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THE SUDAN MALARIA PILOT PROJECT OBJECTIVES AND ACHIEVEMENTS

by

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1. INTRODUCTION

1.1 The Sudan

This is a wide country of one million square miles and of just over ten million population . The majority of the people are engaged in seasonal agriculture and artificially irrigated agricultural schemes of cotton plantation. A large number of the people are nomads.

In this country, not long ago the word malaria was not known to the majority of the people; not because malaria did not exist or there is reason to doubt its existence but local names were given to seasonal fever, more or less describing its main symptom and periodicity. The names were the following:

Umbarid	:	The fever with rigors.
El ghibia	:	The fever that comes every other day.
El Matlota	:	The fever that comes every third day.
Um El sibian	:	The fever characterised by convulsions in children.

High infant mortality following Um El Sibian was well known to the people of the Sudan. In my own town I can easily remember, in my childhood, that during the fever seasons and particularly in years of heavy rains and high Nile flood very few members of a family escaped being attacked and the highest incidence

was among children. It was a very common sight to see physically impaired adults sitting under the shade doing nothing. Thus the seasonal fever, with the above names, followed by high infant mortality and impairment of physique, cannot be anything but malaria.

1.2 Control of Malaria

Before the Insecticidal properties of Chlorinated Hydrocarbons were discovered sanitary measures were initiated aiming at prevention of breeding of mosquitoes near to human habitations in the Northern Sudan. Gradually expansion on Anti-larval control aiming at decreasing the number of mosquitoes assumed an active phase.

In 1947, DDT 5% was added for the first time to Anti-larval oils. In 1951, DDT w.p. was used with limitation as residual insecticide. In 1952, BHC replaced DDT in towns. Since then continuous efforts were taken to expand its use in all provinces but still many villages in the country were not covered with spraying and the majority of the people remained unprotected.

1.3 Results of Above Efforts and Difficulties

Although the very adverse effects of malaria of the past are not so common today, still malaria tops the list of endemic diseases and remains to be a major public health problem. An average of 300,000 malarious patients treated by the Sudan Health Services annually supports the above statement.

Epidemiologically the climate of this country, the seasonal rainfall, the Nile flood, and the agricultural schemes are all in favour of breeding of malaria vectors and the development of the malaria parasite in them. The difficulty in communications once rains start, the bad roads, the scattered population, the low economical and educational standards of the people particularly in the southern parts of the country are the main difficulties facing malaria control activities.

1.4 Call for International Help

In 1955, the Sudan Government has planned to establish with international assistance a pilot project on malaria eradication.

After consultation with WHO experts, a final decision was taken about the project, its objectives, site, staff, budget and other factors involved. WHO and UNICEF agreed on providing technical and material assistance in the undertaking of the Sudan Government.

2. THE PROJECT AREA

2.1. The Choice

The Blue Nile Province has been selected as project centre for the following reasons:

(a) Economical Importance

The Blue Nile Province is to a great measure the centre of the wealth of the Sudan, as it contains the Gezira irrigated area which is the seat of a most intensive and profitable cultivation.

There is every prospect that the economic importance of the Province will be greatly intensified when new irrigated works along the upper reaches of the Blue Nile are in hand. There is a very lively appreciation in the Sudan of the health consequences of alterations in the water balance of the country-side, and the authorities wish to take all possible steps to avoid a repetation of some of the undesirable by-products which followed the start of the original Gezira irrigation in 1925.

(b) The Province has had one of the highest malaria morbidity figures in the Sudan, amounting to an annual average of 4348 per 10,000 population in the period 1951 - 1956, mainly concerning the southern part of the area. (Medical aid centres are more in this province than in any other province in the Sudan.)

(c) The geographical situation of the Blue Nile Province, reaching from 15°N down as to 9°N, thus representing a full variety of climatological, biological, geological, economical and other features.

(d) Facilities of transportation and communications are fairly good regarding connections with Khartoum and at varying degree, ranging from good to utmost difficult in the project area itself, giving opportunity to gather an all-round-experience applying also to other regions.

