESH

1. History of Kala-azar

Masum *et al.* (1990) reported that kala-azar caused "immense human suffering" in rural Bangladesh until the late 1950s. A review of the history of kala-azar through 1985 (Elias *et al.* 1989) reports that the disease occurred in Bangladesh during the British colonial period, but the extent is not clear. The Bengal District Gazetteers, Mymensingh (Sachse 1917), recorded an 1872 kala-azar outbreak in Sherpur Thana describing it as, "a remittent fever, not infectious but usually fatal."

Between 1923 and 1924, a total of 130,952 cases of kala-azar were recorded in Bengal, of that number, nearly 11,000 cases were in Rajshahi district (Ward 1992). In 1950 an outbreak occurred in Iswarganj Thana (Elias *et al.* 1989). K.M. Rahman indicated that from 1959 to 1963 a total of 15,000 to 17,000 cases occurred in Bangladesh (Sanyal 1985). During the 1970s the near absence of cases led to the conclusion that kala-azar had been eliminated as a consequence of DDT spraying carried out in the 1960s under the National Malaria Eradication Programme. The current epidemic in Bangladesh began in 1980-1981 at Sahjadpur Thana in Serajganj District (Masum 1990).

The term "epidemic" is defined as the occurrence of illness clearly in excess of normal expectancy (Benenson 1980). This is contrasted with the term "endemic," which refers to the constant presence of a disease or infectious agent within a geographic area. Historically, kala-azar may have been at times epidemic and at other times endemic in the areas that now constitute the modern state of Bangladesh. The current situation, however, is clearly epidemic because the number of reported cases is increasing dramatically. In 1980-81, only one thana reported infected cases of kala-azar. A decade later, in 1990-1991, 65 thanas reported cases, and the number of cases reported annually is in the thousands (DGHS 1992). Since under-reporting of cases is a serous problem (Ashford *et al.* 1992) the actual number of cases may well be in the tens of thousands.

The most recent outbreak of kala-azar followed the withdrawal of large scale DDT spraying, which led to an increase in vector densities (Elias *et al.* 1989). DDT is now banned in Bangladesh. The government's response to the epidemic, therefore, has been constrained by the DDT ban, as well as by a lack of funding for other forms of vector control. A human reservoir of infection may come from persons with post-kala-azar dermal leishmaniasis (PKDL), untreated cases, or cases imported from India. As a result of the increased vector population, these carriers of *L. donovani* protozoa have an increased probability of being bitten by *P. argentipes*.

2. The Current Epidemic of Kala-azar

The 1980 Sahjadpur epidemic started with 120 serologically confirmed cases of kala-azar. The following year 104 cases were reported. The outbreak occurred after completion of the Serajganj Integrated Rural Project (SIRP) and the Hurasagar flood control project. The two projects consisted of 113 embankments and 29 flood control structures. Of the 583 cases confirmed nationwide between 1980 and 1985, 490, or 84 percent, occurred within the contiguous area that included the SIRP, the Hurasagar project, and the Pabna flood control and irrigation projects. Forty-two percent of the Pabna project was finished by 1981, and the remainder was completed by 1985. Pabna thanas first reported kala-azar cases in

1984-85. Map 1 shows the distribution of kala-azar cases in Bangladesh from 1980-1985. Map 2 shows the distribution of cases in 1991.

The projects radically changed the environments in their respective areas. Before their construction, for instance, Sahjadpur had been deeply flooded most of the year and only deep-water rice was grown. Land lay fallow during the dry season, dairy cattle grazed in the winter, and fish were abundant. The construction of embankments virtually eliminated river flooding in the area for many years, and although rice production increased, fish and milk production declined. It is believed that full flood control was achieved in Sahjadpur prior to the kala-azar outbreak.

Another cluster of cases appeared in Mymensingh District between 1983 and 1985. All the cases came from the Modhupur highland thanas of Trisal and Fulbaria. Several other cases were reported from the Medical College in Mymensingh that borders these highland areas. Cases were also reported in Kalmakanda, a highland thana close to the Indian border. In 1985, cases were reported in Godagari Thana in Rajshahi, a highland area protected by a large embankment. Highland tracts are similar to flood-protected areas in that they are free of deep flooding.

Nine cases were found at Mitford Hospital in Dhaka in 1982-83. These all came from the Pagla area of Demra Thana and Keraniganj Thana (Hossain and Rashid 1987). Demra is a flood-protected area, but the report is unclear about the distribution of cases between the thanas.

The number of thanas reporting cases of kala-azar in Bangladesh has been growing annually. In 1991, 68 thanas reported cases of kala-azar. In some thanas of Serajganj and Pabna, kala-azar has become endemic as newly diagnosed cases have been reported for more than a decade.

Table 1
Distribution of Kala-azar Cases
Relative to Embankments, by Land Elevation*

	Inside Embankments		Outside Embankments		
Year	Lowland % (n=2,668)	Highland % (n=387)	Lowland % (n=243)	Highland % (n=1,195)	Total
1980-85	86†	1	0	13	570
1989	80	0	0	20	991
1991	43	16	4	38	1,123
1992	50	11	11	28	1,809
Total	59	9	5	27	4,493

*Nine cases of unclear distribution are excluded.
†Percent of all cases.