(e) The area offers good prospects for future incorporation of the project into a countrywide-campaign, serving as a nucleus for the same.

2.2 Definition of Area

The Blue Nile Province roughly covers, from Khartoum southwards, the area between White and Blue Nile and its tributary Rahad up to the latitude, where the Blue Nile enters Sudan territory. In the east the Blue Nile Province borders Ethiopia and extends southwards to 9°N.

For the project the southern parts of the B.N.P., i.e. Sennar, Northern and Southern Fung and Kurmuk were foreseen, having a surface of 78,044 Km.^{2} and a population of 592,588, an average density of 7.6 inhabitants/Km.^{2}

In the north the project area is a clay plain and its character changes into bushland, light and finally denser forest as more south one goes; at the same time land becomes increasingly hilly, particularly towards the Ethiopian border. There is a series of rocky hills at intervals of about 40 - 50 kms., situated in the central plain north to south.

2.3 Communications

Sennar lies at a railway-junction. Train services operate to Khartoum, El Obeid, Kassala-Port Sudan, and Roseires, quite regularly in the dry, irregularly during the rainy season. Most of the villages of the project area can be reached by car. However condition of roads is poor, none being macadamized.

During rainy season all the roads are closed for motor-traffic.

Regular steamer services do not exist on the Blue Nile.

Animal transport has to be used generally during the rainy months and in the dry season as several areas are inaccessible for motor-vehicles.

2.4 Meteorology

The B.N.P. lies - as the Sudan - entirely in the tropics. Climatic conditions of northern and southern project area differ considerably. In Sennar annual oscilation of the monthly mean temperature ranges between 25° - 32°C - January being the coolest and May the hottest month - whereas in Kurmuk, the range is between 26° - 31°C - April usually being the hottest month. The mean miminum temperatures never fall below 16°C. Rainy season lasts in Kurmuk from May until October, in Sennar from July to September. Annual rainfall in Kurmuk (940 mm) is about double the quantity in Sennar (471 mm). Relative humidity is low (less than 50%) except during and immediately after the rainy season.

2.5 Housing condition

The round-hut "tukul" is by far the most prevalent type of structure. It is usually constructed of a wooden frame, thatch-walls and a conical thatched roof. Less than 10% of the tukuls are built of mud or bricks, mudwashed or whitewashed. The nomads are using tents made of coarse wool. When assuming settled life, they still put up their tents under the tukuls. Stables are rather rare since it is obviously not necessary to shelter the animals.

3. OBJECTIVES OF THE PROJECT

(a) To set up a malaria eradication pilot project in the Fung District of the Blue Nile Province, extending along the Blue Nile from Sennar in the north to the Ethiopian border in the south, during a three years' period beginning in 1956, by establishing measures of residual spraying with insecticides and other appropriate measures with a view to stopping all malaria transmission in this hyperendemic area.

(b) To carry out investigations in the Fung District and the Gezira irrigated Area, in order to solve the problems connected with a future mass anti-malaria campaign having malaria eradication as its objective.

(c) To train local personnel, including malariologists, entomologists, sanitarians and laboratory technicians in method of malaria eradication and epidemiological surveillance.

(d) The investigations to be carried out by the team to solve problems relevant with nation-wide malaria eradication campaign will include the following:

i. The resting habits of the vector or vectors of malaria in the area.

ii. The biting habits of the malaria vectors and their sporozoite rates.

iii. The period of malaria transmission - whether limited or throughout the year.

iv. The effective residual action of insecticidal formulations to define the cycles of the spraying periods.

v. The degree of susceptibility of the malaria vectors to various insecticides.

vi. The effective dosage of various insecticidal formulations on different kinds of structures.

vii. The role of anti-larval measures in certain arid areas.

viii. The role of drug administration combined with other control measures in stopping malaria transmission.

ix. The problem of seasonal migrants.

4. THE PILOT PROJECT

4.1 Organization, staff, offices, transport

In December 1956 the team established itself in Sennar and the first stage was reached in April 1957 when all key positions were filled by the WHO Senior Adviser, WHO Entomologist, WHO Sanitarian and their National Counterparts.

Moreover the following auxiliary national staff were posted to the project:

6	Public Health Officers
17	Sanitary Overseers
1	Laboratory Technician
3	Entomological Technicians
3	Administrative staff
1	Mechanic
11	Drivers.

Offices, laboratories, insectarium, stores and garages, were established in Sennar Hospital compound. Equipment, vehicles, insecticides and other supplies were provided by WHO and UNICEF.

Total transportation amounts now to 10 landrovers (UNICEF and WHO). The Malaria Pilot Project works under the direct responsibility of the Ministry of Health (Director of Medical Services).

4.2 Budget

The Malaria Pilot Project gets its funds from three sources. Procurements were and are as follows (in US-Dollars for 1960 provisional figures):

	1956	1957	1958	1959	1960	1961	Total
WHO	-	46,790	46,790	43,385	31,047	-	168,012
UNICEF	-	43,000	43,000	54,000	43,800	-	174,800
SUDAN Govt.	48,000x	72,800x	86,800x	86,800x	86,800x		375,200

x = including salaries of personnel paid out of the regular budget of the Sudan Ministry of Health (3 National Counterparts and 6 Public Health Officers.)

5. PRE-OPERATIONAL MALARIA SITUATION IN THE PROJECT AREA

As already mentioned, malaria morbidity in the Blue Nile Province was the highest for the Sudan. Outside the Gezira irrigated area, the figures were as follows:

YEAR	TOTAL POPULATION (BNP.without G.I.A.)	NUMBER OF MALARIA CASES	MALARIA MORBIDITY PER 100,000
1951/52	1,215,864	81,391	6,695
1952/53	1,215,864	84,723	6,967
1954/55	1,215,864	100,808	8,291
1955/56	1,215,864	84,157	6,922
1956/57	1,215,864	115,792	9,523

Diagnosis was mostly clinical and only in about 1% of the cases blood was examined for malaria parasites. According to this P. falciperum was the most common species. Its percentage is 86.5 - 92 and that of P.vivax 8-13.5. General splenometric and parasitological surveys were not done until the pilot project started its activities.

In 1957, pre-operational malaria survey in northern part of project area, covering 38 villages evenly spread over the area, showed the following results:

Spleen Rate	Less than 10%	= Hypoendemic malaria	10 localities
Spleen Rate	10 - 50%	= Mesoendemic malaria	24 localities
Spleen Rate	50 - 75%	= Hyperendemic malaria	4 localities
Spleen Rate	More than 75%	= Holoendemic malaria	0

In 1958, pre-operational surveys were carried out in the southern part of the project area covering 21 localities evenly spread over all the region. The following is the result of this survey:

Spleen Rate	Less than 10%	= Hypoendemic malaria	4 localities
Spleen Rate	10 - 50%	= Mesoendemic malaria	14 localities
Spleen Rate	50 - 75%	= Hyperendemic malaria	3 localities
Spleen Rate	More than 75%	= Holoendemic malaria	0

According to above splenometric findings the rate of endemicity of all localities in the project area is as follows:

Hypoendemic	=	26%
Mesoendemic	=	64%
Hyperendemic	=	10%
Holoendemic	=	-

It is to be noted that the value of splenometry, apart from being not sensitive enough, has to be considered in relation to infections of Kala-Azar and Schistosomiasis which are common in the area of the project.

According to results of blood examinations of fever cases in Sennar Hospital, there are two peaks of malaria incidence the first in October coinciding with the rainfall, and the other peak between February and end of April, coinciding with irrigation of cotton plantation. The second peak is missing in the non-irrigated areas.

6. OPERATIONS

Operations were scheduled to cover the Pilot Project region with residual insecticide spraying (one round per year), except for a small area between Rahad - and Dinder-River, which was left untreated as a check area for malariometrical and entomological assessments.

Dieldrin 50% w.d.p. was employed as the insecticide of choice.

In May - July 1957, Sennar district and part of Northern Fung were sprayed.