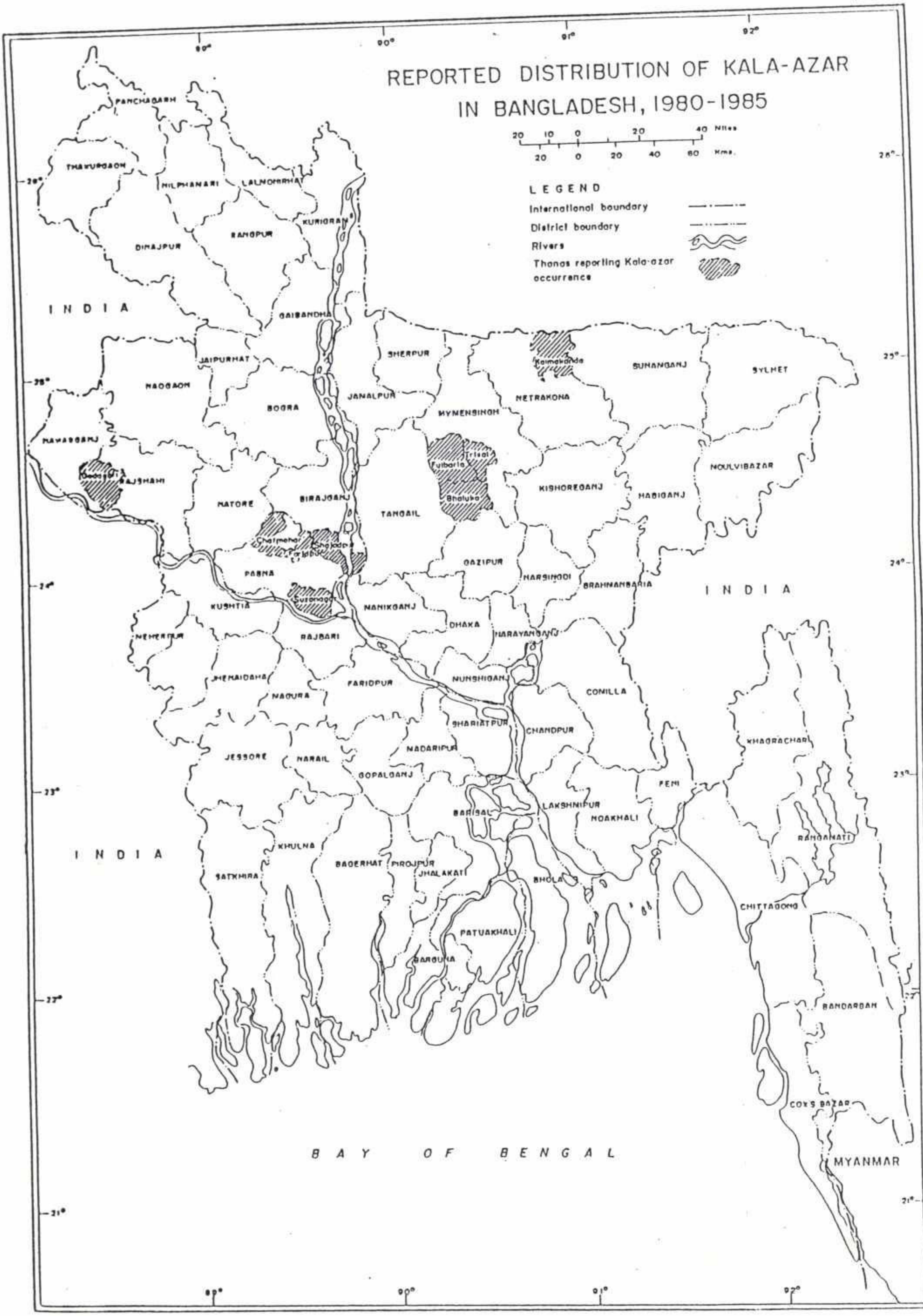
3. Kala-azar Cases Relative to Embankments

Thanas reporting cases between 1980-85 and from 1989-92 were located on a map showing FCD projects completed as of 1989. The distribution of cases was also plotted on a topographical map.

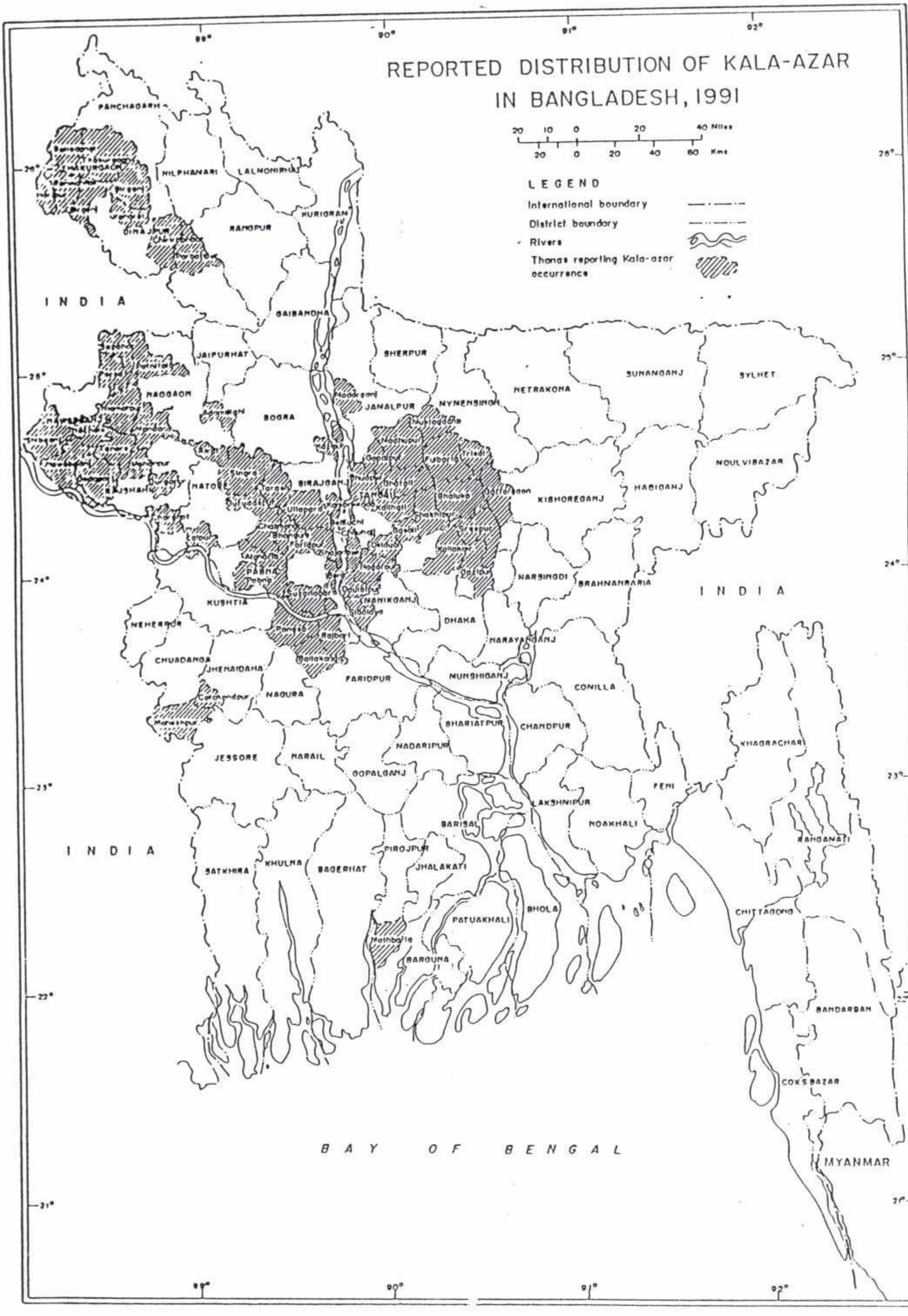
Table 1 shows the distribution of kala-azar cases according to embankment and land elevation.[3]

[3]In this study, medium highland and highland between 1.5 m and 2.0 m above sea level are grouped together.

MAP I


REPORTED DISTRIBUTION OF KALA-AZAR
IN BANGLADESH, 1980-1985
LEGEND
International boundary
District boundary
Rivers
Thanas reporting Kala-azar occurrance
INDIA
INDIA
INDIA
MYANMAR
BAY OF BENGAL
PANCHAGARH
THAKURGAON
NILPHAMARI
LALMONIRHAT
KURIGRAM
RANGPUR
DINAJPUR
GAIBANDHA
JAIPURHAT
NAOGAON
BOGRA
SHERPUR
JAMALPUR
MYMENSINGH
NETRAKONA
SUNAMGANJ
SYLHET
MOULVIBAZAR
HABIGANJ
KISHOREGANJ
Trisal
Fulbaria
Bhaluka
TANGAIL
SIRAJGANJ
NATORE
RAJSHAHI
Godagari
PABNA
Suzanagar
KUSHTIA
MANIKGANJ
GAZIPUR
NARSINGDI
BRAHMANBARIA
DHAKA
NARAYANGANJ
RAJBARI
MEHERPUR
JHENAIDAHA
MAGURA
FARIDPUR
MUNSHIGANJ
COMILLA
SHARIATPUR
CHANDPUR
MADARIPUR
KHAGRACHARI
JESSORE
NARAIL
GOPALGANJ
FENI
LAKSHMIPUR
NOAKHALI
BARISAL
RANGAMATI
KHULNA
SATKHIRA
BAGERHAT
PIROJPUR
JHALAKATI
BHOLA
CHITTAGONG
PATUAKHALI
BARGUNA
BANDARBAN
COX'S BAZAR

MAP 2


REPORTED DISTRIBUTION OF KALA-AZAR
IN BANGLADESH, 1991
LEGEND
International boundary
District boundary
Rivers
Thanas reporting Kala-azar occurrence
INDIA
INDIA
INDIA
BAY OF BENGAL
MYANMAR
PANCHAGARH
NILPHAMARI
LALMONIRHAT
RANGPUR
KURIGRAM
DINAJPUR
GAIBANDHA
JAIPURHAT
NAOGAON
BOGRA
SHERPUR
JAMALPUR
MYMENSINGH
NETRAKONA
SUNAMGANJ
SYLHET
MOULVIBAZAR
HABIGANJ
KISHOREGANJ
SIRAJGANJ
TANGAIL
NATORE
RAJSHAHI
PABNA
KUSHTIA
MANIKGANJ
DHAKA
NARSINGDI
BRAHMANBARIA
NARAYANGANJ
MEHERPUR
CHUADANGA
JHENAIDAHA
MAGURA
FARIDPUR
MUNSHIGANJ
COMILLA
SHARIATPUR
CHANDPUR
MADARIPUR
JESSORE
NARAIL
GOPALGANJ
LAKSHMIPUR
NOAKHALI
FENI
KHAGRACHARI
BARISAL
PIROJPUR
JHALAKATI
SATKHIRA
KHULNA
BAGERHAT
BHOLA
PATUAKHALI
BARGUNA
CHITTAGONG
RANGAMATI
BANDARBAN
COX'S BAZAR

The distribution of cases from 1989 through 1992 was largely concentrated within flood controlled and highland areas. Both the area and the magnitude of the epidemic are increasing, however, and it appears that other land types are becoming involved.

As previously mentioned, kala-azar is seriously under-reported, and it is therefore difficult to determine the magnitude of the epidemic. There is no evidence, however, to suggest that under-reporting reflects a bias for or against flood control project areas. The problem of under-reporting of kala-azar is common wherever the disease occurs. Ashford *et al.* (1992) indicate that the following categories of persons are excluded from case reporting:

- People with no access to medical facilities.
- Misdiagnosed cases.
- Cases that are seen clinically but not reported.
- Infections that remain subclinical and therefore are not seen.

Because the costly treatment for the disease is beyond the means of most rural people, many who suffer from kala-azar do not go to health centers. The number of reported kala-azar cases seen by the Singra Health Center dropped after 1990 when a free supply of medicines decreased. Reported incidence also may have been affected by DDT spraying in late 1989 and 1990.