In April - July 1958, the spraying of the whole area was carried out. Details of spraying for two years were as shown hereunder:

	1957 Operations	1958 Operations
Number of villages covered	654	1,232
Number of structures sprayed	35,851	92,695
Number of population directly protected	222,028	453,400
Total surface treated with dieldrin	6,077,049 M^2	10,531,940 M^2
Total surface area treated with DDT	-	83,800 M^2
Average surface per capita	27.5 M^2	23.4 M^2
Total dieldrin 50% w.d.p. used	5,921 Kg.	10,248 Kg.
Total DDT 75% w.d.p. used		230 Kg.
Dosage of application of dieldrin	0.49g/m^2	0.5 g/m^2
Dosage of application of DDT	-	2.0 g/m^2
Total working days	45	76
Total man-hour for spray-men only	23,472	44,965
Daily Output per worker	1,500 M^2	1,200 - 1,500 M^2

DDT on a minor scale was used in 1958 programme on an experimental basis.

The output per spray-man depended on the local topography of the areas (flat or hilly, open or with jungle or dense bush, etc.), availability of water, and distances between inhabited places (dispersion index). Nearly 100% coverage had been achieved with exception of the nomads of whom only 10,000 could be traced and protected by residual spraying.

For maintenance of the 100% coverage a special Pilot Study Zone of 108 villages with 75,000 population has been set up around Sennar immediately after general spraying operations of 1958. Here 100% coverage was continuously achieved from July 1958 to January 1959 by spraying of new and disturbed surfaces and nomads tents. Fortnightly visits by S.Os were arranged for this purpose and for detection, blood examination and treatment of fever cases and for monthly collection of blood slides of post-seasonal born infants.

In 1959 a special spraying campaign has been arranged for the temporary cotton-pickers' huts established in the pilot study zone:

Number of temporary huts sprayed	8,658
Number of disturbed huts resprayed	1,119
Number of population protected	9,000
Superficial area sprayed	391,000 M^2
Total dieldrin 50% w.d.p. used	428 Kg.
Dosage of application of dieldrin	0.55 g/m^2

In February - March 1959 four spraying teams moved to the southern project area, where the nomads are usually gathering at this season and the following achievements were made:

(a) A census, which revealed, that the number of nomads in the project area is in fact only about 30,000, i.e. much lower than stated in the official census.

(b) Single dose treatment with Camoquine to each nomad in the following dosage:

More than fifteen years old	- 4 tablets (600 mg).
7 - 15 years old	- 3 tablets (450 mg).
2 - 6 years old	- 2 tablets (300 mg).
Less than 2 years old	- 1 tablet (150 mg).

A total of 93,000 tablets were thus administered. This measure aimed at an accelerated reduction of malaria reservoir.

(c) The spraying campaign was as follows:

Number of camps sprayed	233
Number of tents and huts sprayed	8,311
Number of population protected	29,302
Total surface sprayed	190,885 M^2
Total dieldrin 50% w.d.p. used	352 Kg.
Dosage of application of dieldrin	0.6 g/m^2
Average surface per capita	10 m^2

In 1959 the general spraying campaign from April - July has covered the total operational area, again mainly with dieldrin; DDT has been used for protection of 7,000 population (for comparative assessments).

Number of villages covered	1,398
Number of structures sprayed	92,984
Number of population directly protected.	469,560
Total surface treated with dieldrin ...	11,919,600 M^2
Total surface treated with DDT	227,200 M^2
Average surface per capita	25.0 M^2
Total dieldrin 50% w.d.p. used	15,479 Kg.
Total DDT 75% w.d.p. used	642 Kg.
Dosage of application of dieldrin	0.65 g/m^2
Dosage of application of DDT	2.1 g/m^2
Total number of working days	90
Man-hours of all workers	68,120
Daily output per spray-man	1,899 M^2

For the Pilot Study Zone the same procedure as in 1958 was resumed after general spraying. It is planned that in 1960 to expand this area under 100% coverage and surveillance to the whole of the 1957 operational region.