Chapter 3

CASE CONTROL STUDIES IN SINGRA THANA

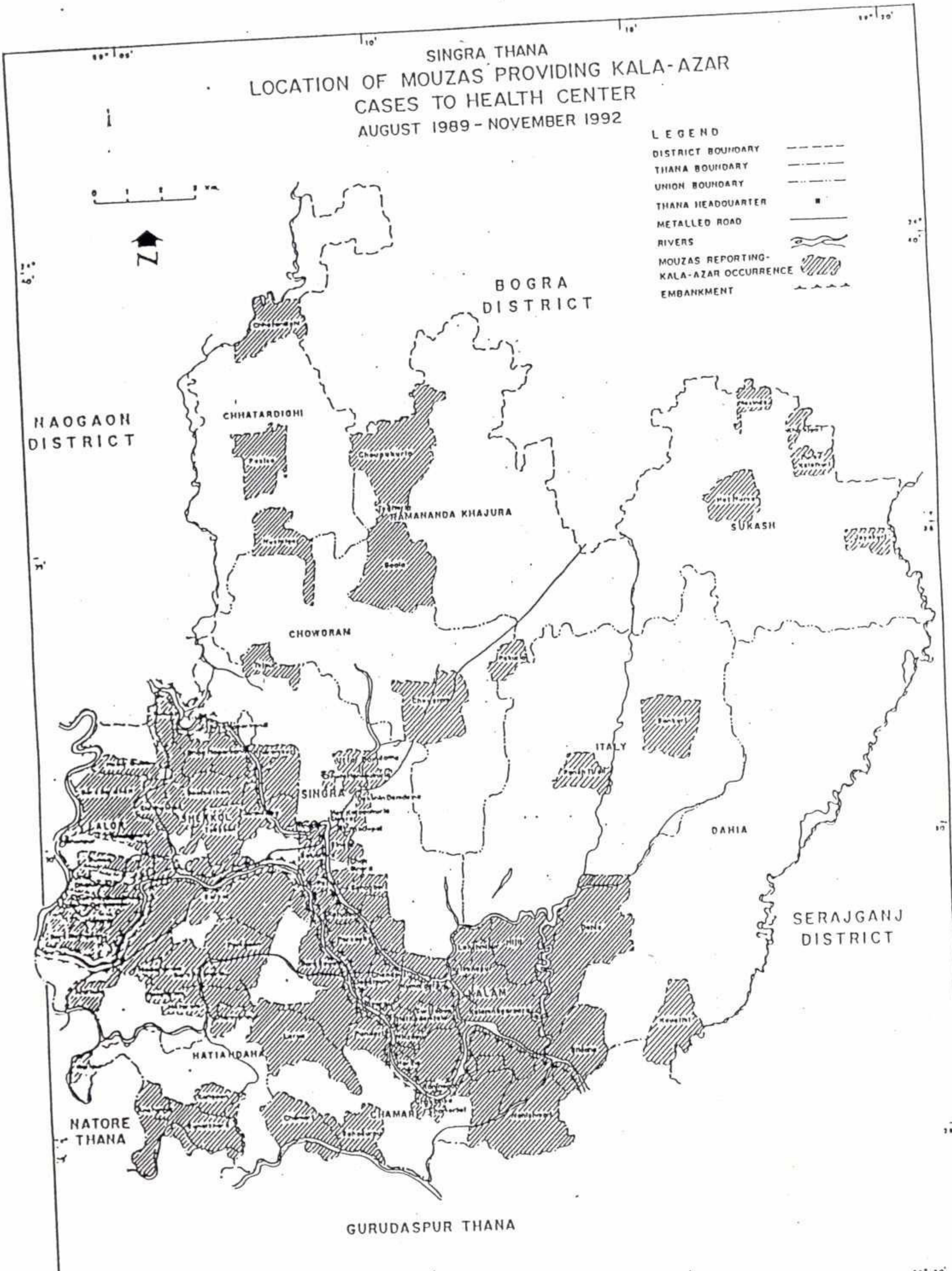
Singra Thana, in Natore District, has many large, deeply flooded areas such as Chalan Beel and a number of rivers: the Gur, Godai, Atrai, Baranai, Gurnai, Nagar, and Pund. Significant portions of these rivers have been embanked as part of the Chalan Beel project and adjacent flood control projects. There were no reported cases of kala-azar in Natore between 1980 and 1985. The first records of leishmaniasis in the district were in late 1988. From the incidence of reported cases by 1989 it was clear that several thanas in Natore were experiencing an epidemic of the disease. In 1989 and 1990, sodium stilbogluconate was made available free of charge through the Singra Health Center (although the quantities provided were less than is needed for full treatment). Diagnosed cases of kala-azar peaked in Singra in 1990 (Table 2). That year, DDT was sprayed in affected areas, and incidence of the disease subsequently declined sharply. The distribution of cases that were recorded at the Singra Health Center, when plotted on maps showing the location of embankments, roads, and rivers, clearly reveals that the cases were heavily clustered within areas protected by Polders C and B (Map 3) in contrast to the origins of Health Center in-patients which were distributed more evenly over the thana (Map 4).

A number of kala-azar cases originated in mouzas that were both inside and outside the embankment. Table 3 compares the three possible exposure categories (inside, inside-outside, and outside) by chi square trend. As the table shows, risk increased according to exposure level. While there was no increased risk associated with living outside the embankment, living in a mouza that had villages both inside and outside the embankment moderately increased risk, and living in a mouza completely within the embankment substantially increased risk.

Table 2
Distribution of Kala-azar Patients
Relative to Singra Thana Embankment
August 1989 - November 1992

	Inside Embankment (%)	Outside Embankment (%)	On Embankment (%)
Aug 1989-July 1990 (n=367)	80	11	9
Aug 1990-July 1991 (n=219)	71	16	14
Aug 1991-July 1992 (n=32)	50	31	19
Aug 1992-Nov 1992 (n=16)	50	38	13
Total (n=634)	75	14	11

As the two-by-two table in Figure 1: shows, people living inside the embankment had a risk of developing kala-azar that was 17.69 times as high as others who used the Singra Health Center. To determine whether age or sex were factors in the


SINGRA THANA
LOCATION OF MOUZAS PROVIDING KALA-AZAR CASES TO HEALTH CENTER
AUGUST 1989 - NOVEMBER 1992
LEGEND
DISTRICT BOUNDARY
THANA BOUNDARY
UNION BOUNDARY
THANA HEADQUARTER
METALLED ROAD
RIVERS
MOUZAS REPORTING KALA-AZAR OCCURRENCE
EMBANKMENT
N
BOGRA DISTRICT
NAOGAON DISTRICT
CHHATARDIGHI
RAMANANDA KHAJURA
SUKASH
CHOWGRAM
ITALY
SINGRA
LALOR
SHERKOL
DAHIA
SERAJGANJ DISTRICT
KALAM
HATIANDAHA
CHAMARI
NATORE THANA
GURUDASPUR THANA