Malariometrical Assessments

In 1957 examination of blood slides of post-operational born infants were done as shown under:

	No. of Slides Examined	No. of Slides Positive For Malaria
July 1957	27	1
August 1957	70	0
September 1957	120	4
October 1957	90	3
November 1957	157	7
December 1957	130	5
January 1958	182	6
February 1958	133	7
March 1958	106	2
Total	1,015	35 = 3.1%

In August 1958 the monthly blood examinations in post-seasonal born infants have been resumed on a large scale including the Pilot Study Zone.

	No. of Villages Covered	No. of Slides Examined	No. of Slides Positive
August, 1958	50	288	2 p.f.
September, 1958	81	523	1 p.f.
October, 1958	86	482	2 p.f. + 2 p.v.
November, 1958	99	566	2 p.f.
December 1958	80	477	-
January, 1959	95	533	1 p.f.
Total		2,869	10 = 0.34%

Only 7 out of about 600 regularly examined post-seasonal born infants have contracted malaria (in 7 different villages). Since none of the post-operational born infants has shown malaria infection, the cases might be interseasonal infection, "season" to be understood as main transmission season. The children parasite rate assessed by examination of 3,335 blood slides of the Pilot Study Zone was 4%. For 1959 the figures are given below (observations till 25/9/59).

	No. of villages Covered	No. of Slides Examined	No. of Slides Positive	Age of infants
August 1959	62	308	0	-
Sept. 1959	83	424	0	-
Total		832	0	= 0.0%

As far as the post-seasonal malaria surveys are concerned, the following were obtained in 1958/59 in the re-visited localities:

	SPLEEN RATES		PARASITE RATES	
	Pre-Oper.	Post-Opr.	Pre.Opr.	Post-Oper.
After one Season Of Protection (1957)	14.0	19.6	11.3	4.0
After two seasons of protection (1957-1958)	15.8	6.9	10.2	1.8

For the whole project area under insecticidal treatment, whether protected since 1 or 2 seasons, a statistically significant drop of the parasite rate has been proved; regarding spleen rates only for the 1957 operational area, whereas the region protected since 1958 has even shown an increase, which is most likely due to Kala Azar and schistosomiasis. For the 1957 operational area splenometry has still maintained a statistical correlation to the parasitological findings.

The overall above findings indicate a dramatic fall in the infant parasite rate, as well as in the general malaria incidence.

In the Post-seasonal surveys 1958-59 the species distribution has been found as follows:

P. falciparum 94.2%, P. vivax 5.8%, P. malaria Nil.

Thus there is no significant change in the species distribution compared with pre-operational findings.

7. ACHIEVEMENTS

The Malaria Pilot Project seems to come close to achievement of its objective of malaria eradication. The following criteria should be considered:

7.1 There has been a significant drop of parasite rates in the area under insecticidal treatment with dieldrin. The longer protection, the more obvious was the regression. The decrease of parasite rates corresponds about to the natural regression rate for untreated falciparum malaria cases.

7.2 The results of blood examinations in postoperational born infants indicate at least drastic reduction of malaria transmission (complete interruption in 93.5% of the villages) for 6 months after residual insecticide spraying.

7.3 Special attention to nomads seasonal labourers in the Pilot Study Zone has prevented outbreak of epidemics and maintained full protection of the settled population.

7.4 The interruption of malaria transmission has brought the pre-existent immunity level nearly down to zero (1957 operational area, 2 seas. prot.). Therefore the system of active case-finding has turned out to be extremely valuable in these regions approaching malaria eradication.

7.5 Entomological studies showed that A. gambiae is the only specie so far incriminated as vector. Its life is much influenced by rainfall. Rain pools and river bed pools are favourable breeding places. It is susceptible to all chlorinated Hydro-carbons. It is endophylic. Out of the nine species of Anophelines collected in the area sporozoites were observed only in A. gambiae during the months of September, October and November. With the occurrence of an initial rainfall of 150 mm., pools necessary for increased output of A. gambiae, are formed and malaria transmission takes place soon afterwards.

7.6 Regarding the use of insecticide, the complete disappearance of A. gambiae in sprayed area and its high prevalence in check area and in unsprayed nomadic camps points to a very effective control of Dieldrin over A. gambiae. Inclusion of Nomads' camps in the residual spraying coverage is necessary. This is again beset with the practical difficulties due to their mobility. Another important point for consideration is suitable arrangement for leaving undisturbed the sprayed surfaces at least six months after spraying. Repairs to the roofs and new plastering of inner surface of the walls were observed at several places, thus providing new untreated surface in the controlled area. This can be avoided by good public education. Comparative studies on DDT and Dieldrin are proceeding. If DDT is effective enough it is preferable for cost and human toxicity being low.

7.7 Regarding training, it was given to 26 permanent Project Staff, all 120 P.H.O. and P.H.I. of Sudan and to the final class students of School of Hygiene.

7.8 Regarding the use of drugs, chloroquine and amodiaquine proved valuable for fever case treatment, and single dose mass treatment in moving reservoirs as Nomads. The fact that P.falciparum is the predominant species is of great importance in malaria eradication campaign as it is amenable to radical cure.

8. SPECIAL PROBLEMS AND FUTURE DEVELOPMENT

8.1 Duration of Malaria Transmission Season

Whereas it is known that the main transmission season in the unirrigated parts of the northern project area lasts only from July to December, little information is available about the duration of the transmission season in the southern sectors. As it is probably much longer or even perennial due to the longer rainy season, this problem deserves special attention, particularly in respect to the residual insecticidal action.

8.2 The present situation suggests the necessity of 2 spraying rounds per year in the irrigated parts of the northern project area, and most probably in all southern sectors. As the problem for the latter is closely linked with the duration of residual insecticidal effect and with the practical accessibility of the area after the rainfalls, this matter deserves a thorough investigation to find practical solutions.

8.3 Full Coverage by Insecticidal Spraying

The rainy season is the main transmission season in the project area, however, also the season for construction of new and repair of old huts as the grass becomes available. Since during rainy season only animal transport with all disadvantages regarding low speed and limited load is practicable, the present staff is not sufficient to assure maintenance of 100% insecticidal coverage in all but the pilot study zone. A way of achieving the maintained coverage for the whole project area has to be sought.

8.4 Check of Malaria Transmission in the Southern Sectors

It has been pointed out, that the duration of transmission season in the southern project area has still to be evaluated. This is a task for the dry season. For examination of the efficiency of the applied measures the same procedure as for the Pilot Study Zone seems to be feasible, i.e. monthly blood examination in post-operational born infants. It would be sufficient to cover about 30,000 population. As this certainly absorbs a considerable number of staff, increase of personnel will be indispensable.

8.5 Nomads, Seasonal Workers, Introduction of Malaria

The special campaigns for protection of nomads and cotton-pickers have proved to be of utmost value also for prevention of malaria outbreaks in the settled population. A system as adopted in the Pilot Study Zone would certainly reduce the risk to a minimum if applied in the whole project area.

The introduction of malaria from neighbouring areas, particularly from the heavily infested Ethiopian border zone bears potential danger. A solution has to be sought in speeding up the start of malaria eradication in Ethiopia.

8.6 Next Stages of Malaria Eradication in the Pilot Project

If the achievements continue to be as favourable as seen so far, the phase of attack may be terminated after four years of insecticidal protection; that is in 1960 and 1961 respectively, provided that conditions for consolidation are fulfilled, for the same reason a well established surveillance is important. For the northern project area surveillance is expected to start working at full scale early in 1960, depending on availability of sufficient transportation.

Since WHO assistance to the project will end in December 1960, establishment of surveillance in the southern project area will be left to the national side. A very careful surveillance is needed to consolidate and maintain achievements.