MAP 4

SINGRA THANA
LOCATION OF MOUZAS PROVIDING IN-PATIENTS CASES TO HEALTH CENTER
AUGUST 1989 - NOVEMBER 1992

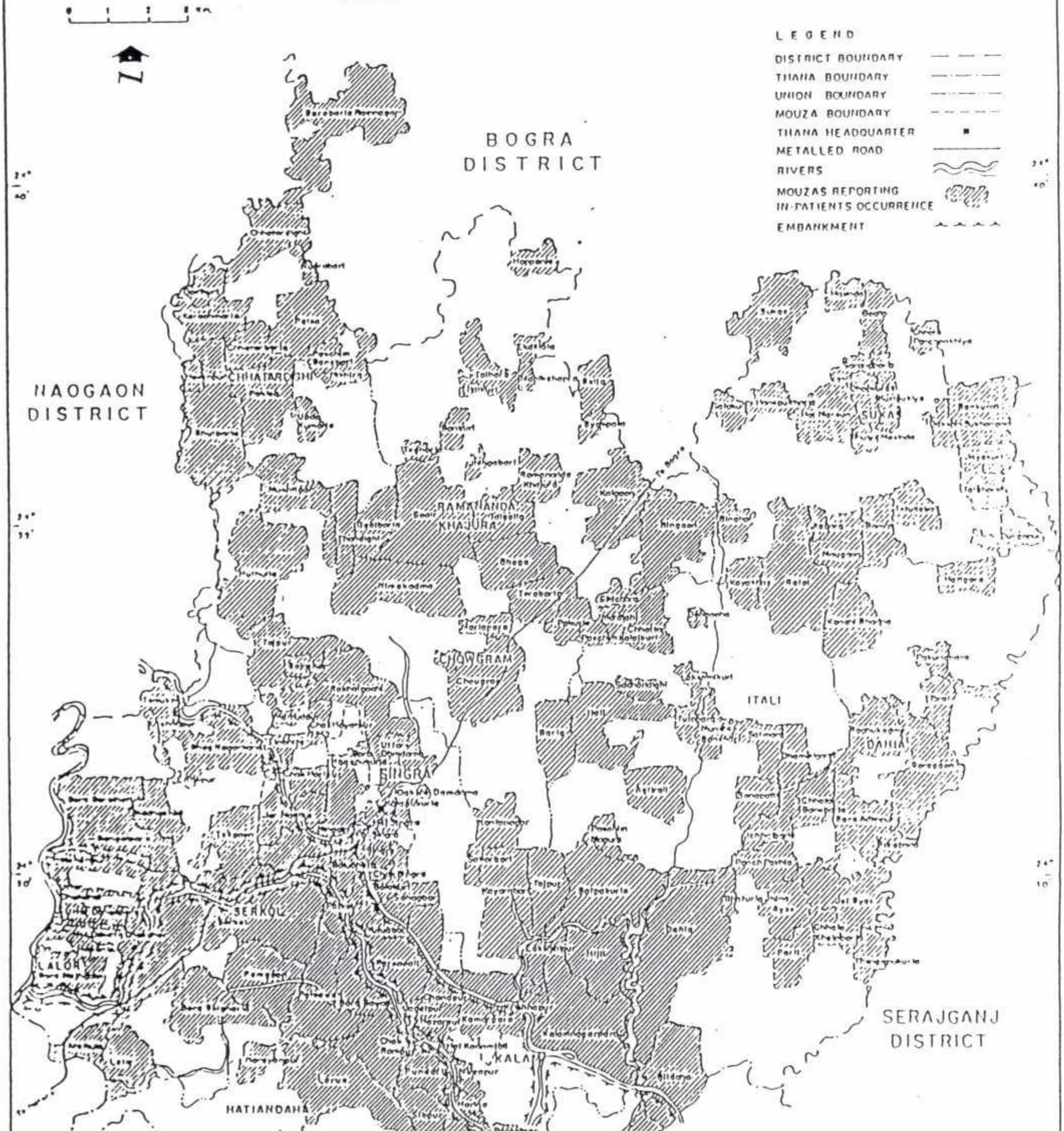


Table 3
Linear Trend Analysis of Case Control Data (by Mouza), in Proportions* (August 1989 - November 1992)

	Number of Cases	Number of Controls	Exposure Relative to Baseline
Outside embankment	91	573	1.00
Inside and outside embankment	71	128	3.49
Inside Embankment	472	168	17.69

*Computed according to Schlesselman (1982)

results, the data for these groups were analyzed separately. Cases and controls were examined in two age groups: those under 15 years old and those 15 years old and over (Figures 2 and 3). The odds ratio for the under 15 group was 17.48, and for 15 and over it was 17.38. An analysis of the cases and controls according to sex found that the odds ratio for males was 15.77 and for females it was 21.27 (Figures 4 and 5). These results indicate that both males and females living inside embankments have significantly higher chances of contracting kala-azar in comparison to those outside. Results of logistic regression analysis (see below) indicate that gender differences are not significantly related to kala-azar incidence.

Because of the fluctuations in the number of cases from year to year during the study, the data were also stratified according to year of diagnosis. This stratification (Figures 7 through 10) found that the odds ratios for the first two years were 20.69 and 20.01, and in the last year, when the number of patients dropped, the odds ratio decreased to 5.42. The declining odds ratios seen in later years is associated with a decrease in the number of kala-azar cases as seen. This decrease in cases may due to declining health center attendance among those with kala-azar, a change in record keeping, or a true decrease in numbers of kala-azar cases. Since this decrease occurs after focal spraying with DDT, it is reasonable to assume that it is at least partly due to a reduction in transmission and in new cases. The declining odds ratio in this period suggests that the risks of living inside an embankment will be reduced where effective vector control programs are in place.

These findings were confirmed by logistic regression analysis (Table 4). When controlling for sex, age, and year of diagnosis, the effects of living inside the embankment on the risk of kala-azar are preserved, strengthening the argument that the finding is due to an effect of the embankment. Sex

Figure 1: Origin of Kala-azar and In-patients (August 1989 - November 1992)

	kala-azar	in-patients	
Lived inside embankment	472	168	640
Lived outside embankment	91	573	664
	563	741	1304

Odds Ratio 17.69 (confidence limits* 13.21-23.72)

Chi-square significance tests: 478.91 p <0.00000001

*Computed according to Cornfield (1956).

Figure 2: Origin of Kala-azar and In-patients, Age <15 (Aug 1989 - Nov 1992)

	kala-azar	in-patients	
Lived inside embankment	297	61	358
Lived outside embankment	56	201	257
	353	262	615

Odds Ratio 17.48 (confidence limits 11.44-26.77)

Chi-square significance test: 228.93 $p<0.000000001$

Figure 3: Origin of Kala-azar and In-patients, Age ≥ 15 (Aug 1989 - Nov 1992)

	kala-azar	in-patients	
Lived inside embankment	175	107	282
Lived outside embankment	35	372	407
	210	479	689

Odds Ratio 17.38 (confidence limits 11.18-27.13)

Chi-square significance test: 227.58 $p<0.00000001$

Figure 4: Origin of Male Kala-azar and In-patients (Aug 1989 - Nov 1992)

	kala-azar	in-patients	
Lived inside embankment	290	99	389
Lived outside embankment	60	323	383
	350	422	772

Odds Ratio 15.77 (confidence limits 10.86-22.94)

Chi-square significance test: 270.1 $p<0.00000001$

Figure 5: Origin of Female Kala-azar and In-patients (Aug 1989 - Nov 1992)

	kala-azar	in-patients	
Lived inside embankment	182	69	251
Lived outside embankment	31	250	281
	213	319	532

Odds Ratio 21.27 (confidence limits 13.05-34.85)

Chi-square significance test: 208.72 p,0.00000001 was found to have no relationship with the risk of kala-azar. Children were found to be at three times greater risk of contracting kala-azar than adults.

The effects of age was surprising, and was therefore checked with a two-by-two table analyzing the age data. The findings appear in Figure 6.

Although children generally are at greater risk than adults, the increased risk associated with living inside an embankment is similar in both children (odds ratio = 17.48, Figure 2) and adults (odds ratio = 17.38, Figure 3). The association with age is difficult to interpret and may simply reflect that adults are more likely to be hospitalized than children. On the other hand, village doctors, who are often the first line of treatment and diagnosis, indicated that children were more commonly afflicted with kala-azar. Children also represented 63 percent of clinically confirmed cases in Singra. A study in Bihar, India, found that about 50 percent of cases were in children below the age of 10 (Aikat *et al.* 1979).

TB patients were selected as a second control group. Records for TB patients were available

Figure 6: Comparison of Adults with Children Kala-azar and In-patients (August 1989 - November 1992)

	kala-azar	in-patients	
Children (age < 15 years)	397	308	705
Adults (age ≥ 15 years)	237	561	798
	634	869	1503*

Odds Ratio 3.05 (confidence limits 2.45-3.80)

Chi-square significance test: 218.81 $p<0.00000001$

*This total includes (1503-1304 = 199) persons that live both inside and outside embankments.

Figure 7: Origin of Kala-azar and In-patients (Aug 1989 - July 1990)

	kala-azar	in-patients	
Lived inside embankment	293	48	341
Lived outside embankment	41	139	180
	334	187	521

Odds Ratio 20.69 (confidence limits 12.71-33.85)

Chi-square significance tests: 204.16 $p<0.00000001$

from October 90 - February 1991. These were compared with kala-azar patients diagnosed during the same period. TB patients were used as controls because they were outpatients with a serious febrile disease. In this respect they are similar to kala-azar cases. They also had a geographic distribution differing from inpatients (Map 5). The results of the TB patients are consistent with those found with in-patient controls. Though the odds ratio apparently lower (10 vs. 17.6), it continues to be dramatically high (Figure 11). The relative small numbers of cases make the findings statistically imprecise (confidence limits 3.17-37.96.) but they indicate a strongly positive increased risk of developing kala-azar within embankments.

The occupation distribution of households was determined from data obtained during a household nutrition survey conducted in Singra thana (ISPAN 1993). A comparison of the occupation distribution inside and outside of the embankment found no significant difference in the distribution, and therefore occupation was ruled out as an explanation for the difference in the incidence of kala-azar. The occupation distribution of Singra thana is shown in Table 5.