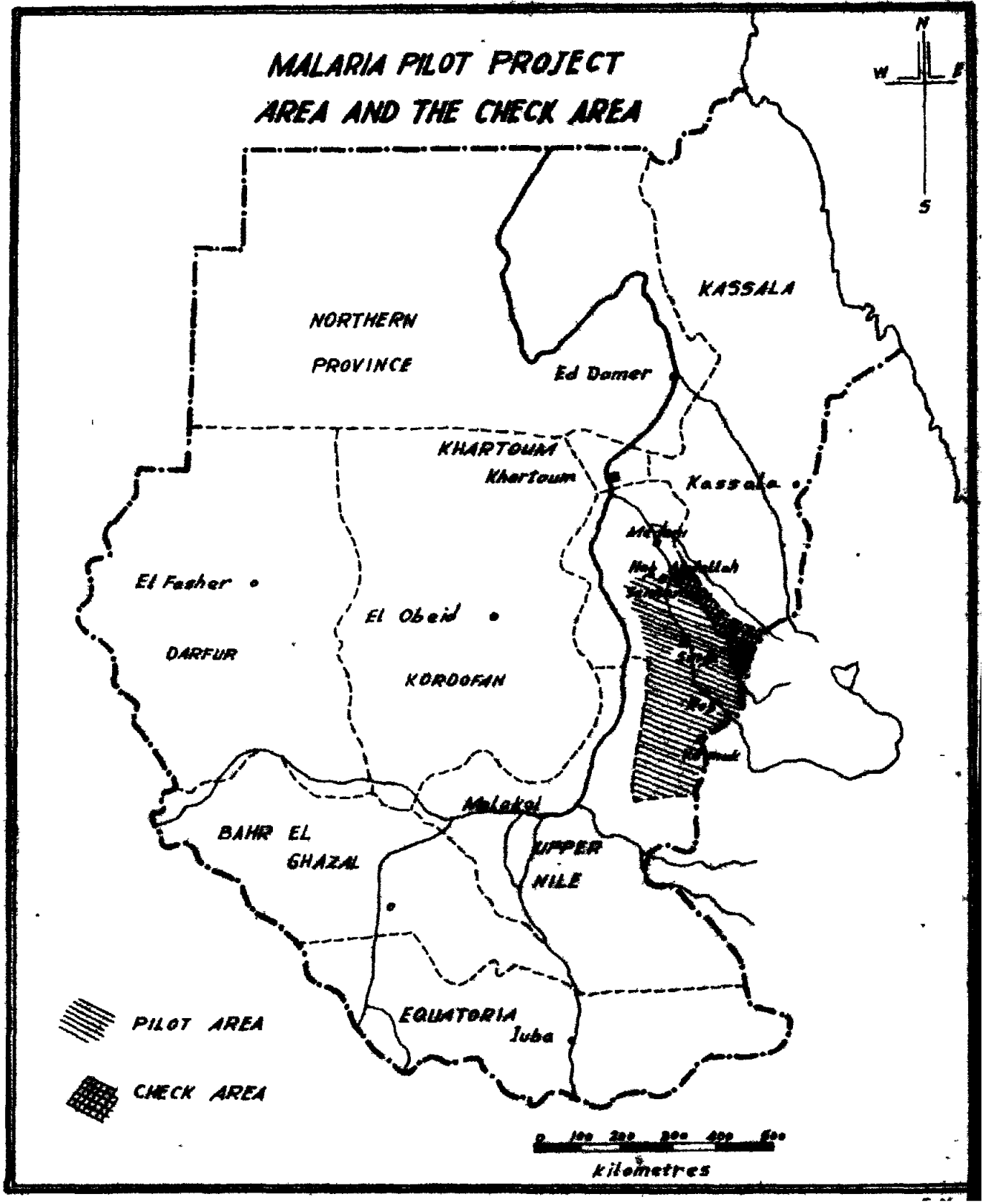
9. Conclusion

I am glad to point out that:

(a) The project materialized its objectives and that the three Parties concerned i.e. the Sudan Government, WHO and UNICEF have carried out their responsibilities in a most commendable way.

(b) Good results were achieved and of these the training of staff and incrimination of the vector were of the utmost importance.

(c) Eradication of malaria in Sudan appears to be possible subject to the availability of international financial and technical assistance. As this programme will be a matter of national as well as international concern, the cooperation of neighbouring countries of the Eastern Mediterranean and African regions, and the synchronization of their eradication programmes have to be assured well in advance, so that unnecessary efforts and heavy expenditures can be avoided.


MALARIA PILOT PROJECT
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