MAP 5

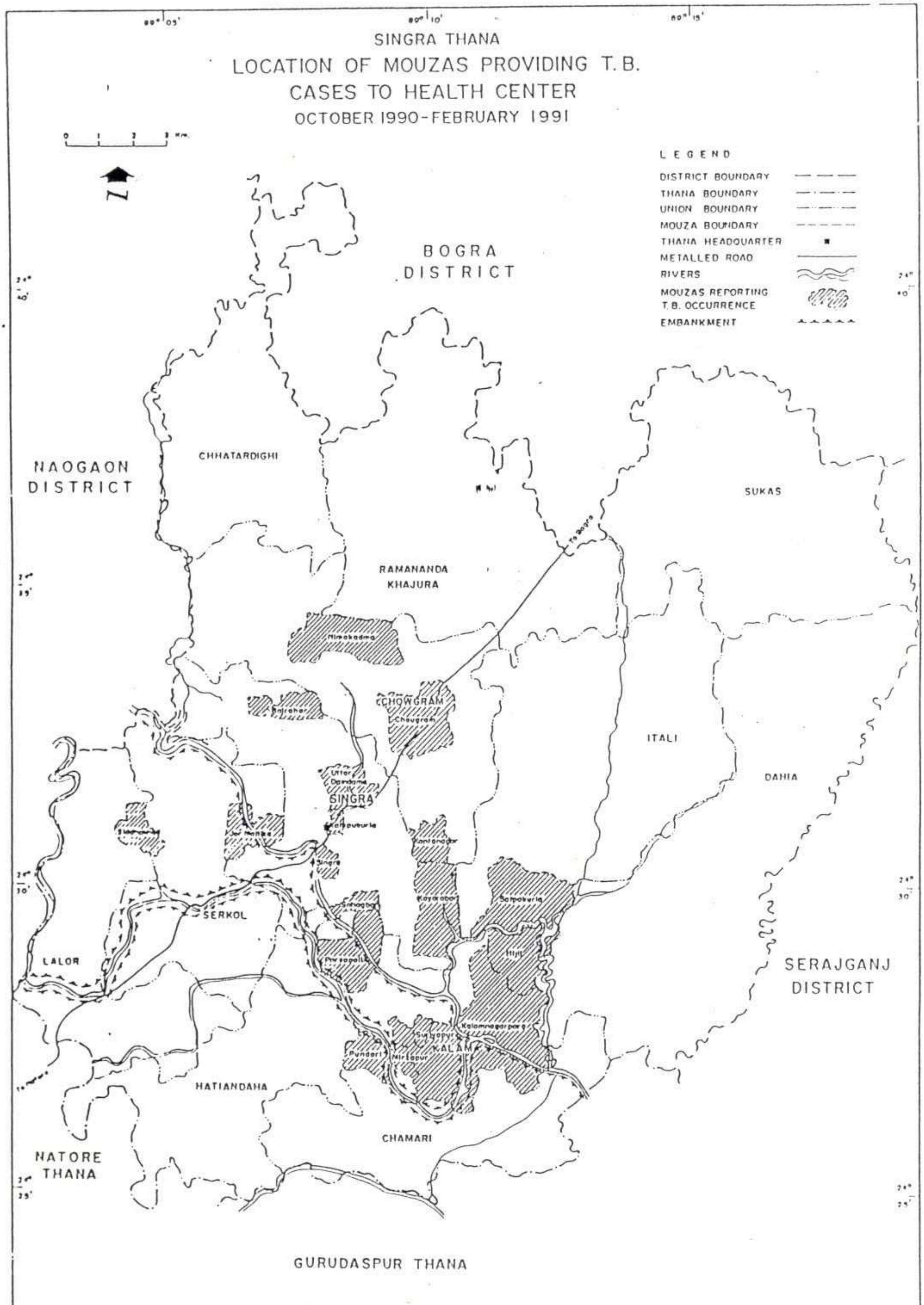

SINGRA THANA
LOCATION OF MOUZAS PROVIDING T.B. CASES TO HEALTH CENTER
OCTOBER 1990-FEBRUARY 1991
LEGEND
DISTRICT BOUNDARY
THANA BOUNDARY
UNION BOUNDARY
MOUZA BOUNDARY
THANA HEADQUARTER
METALLED ROAD
RIVERS
MOUZAS REPORTING T.B. OCCURRENCE
EMBANKMENT
BOGRA DISTRICT
NAOGAON DISTRICT
CHHATARDIGHI
RAMANANDA KHAJURA
SUKAS
ITALI
DAHIA
CHOWGRAM
SINGRA
SERKOL
LALOR
KALAM
HATIANDAHA
CHAMARI
SERAJGANJ DISTRICT
NATORE THANA
GURUDASPUR THANA

Figure 8: Origin of Kala-azar and In-patients (Aug 1990 - July 1991)

	kala-azar	in-patients	
Lived inside embankment	155	41	196
Lived outside embankment	34	180	214
	189	221	410

Odds Ratio 20.01 (confidence limits 11.76-34.24)

Chi-square significance test: 164.42 $p < 0.00000001$

Figure 9: Origin of Kala-azar and In-patients (Aug 1991 - July 1992)

	kala-azar	in-patients	
Lived inside embankment	16	54	70
Lived outside embankment	10	183	193
	26	237	263

Odds Ratio 5.42 (confidence limits 2.17-13.75)

Chi-square significance test: 18.02 $p < 0.00000219$

Figure 10: Origin of Kala-azar and In-patients (Aug 1992 - Nov 1992)

	kala-azar	in-patients	
Lived inside embankment	8	25	33
Lived outside embankment	6	71	77
	14	96	110

Odds Ratio 3.79 (confidence limits 1.05-13.91)

Chi-square significance test: 5.63 $p < 0.0177$

Figure 11: Origin of Kala-azar and TB Patients (Oct 1990 - Feb 1991)

	kala-azar	TB	
Lived inside embankment	56	5	61
Lived outside embankment	20	19	39
	76	24	100

Odds Ratio 10.64 (confidence limits 3.17-37.96)

Chi-square significance test: 21.42 $p < 0.0000037$

Table 4
Relative Odds Ratios for Kala-azar
Singra Health Center
Aug 1, 1989 - Nov 30, 1992
Logistic Regression Analysis

Variable*	Odds Ratio	95% Confidence Interval
Age		
< 15 years	1.0†	(0.24 - 0.42)
≥ 15 years	0.3	
Sex		
Male	1.0	(0.76 - 1.36)
Female	1.01	
Location of Home Relative to Embankment		
Outside	1.0	
Partially Inside	3.56	(2.38 - 5.32)
Inside	15.67	(11.44 - 21.46)

*Model also controls for period of diagnosis
†Reference value

Table 5
Occupation of Sample Households in Singra Thana (percent)

Occupation	Inside Embankment	Outside Embankment	Total
Agriculture (n = 81)	62.0	62.5	62.3
Service (n = 10)	6.0	8.8	7.7
Fishing (n = 8)	6.0	6.3	6.2
Artisan (n = 3)	2.0	2.5	2.3
Non-agricultural labor (n = 3)	6.0	2.5	3.8
Transport worker (n = 3)	4.0	1.3	2.3
Business & other (n = 20)	14.0	16.3	15.4
Total number	50	80	130

Source: Nutritional Consequences of Fisheries Biodiversity (ISPAN 1993)

Chapter 4

DISCUSSION AND CONCLUSIONS

Epidemiology is concerned with the frequencies and types of illnesses and injuries in groups of people and with the factors that influence their distribution. This implies that disease is not randomly distributed throughout a population, but rather sub-groups differ in the frequency of different diseases. Knowledge of this uneven distribution can be used to investigate causal factors and thus lay the groundwork for programs of prevention and control. (Mausner and Kramer 1985)

This study of flood control embankments and kala-azar determined that the distribution of the disease in Singra was not random but was particularly prevalent within the sub-group of the population living within areas protected by flood control embankments. Attention should now focus on developing programs for prevention and control of this deadly disease in areas already suffering from other acute health needs.

Deaths from kala-azar are receiving increasing press attention in Bangladesh. For example, the daily newspaper *Bhorer Kagoj* of May 21, 1993, reported 52 deaths from kala-azar in our study area over a period of five months. Control of the disease is hampered by lack of medicine and approved insecticide. The evidence from Singra Thana suggests that where DDT spraying for kala-azar was carried out during 1989-90 the case incidence decreased. DDT is now banned in Bangladesh, and more costly insecticides are required. Funding for integrated vector control is reportedly under consideration, but as yet neither donors nor the government recognize that the country is facing an epidemic. Interventions to reduce the risk of infection and treatment for the sick are required, as are further studies to understand the population dynamics of sandflies inside and outside embanked areas.

Kala-azar was believed to have been eliminated from Bangladesh during the 1960s when DDT was used for malaria control. While suspension of DDT spraying may have been a pre-condition for the current epidemic, it does not explain why the distribution of cases in the 1980-1992 epidemic was heavily concentrated within flood control projects and highlands. It is possible that these areas provided suitable habitats for a rapid resurgence of *P. argentipes* populations in the post-DDT era.

One biological constraint to dealing with the kala-azar epidemic is that sandfly populations in Bangladesh have not been well studied. It is known that sandfly populations vary seasonally and that they flourish during warm moist conditions. The larvae develop in rich organic material such as soil soaked with cow dung. Human faeces also may provide a suitable habitat, although this medium has not been systematically searched for larva.

P. argentipes, breeds in organically rich, moist soils. Soon after adults emerge in the pre-monsoon season they become sexually active and females begin laying eggs (Chulay and Manson-Bahr 1991). The sandfly larvae feed on organic matter and thrive in the high humidity of the monsoon period during their four worm-like stages. They are often found in loose soil, in cow sheds, and near houses. Floods can disrupt the larval habitat by washing away the cow dung, faeces, and leaf litter that supports development and growth. A 1990 study of the effects of floods on the immature stages of sandflies in Bihar (Mukhopadhyay *et al.* 1990) found that larvae climbed as high as 90 cm. to avoid rising water. Once the flood receded, they returned to ground level. The larval response to hydrological change may provide an important clue for understanding sandfly ecology in Bangladesh.

Flooding may have a negative effect on the earliest stages of sandfly development, when the larvae are least mobile, dramatically decreasing the number of survivors. Should flood protection provide increased opportunities for previously vulnerable larvae to mature and reproduce, the population densities of *P. argentipes* will likely increase dramatically. Increased population densities in turn increase the potential number of sandflies infected with *L. donovani*. As more humans are infected, more biting sandflies become carriers of the disease, and the epidemic spiral continues until the sandfly population stabilizes at a new level. Without embankments, flooding close to dwellings may inhibit sandfly populations, and therefore the spread of kala-azar, by destroying larval habitats.

It also is possible that human settlement patterns increase the risk of kala-azar epidemics. For example, residents in several unprotected beel villages in Singra Thana did not know about kala-azar and sandflies. Their settlement patterns tended to be circular, with latrines facing out over flooded depressions called beels. Although populations seemed as dense as in other areas, the beel villages had less leaf litter, perhaps because disposal was easy and convenient. In many protected villages, on the other hand, kala-azar was well known and the sandfly behavior and feeding patterns were accurately described by residents. In linear villages litter tended to pile up closer to houses and faeces as well as cow dung was observed close to some infected homes.

Flooding may also affect the spread of the vector species. Like many other insects, *P. argentipes* concentrate in small areas in order to facilitate interaction between males and females during reproduction. In other species that exhibit this behavior, when the population passes an optimum density, the adults disperse and colonize new areas (Murray 1990). Floods may interfere with this mechanism by blocking movement. If inundation happens to coincide with peak population size, dispersal between houses and even villages would be inhibited.

In the 1970s a kala-azar epidemic swept through the Indian states of Bihar and West Bengal. In Bihar, some of the outbreaks occurred along embanked rivers protected by the Kosi flood control project. Movement of infected people for trade and other purposes could infect sandflies in new areas, providing a sufficient vector population is present. Indeed, cattle are commonly traded from India to Bangladesh. *P. argentipes* larvae have been found in cow dung, adults have been found on cow shed walls, and large numbers of sandflies congregate on cows during mating season.

It is widely acknowledged that "vectors of pathogens that cause human disease exploit disturbed environments" (Spielman and James 1990). Embankments dramatically intrude upon the ecology of floodplains, where the seasonal rise and fall of flood waters virtually define the environment. Kala-azar is an extremely unstable disease. According to LSTM/NIPSOM-ISPAN (1992), small changes in the number of vectors, vector survival rate, human blood feeding, and the prevalence of infected hosts can have a dramatic effect on the incidence of the disease.

The impact of engineering works on vector-borne disease is of concern in Bangladesh and worldwide (LSTM/NIPSOM/ISPAN 1992). Embankments or irrigation projects can alter the population dynamics of disease-carrying insects by creating new habitats or by extending their reproduction and breeding periods. It is believed that flooding in Bangladesh acts as a natural control of malaria-carrying mosquito populations by reducing the larval breeding sites (Bruce-Chwatt 1985). Floods also may keep sandfly populations down, but the control mechanisms are less clear. Environmental changes have also been implicated in kala-azar epidemics in other part of the world (Ashford 1991).

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Chapter 5

RECOMMENDATIONS

1. Review

The findings of this study should be reviewed by epidemiologists as soon as possible. The Health Ministry, donors, and other FAP studies should be appraised of these findings. PEEM/WHO should also review these findings and make further recommendations. Discussion of important policy issues and interventions should be undertaken without delay.

2. Prevention

A program of goals for monitoring and preventing outbreaks of kala-azar within flood control projects is required. This would include:

- A system of testing, reporting, and treatment within flood control projects and other affected areas should form the basis for control activities. Adequate supplies of drugs must be available for free or at a low cost in order to ensure that kala-azar sufferers report to health centers for testing. Successfully treated individuals are no longer carriers of the parasite and, therefore, treatment is an important component in preventing epidemics and saving lives.

- Focal insecticide spraying of houses and cow sheds in villages with kala-azar outbreaks.

- Sanitation and education efforts to reduce the size and possible distribution of larval habitats.

3. Recommended Studies

It is recommended that similar studies over a wider geographical area encompassing different types of embanked and non-embanked scenarios be conducted. To understand the total situation would require that the study addresses eco-epidemiological aspects as well as socio-behavioral and demographic factors. The following are some specific suggestions in this regard.

- A 'prospective study' should be taken up to throw more light on the findings of this case-control 'retrospective study'. It would then be possible to define the 'case' and 'control' groups in ways which are more appropriate than what has been possible here by relying only on available medical records.

- In the 'prospective study', it would be advisable to incorporate precise and rapid diagnostic techniques for confirming Kala-azar infections.

- Epidemiological data should be gathered on the presence of sand-fly vectors and their distribution spatially. Besides, it would be necessary to study sand-fly bionomics in relation to embankments.

- To explain why there are differences in the occurrence of Kala-azar at different locations, it is necessary to collect and analyze location-wise data on human settlement and sanitation, housing and ecological aspects, occupation pattern and movement of people.

- Data bases using a Geographic Information Systems framework should be utilized to prepare maps for overlaying of distribution of Kala-azar cases, vector densities, embankments, etc.

4. Budgets

If the recommended future studies continue to indicate increased risk when living within embanked areas, then projects creating embankments should accept the burden of preventing and treating kala-azar as a component of project implementation. Funds and personnel may come from the government-approved Integrated Vector Control Project.

5. High Priority Areas

There are several FAP areas where the risk of provoking kala-azar epidemics should be of immediate concern. The Tangail CCP project borders on thanas with high incidences of kala-azar. The elevations of these thanas make them less flood prone. Changes in the flood regime within the Tangail project area could substantially increase its vulnerability to kala-azar. Risk assessment should be incorporated in evaluating alternative project proposals under study by FAP 20.

FAP 3.1 already has kala-azar along existing embankments in Jamalpur. The embankments proposed by FAP 3.1 should be reviewed in order to estimate the increased risks of kala-azar.

The coastal embankment construction employs large numbers of labors from Jamalpur and Tangail districts who could be carriers of leishmania infection. Outbreaks have occurred along the coastal belt. Kala-azar investigation and control measures in areas where labors are imported should become a public health priority. Any reports of kala-azar from these areas should result in vector control activities coordinated by the Director General of Health Services.

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